The Servicing of TELEVISION RECEIVERS

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Foreword

Much has been predicted concerning the future of television as a major industry and its far reaching effect upon the daily lives of all people. The proof of these predictions is about to be demonstrated as new television stations are established and manufacturers prepare to place television receivers upon the market.

As television becomes a reality, another prediction is about to be fulfilled—namely, that a vast new field of opportunity will open up for the qualified radio serviceman. The public at large knows nothing about the installation, operation or performance of television receivers. Therefore, the industry will have to lean heavily upon informed service technicians for the successful introduction of television to the general public.

Therein lies the opportunity today for the farsighted radio serviceman. For those who wish to take their part in the tremendous expansion of the television industry, the time to begin—the time to acquire the necessary technical knowledge and training—is *now*.

The material in this book is compiled from many years of actual television field service experience. It gives you not only the principles of television receivers but also practical facts which will enable you to meet actual conditions as they occur in the home. The basic background material of this publication may be supplemented by the manuals for specific television receivers which will be placed on the market by the various manufacturers.

A television receiver is necessarily a more complicated electronic instrument than a radio receiver. Remember——only the *trained* serviceman will be able to profit from the growth of the television industry.

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Introduction

In the preparation of this publication, careful consideration of both the technical and non-technical reader was of utmost importance. It was decided that, aside from a general knowledge of the processes involved, the serviceman will not be interested in the technical aspects of television broadcasting, since his primary interest is in the operation and servicing of television receivers. It was further assumed that the technician will possess a general understanding of radio, electrical and electronic theory and practice and this knowledge will enable him to cope with the technical aspects of the text material. The written material is reinforced by an abundance of carefully prepared illustrations. Finally, the serviceman will recognize the necessity of dealing in generalities in connection with those aspects of television which are still being developed. However, specific information is given, sufficient in detail, to make this publication of greatest value to anyone who intends to service television receivers.

The contents of this book are divided into five sections. The first deals in a general way with the complete television system; the second describes the make-up of a composite television signal; the third contains an analysis of television receiver circuits; the fourth covers television antennas; the fifth contains detailed data on servicing a television receiver and its related units. For ready reference, a complete index and a glossary of television terms will be found at the back of the book.

TP-909

THE BASIC TELEVISION SYSTEM

THE MAJOR UNITS OF A TELEVISION SYSTEM

The operation of a complete television system requires the transmission and reception of both video and audio signals. For technical reasons, separate transmitters are used for the video and the audio transmission, but reception is accomplished by a single receiver. The relationship of these components is shown in figure 1.

THE TELEVISION TRANSMITTERS

In the picture, or "video," transmitter, the camera section views the scene with a camera tube which divides the scene into thousands of elements and converts the amount of light in each element into an equivalent electrical potential, or video signal. The sequence in which the elements are selected, or scanned, is determined by the timing-circuit section. The resulting video signal is then amplified and combined, in the video-line amplifier, with synchronizing signals supplied by the timing-circuit section. The combined signal contains all the components necessary to construct a picture when supplied to the proper electronic circuits, and is known as the "composite video signal." The composite video signal is fed to the transmitter section where it is superimposed upon, or "amplitude-modulates," the radio frequency carrier, which in turn is fed to, and radiated from, the antenna system.

Simultaneously, with the viewing of the picture, a microphone is picking up the sound which attends the scene, and converting this sound into equivalent electrical potentials. These potentials are then amplified and used to "frequency-modulate" the radio-frequency audio carrier. This audio carrier is 4.5 megacycles above the frequency of the video carrier. The audio transmitter embodies standard frequency-modulation techniques, and for further information on frequency modulation, the reader is referred to the abundant material in trade publications.

THE TELEVISION RECEIVER

The television receiver may be divided into two parts for studying its functions. In the video section, the received composite video signal and the frequency-modulated audio signal are received and amplified. The audio signal is separated and fed to the audio section. The composite video signal is then further amplified, detected, and fed to both the video amplifier and the sweep circuits. From the video amplifier the signal goes to the picture tube where it produces light variations in the picture-tube beam. In the sweep circuits, the synchronizing signals are separated and used to control the necessary scanning action of the beam of the picture tube. This scanning action is thus synchronized with the scanning of the camera tube at the transmitter, and to the eyes of the television audience, the televised scene is reproduced as a complete picture.

THE TELEVISION ANTENNAS

For ordinary radio reception, the antenna is not critical. In television, however, the antenna is of great importance. At the transmitter, great care is taken to achieve radiation that will be substantially equal in all directions along the earth's surface. Special arrays of half-wave dipoles and matched transmission lines are used. Of almost equal importance is the choice of, and installation of, an antenna for the receiver. Usually it will be desirable to install an antenna of high directivity, in other words, an antenna that receives signals from one direction to the exclusion of signals from other directions. These antennas usually take the form of half-wave dipoles with reflectors. The importance of the receiving antenna is such that it is discussed at length in the servicing section of this publication.

THE BASIC TELEVISION SYSTEM

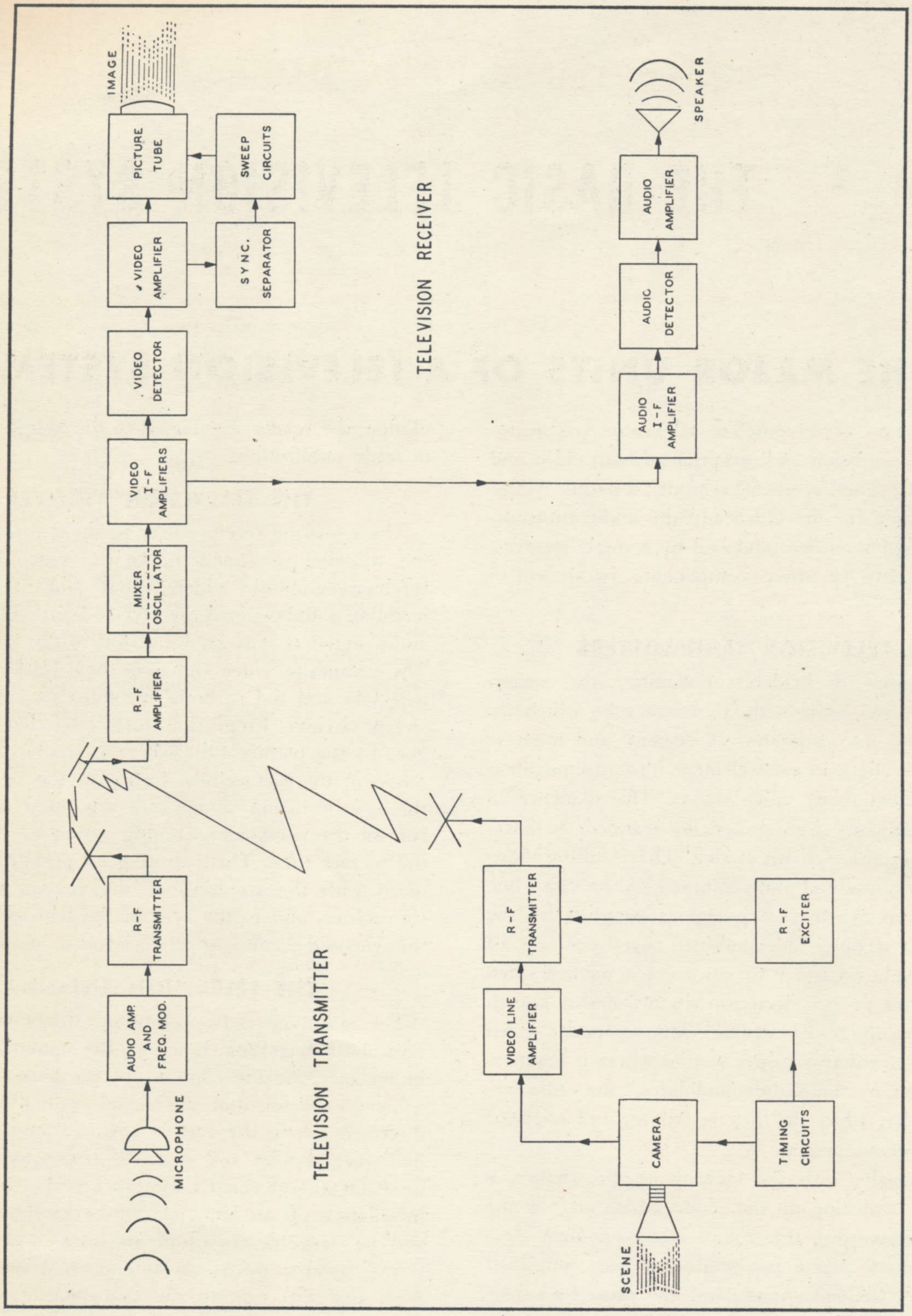

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Figure 1. A Simplified Diagram of a Television System.

TELEVISING PROCEDURES

PICTURE ELEMENTS

The principles developed and now in use in televising a picture employ some method of breaking the picture into individual elements, transmitting these elements in sequence, and reassembling them at the receiver.

An excellent example of pictures reproduced by the use of individual elements is found in any half-tone picture. This type of picture reproducing is the common method used by newspapers and books. An examination of a half-tone picture with a magnifying glass reveals that these pictures are composed of thousands of evenly spaced dots. The size of the individual dots determines the shade of the picture. That is, large dots produce dark areas, smaller dots produce light areas. When the assembled dots are viewed from a distance, they cannot be seen individually but blend together and appear as a complete picture. The detail of the picture is improved in direct proportion to the number of dots per square inch.

When many pictures presenting a sequence of closely related actions are rapidly presented to the eye, the illusion of motion is obtained. This fact is effectively illustrated by motion pictures. Therefore, a picture in which motion appears to take place can be constructed and presented to the eye. As a result of experiment with motion pictures, it was found that picture appearance was improved by the use of certain proportions. Thus the ratio of a picture's width to its height, called the aspect ratio, was established at 4 to 3.

A later development disclosed a reduction in flicker as the camera-shutter rate was increased. An increase in shutter rate does not necessarily mean an increase in the number of individual film pictures, or frames, as the shutter rate can be increased by projecting a single frame more than once.

SCANNING

Television pictures are similar to motion pictures in that they too are made up of elements and frames, and depend upon the retentiveness of the eye to give the illusion of motion. Unlike the motion picture, the elements of the television picture cannot be transmitted simultaneously, but must be transmitted individually and in a definite sequence, each transmitted element being reproduced by the receiver in the same sequence in which it was transmitted and given the same relative light value it originally represented. The method by which these elements are reproduced in their correct sequence is called scanning.

SCANNING DEVICES. An early method of television scanning employed a mechanical device. This method utilized a rotating disc, usually made with a spiral of apertures arranged around the outer circumference and spaced so that there was no overlapping. This disc was used as a means of breaking down a picture into many individual light values or elements. At the transmitter, placed immediately behind the disc and in line with the apertures, was a photocell, a device capable of translating light variation into corresponding electrical variations. This mechanical system offered many handicaps, such as difficulty in synchronism and other mechanical failures.

The basic idea of breaking the picture into many individual elements is still used, but the method of scanning first used has been replaced by the electronic gun in the camera tube of the transmitter, and by the cathode-ray tube of the receiver.

The camera tube is used to convert the light values of a scene, or picture, into equivalent electrical potentials. The tube is constructed so that any image can be focused upon a light-sensitive screen, or photo-sensitive screen, called the "mosaic." See figure 2. In televising motion-picture film, the motion-picture projector is focused directly onto the mosaic within the camera tube. The photo-sensitive screen has thousands of light-sensitive globules placed one layer deep on one side of an insulating surface such as mica; each globule is insulated from every other globule. Placed on the other side of the insulating surface is a conducting plate of either silver or graphite. Each of the little light-sensitive elements can be considered as one plate of a capacitor; the large plate on the other side of the dielectric is the other plate, and is common to every individual light-sensitive element. The light-sensitive elements have the property of losing electrons when subjected to light, the brighter the light the greater the number of electrons emitted, causing the light-sensitive elements to assume a positive charge in relation to the common plate. Therefore, if a picture representing many different light values is focused upon the mosaic, each element of the mosaic will assume a charge proportional to the light falling upon it. The individual

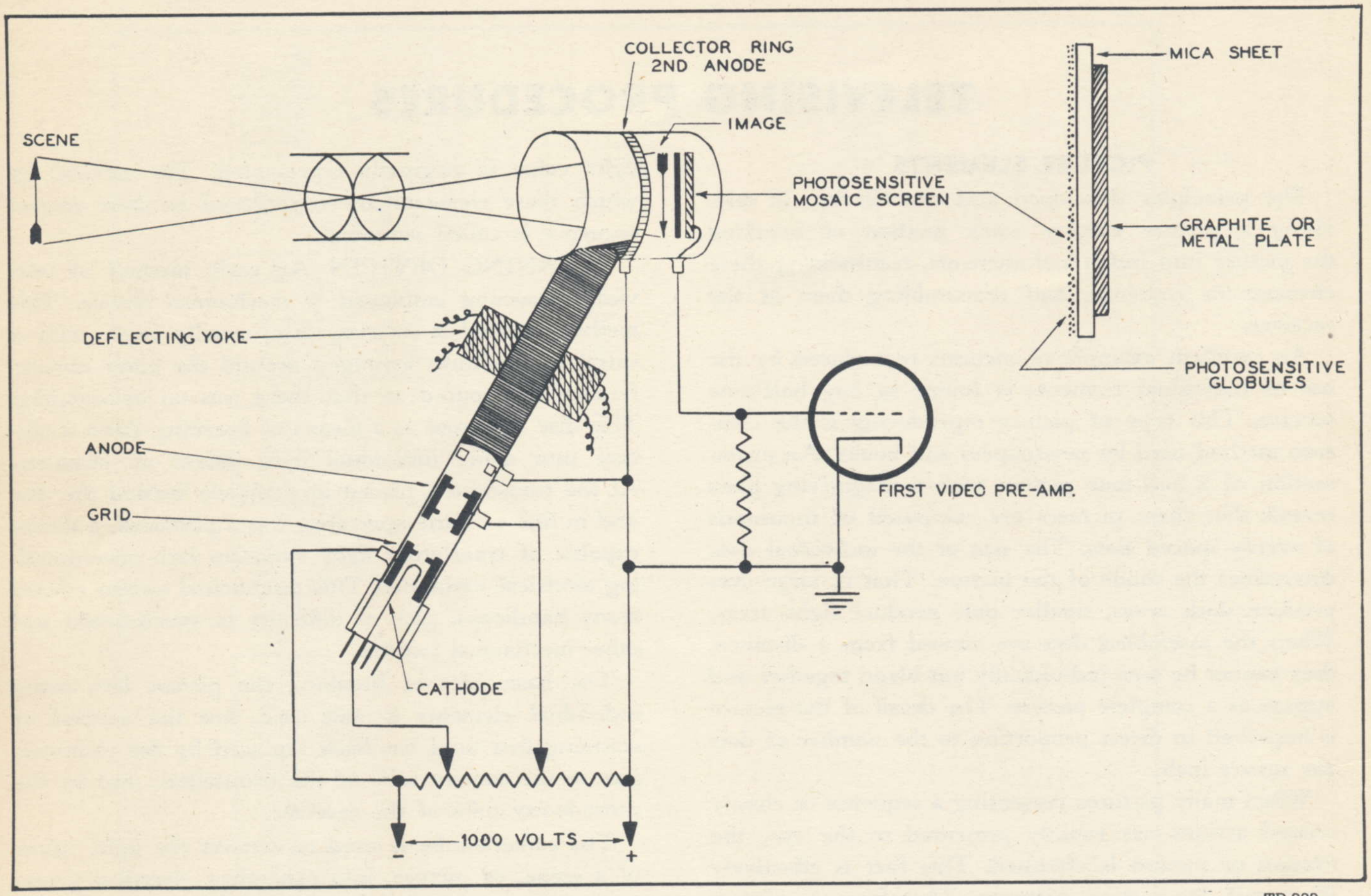

Figure 2. A High-Velocity Camera Tube. TP-339

elements will retain their charge until discharged. This storage action of the mosaic is very important, because it allows the individual charges to be removed one at a time in a definite sequence, producing the desired electrical equivalent for the amount of light falling upon the individual element. These elements are discharged in a given sequence by the scanning action of a beam of electrons, which are generated and controlled in a manner identical to that used in the cathode-ray tube. The type of deflection used may be either electrostatic or electromagnetic. The electrons displaced by the high-velocity scanning beam are attracted to a collector ring placed around the inside of the tube. Undesirable shading effects, resulting from secondary emission, are characteristic of high-velocity camera tubes.

Another type of camera tube contains practically the same elements as the camera tube previously described, although the physical size and location of the elements are somewhat different. The mosaic is smaller and practically transparent, as the silver coating on the insulating plate is extremely thin. The tube is approximately 18 inches long and 4 inches in diameter. The picture is focused onto the silvered side of the mosaic, and the scanning operation is performed on the opposite side. A very low velocity beam is used for scanning, which gives the tube high efficiency by eliminating secondary emission and its consequent shading effects. Because of its high efficiency, this tube is quite sensitive and can be used to pick up pictures where good lighting is not possible. These advantages would seem to make this tube particularly adaptable for all television cameras. There are, however, two disadvantages. A combination of electrostatic and electromagnetic deflection is used which necessitates complex and critical deflection circuits. Usually, to avoid interaction, it is desirable to include these circuits within the camera. In addition, because of the diameter of the tube and the strong magnetic field needed for focusing, a very large and heavy focus coil is necessary. These disadvantages add such a tremendous weight to the camera that it becomes awkward to handle and is therefore used only to pick

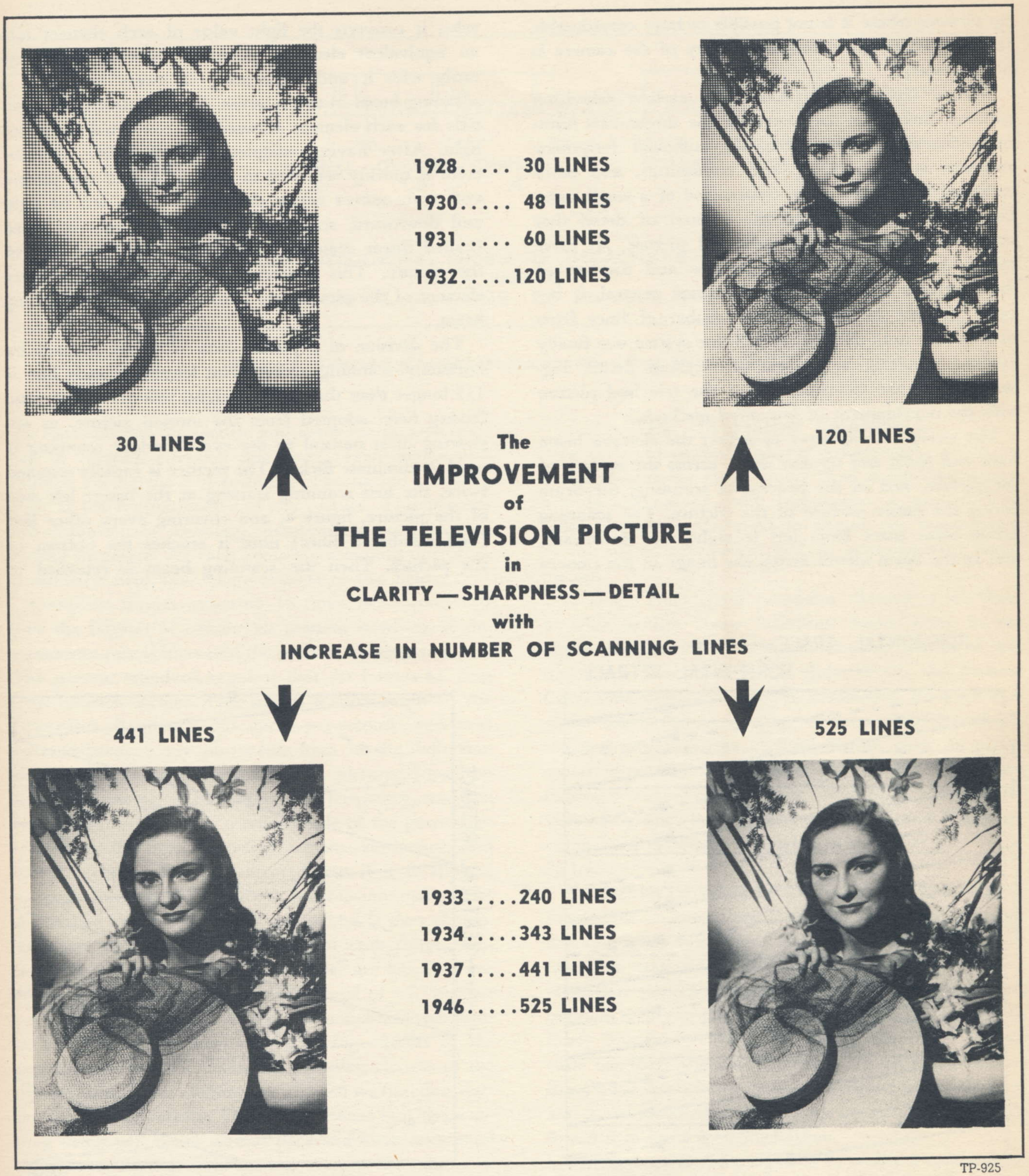

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Figure 3. Improvement of the Television Picture.

up pictures where it is not possible to have considerable light, or where great maneuverability of the camera is not necessary.

SCANNING METHODS. The earliest television pictures, limited as they were by the mechanical scanners, the difficulty in obtaining sufficient frequency response in the receiver and transmitter, and other technical limitations, were constructed of a small number of lines. This limited the amount of detail that could be presented in the televised picture. As these technical limitations were overcome and the use of the electronic scanning devices became general, it became possible to increase the number of lines from time to time until the present 525-line system was finally evolved, resulting in pictures of excellent detail. Figure 3 shows the improvement of the televised picture with the development of improved methods.

The sweep circuits serve to deflect the electron beam back and forth and up and down across the surface of the picture, and in the process of scanning, the beam covers the entire surface of the picture. The scanning action takes place from left to right, and downward, and as the beam moves across the image in the camera tube, it converts the light value of each element into an equivalent electrical potential. Moving simultaneously with it and duplicating its every motion is a scanning beam in the receiver, and the electrical potentials for each element scanned are converted back into light. After having completed the first line, the element is quickly returned to the left side of the picture and again moves across the picture from left to right and downward, scanning at a constant rate of speed (called linear scanning) and covering a new part of the picture. This procedure is continued until every element of the picture has been scanned by the moving beam.

The division of a picture into 525 lines is made by horizontal-scanning action. The length of each line is 1/3 longer than the picture height, this 4:3 aspect ratio having been adopted from the motion picture, as appearing most natural to the eye. Interlace scanning is used to eliminate flicker. The picture is rapidly scanned twice, the first scanning starting at the upper left side of the picture, figure 4, and covering every other line (odd numbered lines) until it reaches the bottom of the picture. Then the scanning beam is returned to

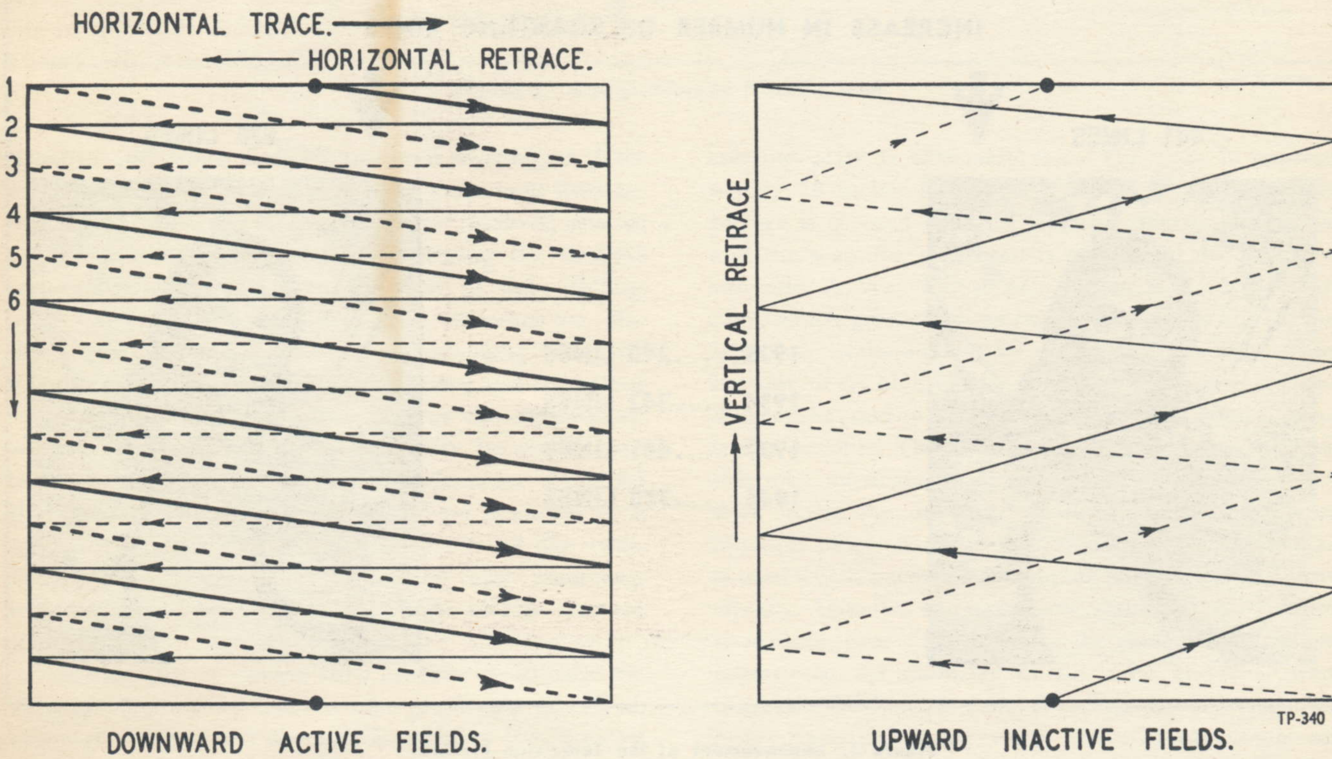

Figure 4. Interlace Scanning.

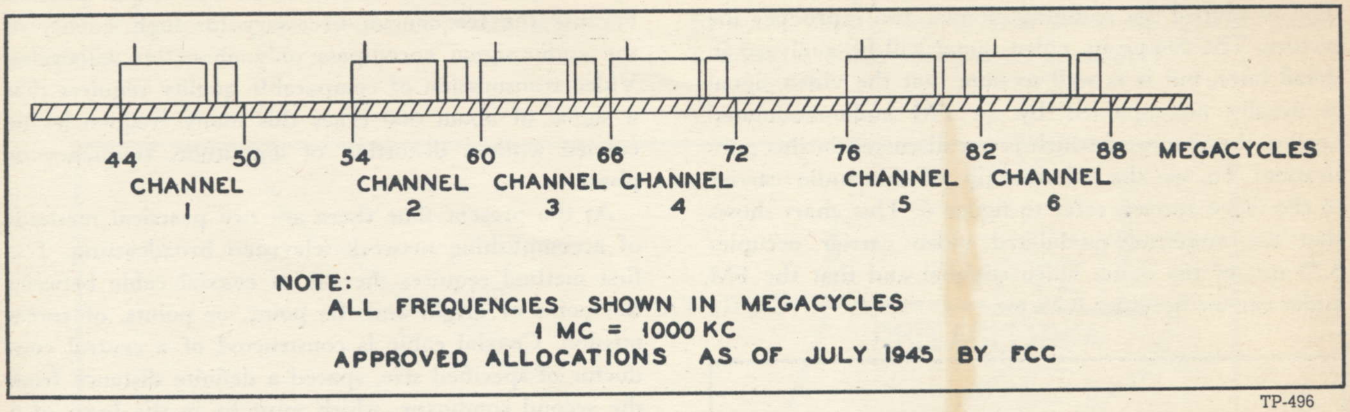

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Figure 5. Television Channels, Frequency Allocations Below 100 MC.

the top center of the picture and scans the picture from top to bottom, covering the lines (even numbered) skipped during the first scanning. The second scanning ends at the bottom center of the picture. This procedure requires two scanning operations to complete the picture or frame. As each complete scanning operation is termed a field, one frame consists of two fields.

Complete frames recurring 16 times per second will give the illusion of continuous motion; however, if the recurrence rate is increased the picture flicker is reduced. The present standard requires that 30 frames be constructed each second. This rate is a submultiple of the power-line frequency, 60 cycles-per-second, and was selected because any power-line hum in the deflection circuits will cause distortion of the picture. Since the hum is recurring at the power-line frequency, and the frame recurrence rate is a submultiple of the power-line frequency, the hum distortion remains stationary, and if not excessive, can be tolerated, but if it is allowed to move through the picture it becomes annoying. The recurrence rate of 30 frames per second is thus chosen. This rate and the double scanning of each frame eliminates objectionable flicker. Since there are 525 lines per frame and 30 frames per second, a total of 15,750 lines per second are scanned. In order to maintain synchronization between the horizontal-scanning circuits of the camera tube and the horizontal-scanning circuits of the picture tube, these circuits are allowed to function during the vertical retrace. This action means that the scanning beam will make several back-and-forth horizontal movements during each vertical retrace. See figure 4. However, these back-and-forth movements of the beam are not visible because the cathode-ray tube is blanked during the vertical retrace.

THE TELEVISION CHANNELS

In order to transmit picture information, which includes frequencies much higher than audio frequencies, a wide channel of radio frequencies is needed. The video channel is designed to permit the transmission of the video information and its accompanying audio carrier.

A single commercial television channel is six times as wide as the entire broadcast band. Only in the higher frequency spectrum are channel widths of this magnitude available. As of July, 1945, the Federal Communications Commission established thirteen television bands for the purpose of commercial broadcasting and reception. Six of these bands, each six megacycles in width, fall between 44 and 88 megacycles. Figure 5 shows clearly these allocations. Seven television-frequency bands exist between 172 and 216 megacycles, and experimental bands from 480 to 920 megacycles.

To prevent crowding of stations in one area, regulations allow no more than 7 stations to an area, although the frequency allocations provide for more than 500 television stations to blanket the country. Local area allocation provides that a station in an uncrowded, isolated area use the 44 to 50-megacycle channel with fairly low power. In areas where cities are located close together, alternate channels are assigned, such as the Philadelphia-New York area where channels 2, 4, and 5 are assigned to New York stations, and channels 3 and 6 to those in Philadelphia.

The composite video signal is in reality a combination of signals generated by the camera tube and its associated scanning and keying circuits. The composite video signal is used to amplitude-modulate a television transmitter, and at the receiver, this composite waveform is used to control the scanning circuits and reproduce the picture. The composite video signal will be analyzed in detail later, but it is well to note that the video signal is usually accompanied by an FM audio-modulated carrier, the nature of which is not discussed in this publication. To see the relationship of the audio carrier to the video carrier, refer to figure 6. This chart shows that the amplitude-modulated video carrier occupies 5.75 mc. of the 6-mc. video channel and that the FM audio carrier occupies 0.25 mc.

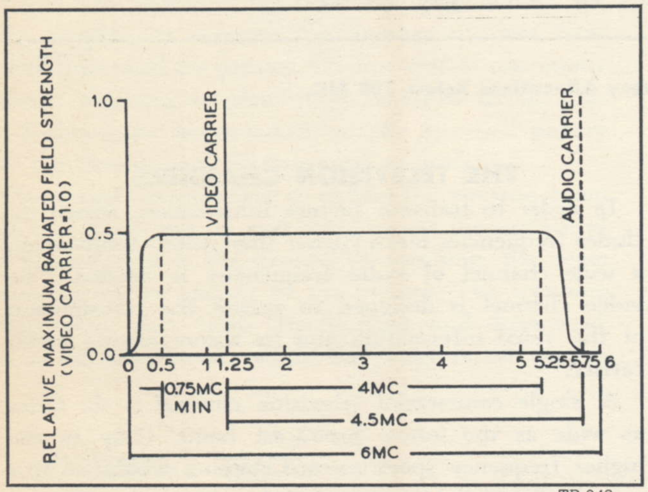

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Figure 6. Ideal Picture-Transmission Characteristics.

The chart, figure 6, further shows that the transmitted video signal does not have equally wide side bands. The bandwidth of the lower side band and carrier is only 1.25 mc.; the bandwidth of the upper side band and carrier is 4.5 mc. The suppression of one side band is known as vestigial side-band transmission, and this type of transmission permits the use of a video signal of wider frequency range, resulting in a better defined picture without greatly increasing the total required frequency band per channel. The transmission of part of the lower side band with the upper, results in an over-emphasis of the low modulating frequencies, since the low frequencies of the partially suppressed lower side band add to the low frequencies of the upper side band. To avoid this over-emphasis, the receiver must be designed to attenuate the carrier frequency 50%.

THE TELEVISION NETWORK

Network broadcasting of sound programs is normally carried out by the use of wire transmission of programs from the point of origin to the point or points of broadcasting. This is a relatively simple process, because the frequencies necessary for high fidelity of the audio signal encompass only about ten kilocycles. Video transmission of comparable quality requires that a signal of about 600 times this many frequencies be carried without distortion of amplitude, frequency or phase.

At the present time there are two practical methods of accomplishing network television broadcasting. The first method requires the use of coaxial cable between the point of origin and the point, or points, of transmission. Coaxial cable is constructed of a central conductor of specified size, spaced a definite distance from the second conductor, which must be in the form of a hollow tube surrounding the central conductor. It can be readily seen that such a conductor requires precision construction methods and special materials. Since the most practical installation for such a conductor requires that it be buried, it is apparent that the use of coaxial cable for network television purposes envisages the expenditure of a great amount of money and involves considerable technical difficulty.

Because of the drawbacks of the coaxial-cable method, a substitute method was sought. The obvious answer was found in the principle of sending the picture, from the origin to some point between the origin and the desired point of broadcasting, by television methods. At this intermediate point the picture would be received by a television receiver and re-broadcast by a television transmitter to the next point, and so on until the desired point was reached. Many technical difficulties were encountered in the development of this basic idea, such as interference between adjacent relay transmitters and receivers, operating on the same frequency.

A multiple-relay television network linking two major cities is now in operation between Washington, D. C., and Philadelphia. Developed by Philco engineers, it proves that the transmission of a television picture over long distances by a series of wireless relays is possible and practical.

In this network, television pictures are relayed from Washington, D. C., through booster stations at Arlington, Va., Odenton, Md., Havre de Grace, Md., and Honeybrook, Pa., to Philco Station WPTZ in Philadelphia and its television audience, as shown in figure 7. The interference mentioned in a preceding paragraph has been eliminated by having each relay transmitter on a different frequency. For example, at Odenton the receiver is set to the Arlington transmitting frequency, while the transmitter at Odenton and the receiver at

Havre de Grace are on another frequency, and so on, each unit thus avoiding the frequency of the adjacent transmitters.

This technique is a scientific forerunner of the means by which signals may be sent across the United States to form a nation-wide television network.

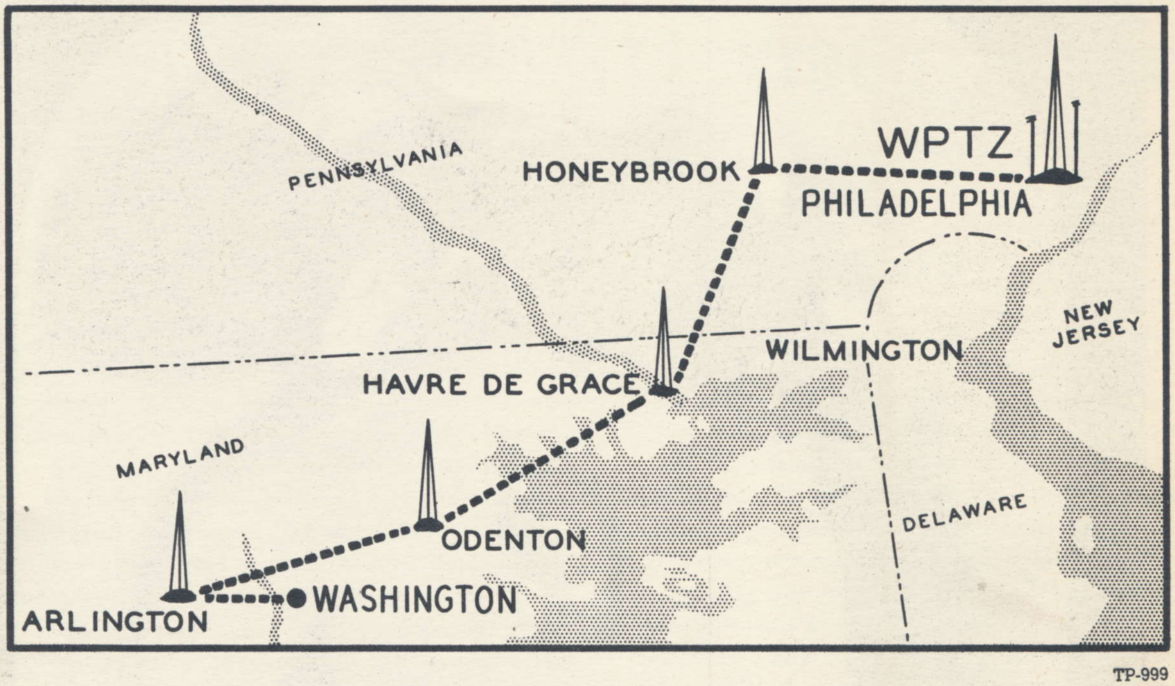

Figure 7. A Television Relay Network.

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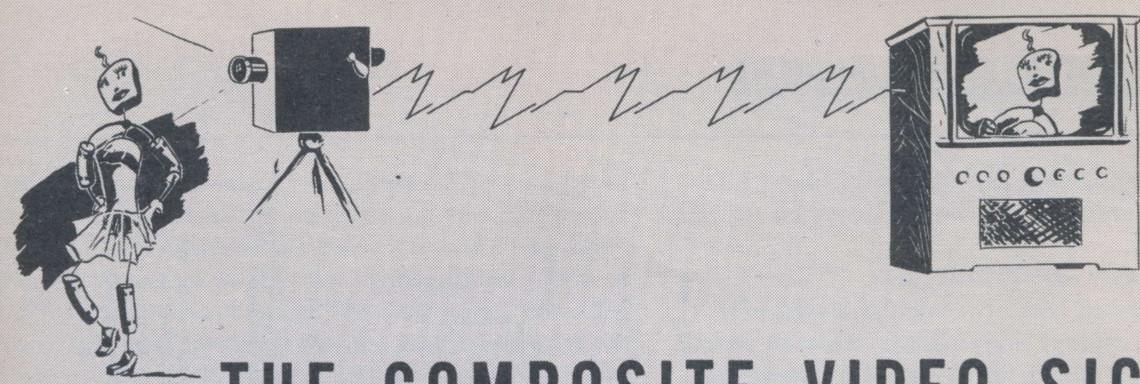

THE COMPOSITE VIDEO SIGNAL

VIDEO-SIGNAL COMPONENTS

An analysis of the complex nature of the composite video signal is necessary to understand the correlation of the functions of transmitter and receiver circuits. This section describes the nature of the signal composition, and the sequence relationship of the signal components. The waveform of the composite video signal, as prescribed by the Federal Communications Commission, is shown in figure 8. An examination of this waveform will show that the composite video signal consists of several component-signal pulses; (1) the video signal, (2) the blanking pulse, and (3) the pedestal sync pulses. The sync pulses may be classified according to their particular functions; (a) horizontal-sync pulses, (b) vertical-sync pulses, (c) equalizing pulses.

The composite video signal produces simultaneous effects at various points in the receiver, as shown in figure 8F. These effects are shown, in time sequence, for a very small portion of the complete frame. First the picture tube is blanked out at the end of line 246 and the horizontal sweep returns to the left side of the picture; then the picture tube is unblanked, and the beam sweeps across the tube from left to right while the video signal modulates the beam. The picture tube is then blanked again and the process is repeated, completing line 247, the last line at the bottom of this field. This time the tube is blanked for 1016 microseconds equal to the time required to sweep 16 horizontal lines, while the vertical sweep returns the beam to the top of the picture. During this time the horizontal sweeps continue, unseen because of the blanking, in order to preserve their synchronization. Immediately preceding and succeeding the vertical-sync pulse, the equalizing pulses appear, to aid in preserving the proper relationship between the interlaced lines. By this time the sweep has returned to the top of the screen and is ready to start slowly down again. The screen is again unblanked and the horizontal sweep again moves the beam from left to right across the screen to form line 263. As before, when unblanking occurs, the video signal is impressed on the beam. When the beam reaches the right side of the screen, blanking occurs, and the beam is quickly returned to the left side of the screen, ready for line 264. Note that as each visible horizontal line is swept, the vertical sweep is operating and the beam is progressively lowered on the screen, so that each sweep is a slanting line, tilted down to the right side. The simple repetition of these actions forms the desired picture on the screen.

FUNCTIONS AND CHARACTERISTICS OF THE COMPONENTS IN A COMPOSITE VIDEO SIGNAL

The exact nature of the component signals in the composite video signal will be more apparent when analyzed in terms of functions, relationships, and relative amplitudes. Drawing "A," figure 8, shows a series of equalizing pulses, vertical pulses, and equalizing and horizontal-sync pulses in the exact sequence named. These pulses are located on top of a long blanking pulse called a pedestal, which has a duration of approximately 16 horizontal lines, or 1016 microseconds, which is located between two successive fields. The relative amplitudes of the signals, as shown, place the blanking-pulse level at 75% (plus or minus 2.5%) of

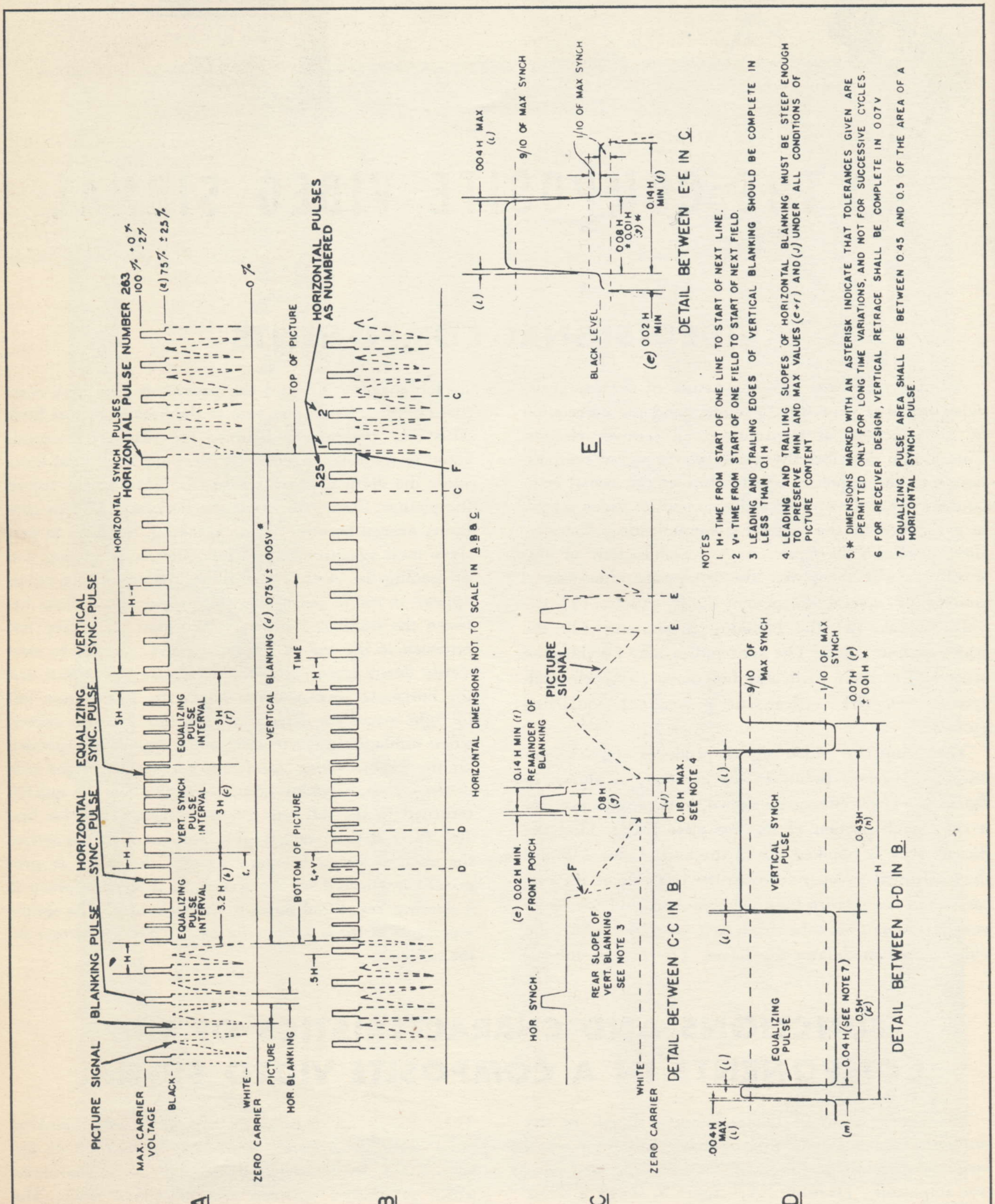

Figure 8. The Standard Television Synchronizing Waveform.

the total composite-signal amplitude. The polarity of the composite signal is arranged to bias the picture tube to cutoff, blanking out the screen when the amplitude of the signal reaches the blanking level (75% of the total signal amplitude). The sync pulses extending above this level are located in the region known as the "blacker-than-black" portion of the composite video signal. It follows that if the signals of blanking-level amplitude, or greater, will bias the picture tube to cutoff, blanking out the fluorescent screen, then signals of less amplitude will allow the bias to become less, resulting in the tube resuming operation. The less the bias the more brilliant the screen. A detailed description of each of the above mentioned component signals in the composite video signal follows:

VIDEO SIGNALS

The video signal is a varying electrical potential, representing progressive changes of light value for each line scanned. It causes the grid bias in the picture tube to be varied, thus reproducing the original light values, and it is always located between blanking pulses. To better understand the signal composition when a half-line is scanned, refer to point "F" of drawing "B."

Point "F" on drawing "B" corresponds with point "F" on drawing "C," which is an enlargement of the signal between "C-C" on drawing "B." Point "F" represents the half-line at the beginning of the picture.

The video signal will vary rapidly in amplitude; this variation, represented by a frequency change which would be needed to reproduce the most complex picture (the most difficult picture to televise is a checkerboard pattern, each square representing one picture element), can be approximated by the following method. Consider one line to be one element wide; this means that if the picture is 525 lines, or elements, high vertically, it will be 4/3 of 525 or 700 elements wide (4:3 is the aspect ratio). The frequency at which a frame is scanned is 1/30 of a second. (Remember, one cycle equals two elements because only alternate lines are scanned each frame.) Then, to obtain the maximum frequency it is only a matter of multiplication:

$525 \times 700 = 367{,}500$ elements for one frame.

$367{,}500 \div 2 = 183{,}750$ elements per cycle.

$183{,}750 \times 30 = 5{,}512{,}500$ elements reproduced in one second.

Thus it is evident that the video signal is a high-frequency signal and will require a wide channel for transmission. In actual transmission, however, the maximum allowable video-channel bandwidth is 4.25 mc. This produces a slight loss in horizontal resolution but is not noticeable on the receiver picture-tube screen.

THE BLANKING PULSE

The blanking pulse is located between the successive lines of video signals, and between successive fields, and serves to blank out the picture tube 0.02H before, during, and 0.06H after the horizontal and vertical retraces. See figure 8-C. The amplitude of the video blanking pulse is critical and the limit of allowable variation is a plus or minus 2.5% from the plus 75% modulation point. This is the point that will cause the picture-tube bias of the receiver to increase and blank out the picture. If the level is increased to 80%, the amplitude of the sync pulses is reduced. This in turn makes synchronization of receiver sweep circuits very difficult. If the level is too low, the relative amplitudes of the video signal are reduced, resulting in such a small change of potential between light and dark that the picture appears bleached, i.e., lacks contrast.

Drawing "A" or "B," figure 8, shows that blanking pulses of two different time durations are transmitted. The short blanking pulse, located between successive lines, has a duration of 16% of a line, or approximately 10 microseconds, and is transmitted to blank out the horizontal return line. The long blanking pulse, located between fields, has a duration of about 16 lines, or approximately 1016 microseconds, and is transmitted to blank the horizontal sweeping of the beam while being returned to the top of the picture.

THE SYNC PULSES

Each of the sync pulses is mounted on top of a blanking pulse, and they are divided into three groups, horizontal, vertical, and equalizing, according to their function.

The horizontal-sync pulses, located on top of each of the blanking pulses between each of the 525 picture-signal lines, serve to keep the horizontal-sweep generator in the receiver in synchronization with the horizontal-sweep generator at the transmitter during the period a frame is being scanned. During the vertical retrace, however, the equalizing pulses and the serration in the vertical pulse will trigger the horizontal sweep at a constant line interval of 63.5 microseconds. The horizontal pulse has the following time relationship, as shown in drawing "E," figure 8. It is mounted on the horizontal-blanking pedestal and has a time duration of 8% of one line, or 5 microseconds. It occurs 1.3 microseconds after the start of the horizontal-blanking

THE COMPOSITE VIDEO SIGNAL

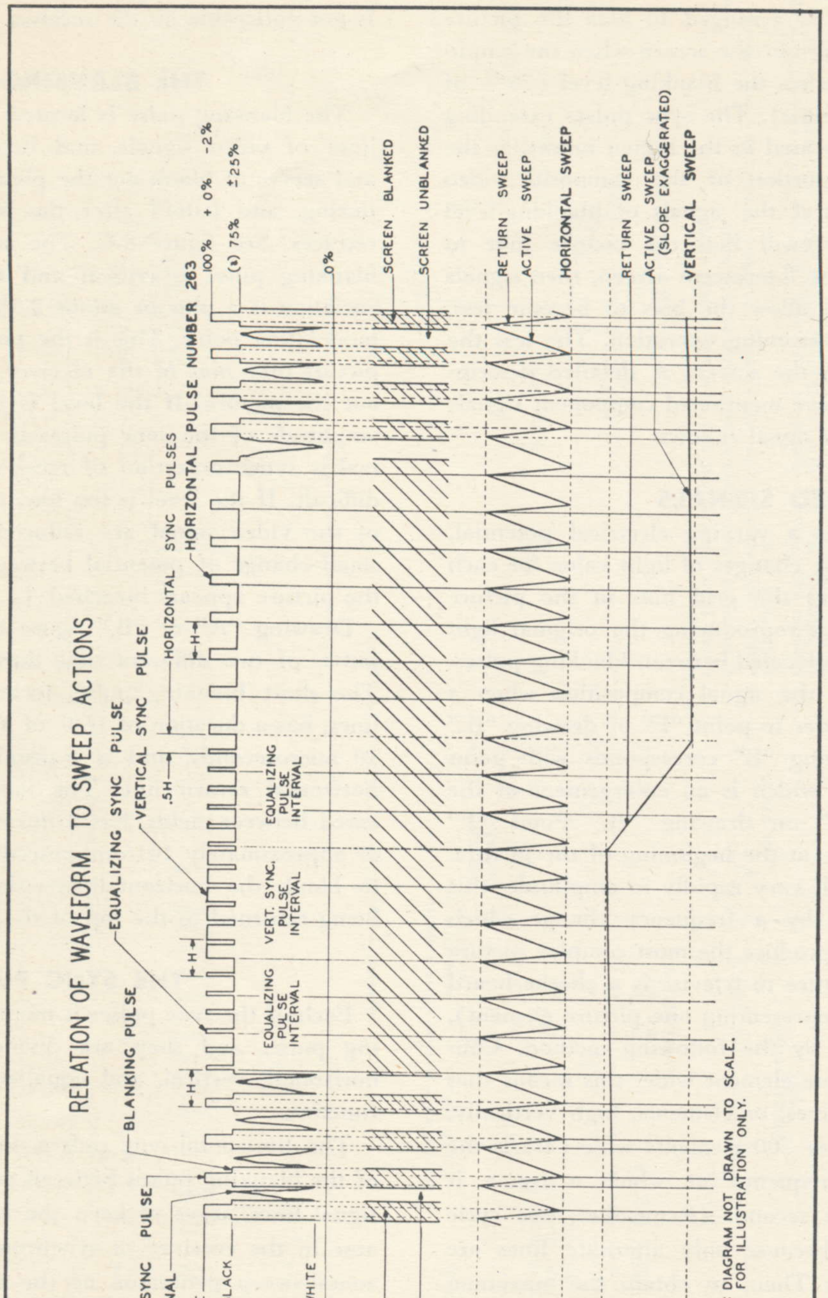

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Figure 8F. Relation of the Standard Waveform to the Sweep Actions.

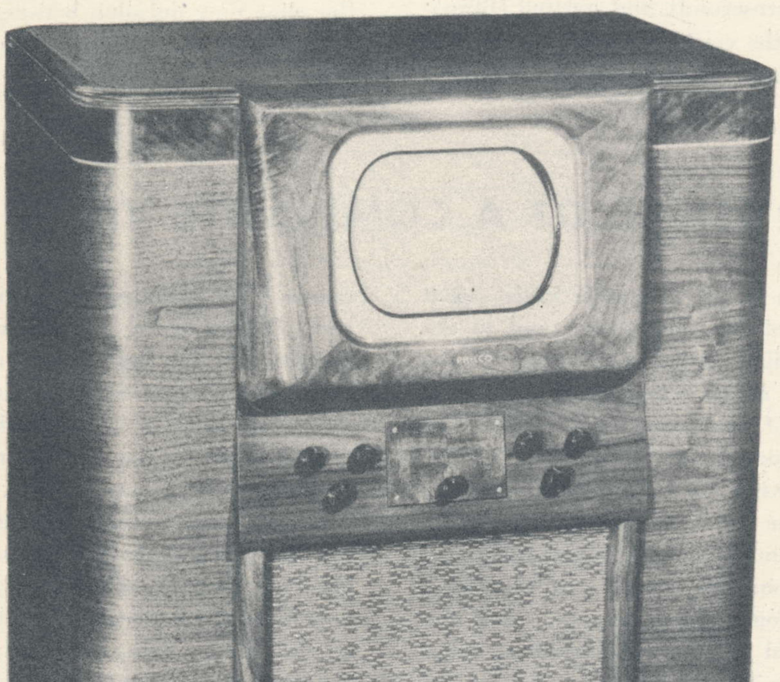
signal, having approximately 4.9 microseconds of time for retrace completion, before the screen is unblanked for the next trace.

The vertical-sync pulse is mounted on the vertical-blanking pedestal between fields and functions to trigger the vertical-sweep generator of the receiver, keeping it in synchronization with the sweep generator at the transmitter. The form of these pulses is shown in figure 8 as having a series of serrations placed at half-line intervals. It is these serrations which continue to furnish the synchronized signal to the horizontal-sweep generator during the vertical sweep return period. The serrations do not affect the total desired result of vertical triggering, and the serrated vertical pulse is considered as one pulse having a duration of three horizontal lines, or 190.5 microseconds, and starting approximately three lines after the vertical-blanking pulse. The picture-tube screen remains blanked out for approximately 11 lines, or 700 microseconds, after the vertical-sync pulse.

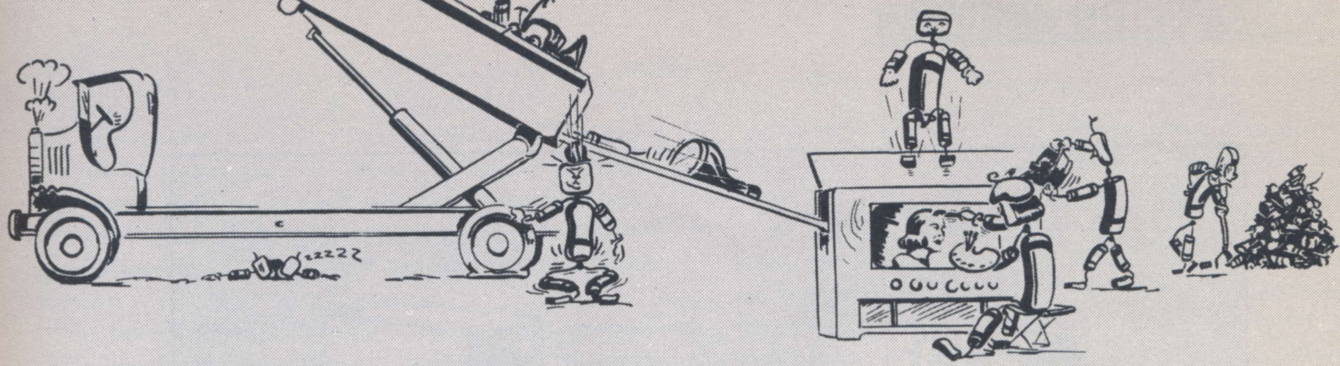
The equalizing pulses are located on top of the vertical-blanking pulse, six equalizing pulses preceding and six following the vertical-sync pulse. These pulses, having a frequency rate of twice that of the horizontal-sync pulses, are placed at half-line intervals. They are present to compensate for field differences, and continue to trigger the horizontal-sweep generator at the correct line interval of 63.5 microseconds. The individual equalizing pulse has a line duration of 4%, or 2.5 microseconds. During a vertical-sweep period, these equalizing pulses, in conjunction with the pulses obtained from the serrated vertical pulse, provide the necessary sync signals for the horizontal-sweep generator. This permits the use of a vertical-blanking pulse of the same time duration between fields and frames without affecting the synchronization of the horizontal-sweep generator.

THE SEQUENCE OF A COMPOSITE VIDEO SIGNAL

The above description of the composite video signal has shown the nature of its composition, and to obtain a better understanding of the relationship of the components during the actual scanning of a picture, the following resume of the sequence is given and should be studied in conjunction with figure 8. Referring to figure 8, drawing "B," the pulses necessary to return the beam to the top of the picture and at the same time maintain control of the horizontal-sweep circuit, are mounted upon the long vertical-blanking pedestal. The last horizontal pulse mounted upon the vertical-blanking pedestal will be considered as pulse 525; it returns the beam to the left-hand side of the picture. As the beam sweeps from left to right the vertical-blanking pulse is removed. The point at which the blanking pulse is removed is shown as point "F" on drawing "B." At this point the beam is at the top center of the picture and begins to actively scan the remainder of the line; thus the line reproduced is only half a line long. At the same time that the scanning beam reaches the right-hand side of the picture, horizontal-blanking pedestal number one, upon which is mounted horizontal-sync pulse number one, is received; therefore, the picture will be blanked out for approximately 10 microseconds, while the beam in the picture tube returns to the left-hand side of the picture-tube screen. The scanning action will then begin for line two, the line being constructed of variations of light representing the light values of the television picture. The beam reaches the right side of the picture tube at the same time a horizontal-blanking pedestal is received; mounted on top of the blanking pedestal is horizontal pulse number two. This pulse causes the scanning beam to return to the left-hand side of the picture tube, while the picture is blanked out. The blanking pedestal terminates, and then horizontal line four starts; this further represents the light variations of the picture being televised. This cycle of events is repeated until every other line has been scanned and the scanning element reaches the bottom center of the picture. At this point, a long blanking pulse, called the vertical-blanking pedestal, shown in drawing "A," figure 8, will blank out the picture. Upon this long pedestal are mounted the following pulses in the exact sequence named; equalizing pulses, vertical pulse (the pulse returning the scanning beam to the top of the picture), equalizing pulses, and the horizontal-sync pulses. The last horizontal-sync pulse on top of the long pedestal is horizontal-sync pulse 263 returning the beam to the left side of the picture. Immediately after horizontal sync 263, the long blanking pedestal terminates, and the beam starts to scan line 263 (line 263 is represented in figure 8-A). The sequence of events is again the same as for the other scanning operation; however, this time the beam scans the lines missed in the previous field, or scanning operation. This action is known as interlace scanning. Finally, the beam reaches the bottom of the picture, and this time it will scan to the right-hand side. Again a long vertical pedestal blanks the screen, and the beam is again returned to the top of the picture by the serrated vertical pulse. The last horizontal pulse on the long blanking pedestal is horizontal-sync pulse number 525, and the end of a complete scanned frame. The pulse immediately following the long vertical-blanking pedestal is again horizontal-blanking pedestal number 1.



THE TELEVISION RECEIVER



TYPES OF TELEVISION-RECEIVER CABINETS

Although at the present stage of television development it is not possible to make a complete review of television-cabinet design, it is pertinent to consider briefly the various types the serviceman may encounter. In general, two types predominate, table models and consoles, the former containing a smaller viewing screen and receiver, and the latter embodying many variations of large screens and receivers. In most modern television receivers both video and audio sections are combined, with the operating controls for both consolidated on the front of the cabinet. Most receivers have but five or six controls for operating the set, although the number will vary with the developments of the various television companies. The Servicing section of this publication contains a brief analysis of the function of the various operating controls. Viewing-screen size is limited by the size of the cathode-ray tube used in the receiver. In general the larger the screen the better the presentation of the picture, and the greater the customer's satisfaction. Experimentation with methods of projection of the picture from the screen to a larger surface to facilitate viewing is now in progress, and will undoubtedly be made available to the public in the near future. This picture projection will add to the serviceman's installation problems but also add to the customer's satisfaction with television reception.

As a brief review of types of television cabinets, the following illustration will show the serviceman what he may encounter. See figure 9. Although the cabinet types will vary greatly, the television receivers will be found basically the same. Because of this fact, this publication uses a test receiver, made for television-transmission-quality surveys, as a typical receiver for circuit analysis. This section describes the interrelated-circuit actions, in conjunction with a functional block diagram, and pertinent detailed circuit schematics.

FAMILIAR RADIO PRINCIPLES IN TELEVISION RECEIVERS

The television receiver is very similar to the amplitude-modulation superheterodyne receiver with which every serviceman is familiar. The principal differences arise from the wide frequency band of the television receiver.

The familiar "superhet" receives a signal which varies approximately 5 kilocycles on each side of the carrier frequency. This means that the band pass of this type of receiver is only 10 kilocycles. The television video signal, on the other hand, is 6 megacycles in width, so, obviously, the amplifiers of the television receiver will be different from those in the normal radio receiver.

The radio receivers with which the serviceman is familiar, operate in the carrier-frequency range from 540 to 1600 kilocycles, with short-wave bands somewhat higher, but still in the relatively low frequencies. The television carriers start at about 50 times this frequency and continue up into the super-high frequencies. As frequencies increase, the problems of radio-receiver design and construction become complicated by many factors which are negligible at the broadcast frequencies. For instance, the input capacity of an ordinary vacuum tube may be an effective short circuit at super-high frequencies.

The following comparisons may be made between the two types of receivers. The r-f amplifier in the broadcast receiver is of high gain, good stability, and is easily tuned by variable capacitors. In the television receiver, the r-f amplifier, to be stable, must be mechanically rugged, while the frequencies involved make very small

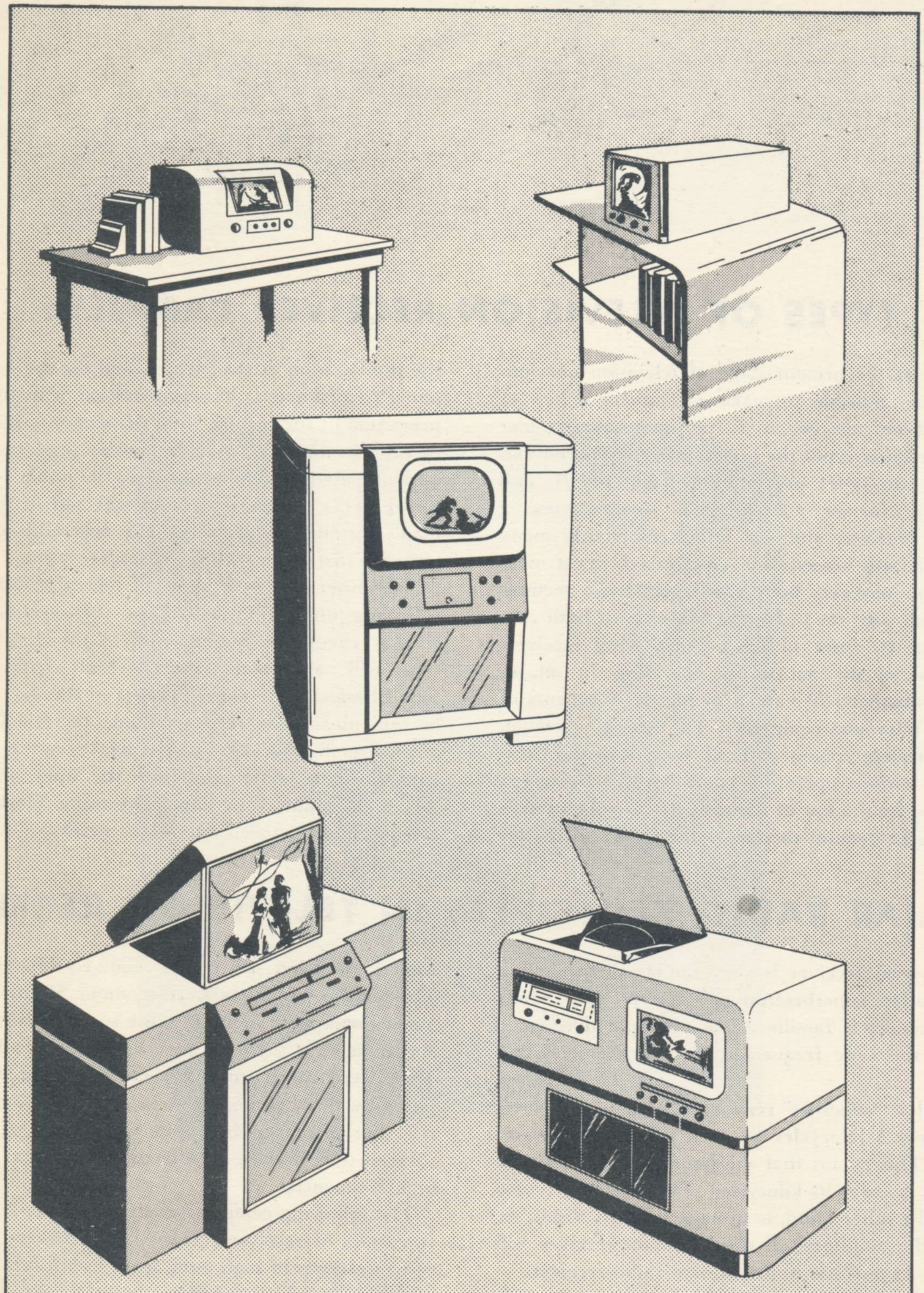


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Figure 9. Typical Cabinet Designs for Television Receivers.

dimensions and delicate parts mandatory. The compromise necessary here results in the use of individual fixed-tuned circuits for each carrier-frequency channel. Tuning is accomplished by switching the proper tuned circuits into the r-f and local oscillator circuits of the receiver.

The conventional i-f amplifiers, operating at comparitively low frequencies, can utilize iron-core transformers, and ordinary tubes, resulting in high gain per stage. The television intermediate frequency must be high, because the video signal contains such a wide frequency band. For this reason the television i.f. is many times the frequency of the r.f. of the broadcast band, the gain per stage is very low, and the band pass very wide.

The common broadcast radio receiver employs detector, automatic-volume control, and local oscillator circuits similar in principle to those in the television receiver.

High and low band-pass filter circuits, or traps, are familiar to the average serviceman. One form of these circuits can be compared to the filter system in the power circuits, to tone control circuits, or by-passing of grids, etc. In the television receiver, the filter circuits are designed for specific purposes, such as separating the video signal from the sync pulses, separating the audio from video signals, and separating the different kinds of sync pulses.

Any serviceman familiar with a common cathode-ray oscilloscope will have no difficulty in understanding the generation of the sweep voltages in the television receiver, and the use of synchronizing voltage pulses to control the sweeps.

With these similarities in mind, and knowing the basic reason for differences in design, the serviceman should experience no great difficulty in understanding the operation of the television-receiver circuits.

THE RECEIVER BLOCK DIAGRAM

An analysis of the block diagram of the receiver being used as an example follows. See figure 10. The received video-signal carrier and the received FM sound-signal carrier are fed into a broad band-pass r-f amplifier. The coupling between the r-f amplifier tube (1232) and the grid of the mixer tube (1232) is also used as a means of injecting the local-oscillator frequency into the grid of the mixer. The local-oscillator tube (7A4) operates at a frequency that is 19.5 mc. higher than the incoming video carrier, and 15 mc. higher than the incoming audio carrier. As a result of the heterodyning action of the mixer tube, two new frequencies, 19.5 mc. and 15 mc., are produced. These frequencies, modulated with the picture signal and the audio signal, respectively, are fed into the four-stage video i-f amplifier, which has a bandwidth of 6 megacycles and employs type 1232 tubes.

> NOTE: The words "audio" and "sound," as well as "video" and "picture" have been used interchangeably throughout this book so that, regardless of which words the reader is accustomed to use, the continuity of the text would be unaffected.

At the second video i-f amplifier stage, the audio signal is separated from the video signal and fed to the audio i-f amplifier. The video signal, after its separation from the audio signal, is fed through the second, third, and fourth video i-f amplifier stages. These stages are similar in design and have a wide band pass, as previously mentioned.

The fifth video i-f transformer in the detector stage feeds signal energy to both the video-detector circuit, and the a-v-c circuit, using 7A6 tubes. The a-v-c energy developed from the sync pulses, which are a direct measure of the amplitude of the carrier envelope, is used to regulate the bias on the r-f, mixer, and first, second and third video i-f stages. The detector, receiving the same signals as the a.v.c., detects and passes on to the first video-amplifier tube (1232) the composite video signal, made up of video component, vertical sync, horizontal sync, and equalizing and blanking pulses.

The first video amplifier feeds this composite video signal to both the sync-separator tube (6Y6) and the second video-amplifier tube (6V6). The second video amplifier is directly coupled to the grid of the picture tube (10AP4), and develops a d-c bias which regulates the average brightness of the picture tube, and at the same time amplifies the video signal whose electrical variations are reconstructed into a picture on the picture tube.

The sync separator extracts vertical and horizontal-sync pulses from the picture signal. The sync pulses are then separated from each other by the input circuits to the horizontal and vertical-sync amplifiers.

THE TELEVISION RECEIVER

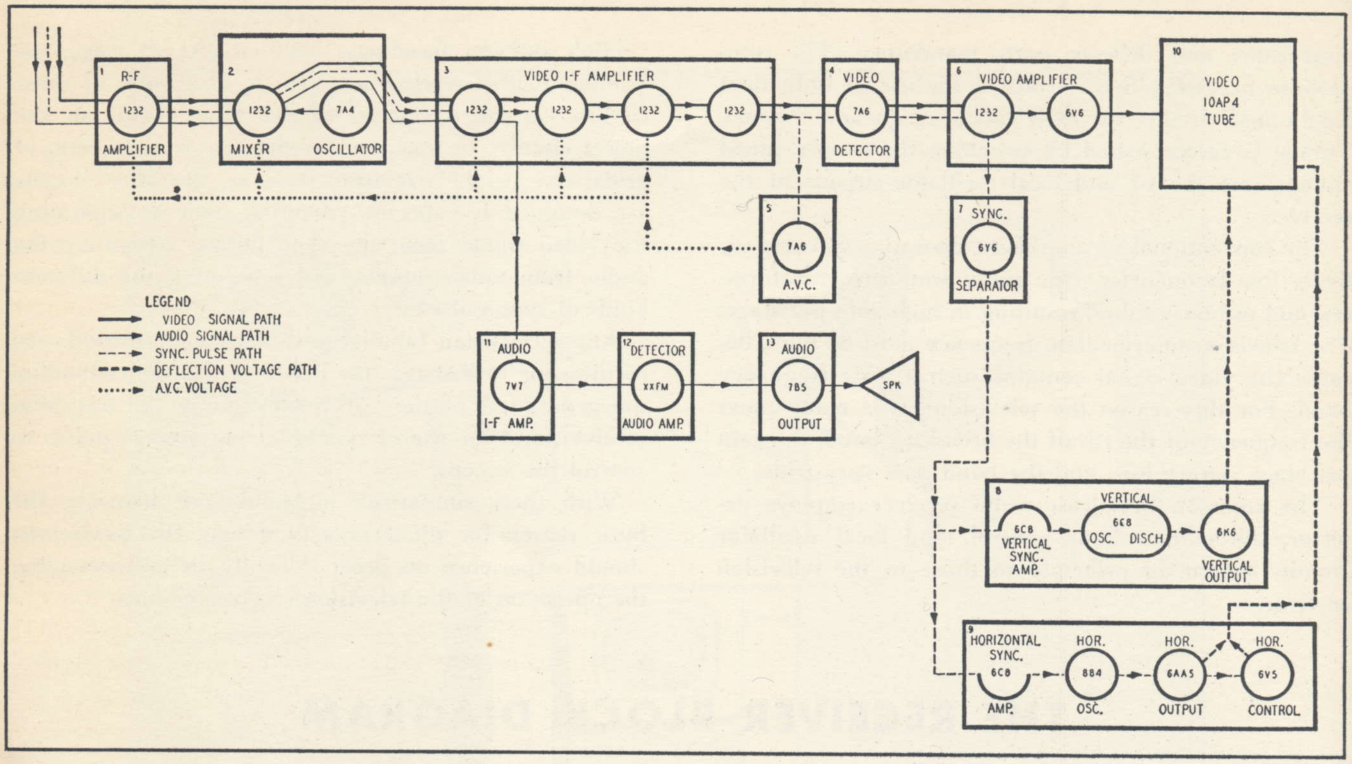

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Figure 10. A Block Diagram of a Television Receiver.

Horizontal-sync pulses are used to trigger the horizontal-sweep-generator tube (884), which generates the positive sawtooth deflection required for horizontal deflection of the electron beam in the picture tube. The output from the horizontal-sweep-generator tube is amplified by the horizontal-output tube (6AH5) and controlled by a type 6V5 control tube. The horizontal-output and horizontal-control circuits are coupled to the horizontal-deflecting coils of the picture tube through a matching transformer.

Vertical-sync pulses are used to trigger the vertical-sweep generator (one section of a 6C8 type tube) whose output is coupled to a discharge circuit (other section of same 6C8 tube). The output of the vertical-discharge tube has a sawtooth waveform and is amplified by the vertical-output amplifier tube (6K6). The output of the vertical amplifier is coupled to the vertical-deflecting coils of the picture tube through a matching transformer.

The 15-mc. i-f audio signal from the second video i-f transformer is fed into the first audio i-f transformer and is amplified by the first audio i-f amplifier tube (7V7). The audio signal from the plate of the first audio i-f tube is coupled, through the discriminator transformer, to the audio detector and amplifier tube (XXFM). The audio frequencies from the detector-amplifier stage are amplified in the audio-output stage and coupled to the loudspeaker through a matching transformer.

THE RECEIVER CIRCUIT ANALYSIS

THE VIDEO CIRCUITS

The reception, amplification, and reproduction of the composite video-signal carrier and its accompanying audio-signal carrier required that a wide band-pass r-f amplifier be constructed; further, that the video amplifier be capable of amplifying the signal carriers without introducing phase, amplitude, or frequency distortion. This construction presents many difficulties not encountered in ordinary radio-frequency amplifiers and requires many compromises, the faults of one circuit being corrected by the merits of another. The receiver under discussion is an example of the way in which these compromises can be made.

The composite video-signal carrier and its accompanying audio-signal carrier are picked up by a dipole antenna and fed to the receiver through a transmission line. In the chassis, the two signal carriers are fed to a five-channel switch, the switch connecting any one of five r-f transformers to the antenna circuit. As the operation of each channel is similar, for the purpose of circuit analysis, assume that channel 3 has been selected. This means the received video-signal carrier will be 61.25 megacycles and its accompanying audio-signal carrier will be 65.75 megacycles.

With the wave-band switch turned to channel 3, the antenna circuit is automatically connected to the third r-f transformer, and the r-f stage functions as follows: (refer to figure 11).

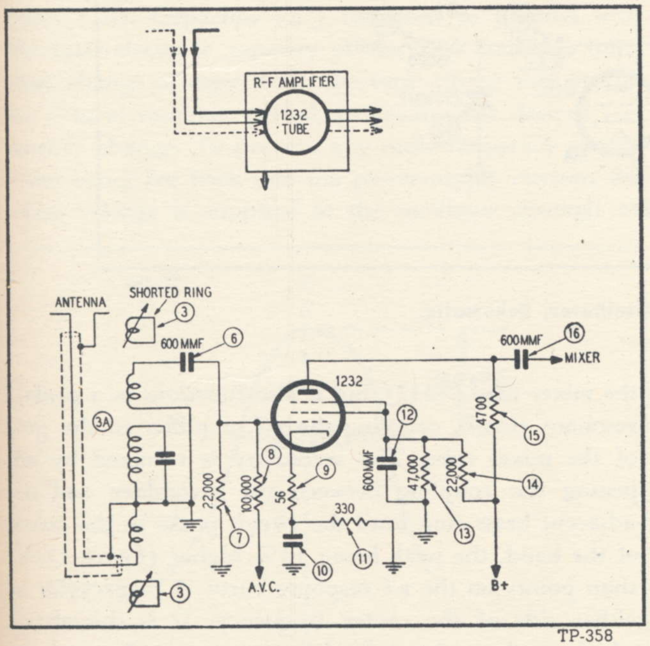

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Figure 11. R-F Amplifier, Schematic.

R-F STAGE—The r-f transformers consist of three windings. The primary winding is of low impedance and is impedance-matched to the antenna through the transmission line, thus meeting the requirement for maximum transfer of signal energy from the antenna. The tertiary winding is tuned by a variable capacitor to the proper frequency, in this case channel 3. The grid winding is tuned to resonance by the combined capacities of the leads, distributed coil capacity and the input capacity of the first r-f tube, and is tightly coupled to the primary winding. The tertiary winding serves to increase this coupling, resulting in a double-peak response curve, as shown in figure 12.

Two adjustable brass rings (shorted turns), placed at the ends of the coil, are provided to tune or vary the primary and secondary inductances, the desired adjustment producing two resonant peaks 6 megacycles apart. The dip between the peaks is 30% down and is at the center of the frequency of the desired channel.

Overcoupling results in a broadly tuned circuit whose frequency response is not linear. This is compensated for in the local-oscillator transformer (20) discussed later.

The selected frequencies, video carrier of 61.25 mc. and audio carrier of 65.75 mc., pass from the secondary of the r-f transformer through coupling capacitor (6) into the grid of the 1232 r-f amplifier tube. This tube functions as a tetrode (see figure 11), its elements being connected as follows: The cathode is connected to ground through resistors (9) and (11). Resistor (11) is by-passed with capacitor (10), developing a minimum fixed bias of approximately 3 volts. Resistor (9) is not by-passed, introducing a small amount of degeneration which improves the frequency response. The grid is supplied a-v-c voltage by a voltage divider, connected to the a-v-c supply and made up of resistors (7) and (8). Reducing the a-v-c bias of the r-f amplifier allows it to operate with high gain at all times, improving the signal-to-noise ratio. The suppressor and screen are tied together and are supplied with approximately 150 volts by a voltage divider made up of resistors (13) and (14). Resistor (13) is by-passed with capacitor (12). The plate is supplied with approximately 220 volts through resistor (15). This plate load is of low resistance, keeping the output more nearly constant for

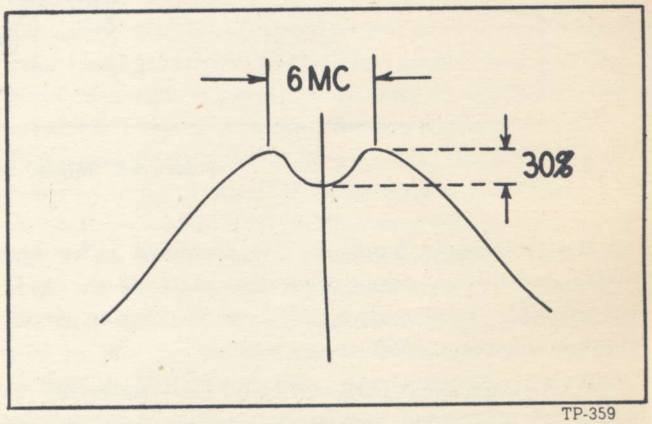

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Figure 12. R-F Amplifier, Response Curve.

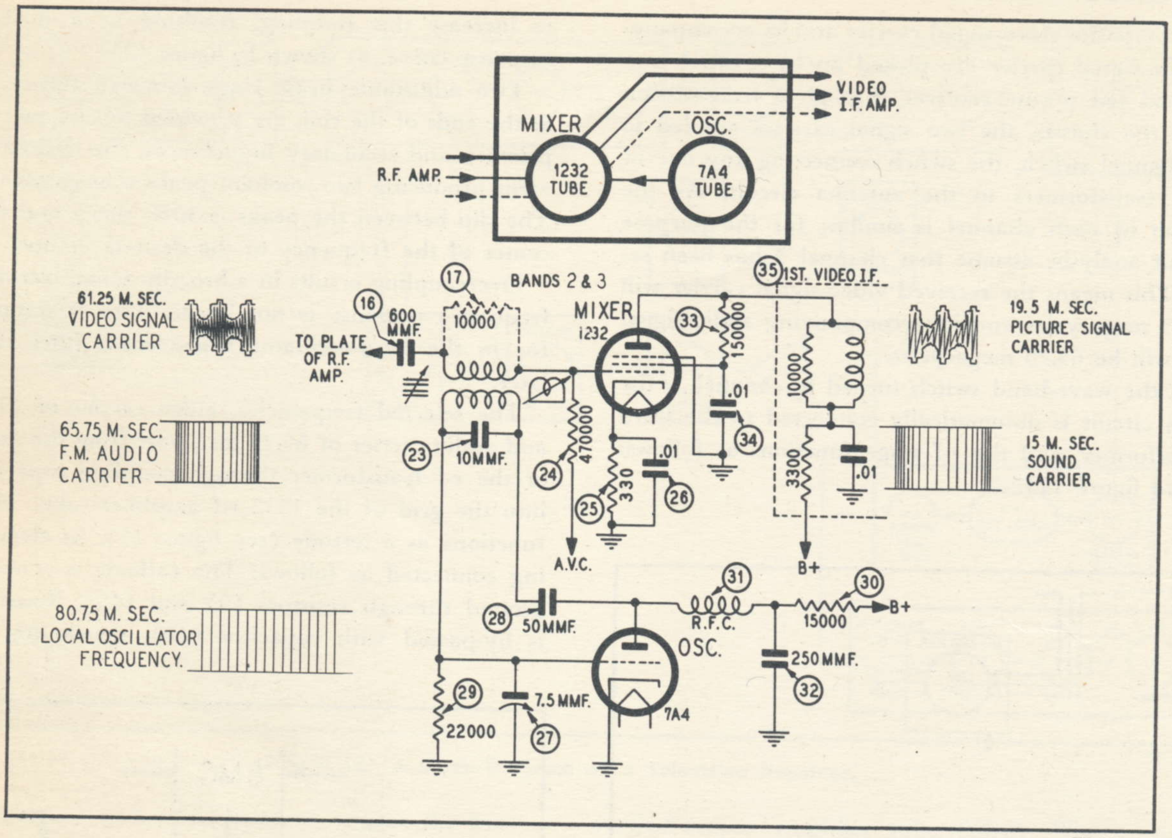

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Figure 13. Mixer, Local Oscillator, Schematic.

all the frequencies handled. The amplified video and audio carriers are taken from the plate of the 1232 r-f amplifier tube and coupled to the mixer circuit through capacitor (16).

MIXER-OSCILLATOR CIRCUITS—Referring to figure 13, the video and audio carriers from the r-f amplifier are coupled to the grid of the 1232 mixer tube through capacitor (16), and the secondary winding of the local-oscillator transformer (20). This transformer is automatically connected into the proper circuits by the oscillator section of the channel selector switch. The transformer performs the important function of injecting into the mixer tube, along with the incoming frequency, the frequency generated by the local oscillator. This coupling transformer (see figure 14) is constructed and functions as follows:

The transformer is made up of two windings; the primary is part of the oscillator-tank circuit and is tuned by both fixed capacitor (23) and by varying the position of its permeability core. The secondary is not only inductively coupled to the primary, providing a means of injecting the local-oscillator frequency into the mixer tube (1232), but it also functions as a peaked resonant circuit, coupling the r-f amplifier to the grid of the mixer tube. The secondary is trimmed by adjusting the coupling between the secondary and the adjacent brass ring until the circuit peaks in the center of the band, the peak being 30% higher (figure 15-A) than points on the r-f response curve, 3 megacycles on either side of the center frequency. It is this circuit which produces the desired linear response by compensating for response defects introduced by the r-f amplifier (figure 15-B); the secondary coil is shunted by resistor (17) on bands 1 and 2 only, to compensate for the increased Q of the coils at the lower frequencies.

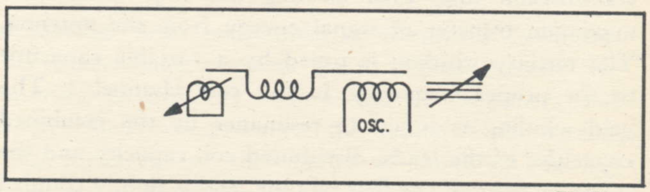

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Figure 14. Local-Oscillator Coupling Transformer.

Three separate frequencies are present at the grid of the mixer tube, the video carrier at 61.25 mc., the audio carrier at 65.75 mc., and the local-oscillator frequency at 80.75 mc.

Before analyzing the mixer circuit, a brief analysis of the local-oscillator circuit will be given. See figure 16. The local oscillator is a modified Colpitts and functions as follows: Changing plate potentials are coupled to the resonant-tank circuit through capacitor (28). The tank circuit is tuned to resonance at the desired frequency (80.75 mc. in this case) by varying the inductance of the coil with the adjustable permeability core and by fixed capacitor (23). Small frequency variations, due to the changing value of circuit constants, are compensated for by the use of the vernier tuning control, a variable capacitor (27). This capacitor is connected between grid and ground, in parallel with grid-leak resistor (29). Capacitor (27) functions in parallel with the inter-electrode capacity of the 7A4 oscillator tube. Any change of capacity in the tank circuit will change its natural resonant period, producing the desired frequency change. To prevent any radio-frequency energy from being fed back into the power-supply circuits, the plate voltage is supplied to the oscillator through an isolating r-f choke (31), the choke being by-passed with capacitor (32) at its junction with plate-voltage dropping resistor (30).

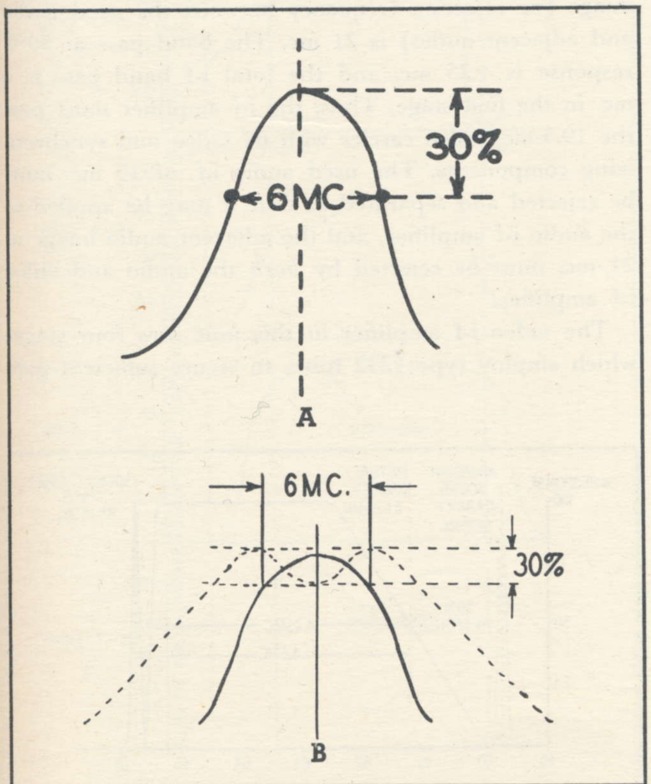

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Figure 15. Local-Oscillator Coupling Transformer, Response Curves.

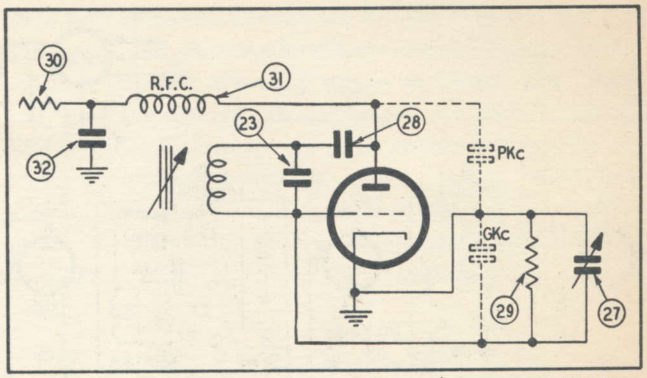

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Figure 16. Simplified Local Oscillator, Schematic.

The mixer circuit (figure 13) functions in the conventional manner and the elements of the mixer tube are connected as follows: The cathode is connected to ground through resistor (25), developing a fixed minimum bias. Resistor (25) is by-passed with capacitor (26). The grid is connected to the a-v-c circuit through an isolating resistor (24). The screen voltage is applied through resistor (33), and is by-passed with capacitor (34). The suppressor is connected to ground. Plate voltage is applied to the tube through the primary winding of the first video transformer. The three frequencies which entered the mixer-tube grid are present at its plate, but in addition to these three, as a result of the heterodyning action, two new frequencies are present, each containing the same signal information as did the original received carriers. (In addition to the desired frequencies, the audio carrier of the next lower television channel will also produce a heterodyned frequency within the band pass of the succeeding stages. Removal of this frequency is accomplished by the "adjacent-sound trap," discussed later). One resultant intermediate frequency of 19.5 mc., containing the video signal, and the other resultant intermediate frequency of 15 mc., containing the audio signal, will predominate in strength over the three original carriers, because the mixer-tube plate load represents a high impedance to these new frequencies. The two new frequencies are passed into the selective video i-f amplifier, the original carriers being rejected.

VIDEO I-F AMPLIFIER STAGES — The video (picture) i-f amplifier functions to accept and amplify the video i-f and audio i-f frequencies present in the mixer-plate circuit, in the first i-f stage, and to reject all audio intermediate frequencies in succeeding stages. The

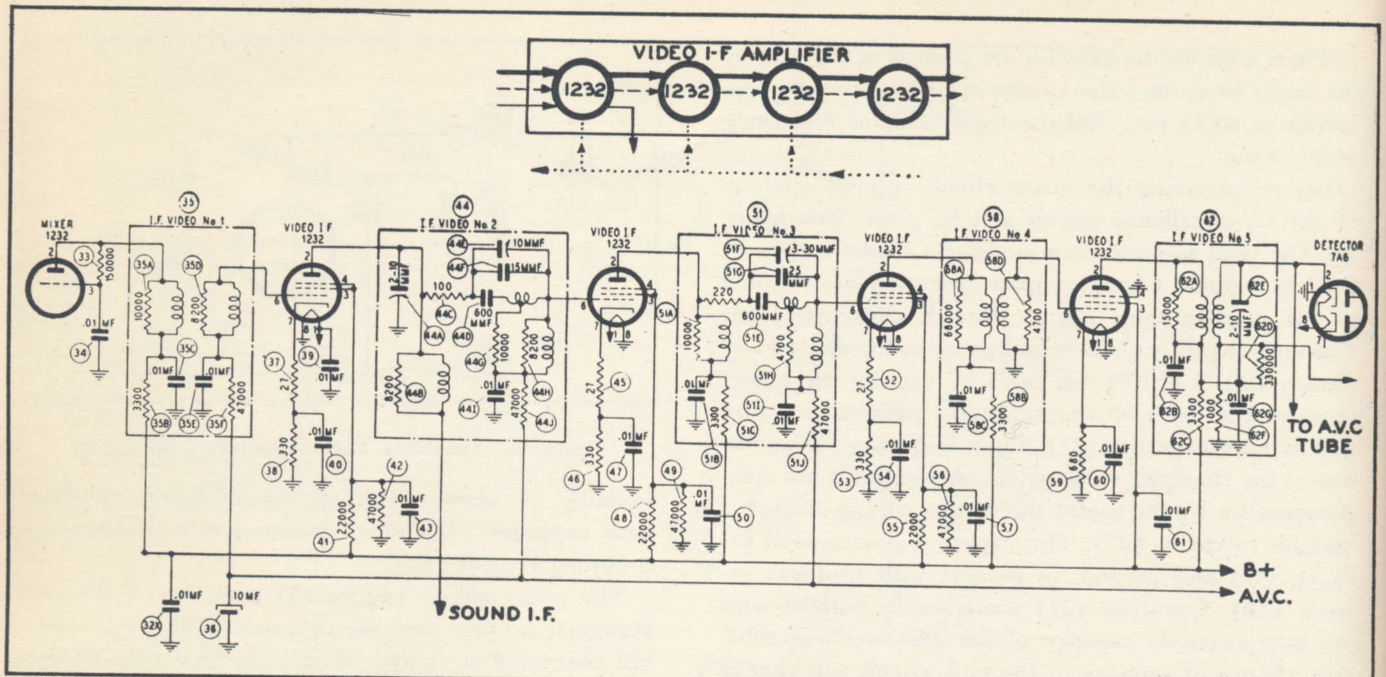

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Figure 17. Video I-F Amplifier, Schematic.

video i-f amplifier acts as an audio and video i-f separator so that eventually only the video i.f., containing the picture and synchronizing signals, is amplified and appears at the video second detector. A separate audio i-f amplifier is used to amplify the audio intermediate frequency.

To perform the above functions, several unique band-pass circuits are used. Figure 18 shows the idealized r-f and i-f response curve for the entire unit. The major shaping of this response curve occurs in the video i-f amplifier. It is evident that the input circuit must respond to the channel 3 audio carrier at 65.75 mc. A 50% response at the video-carrier frequency of 61.25 mc. is desired, because in practice it was discovered that a portion of the low-frequency side band will be transmitted. Because of technical limitations in transmitter filters, it is impossible to reject the entire lower video side band. (In some systems both upper and lower side bands are used at a sacrifice of picture definition for a standard channel bandwidth.) Since the accompanying audio must not modulate the picture, it is evident that the adjacent audio (from the station in the next lower channel) must also be eliminated. It is further desired that *at least* 3 mc. of the video i.f. be of flat response. Apply these idealized conditions to this amplifier and the following requirements exist. With the receiver set on channel 3 and the local oscillator at 80.75 mc., the video (picture) i.f. is 19.5 mc., the "used" audio i.f. is 15 mc., and the adjacent audio image (or rejection frequency between the used audio and adjacent audio) is 21 mc. The band pass at 50% response is 4.25 mc. and the total i-f band pass is 6 mc. in the first stage. Thus, the i-f amplifier must pass the 19.5-mc. video carrier with its video and synchronizing components. The used audio i.f. of 15 mc. must be rejected and separated so that it may be applied to the audio i-f amplifier, and the adjacent audio image at 21 mc. must be rejected by *both* the audio and video i-f amplifier.

The video i-f amplifier in this unit uses four stages which employ type 1232 tubes to secure sufficient gain

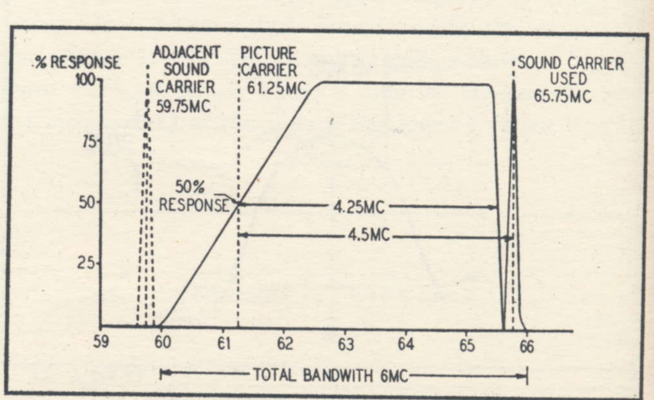

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Figure 18. Idealized Overall Response Curve.

with the desired band pass. Figure 19 shows the individual response of each of the i-f transformers. The cathode circuit of the first three i-f stages utilizes a slight amount of degeneration. This degeneration is accomplished by not by-passing the entire cathode resistor, helping to flatten the frequency response. The last i-f stage contains a higher value cathode resistor to prevent overload with large signals. Voltage-divider resistors maintain each screen potential at a constant value to prevent screen-current fluctuations. The last i-f screen is connected directly to B+ for maximum gain, and all screen circuits are by-passed in the conventional manner. Automatic-volume-control voltage is applied to the first three i-f stages as shown. The plate and grid circuits of all i-f stages are decoupled by conventional filters. In order to secure a larger transconductance-to-plate-current ratio, which minimizes thermal agitation and shot effect at high gain, the first three i-f stages have their suppressors and screens paralleled. Thus, a high signal-to-noise ratio is obtained.

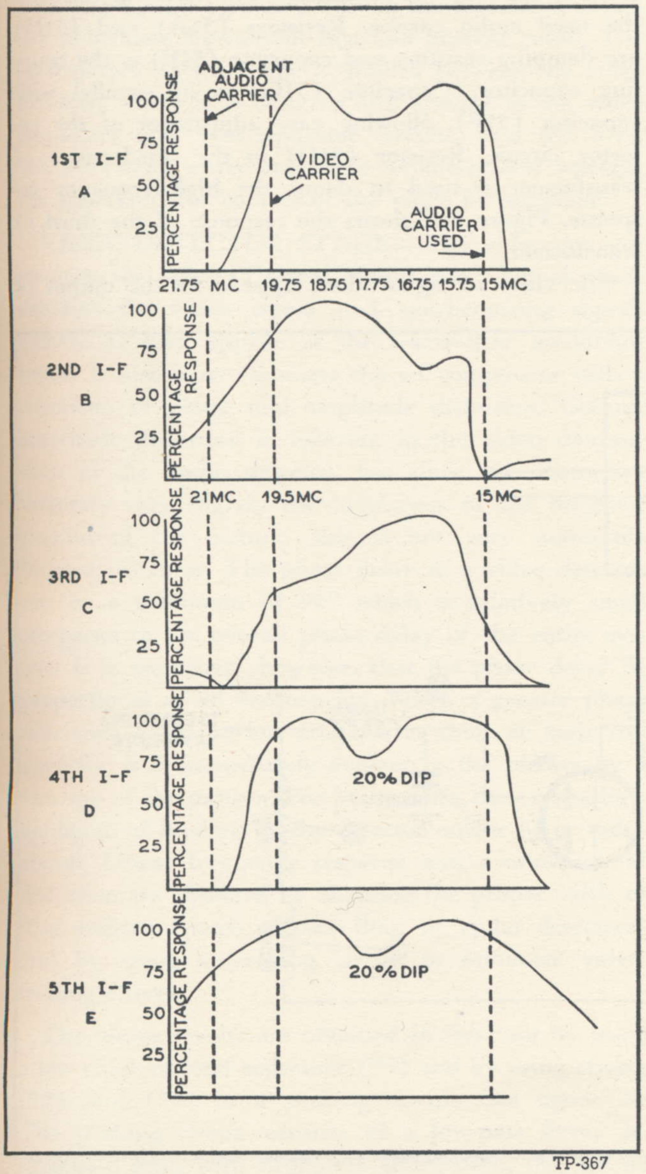

Figure 19. Response Curves of the Individual I-F Stages.

With the receiver tuned to a signal in channel 3, the first video i-f transformer selects the i-f video and audio signals from the frequencies existing on the plate of the mixer tube, utilizing the different frequency in both cases. This transformer, as can be seen from figure 17, is fixed-tuned by the distributed capacity of the circuit and the tube element-to-ground capacity, so that peaks exist at the frequencies shown in figure 19. The primary and secondary coils are overcoupled, producing a double peak response. Damping resistors (35A) and (35D) broaden the double peak, preventing too great a dip in response at the mid-band video i.f. and thus compensating for the degree of coupling used. The video and audio signals appear on the grid of the first video i-f amplifier tube and are amplified by the tube action. Resistor (37) provides a slight amount of degeneration, helping to flatten the frequency response, while resistors (37) and (38) together develop the desired bias caused by plate-current flow. The screen is kept at a fixed potential by resistors (41) and (42). Capacitor (43) provides the screen-to-ground by-passing to prevent undesired degeneration. The signal in the plate of the first video i-f tube is developed across the second video i-f transformer primary, which is tuned by the variable capacitor (44A) to 18.5 mc., while damping resistor (44B) broadens the response so that the 4.25-mc. bandwidth is obtained. The resulting signal is then transferred to the secondary through a series network, made up of resistor (44C), coupling capacitor (44D), and a parallel-resonant rejector circuit composed of a tapped inductance and capacitors (44E) and (44F). Resistor (44C) is used to damp the low-frequency end of the transformer response. The rejector trap is tuned to resonance with two parallel capacitors, fixed capacitor (44F) and vernier capacitor (44E). When the rejector trap is tuned to resonance at 15 mc., it offers a high-impedance path to a 15-mc. signal, but losses in the coil of the trap tend to prevent complete blocking of this signal. This fault is counteracted by the use of a circuit trick, consisting of resistor (44G) connected between r-f ground and a tap on the rejector-trap coil. The resistor (44G) produces a bridge-like action, causing the circuit to be balanced at 15 mc. When the circuit is in balance, it offers an infinite impedance path to a 15-mc. signal, resulting in zero transmission of the signal to the secondary, and, since the grid of the second i.f. is connected to the secondary, the 15-mc. signal will be blocked from it, preventing further amplification of the 15-mc. signal, and eliminating it from the video i-f signal. This 15-mc. rejection band is extremely narrow and, for FM audio with ±25-kc. deviation, will provide infinite rejection only at the mid-band. The audio i-f amplifier is connected to the primary of the second video i-f transformer and is designed and tuned to accept the 15-mc. audio signal and reject the 19.5-mc. video signal with its side bands. Thus complete separation of the two signals is effected.

The secondary circuit of the second video i.f. is tuned by the input capacitance of the second video i-f tube and the distributed circuit capacity. The response of the second video i.f. is broadened the desired amount with damping resistor (44H). Since the primary and the secondary are broadly tuned to reject a 15-mc. signal, the circuit response is sharply attenuated at this point. See figure 19B. Now the signal at the second video i-f grid consists of the video i-f component with synchronizing signals. However, while the used audio signal has been rejected, the adjacent audio signal can be present because this beat-frequency has not previously been rejected; so, after amplification in the second i-f tube, the third video i-f transformer is provided with a rejector circuit tuned to the adjacent audio i.f. of 21 mc. This transformer functions similarly to the second i-f transformer, except that the rejection circuit functions at 21 mc. and the secondary peaking has been shifted to a lower frequency to compensate for attenuation of the video i-f component as a result of rejecting the used audio carrier. Resistors (51A) and (51H) are damping resistors and capacitor (51E) is the coupling capacitor. Capacitor (51G) is in parallel with capacitor (51F), allowing easy adjustment of the rejector circuit. Resistor (51D) in the third video i-f transformer is used to damp the high-frequency response. Figure 19C shows the response of the third i-f transformer.

The video i-f signal alone appears in the output of

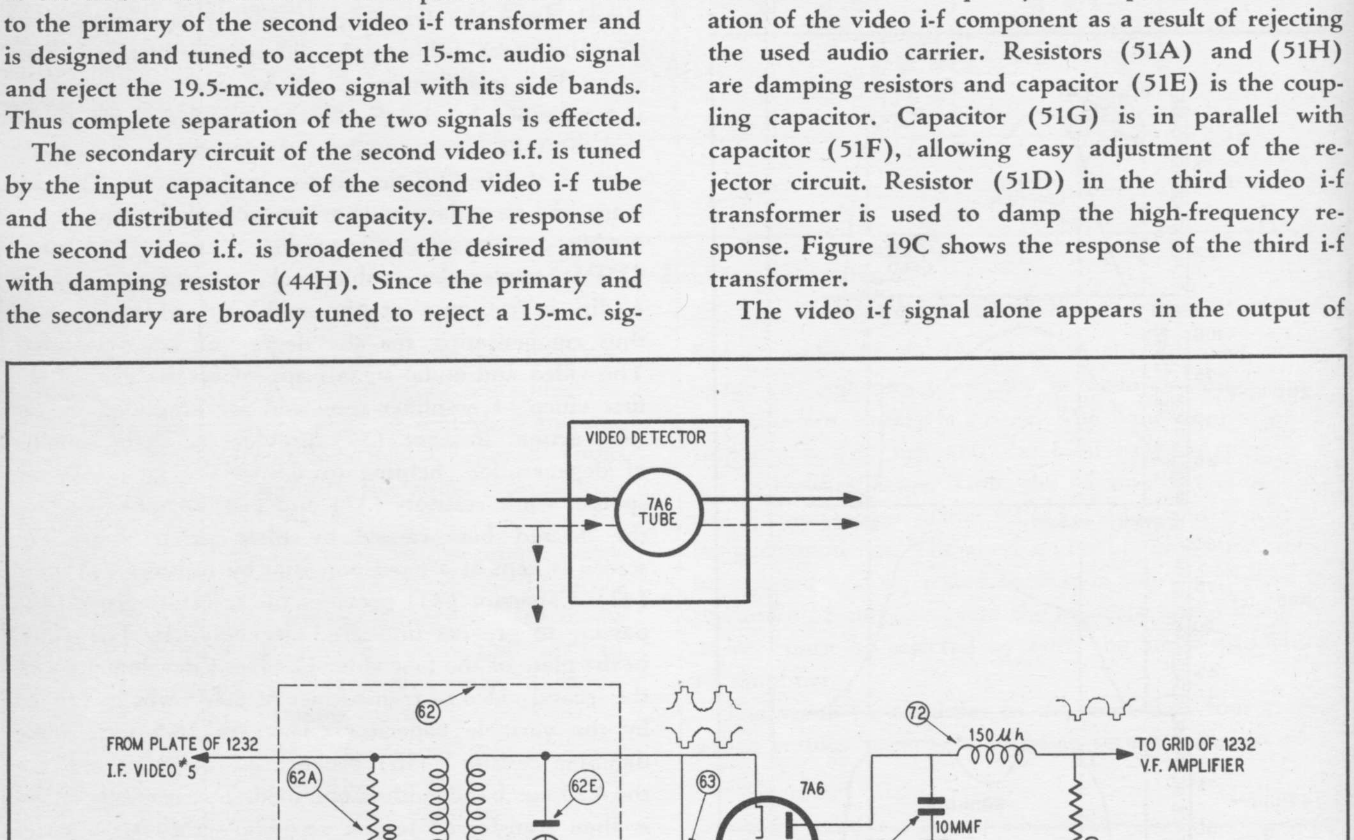

Figure 20. Video Detector, Schematic

the third video i-f tube and the overcoupled fourth video i-f transformer is tuned by the tube and distributed circuit capacitance and damped by resistors (58A) and (58D) so that it is relatively broadly resonant, as shown in figure 19-D. The last video i-f tube is a pentode, connected as a conventional amplifier. Its output is coupled to the detector and the a-v-c circuits through the overcoupled fifth video i-f transformer. The primary is tuned by tube capacity and damped with resistor (62A). The secondary is tuned by capacitor (62E) and circuit capacity. Capacitors (62B) and (62G) are plate and grid-decoupling capacitors, respectively. Resistors (62D) and (62C) are voltage dividers and place a positive bias on the first video amplifier to balance the cathode bias and prevent cutoff. The final output of this stage is divided between the video detector, where it is detected and applied to the video amplifiers and sync-separator circuits, and the a-v-c rectifier circuit where automatic-volume-control voltages are generated for control of the video i-f amplifier.

VIDEO-DETECTOR STAGE—The video detector converts the video i-f signal carrier into a signal which contains the video signal and synchronizing signals exactly as they appear at the transmitter modulator input. It also must eliminate the r-f component with a minimum of phase and amplitude distortion. Greater amplitude distortion is inherent in the video detector than in the audio detector, but since this distortion increases very slightly the brightness of the brightest portion of the picture, this is not very noticeable in most instances. The phase delay in a video detector can be a maximum of 90° which is relatively small compared to the overall phase delay of the entire system. It is important, however, that the phase delay be proportional at all frequencies. When a greater phase difference exists at low frequencies than at high frequencies, it is immediately evident in the picture by a blurring of the pattern. For best results, there must be a minimum of loading by the detector on the i-f or video circuit. Linear frequency response and a minimum of distortion are obtained by choosing the proper value of load resistor (much smaller than in audio detectors) and by using a peaking circuit to minimize video-loading effects.

The above results are obtained in this unit by using a low value of load resistance (73) and by using chokes (72) and (74) in a peaking circuit. See figure 20. The peaking circuit consists of a low-pass filter, designed to pass, with negligible attenuation, frequencies up to approximately 5 mc. When a positive signal appears on the detector cathode and a negative signal appears on its plate, no conduction occurs; however, when the cathode is driven negative with respect to the plate, conduction occurs, and the video and synchronizing signals are rectified and separated from the i-f carrier and its side bands. The i-f signal and any harmonics produced by distortion in the detector, are of a much higher frequency than the cutoff frequency of the detector-peaking-circuit load and are therefore bypassed around the load by capacitor (71). Thus, the rectified video and synchronizing signals are passed on to the first video amplifier, where a portion of the signal is applied to the sync-separator tube for synchronizing purposes. At the same time, the video signal, with its blanking and sync pulses, is amplified further by the second video amplifier and inverter for proper operation of the picture tube.

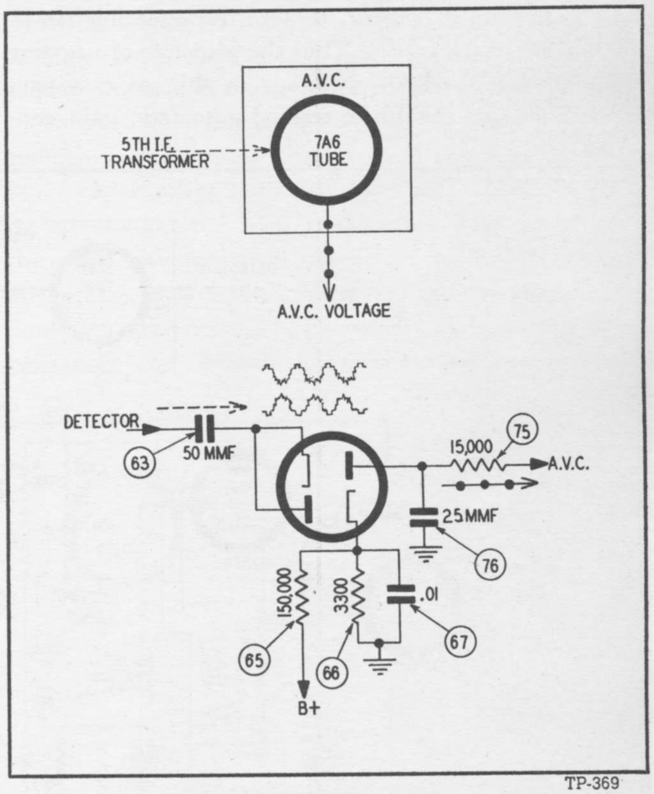

Figure 21. Automatic Volume Control, Schematic.

AUTOMATIC-VOLUME-CONTROL CIRCUIT—The a-v-c potential varies the gain of the video i-f amplifier in accordance with peak-carrier variations, so that the picture, as seen, will not vary with changes in carrier amplitude caused by local effects. Unless compensated for, changes of signal strength would cause variations of picture contrast that were not actually transmitted. Also, for convenience in tuning from station to station, the volume and contrast controls will not have to be adjusted. Another important fact is that slow variations of the receiver power supply, causing changes of i-f gain, will be compensated for by a.v.c. However, this a.v.c. is different from the conventional a.v.c. as used in broadcast receivers, because in the broadcast receiver the *average variation of the carrier* is used to furnish a d-c bias level for a.v.c. If this were done in the television receiver, the a.v.c. would vary with each picture as the contrast varied, because the average variations in a television carrier are the picture components. Therefore, a means of getting a constant d-c level equal only to the ***maximum carrier strength*** of the television signal must be used. This is done by using the sync tips of the video signal, which recur at a rate of 15,750 times per second and are a constant indication of carrier strength, representing 100% modulation of the carrier. Thus the principle of negative modulation is used to advantage in this a-v-c system. (Note that this should be termed automatic gain control, but is called a.v.c. in this discussion in order to use a term familiar to the average serviceman.)

A unique circuit, employing a 7A6 type tube connected as a voltage doubler, is used to secure better a-v-c action and eliminate need for an a-v-c amplifier tube. See figure 21. Resistors (65) and (66) form a voltage divider, which applies a positive bias to the lower cathode so that only signals above a determined amplitude level will operate the circuit. Thus, only the synchronizing peaks of the signal are effective in developing the desired a-v-c action. Since a negative voltage is developed across the lower diode and the upper diode will operate only when its cathode is negative, the negative portion of the i-f modulation envelope will combine with the rectified positive portion to produce a net effect equivalent to doubling the voltage in the upper diode. Capacitor (67) is a filter capacitor determining the time-constant of operation of the lower diode; capacitor (76) is an i-f by-pass capacitor; resistor (75) is a decoupling and filter resistor through which the negative d-c automatic-volume-control voltage is applied to the grids of the video i-f stages.

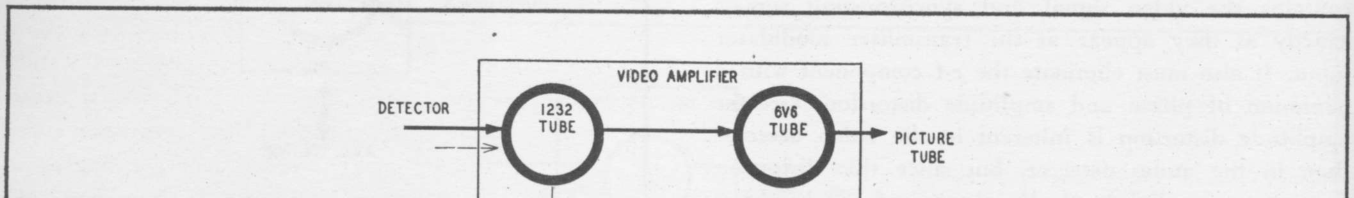

Figure 22. Video Amplifier, Schematic.

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VIDEO-AMPLIFIER STAGE—The video amplifier amplifies the detected video signal with its blanking and synchronizing components to a level sufficient for proper operation of the picture tube. This amplification is necessary, since the output from the detector, while of the proper polarity, is not of sufficient amplitude to drive the grid of the picture tube between the normal limits of operation. In the receiver under discussion, the peak-to-peak limit has been set to 50 volts. The lower limit, representing high-negative bias, is adjusted to blank out the picture tube, preventing the retrace from being seen and, at the same time, removing the sync pulses from the video signal. See figure 23. The upper limit, representing low-negative bias, produces maximum screen brilliance. Thus, if the grid is not driven sufficiently the overall contrast will be poor. However, by amplification the signal is brought to the correct amplitude and the background control (overall brightness) is regulated to agree with the light values of the original picture. The background control regulates the lower limit of the picture-tube grid bias, thereby fixing the blanking level. The contrast control is provided to regulate the amplitude of the video signal, allowing the grid to be driven in a positive direction toward the upper limit and providing the needed contrast for good picture reproduction.

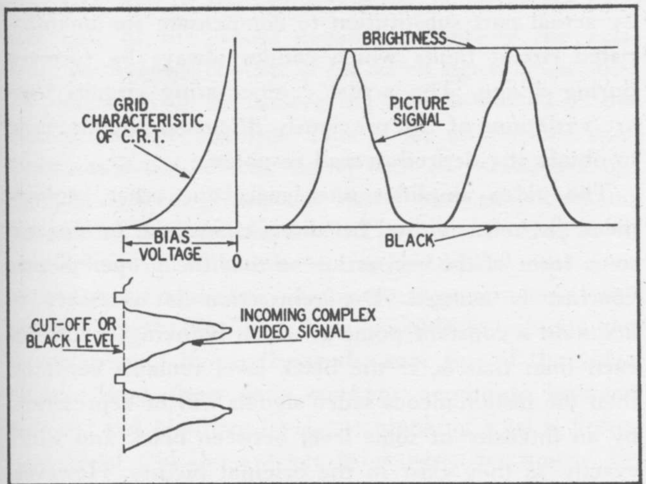

Figure 23. Sync Pulse—Video-Separation Diagram.

The video amplifier is designed for good response characteristics. The correct amplitude, frequency, and phase relationships are maintained to produce the desired results. As long as the phase varies linearly with the frequency, no harmful effects are noticeable, but when the phase shift at low frequencies is greater than at high frequencies, serious distortion results. This distortion would make the details of the picture smudged or blurred; since this cannot be tolerated, low-frequency compensation is used. The shunting effect of the tube-input capacitances normally cause amplitude distortion by attenuating the high frequencies. This means that the video waveform will not be reproduced as it exists at the camera tube and, therefore, high-frequency compensation must be used. The object of frequency compensation is to obtain a linear response, from approxi-

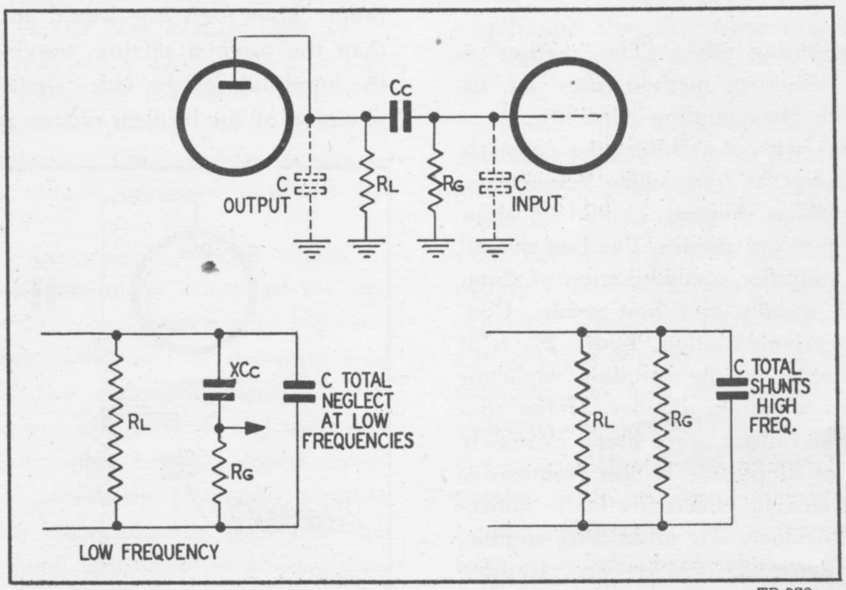

Figure 24. Response-Limiting Characteristics of Resistance-Coupled Amplifiers.

mately 30 to 4,000,000 cycles-per-second, from the video amplifier.

The conventional resistance-coupled amplifier and the frequency-attenuating components at low and high frequencies are shown in figure 24. It is evident that at high frequencies the coupling capacitor is a short circuit, since it offers little reactance, but the tube-to-ground capacities shunting the circuit will also offer little opposition to high frequencies; as the frequency increases, a greater portion will be shunted to ground. By using tubes with low element capacities, this effect is minimized, and, by placing an inductance in series with the load resistor, the high frequencies will develop greater voltages across the plate load and thereby make

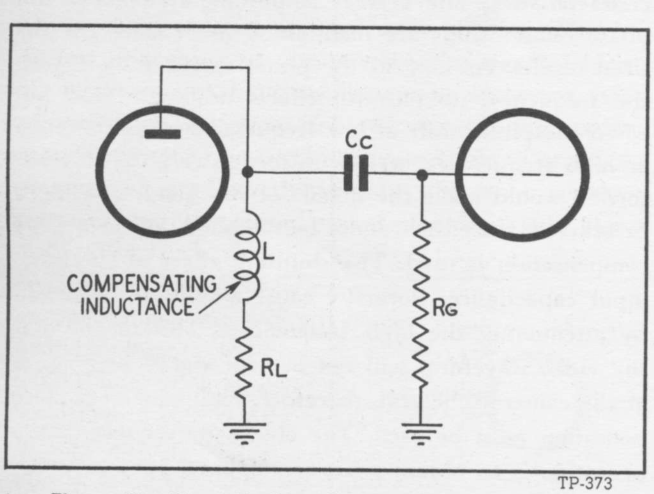

Figure 25. Shunt-Peaking Frequency Compensation.

up for the loss in shunting effect. This method is called shunt-peaking. Another method uses an inductance, in series with the coupling capacitor, of a value that will resonate with the shunt-tube capacity, to form a resonant circuit at high video frequencies. This is called series-peaking. Figures 25 and 26 show both shunt- and series-peaking circuits. For best overall response of the video amplifier, a combination of shunt and series-peaking will usually give best results. Considering low-frequency compensation, figure 27, it is evident that the reactance of the coupling capacitor and grid resistor forms a voltage divider. If the coupling capacitor and grid resistor were made extremely large, very little loss of amplitude at low frequencies would occur, but grid current effects are made noticeable by large grid resistance. To offset this trouble, the circuit shown in figure 27 was devised. Resistor (Rf) and capacitor (Cf) compensate for Rg and Cc, thus equalizing low-frequency response and phase delay.

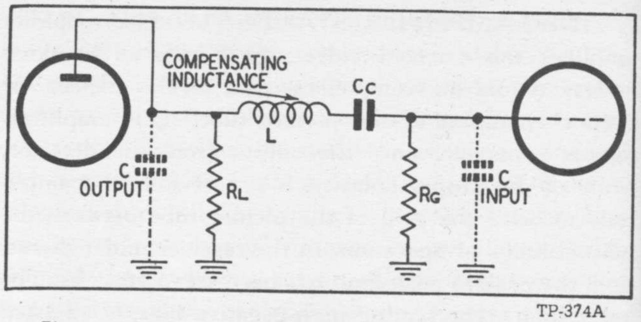

Figure 26. Series-Peaking Frequency Compensation.

While the compensating circuits are derived mathematically, the circuit components must be determined by actual part substitution to compensate for unanticipated circuit faults which cannot always be foreseen during design. The actual compensating circuits used are variations of the previously discussed circuits, used to obtain the desired overall response.

The video amplifier must meet one other requirement: it must either be direct-connected or contain some form of d-c reinsertion so that the proper picture contrast is assured. D-c reinsertion is necessary to maintain a constant point at which blanking occurs for each line; that is, if the black level remains constant, then the instantaneous video signals will be represented by an intensity of some level between black and white exactly as they exist in the original picture. However, if this black level were not maintained constant, the instantaneous signal would be confined within a small range. Thus each line would appear darker or lighter than the original picture, varying in accordance with the amplitude of the video signal so that a true representation of the original picture would not be obtained.

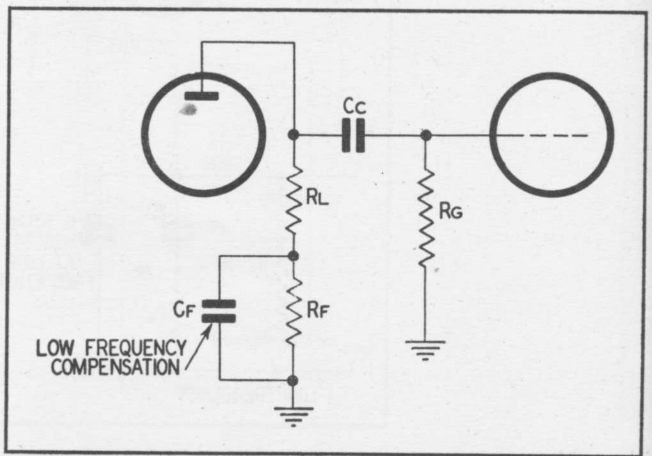

Figure 27. Low-Frequency Compensation.

For example, assume a picture taken of a person outdoors in bright sunlight and the same picture taken indoors where little illumination exists. Since the person's physical appearance is the same, the same general waveform or a-c signal will exist in both cases, regardless of backgrounds. However, the outdoor picture will contain much light and appear bright, while the indoor picture (assuming no special lighting has been provided) will contain little light and appear dim and dark. It is this "average-brightness" level, governing the overall average of brightness that must be reinserted for true picture reproduction. Whenever a signal is passed through a capacitor, it arranges itself about a zero axis; half of the signal positive, or above the axis, and half of the signal negative, or below the axis. Since the average content of the video signal is variable, the bias level of the succeeding tube is shifted as the picture content changes. This is an undesirable condition, as a uni-polarity signal with an established d-c level is desired. Thus, the signal may vary only on one side of the tube-bias level. The tube-blanking level, or potential at which the screen is blacked out, must be constant, regardless of the average content of the picture signal. However, it is possible to reinsert the d-c component by rectifying the sync tips of the video signal. Since there is a constant amplitude between sync tip and blanking level, the blanking level is firmly established and the average brightness, determined by the amount of grid current, varies with respect to the blanking level and not with respect to the zero axis, or bias point of the tube, thus creating an average-brightness level equal to the true average-light value of the picture. These results are accomplished in this television receiver by using the necessary frequency-compensating components and providing d-c reinsertion in the video-output amplifier. This amplifier is direct-coupled to the picture tube to prevent loss of the d-c component.

To illustrate the function of the video amplifier, assume that a signal appears at the output of the detector (figure 22). As this signal increases in negative amplitude, the brilliance of the picture decreases and will swing the (1232) first video-amplifier-tube grid negative. The plate current will decrease and the cathode resistor (78) will have less bias developed across it. Since the sync tips represent the maximum negative swing, the bias on this stage must be such that the sync tips never reach cutoff. Therefore, a positive bias is applied to the first video-amplifier grid bias voltage divider (62C), (62D), and (62F) to balance the excess negative bias introduced by the cathode resistor. The cathode resistor (78) introduces some degeneration, which allows larger input signals to be handled without overload. The screen voltage is fixed by the voltage divider, consisting of resistors (88), (89), and (91). A compensating inductance (80) and its associated capacitor (81) are placed in the screen circuit and a signal is taken directly from the screen and applied to the sync-separator tube. This minimizes loading effects of the sync separator on the video amplifier. Resistor (79) and coil (80) act as the screen load across which the signal, applied to the sync separator, is developed. In the plate circuit, inductor (94) forms a shunt-peaking circuit in series with the load resistor (93), while capacitor (81A) is the plate by-pass capacitor. Resistor (75) acts as a plate-decoupling resistor. The parallel combination, potentiometer (96) in series with resistor (97), across the plate-load circuit, forms a voltage divider so that the proper amplitude for good contrast may be selected. Coupling capacitor (98), while passing the a-c signal component, removes the d-c component. This d-c component is reinserted by resistors (99) and (100), located in the grid circuit of the 6V6 video-output tube. Since the second video amplifier has no bias applied, it operates at the zero-bias point when no signal is present. When a signal is present, rectified grid current flows through resistors (99) and (100). The bias developed by this current flow is proportional to the amplitude of the signal applied to the grid of the video-output tube. Since the blanking pulse always occurs at the same point (75% of maximum signal amplitude), this developed bias will automatically fix the blanking level at the same point for each signal on the grid of the video-output tube. That is, the video signal may vary below this level and thus cause a reduction of plate current which, in turn, swings the picture-tube grid positive (since the grid is directly connected to the plate of the video-output tube), but when the sync tips vary above the d-c level, the plate current is increased, thus swinging the picture-tube grid negative. When the picture-tube grid swings positive, a bright spot appears on the screen, and when it swings negative, less light appears on the screen. Thus, the blanking signal cuts off all light from the screen during the retrace period and although the sync signals are present, they are below the black level and cannot be seen. Capacitor (81B) prevents screen fluctuations from causing degeneration. Capacitor (109) couples the cathode of the picture tube to the other end of the load resistor (101) and applies sudden plate-voltage irregularities to the picture-tube cathode as well as the grid, thus preventing flicker. Resistor (105) is a decoupling resistor and resistors (106) and (108) form a picture-tube-protection bias divider, so a high positive voltage is applied, by the protective switch (131A), to the cathode when the unit is switched off, preventing an uncontrolled surge of electrons from burning a spot on the screen. Resistor (112) and background-control potentiometer (111) form the voltage divider which normally applies the proper bias to the picture tube, so that by varying this control the entire illumination of the picture is varied. The background control is normally adjusted just below the point where the retrace signal would appear. Resistor (110) compensates for variations of voltage at the screen of the 6V6, between light and dark pictures. When an all-white picture is received, the average plate current of the 6V6 drops and the plate-supply voltage rises, driving the picture-tube grid more positive. The increased current through resistor (110) compensates for this action. Capacitor (102) and resistor (103) prevent the picture tube from drawing excessive grid current, if the grid is made positive with respect to the cathode, and also, with inductor (104), maintain satisfactory frequency characteristics for the circuit. Thus, the picture is reproduced faithfully by the video amplifier.

SYNC-SEPARATOR CIRCUIT—This circuit separates the vertical-sync, horizontal-sync and equalizing pulses (located on top of the blanking signal in the blacker-than-black region) from the composite video signal. When the video signal is applied to the grid and the cathode of the sync-separator tube (6Y6-G), the average value of the blanking pulse produces grid rectification, biasing the tube to cutoff. The sync pulses drive the plate current from cutoff to saturation, as shown in figure 29. Very low plate and screen voltages are utilized to allow this action on relatively weak signal inputs. As only a portion of the sync pulses appear across the plate load (due to the clipping action), variations in input signal will not affect the amplitude of the pulses appearing across the plate load.

Referring to figure 28, the signal is applied between control grid and cathode, resistor (83) being the grid leak. The average value of the composite signal causes grid rectification, biasing the tube beyond cutoff. Resistor (90) and resistor (84), effectively in parallel for a.c., form the plate load. Resistor (90) provides the plate voltage for the 6Y6-G but resistor (84) is the predominant load resistor for the developed signal, and is connected between plate and cathode to maintain an equal potential between these elements for wide variations of signal input voltages. The overall action

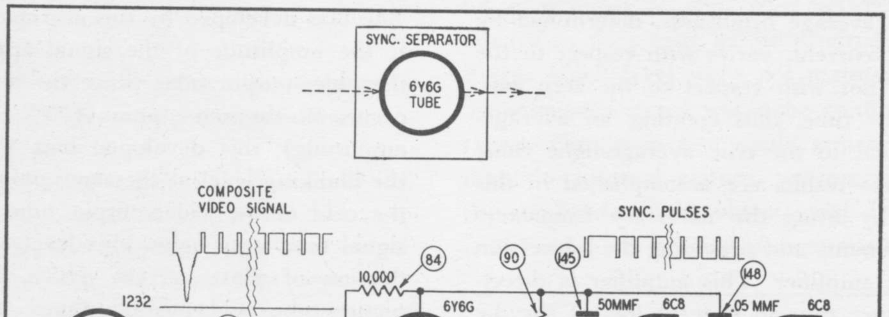

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Figure 28. Sync Separator, Schematic.

of the voltage-divider networks used in this stage is to cause the limits of plate-current cutoff and saturation to be the same amplitude for a wide variation of signal inputs, resulting in clipped pulses of the proper amplitude over a wide range of values of signal input.

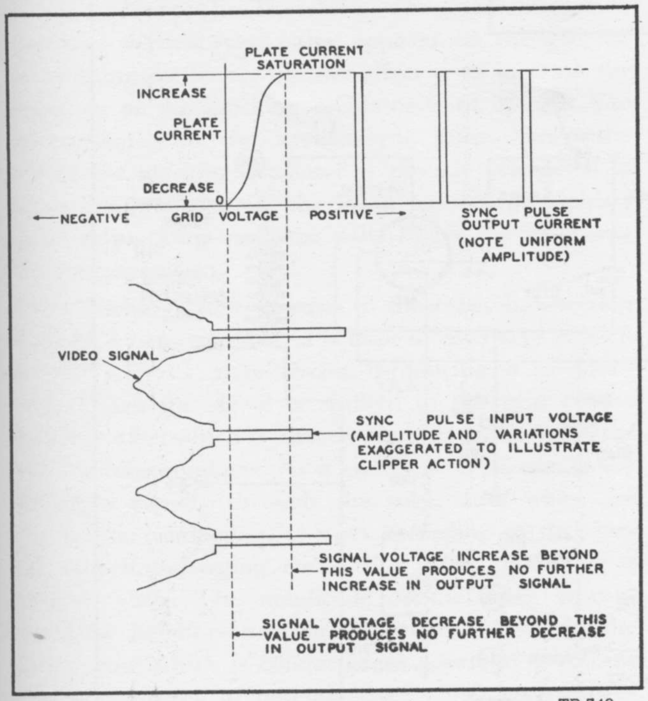

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Figure 29. Sync-Separator Tube Action.

VERTICAL-DEFLECTION CIRCUIT — The vertical-deflection circuit consists of a vertical-synchronizing amplifier, an integrating circuit, blocking-tube oscillator, vertical-discharge circuit, and a vertical-sweep-output circuit. The purpose of these circuits is to produce vertical scanning. To accomplish this, the synchronizing pulse from the sync-separator tube is amplified and used to synchronize the blocking-tube oscillator. The output of the blocking-tube oscillator is converted into a sawtooth wave by the vertical discharge circuit, is amplified, and applied to the vertical-deflection coils of the picture tube, where it produces vertical scanning.

A serrated, vertical sync, negative pulse of approximately 190 microseconds duration, a horizontal sync, negative pulse of approximately 5 microseconds duration, and equalizing pulses, from the sync-separator tube, are applied to the grid of the vertical-sync amplifier through coupling capacitor (148) (figure 30). Resistor (149) is the grid-return resistor. When the negative pulse is supplied to the grid of the sync-amplifier tube, which is normally conducting, this grid is driven more negative. A positive potential is thus developed in the plate circuit and applied through coupling capacitor (152) to the grid of the blocking oscillator. Plate potential is supplied to the vertical-sync amplifier through a series resistor network, composed of resistors (151) and (162), and is decoupled by capacitor (159A).

An integrating network, composed of resistor (151) and capacitor (153), separates the vertical-sync pulses from the horizontal-sync pulses existing in the output of the sync amplifier. This can be accomplished because the horizontal pulses are of such short duration that they have little effect on the vertical-sync integrating circuit. (The equalizing pulses make each vertical-sync pulse appear of the same shape and duration for exact synchronization.) A typical integrating circuit and its resulting waveform are shown in figure 31. The pulses from the vertical-sync-amplifier plate charge capacitor C1 and a portion of the charge is retained until the next pulse comes along which charges C1 higher; each pulse adds to the charge of the capacitor. This continues until the potential across the capacitor is sufficient in amplitude to overcome the control level on the next tube, as shown in figure 31. This control level is fixed by resistor (150) in the cathode circuit. Note that resistor (150) is common to both the vertical-blocking oscillator and vertical-sync amplifier. Therefore, when vertical-sync pulses are applied, reduction in current flow aids in reduction of bias on the blocking-tube oscillator. (An applied signal with less average signal content will result in a higher bias across the cathode resistor. This high bias prevents noise, horizontal, or equalizing pulses from operating the circuit, and will permit the capacitor to discharge more quickly.) The vertical-sync pulses, in conjunction with a reduced bias, trigger the blocking oscillator into synchronism.

The vertical-blocking oscillator utilizes one-half section of a 6C8 twin-triode tube, and is synchronized by the vertical-synchronizing pulse from the sync amplifier at 60 c.p.s. As the oscillator tube conducts, plate current will flow, causing a voltage to be induced in the secondary winding of the oscillator transformer; the transformer is connected so that a positive potential will be applied to the grid, driving the tube to saturation. As the transformer field then collapses, a high negative voltage will cut off the tube, charging the capacitor (158), which will hold the tube at cutoff until the charge has leaked off through resistor (155) and hold control (154). The time constant of this r-c

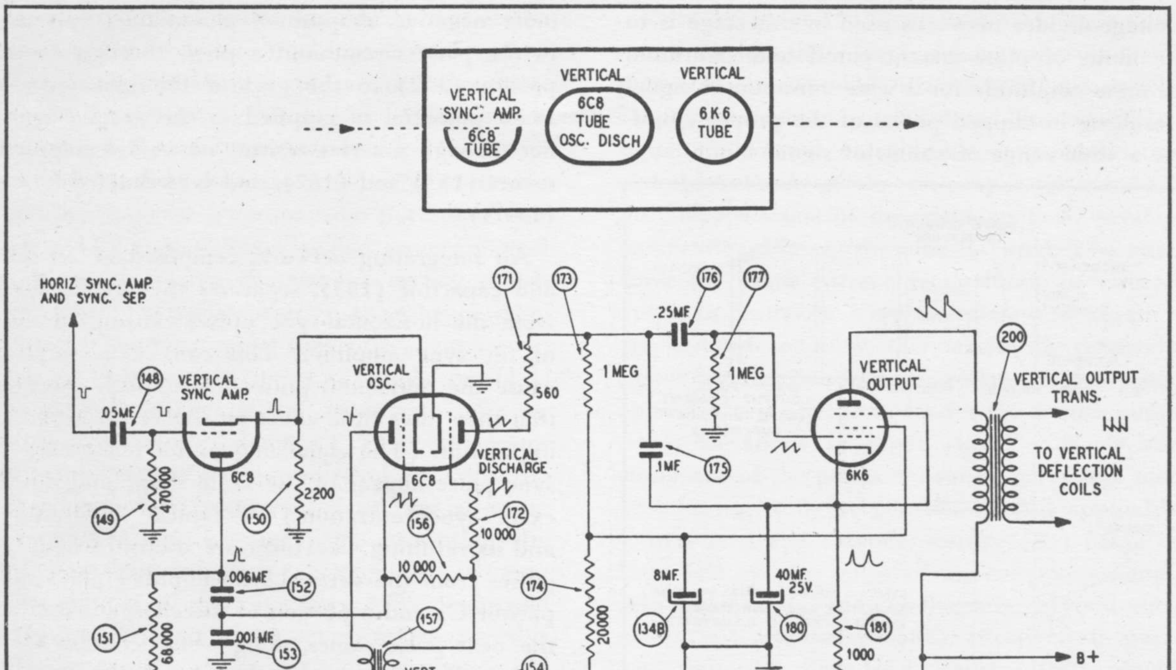

Figure 30. Vertical-Deflection Circuit.

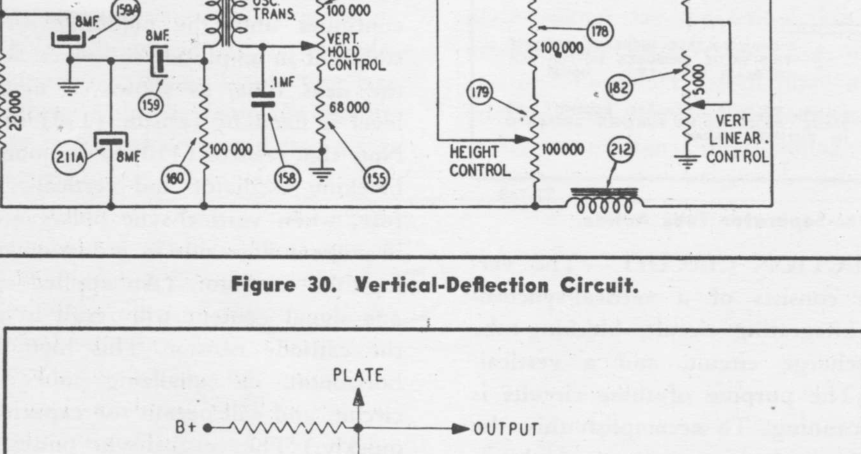

Figure 31. Integrating Circuit and Waveform.

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combination determines the cutoff period of the oscillator. When the charge has leaked off the holding capacitor, the cycle is repeated. Normally, the natural frequency of the blocking oscillator is chosen so that it is slightly lower than that of the vertical-sync frequency (60 c.p.s.). Therefore, when the integrated (positive) vertical-sync pulse appears on the grid of the blocking oscillator, the net effect is to increase the frequency of the blocking oscillator until it locks into synchronism with the vertical-sync pulse. Since the grid of the blocking oscillator is directly connected to the discharge-tube grid, the large positive grid pulses from the blocking oscillator will trigger the discharge tube into operation.

The discharge tube consists of the other half-section of the 6C8 twin triode, and is used to discharge capacitor (175) in its plate circuit, producing a sawtooth wave. When the signal is applied to the grid of the discharge tube, which is directly coupled to the oscillator grid, the tube conducts. As it conducts, capacitor (175) discharges rapidly through the tube, and, when the tube is non-conducting, charges according to the normal capacitor-charging curve E :: t/rc, producing a sawtooth wave. The amplitude of the wave is controlled by height-control potentiometer (179), in the plate circuit, which is connected as a part of a voltage divider, consisting of potentiometer (179) and resistor (178). Resistor (174) is the screen-dropping resistor for the output tube and is by-passed by capacitor (134B). Resistor (171) is a plate-current-limiting resistor to keep the peak plate current to a safe value for the tube when the sweep-generating capacitor (176) discharges. Resistor (173) is the plate resistor across which the sweep is developed.

The vertical-output circuit consists of a 6K6-GT tube, used to further amplify the sawtooth wave and apply it through a matched output transformer to the vertical-deflection coils of the picture tube. The sawtooth signal from the discharge circuit is applied to the grid of the vertical-output tube through coupling capacitor (176) across the output-grid resistor (177). Note that the discharge capacitor (175) is returned to the cathode of the vertical-output tube so that a linear sawtooth wave can be developed between grid and cathode of the 6K6-GT tube. This varies the bias and operating point on the tube's characteristic curve, producing the desired change in linearity.

HORIZONTAL-DEFLECTION CIRCUIT — The horizontal-deflection circuit is similar to the vertical-deflection circuit. However, the horizontal sweep occurs 262-1/2 times as often and therefore is much shorter in duration than the vertical sweep. To produce this very fast sweep, some differences in circuit details are required.

Negative rectangular pulses from the sync separator are coupled to the grid of the horizontal-sync amplifier (figure 32) by a differentiating circuit (figure 33) consisting of capacitor (145) and resistor (146). The time constant of this combination is small enough to convert a 5-microsecond negative rectangular pulse into a sharp negative pip at the start of the rectangular pulse, tapering back almost to zero before the end of the rectangular pulse, and then, at the end, developing a sharp positive pip which tapers back toward zero at the same rate. The horizontal-sync amplifier employs one section of a 6C8 twin-triode tube, self biased for class A1 operation by cathode resistor (147) (figure 32). This resistor is not by-passed, and the degenerative current feedback improves the linearity of amplification. The d-c plate current is limited by two resistors (161) and (162), connected in series. However, resistor (161) is by-passed to ground by an electrolytic capacitor (157A) and does not form part of the signal-plate load. The horizontal-sync amplifier phase-inverts and amplifies both the negative and positive pips furnished by the differentiating circuit, and couples the amplified pips to the grid of the 884 thyratron gas tube, by means of a tuned circuit, coupling capacitor (165), and oscillation-suppressing resistor (166). Disregarding these pips for a moment; in the oscillator circuit, B+ voltage is applied through resistor (185), and the oscillator is connected, in series, to the series combination of capacitors (186) and (188) with resistor (184). The capacity of the two capacitors in series is so nearly that of capacitor (188) that capacitor (186) can be neglected insofar as its influence in the time constants is concerned. The voltage across capacitor (188) builds up positive at a rate determined by the r-c combination of capacitor (188) in series with resistor (185). It is the nature of a gas tube that when the potential difference between plate and cathode is sufficient, it will "fire"; that is, suddenly conduct heavily. When the voltage across capacitor (188) reaches the firing voltage of the 884 gas tube, the tube fires, and capacitor (188) discharges rapidly through the tube, charging capacitor (169) in the cathode circuit of the tube. When the potential difference between plate and cathode has been reduced sufficiently, the tube will be extinguished. The rise of voltage across capacitor (188) constitutes the sawtooth sweep rise, and the rapid discharge constitutes

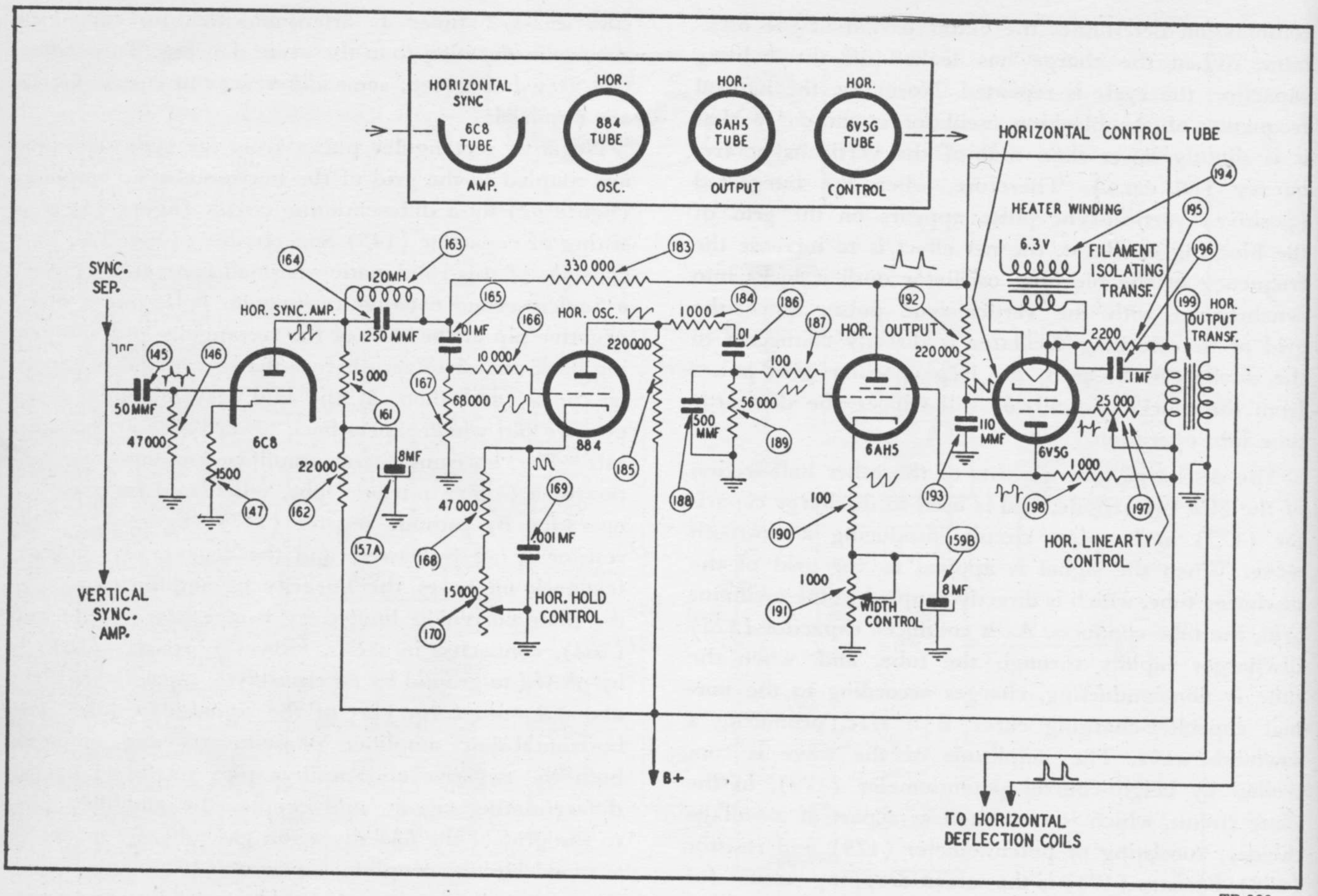

Figure 32. Horizontal-Deflection Circuit.

the return trace. Resistor (184), in series between capacitor (188) and the 884 tube, increases the discharge time somewhat, but is necessary to prevent excessive current flow through the 884 tube.

Capacitor (169), in the cathode circuit of the 884 tube, holds the cathode positive at a substantially constant value determined by the average cathode current and the resistance in the cathode circuit. This resistance is varied by the HOR. HOLD control potentiometer (170). The more positive the cathode, the longer it takes for sufficient potential difference between plate and cathode to build up across capacitor (188) to fire the tube. On the other hand, the lower the cathode potential, the quicker the tube fires and the faster is the recurrence rate of the sawtooth voltage. The HOR. HOLD control, therefore, varies the sweep frequency.

So far, the 884 tube has been considered as a diode. The grid in a gas tube, however, determines at what potential difference between plate and cathode the tube will fire, although once it has fired, the grid cannot stop the conduction. However, there are present on the grid both the negative and positive pips from the horizontal-sync amplifier. The negative pips have no effect on the circuit, but the positive pips can fire the tube. The circuit constants are such that the positive pips on the grid occur when the sawtooth voltage across capacitor (188) has built up almost to the point where the tube will fire; the positive pip then fires the tube, locking the sawtooth frequency in step with the leading edge of the incoming 5-microsecond horizontal-sync pulse.

Positive sawtooth voltage is applied to the grid of the horizontal-output-amplifier tube, a 6AH5 beam-power tetrode, for current amplification. Capacitor (186), which is considered to be in series with capacitor (188) in regard to the charging cycle, is used primarily to isolate B+ from the grid of the 6AH5 tube. A resistor (187) is used to prevent parasitic oscillation, and resistor (189), connected across (188), is the grid return for the 6AH5 tube. The gain of the tube determines the amplitude of the sawtooth voltage, and therefore the width of the sweep. The gain is controlled by varying the tube's operating point with the WIDTH control. This control, potentiometer (191), by-passed by electrolytic capacitor (159B), shorts out more or less of the total biasing resistance in the cathode circuit. Resistor (190) in the cathode circuit is used to limit the maximum current drawn by the tube. Positive sawtooth voltage from capacitor (188) is applied to the grid of the 6AH5 tube, and negative sawtooth current variations are passed through the main plate load, which is the primary of the horizontal-output transformer.

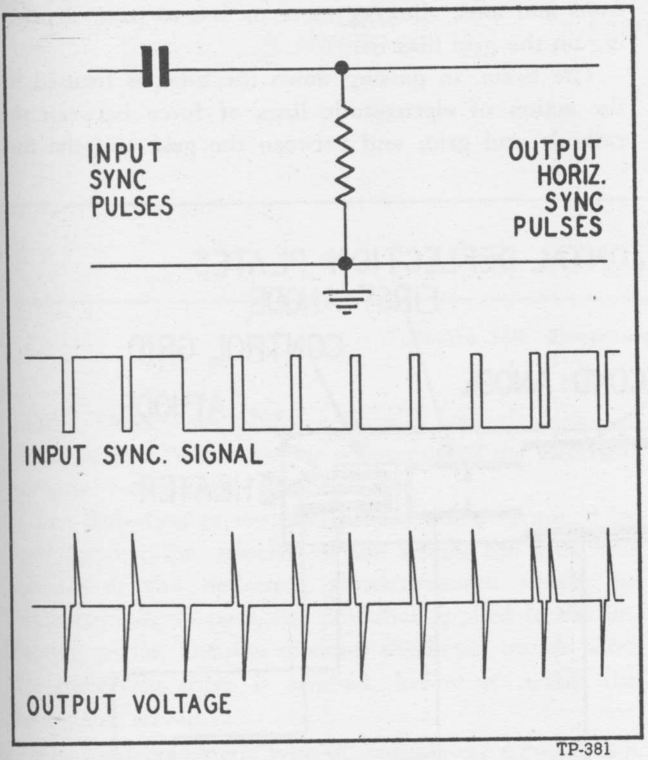

Figure 33. Differentiating Circuit and Waveform.

The 6V5 tube is connected in series with resistor (198) and the transformer primary to damp undesired oscillatory transients in the transformer and deflection coils, to improve the sawtooth linearity, and to make the output circuit more efficient so far as power requirements are concerned. The heater is supplied by a separate filament transformer to prevent heater-to-cathode breakdown; during the return time, there may be 3000 volts peak developed across the output circuit. The bias is determined by cathode resistor (195) by-passed by capacitor (196). The extent to which the 6V5 affects the deflection current flowing in the transformer is controlled by screen potentiometer (197), the HORIZONTAL LINEARITY control.

The operation of the 6AH5 and 6V5 tubes is as follows: A positive sawtooth voltage is applied to the grid of the horizontal-output tube, and a sawtooth of current is desired in the transformer primary. During the last half of the sawtooth, the 6AH5 is conducting with increasing current up to the moment the return time begins, while the 6V5 is conducting only a small amount. During the return, a high-positive peak voltage develops on the 6AH5 plate and the 6V5 cathode, cutting off the latter. The current in transformer (199) executes a transient oscillation, during which it reverses its direction. Since the 6AH5 is a tetrode with high plate impedance, this oscillation would continue for several cycles and consequently disturb the desired linearity. Conduction of the 6V5, when the cathode voltage tends to swing negative after the first half cycle of the transient, damps the oscillations. The 6V5 conducts strongly during the first part of the deflection sawtooth, controlling useful current which need not be supplied by the 6AH5. The connection of the 6V5 plate load to the 6AH5 screen reduces the output-tube current correspondingly, with resulting economy in power requirements. During the latter part of the sawtooth, the 6V5 current is reduced, as noted previously. On its grid is an approximate sawtooth of voltage derived from the 6AH5 plate pulse applied to the r-c circuit; this aids in obtaining the desired linear sweep.

The sweep frequency must be 15,750 cycles per second, corresponding with the frequency of the 5-microsecond horizontal-sync pulses from the sync separator. If no other pulses arrived at the grid of the horizontal-sync-amplifier tube, the 5-microsecond horizontal-sync pulses would definitely establish the desired sweep frequency; but the vertical-sync pulses and equalizing pulses are also present at the input of the horizontal-deflection circuits, and means must be provided to prevent these pulses from firing the 884 horizontal-oscillator tube prematurely. Therefore, a tank tuned to 15,750 c.p.s., and made up of inductance (163) and capacitor (164), is included in the coupling circuit between the horizontal-sync amplifier tube and 884 tube. This tank is kept in oscillation at 15,750 c.p.s. by energy supplied from the plate of the horizontal-output tube, through a 330,000-ohm isolating resistor. The phase of the tank oscillation is such that the leading edge of the differentiated and phase-inverted horizontal-sync pulse arrives at the grid of the 884 tube as a positive pip at exactly the same time that the positive peak of the sinusoidal tank oscillation raises the grid potential. Neither signal alone is sufficiently strong to fire the 884 tube; but the combination of both signals does fire the tube. During the vertical blanking and scanning period, the recurrence rate of the equalizing pulses and the pulses obtained from the serrated vertical pulse are double the normal horizontal-pulse frequency and therefore arrive at the grid of the 884 tube at a time when the sinusoidal voltage is not at its positive peak. Because of this fact, they cannot fire the 884 tube. The horizontal-sweep frequency is therefore absolutely fixed at the desired frequency, and the start of each sweep corresponds exactly to the leading edge of the horizontal-sync pulse.

PICTURE-TUBE CIRCUITS — The cathode-ray tubes shown in figures 34A and 34B are conventional types and are presented here in order that the serviceman may compare these familiar types with the Philco (10AP4) picture tube. Detailed explanation is attempted only for the 10AP4, which has certain radical departures from conventional construction, since the conventional cathode-ray tube has been the subject of many detailed and technical analyses. The serviceman who is interested in such technical analyses of the cathode-ray tube will find an abundance of material available in trade publications.

In the electrostatic-type tube shown in figure 34A, the heated cathode emits electrons and ions, which are accelerated by high anode potentials along a path toward the far end of the tube. The control grid is adjacent to the cathode and controls the flow of electrons and ions, allowing more or less to pass, depending on the grid bias.

The beam, in passing down the tube, is focused by the action of electrostatic lines of force between the cathode and grid, and between the grid and the first

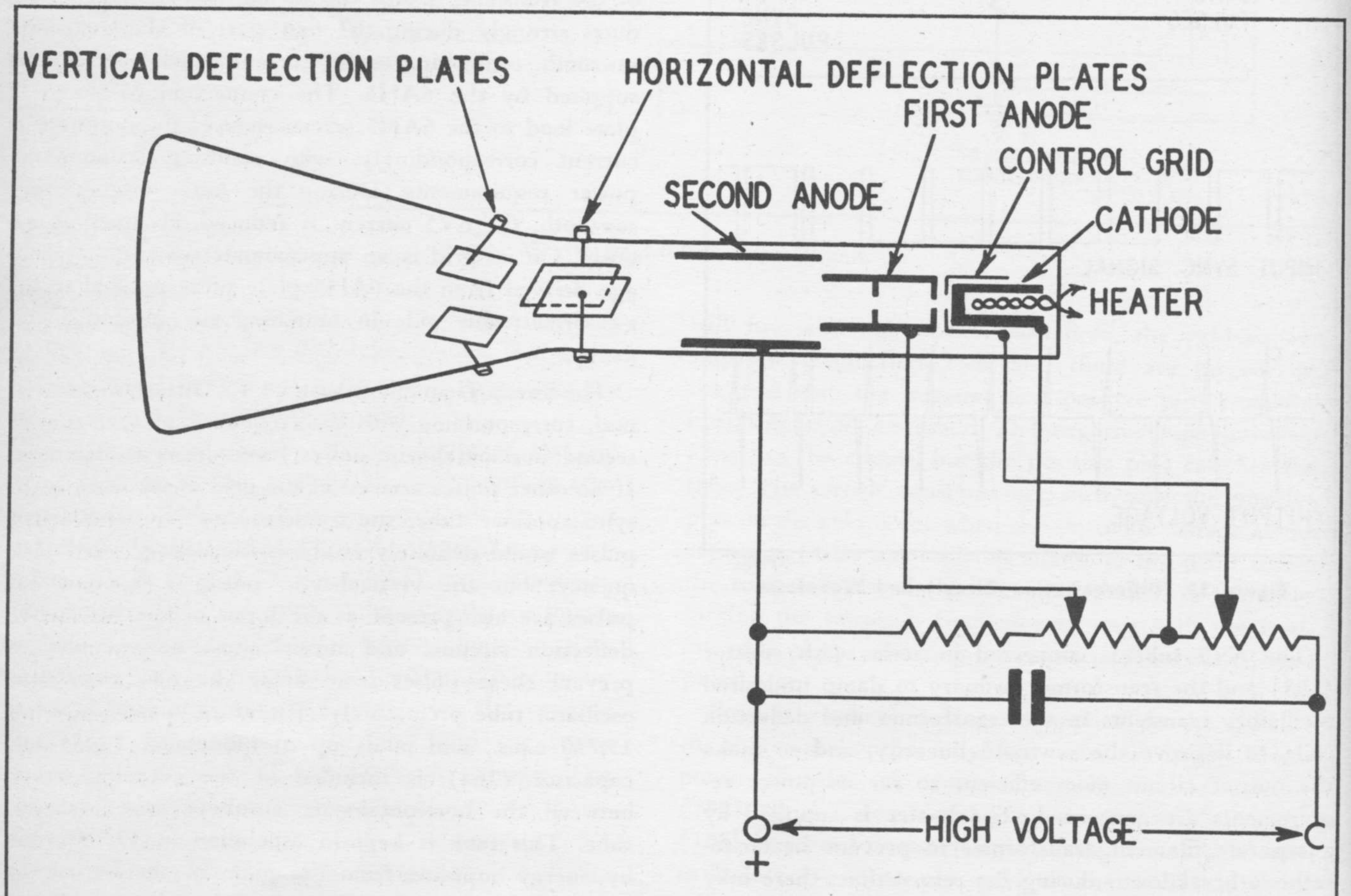

Figure 34A. Electrostatic Cathode-Ray Tube.

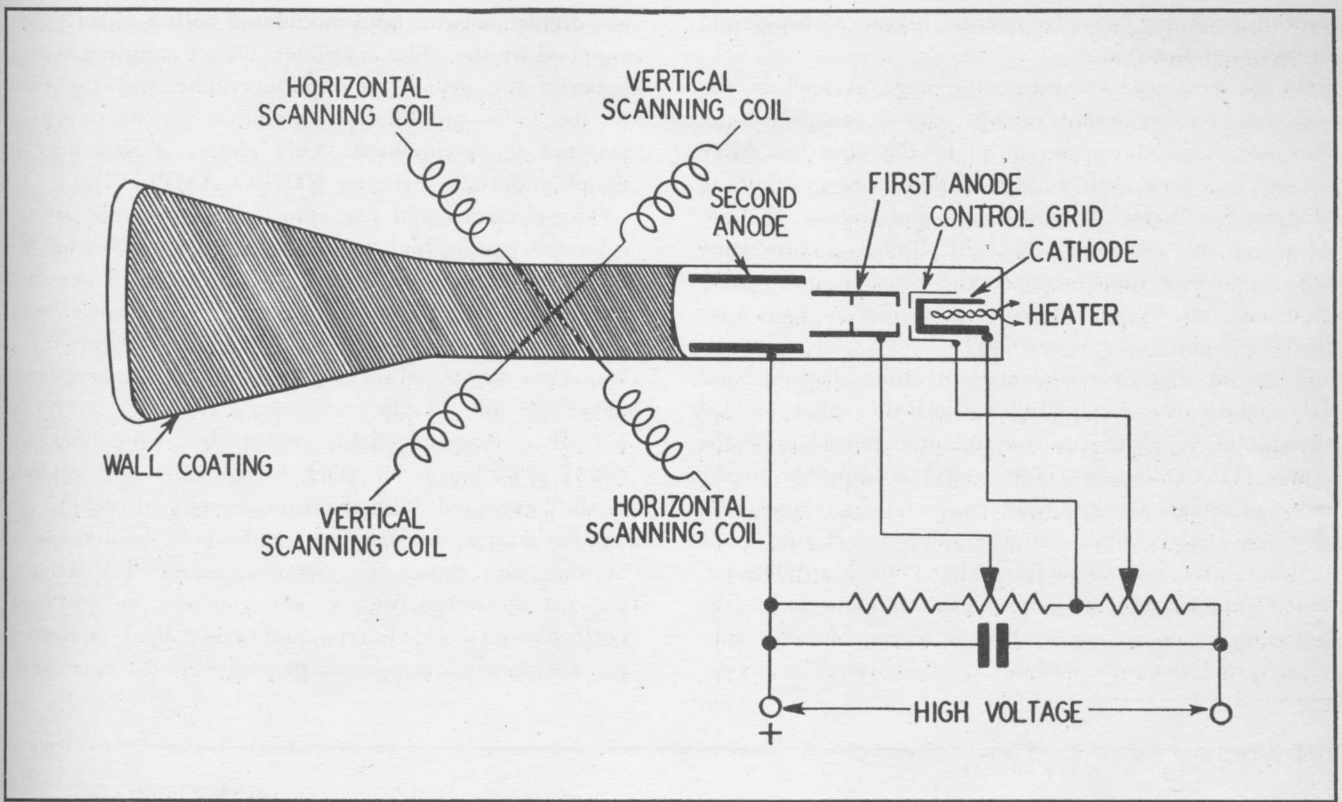

Figure 34B. Electromagnetic Cathode-Ray Tube.

anode. These lines of force form a sort of electronic "lens," whose "curvature" is a function of the electrical potential between the tube elements.

The deflection of the electron beam is determined by four factors: the velocity of the beam, the area and spacing of the deflection plates between which the beam is made to pass, the potential applied to the deflection plates, and the distance the beam travels after the deflecting force is applied, before it strikes the fluorescent screen.

The electromagnetic type of cathode-ray tube, shown in figure 34B, also has an electron gun, consisting of the heated cathode, grid and accelerating anodes. Focusing and deflection, however, are accomplished by magnetic fields, set up by currents flowing in coils. The action of these coils is detailed in the discussion of the Philco (10AP4) picture tube.

The conventional types of picture tubes use the curved viewing surface, because the curved surface, like the arch of a bridge, is more resistant to the external air pressure against the highly-evacuated thin-glass tube, and because the use of the curved surface makes possible a path of constant radius from the point of deflection of the electron beam. Without this path of constant radius, the point where the beam is in focus will appear at different points on the screen and the amount of deflection occurring will be different at different points on the screen. This latter condition is called line distortion.

The curved screen presents two distinct disadvantages in television. First, viewing must be from directly in front of the center of the screen, or the picture will appear distorted. Second, the curved surface will pick up and reflect light in all directions, so that any extraneous light in the vicinity of the screen will prove distracting to those viewing the television program.

To obtain the advantages of the flat screen, the Philco (10AP4) picture tube uses a heavy safety-glass viewing screen which, because of its strength can be made flat, and at the same time, much more resistant to breakage with its attendant danger to the television audience. To counteract the inherent line distortion of the flat screen, an ingenious compensating circuit is used, as explained later. A further safety feature is introduced by the use of a canvas cover on the back of the tube, preventing flying glass fragments in case of accidental breakage of the tube.

In the conventional tubes, the ions, as well as the electrons, are accelerated against the screen. Since the ions are very heavy compared to the electrons, they strike the screen with a great deal of energy, tending to burn the surface of the screen and shorten the life of the tube. To avoid this, the Philco picture tube uses a novel arrangement of the electron gun which forms an ion "trap." This arrangement is known as the "bent gun." See figure 34D.

When the cathode is heated, it emits electrons and ions, which are accelerated toward the other end of the tube by the high positive potential placed upon the anode. This potential (6000 volts) is supplied to the anode through the graphite coating on the inside of the tube. Contact between the coating and the anode is made with a small metal spring. The graphite coating is connected with an external conductor to the high-voltage power supply. The grid regulates the flow of electrons from the cathode, and is biased by a voltage-divider network and modulated with a video signal, supplied by the video amplifier. Direct coupling is used between the grid of the picture tube and the plate of the video amplifier, to maintain the necessary re-inserted d-c component. This circuit is described in detail under the heading VIDEO AMPLIFIER.

The electrons and ions which pass the grid are accelerated by the high positive potential existing on the anode, and enter the anode through a small aperture. See figure 34C. These electrons and ions continue to travel in a straight line, but the anode is bent; therefore, they would collide with the wall of the anode and never get out of the other end. However, with the aid of a magnetic field, set up by a bending coil (206) placed over the neck of the tube and adjacent to the bent anode, the electrons are passed through the anode, because the strong magnetic field created by the bending coil causes the electron path to be changed; i.e., the deflecting force of the magnetic field is regulated to cause the electron path to be bent or curved, permitting the electrons to pass through the gun with-

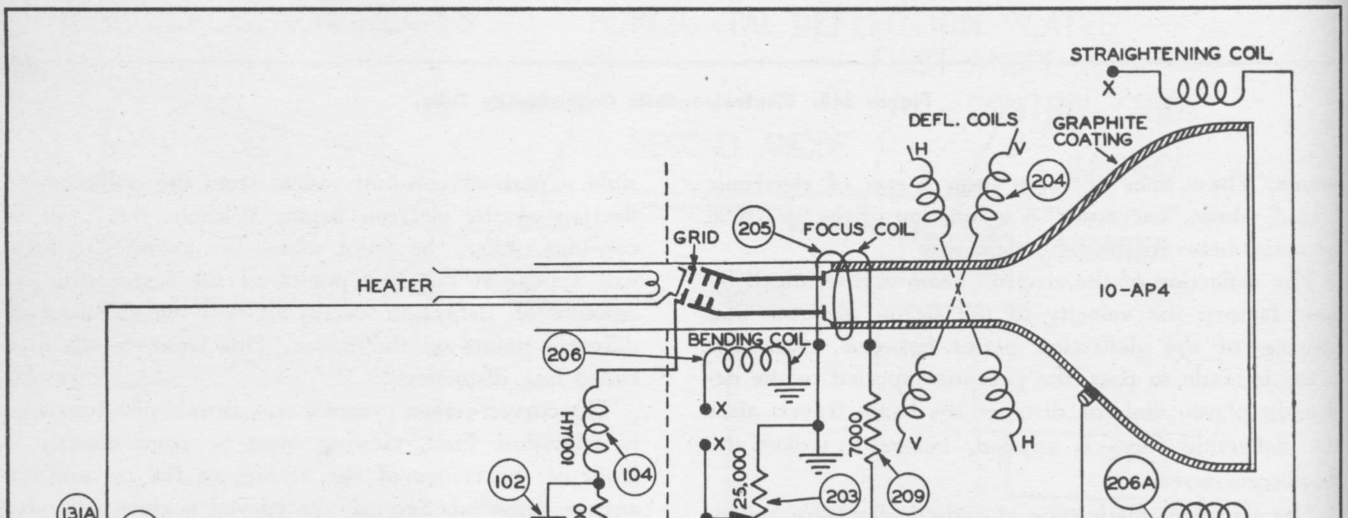

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Figure 34C. Bent-Gun Picture Tube and Schematic.

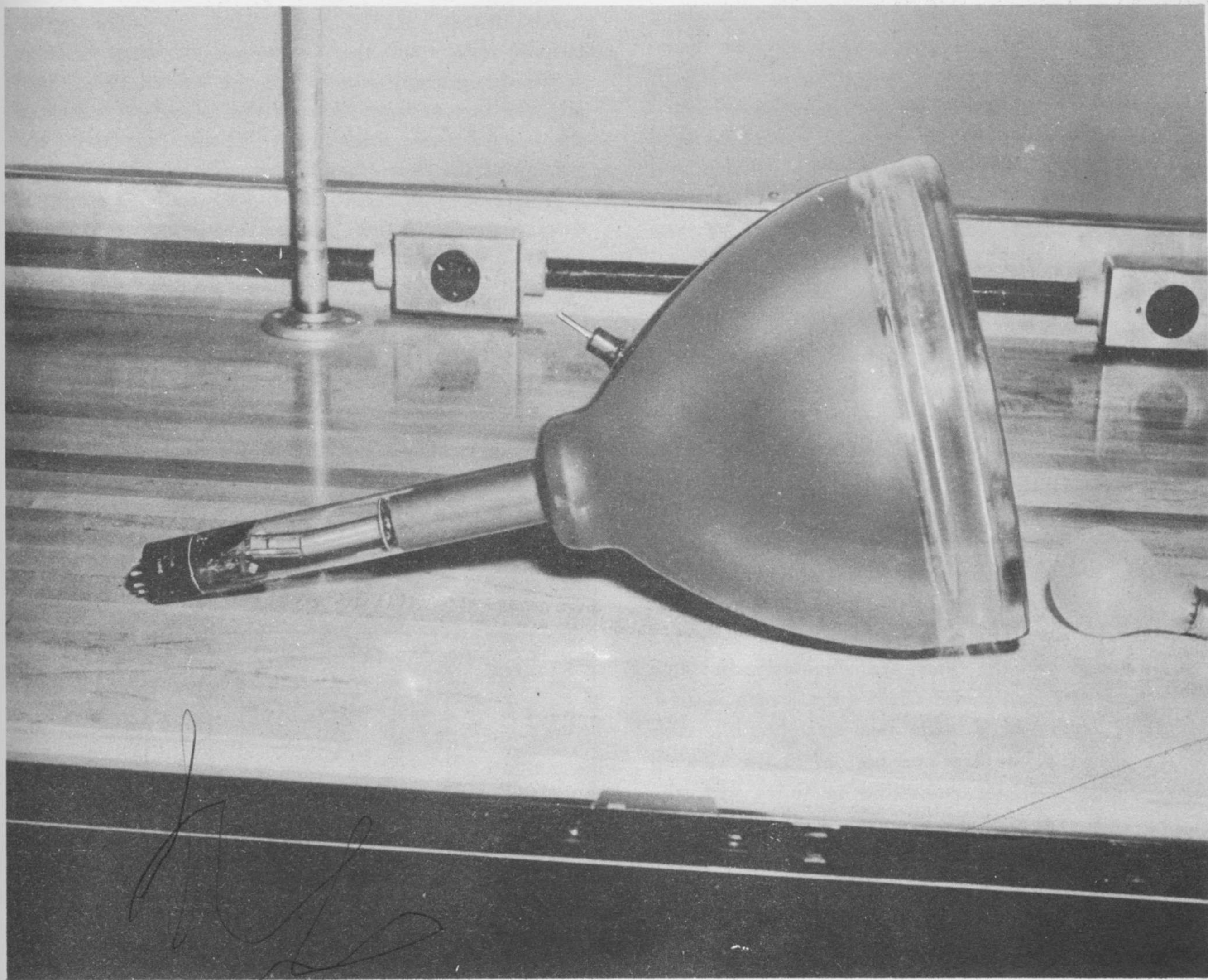

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Figure 34D. External View of a Bent-Gun Picture Tube.

out striking the side of the anode. However, the ions, which are a part of the electron stream, are many times heavier than the electrons and are not substantially affected by the field which deflects the electrons. Therefore, the ions continue to travel in a straight line and strike the anode wall. If the ions were not trapped they would strike the fluorescent screen, located at the end of the tube, with sufficient force to burn a brown spot. The strength of the magnetic field is regulated by varying the current flowing through the bending coil with centering control (203). The centering control is part of a voltage-divider network, made up of resistors (202) and (201). The stream of electrons pass from the electron gun into a magnetic field generated with focusing coil (205). The strength of the magnetic field is regulated with a focus control (210), which is connected in series with resistor (209) and focusing coil (205). The purpose of this coil is to concentrate or focus all the electrons into one small spot on the viewing screen, located at the extreme end of the tube. The focusing action is accomplished in this manner: the generated magnetic lines of force are parallel to the axis of the tube and electrons traveling along the axis are not affected, but those electrons which are not traveling on a path parallel to the lines of force, located at the axis of the tube, are deflected toward the axis, following a spiral path rotating about the central axis of the tube. This spiral path narrows and finally converges at the axis, the point of convergence being determined by the strength of the magnetic field created by the focus coil. The electron beam passing from the focus coil is deflected horizontally or vertically across the face of the viewing screen, located at the end of the tube, by the magnetic fields generated by the deflecting coils. The current for the coils is generated in the deflection circuits described under headings VERTICAL-DEFLECTION CIRCUIT and HORIZONTAL-DEFLECTION CIRCUIT. The beam of the electrons finally strikes the fluorescent screen, called the viewing screen, causing it to produce a white light. The amount of light produced is proportional to the number of electrons striking the screen. The material of the screen has the property of short persistence; i.e., once the electron beam is removed, the fluorescent screen immediately stops glowing. The viewing screen of the (10AP4) picture tube is not like the conventional viewing screen, because it is flat instead of curved, thus eliminating image distortion caused by a curved screen, but introducing line distortion. Line distortion is caused when the radius of the deflected beam is not always the same, and obviously the same radius cannot be maintained when a flat screen is used. This fault is corrected with two straightening coils (206A) placed at the top and bottom of the viewing screen. These coils are connected in series with the bending coil and generate magnetic fields at the top and bottom of the viewing screen. When the electron beam is deflected into the magnetic field created by either straightening coil, it is attracted toward the straightening coils, thereby lengthening the radius of the shortened beam, straightening the lines produced by the beam when it sweeps across the screen, thus eliminating line distortion. Vertical correction is unnecessary because of the length of the horizontal sweep. The motion of the beam is synchronized with the motion of the scanning beam in the camera tube, located at the transmitter.

The picture-tube beam is modulated by the video signal on the picture-tube grid, causing the intensity of the light generated by the fluorescent screen to vary. Thus, as the beam rapidly scans the viewing screen, it builds a picture out of white and black, duplicating the original picture being televised.

AUDIO CIRCUITS

AUDIO I-F AMPLIFIER STAGES—The signal-output voltage of the first video i-f stage appears across the primary winding of the second video stage and also across a portion of the primary winding of the first i-f audio transformer. The voltage across the portion of the first i-f audio primary winding develops a greater voltage across the entire winding because of autotransformer action. The primary winding is permeability tuned, and, in conjunction with the capacitor (114A), resonates at 15 mc., therefore offering very low impedance to the 19.5-mc. video i.f., but causing maximum audio-signal energy to appear across the winding. The resistor (114B) and capacitor (114C), figure 35,

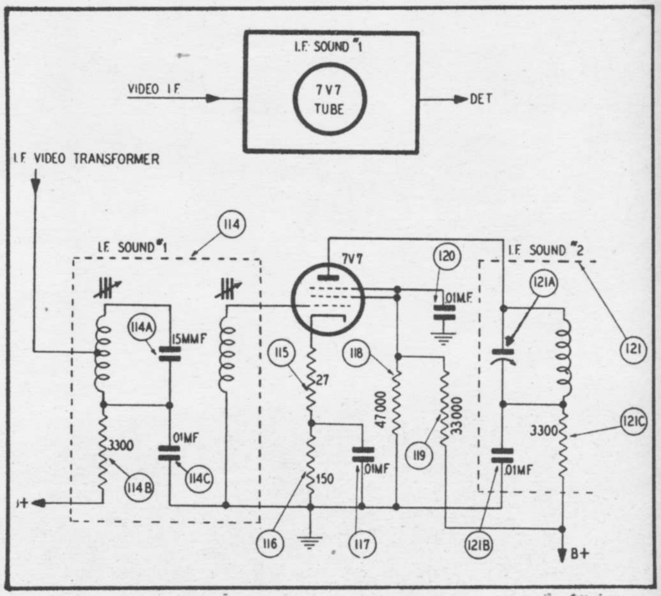

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Figure 35. Audio I-F Amplifier, Schematic.

connected to the primary winding, provide a low-impedance r-f path, and also isolate the plate circuit from associated circuits. The primary winding is inductively coupled to the secondary winding which is permeability tuned, and, in conjunction with its distributed capacity and the inter-electrode capacity of the 7V7 tube, resonates at 15 mc. The signal voltage developed across the secondary is applied to the control grid of the 7V7 tube. The screen and suppressor grids are tied together and connected to the junction of the resistors (118) and (119), which form a voltage divider between B+ and ground. By using a voltage divider, the potential of the screen and suppressor grids remains fairly constant, causing the 7V7 tube to have a sharp cutoff characteristic. The capacitor (120) is connected to the primary winding of the second audio i-f transformer, which is tuned to resonate at 15 mc. by the trimmer capacitor connected across the primary winding, and the other end of the primary winding is connected to B+ through the isolating resistor (121C). The capacitor (121B), provides a low-impedance path for r.f. Bias voltage is developed across resistors (115) and (116) in the cathode circuit. Resistor (116) is by-passed for r.f. by capacitor (117), and resistor (115) provides a slight amount of degeneration for improving the frequency response.

AUDIO DETECTOR AND FIRST AUDIO-AMPLIFIER STAGE — In the detection of frequency-modulated signals, it is necessary to convert the frequency variations to amplitude variations, so that audio amplification can take place. The frequency-modulated signal is applied to the detector (discriminator) stage, and the sum of the voltage developed across each half of the secondary winding, plus the voltage across the tuned circuit (121D), (taking into consideration the phase difference between the two voltages), figure 36, appears across the load resistor of each diode. The voltage across the load varies in amplitude as the input frequency varies from the frequency to which the discriminator primary is tuned. The rate of frequency variation determines the frequency of the detected audio signal, and appears at the load of each diode as a rate of voltage variation.

The discriminator transformer consists of a tuned primary, to which is coupled a secondary composed of two untuned sections joined at their center tap to one lead of a tertiary winding. This winding is tuned, as is the primary, by parallel variable capacitors.

The output voltages of the two secondary windings are impressed on the plates of the XXFM tube, resulting in alternate conduction at these plates equivalent to a 180-degree phase displacement of the two currents. The output voltage of the tuned tertiary winding varies

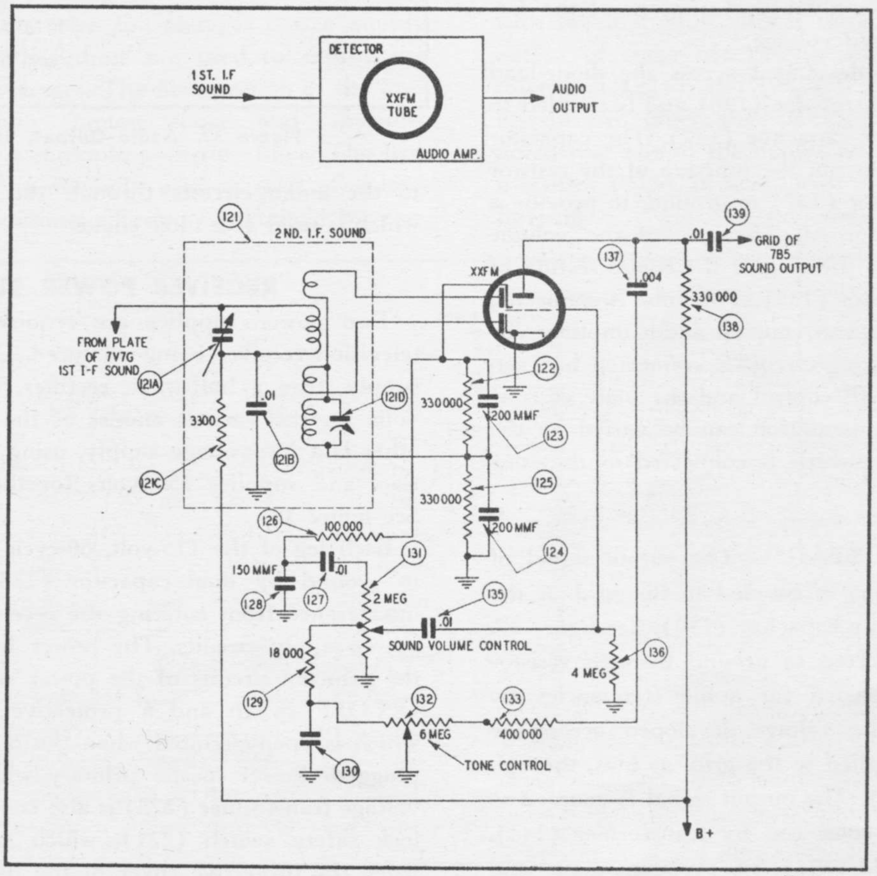


Figure 36. Audio Detector and First Audio Amplifier, Schematic.

in amplitude as the impressed voltage varies in frequency above and below the resonant frequency to which the tertiary winding is tuned. In addition, the phase relationship between the tertiary voltage and each of the secondary voltages varies with the impressed frequency, in accordance with the well-established principle that the apparent reactance of a parallel-tuned circuit is inductive at frequencies below resonance, purely resistive at resonance and capacitive at frequencies above resonance.

Since the output voltage of the tertiary winding is added, through the center tap to the two secondary windings, the total resultant voltage will vary, therefore, in both amplitude and phase. The resultant rectified d-c output voltage across resistors (122) and (125) will accordingly vary with the frequency variation impressed across the primary, and the variation will be at a rate corresponding to the rate of frequency variation of the impressed voltage. Variations in amplitude of the impressed voltage will not affect the output voltages, because of the balancing effect of the two secondary windings. The output voltage, then, is a d-c potential which varies only with variations of the frequency of the impressed voltage.

The audio voltage developed across the diode-load resistors is fed through resistor (126) and is coupled to the volume control by capacitor (127). The capacitor (128) is connected between the junction of the resistor (126) and the capacitor (127) to ground, to provide a low-impedance path for r.f. The arm of the volume control is connected to the grid of the triode section of tube XXFM by capacitor (135). This tube is connected in a conventional resistance-coupled audio-amplifier circuit. A tone-compensating circuit is connected between a tap on the VOLUME control and the plate of tube XXFM. The tone compensation can be varied by the TONE control (132), which is connected in the tone circuit.

AUDIO-OUTPUT STAGE—The output signal of the first audio amplifier is coupled to the grid of the output-amplifier tube by capacitor (139). See figure 37. The cathode is connected to ground through resistor (141), which is by-passed for audio frequencies by capacitor (134A). The voltage developed across the cathode resistor is applied to the grid, as bias, through the grid resistor (140). The output signal is coupled to the dynamic-speaker voice coil by transformer (143). The capacitor (142), connected between plate and ground, attenuates the high frequencies. B+ is supplied

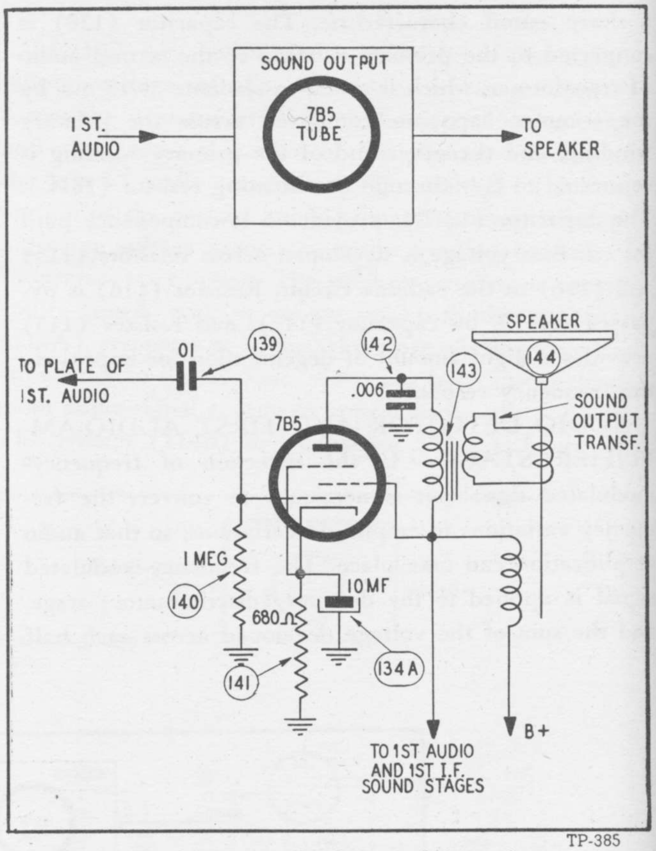


Figure 37. Audio Output, Schematic.

to the audio circuits through the speaker field coil which is used as a filter choke.

RECEIVER POWER SUPPLY

Two power supplies are required to operate the television receiver being analyzed. One, a high-voltage supply, uses a half-wave rectifier, and supplies 6000 volts for the various anodes of the picture tube. The other is a low-voltage supply, using full-wave rectification, and supplies 350 volts for the receiver circuits. See figure 38.

Each leg of the 115-volt, 60-cycle input is by-passed to ground by dual capacitor (228), preventing line interference from entering the receiver by way of the power-supply circuits. The power line is connected to the primary circuits of the power supplies through an ON-OFF switch and a protective connector contact, which is open-circuited when the deflection coil is unplugged. Power to the primary winding of the high-voltage transformer (222) is also controlled by an interlock safety switch (221), which automatically opens when the protective cover of the high-voltage rectifier tube is removed.

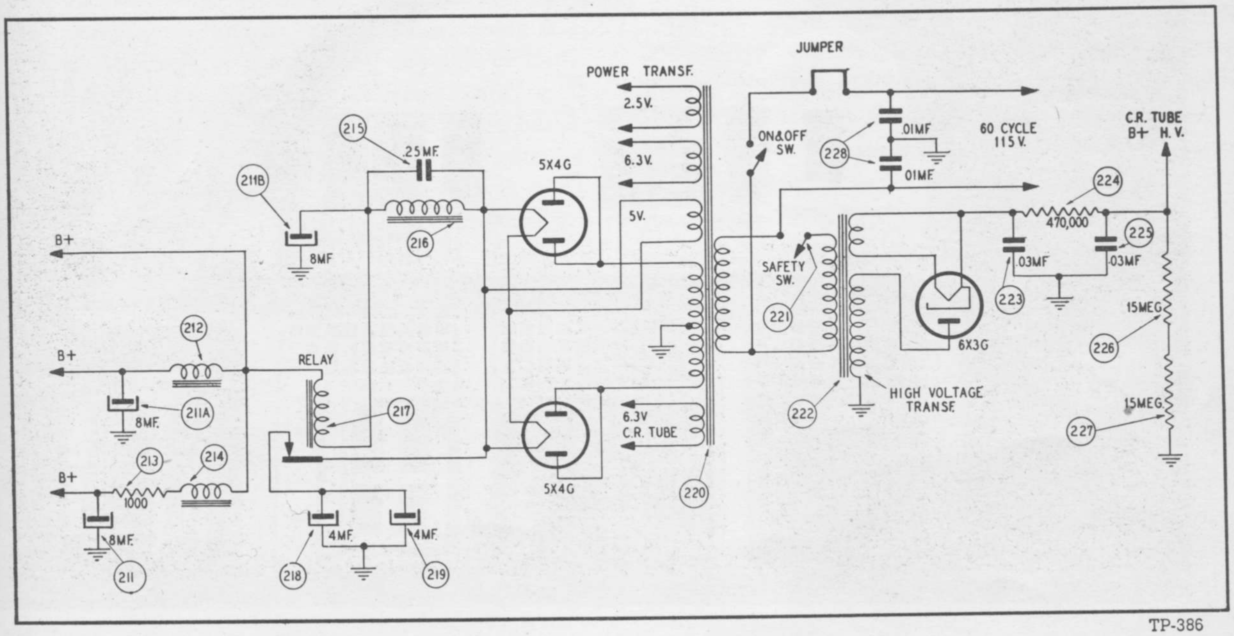
CAUTION: The serviceman with the long grey beard is the man who never trusted any interlock or safety switch. He always disconnected the power and discharged the capacitors.

The high-voltage half-wave rectifier tube is type 6X3. Because the current drain from this circuit is extremely low, a pi-section filter, consisting of two capacitors (223) and (225), and a resistor (229) provides sufficient filtering action. The low current drain also permits the potential at the filter input to build up to 6000 volts from 4500 volts r.m.s. Two resistors (226) and (227) are connected in series across the high-voltage-supply output, and act as a bleeder, providing a protective load for the circuit and discharging the circuit when it is not in operation.

Two 5X4-G tubes are used in the low-voltage power supply in order to carry the large current (250 ma.) required by the receiver circuits. The plates of each rectifier tube are paralleled, and the tubes are connected so that full-wave rectification is obtained.

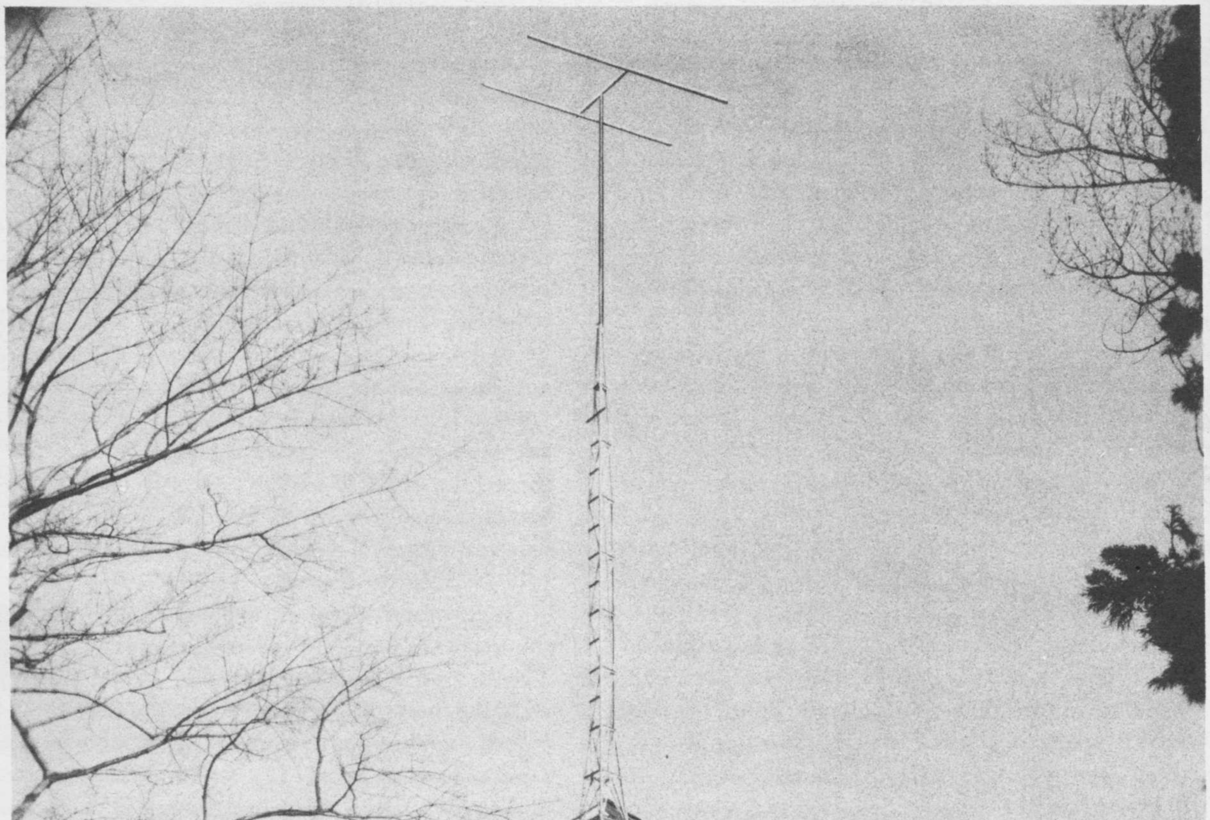
The low-voltage transformer (220) used in this set has five secondary windings but only four are used. One winding is for the low-voltage power supply (350 volts); the other three are used to supply the required filament voltages. The filter section of the low-voltage power supply employs chokes and capacitors connected to form a multiple pi-section filter. The first filter choke (216) is not only used as part of a low-pass filter, but additional filtering is obtained by connecting capacitor (215) in parallel with it forming a parallel resonant circuit which filters out the objectionable 120-cycle ripple. The power-supply side of the choke is by-passed with capacitors (218) and (219), connected in parallel. The load side of the first filter choke is by-passed with capacitor (211B). Connected in series with the first filter choke (216) and the rest of the filter circuits, is a relay (217). This relay is used because the cathodes of the 5X4G rectifier tubes are directly heated, and therefore, the power supply furnishes voltage before the remaining cathodes permit plate current flow. The initial high-voltage surge would be destructive to the input capacitors (219) and (218) and other components in the equipment. Therefore the voltage is prevented from reaching an excessively high potential, while the current drain is low, by the use of the relay, which disconnects the input capacitors, and leaves a choke-input-type circuit. When the equipment heats up, the relay closes and connects the input capacitors into the circuit.

One of the B+ busses is connected at the junction of the relay and the two filter chokes (214) and (212). The two filter chokes (212) and (214), in conjunction with the first filter choke, form double-pi filters. The output of these two pi-type filters is by-passed with capacitors (211) and (211A) and supplies B+ voltage to two other B+ busses; however, it should be noted that one of the double section pi-type filters uses a resistor (213), in series with the choke, for additional filtering.



TP-386

Figure 38. Power Supply, Schematic.



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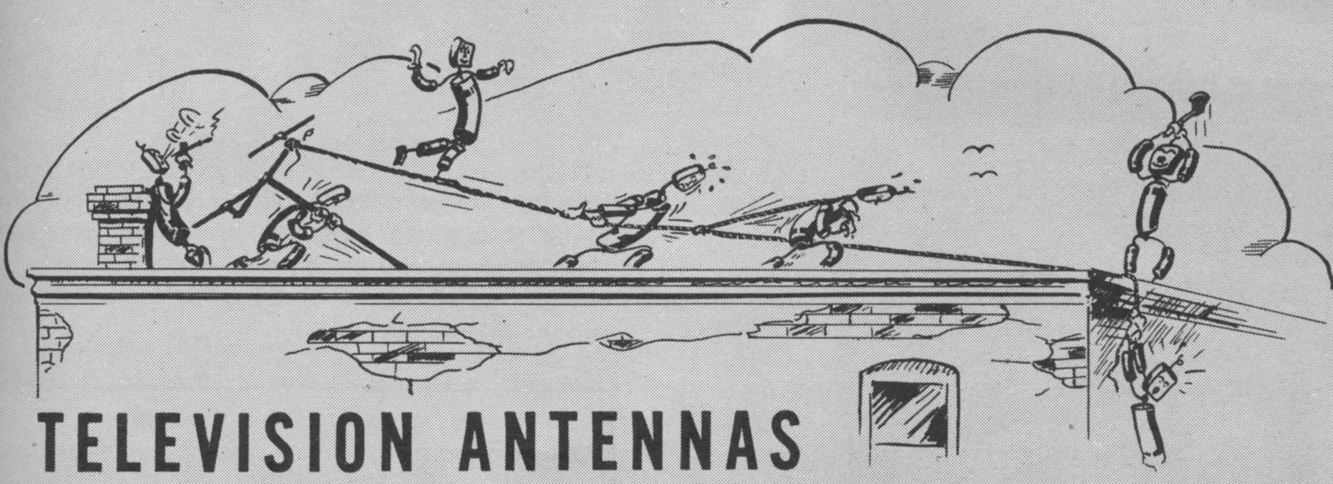

TELEVISION ANTENNAS

VERY-HIGH-FREQUENCY TRANSMISSION and RECEPTION

The nature of the very-high frequencies used for television purposes is such that the radio waves are propagated through space along line-of-sight paths. This definitely limits the transmission and reception of a television signal over long ranges, as line-of-sight paths do not follow the curvature of the earth. Thus signals cannot be reliably transmitted or received beyond the horizon. See figure 39.

Very-high-frequency antennas used as television antennas usually serve a twofold purpose; first, to receive or transmit efficiently the transmitted or received signals, secondly, to provide directivity permitting selection of an individual station in the case of reception, and to eliminate directivity in the case of transmission.

Increasing the range of normal television transmission and reception primarily involves increasing the height of the receiving or transmitting antenna, or both. The best locations for receiving antennas are upon masts erected on house tops, apartment or office buildings, and upon hill tops. Another factor of antenna location involves the choice of a site where intervening objects such as hills and buildings are not in the line-of-sight. When the receiver is at a great distance from the transmitter, reference to a topographical map should be made before receiver installation is made, in order to determine whether a line-of-sight exists between the transmitter and receiver. Refer to the servicing section for formulae for calculating reception distances.

TRANSMITTING ANTENNAS

Inasmuch as this manual is aimed at data pertinent to servicing the television receivers, it is not necessary to elaborate upon the design and installation of transmitting antennas. It should be noted, however, that television transmitting antennas do not generally possess the directive features of receiving antennas. In order to transmit in all directions with good signal strength, transmitting antennas have been designed to avoid directive features. See figure 40. The need for height to increase the range of transmission is the primary factor in installation of these antennas, resulting in placement upon extremely high buildings or high topographical points.

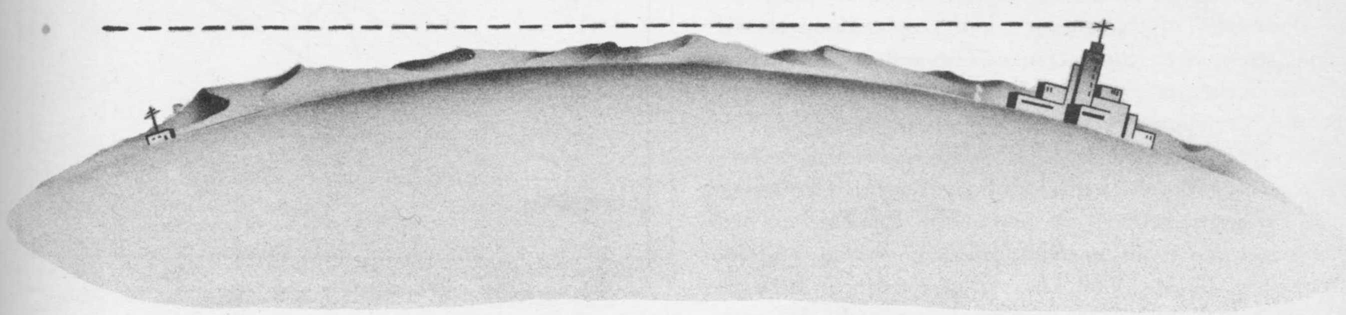

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Figure 39. Line-of-Sight Transmission and Reception.

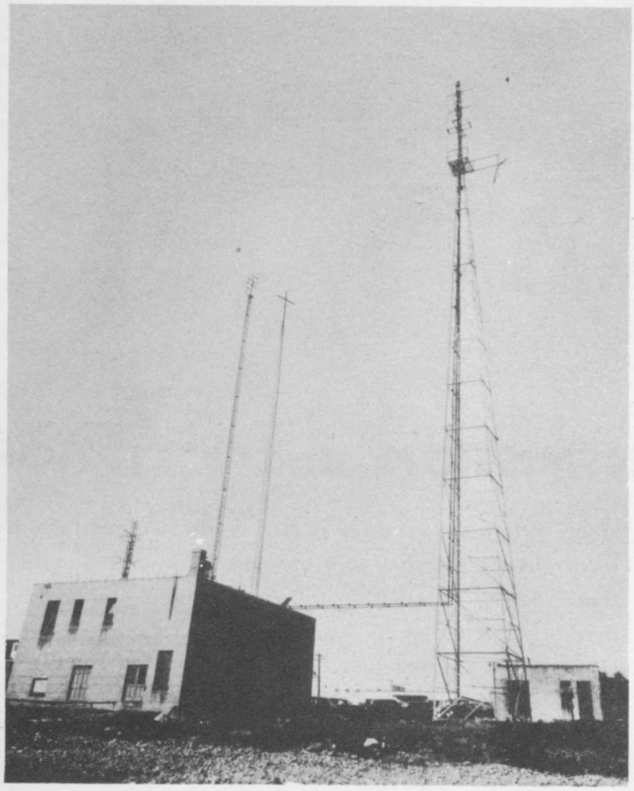

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Figure 40. A Typical Transmitting Station and Antenna

RECEIVING ANTENNAS

Although television receiving antennas are yet in the stage of design, the average serviceman will ordinarily encounter four types in present-day installations. See figure 41.

The first type is a normal ½-wave dipole antenna consisting of two ¼-wave stubs. A major characteristic of this type is its bi-directional feature, which enables it to receive signals from opposite directions with good signal strength, providing the stations are of normal strength and good location. The second type is more widely used. It is a normal ½-wave dipole with one reflecting element spaced approximately ¼-wave length behind it. The use of this reflector increases the directivity of the antenna and results in increased signal strength to the receiver. The reflecting element also tends to prevent or reduce signal reception from the direction opposite to the transmitter location. The third type is a folded dipole which consists of a center-fed ½-wave dipole with another element (½-wave) folded directly between its ends. The spacing between the two elements is normally about 3 inches at television frequencies. The last type, sometimes used, is the stacked dipole. Two or more ½-wave dipoles with reflectors, are mounted one above the other providing greater than normal directivity, wider band pass, lower angle reception, and greater sensitivity. Other types of antennas include the V antenna, the fanned antenna, and the conical antenna.

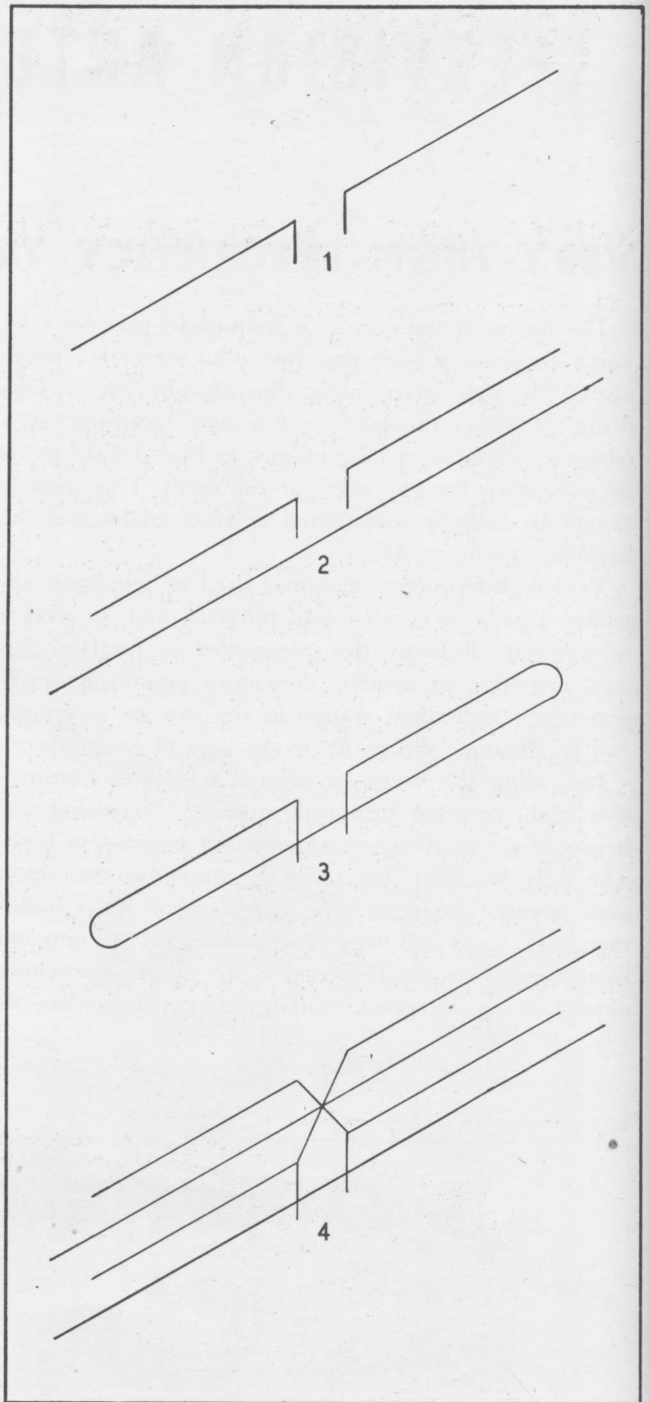

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Figure 41. Types of Television Receiving Antennas.

ANTENNA PROPERTIES

Antennas used for television reception have five major properties. These are polarization, radiation angle, impedance, directivity, and physical aspects.

Polarization is the position of the antenna with respect to the earth. A horizontal antenna radiates or receives horizontally polarized waves and a vertical antenna radiates or receives vertically polarized waves. Actually, because of the action of several forces upon the radiated energy, the wave entering a receiving antenna contains both vertical and horizontal components. This action is less pronounced at v.h.f.; so at these frequencies the same antenna polarization is required at both the transmitter and receiver. If the transmitting antenna is horizontally polarized so must be the receiving antenna. Although antennas of either polarization may be used for television, it has been proven more advantageous to use horizontal polarization, as this type of polarization tends to improve distant transmission and reception. In receiving antennas, horizontal polarization tends to eliminate noise interference, as noise is generally vertically polarized.

The radiation angle of an antenna is the angle above horizontal at which the antenna radiates or receives best. Inasmuch as television transmission is line-of-sight, radiation at low angles is necessary in order to avoid the losses resulting from high-angle radiation which would merely be dissipated in space. Similarly,

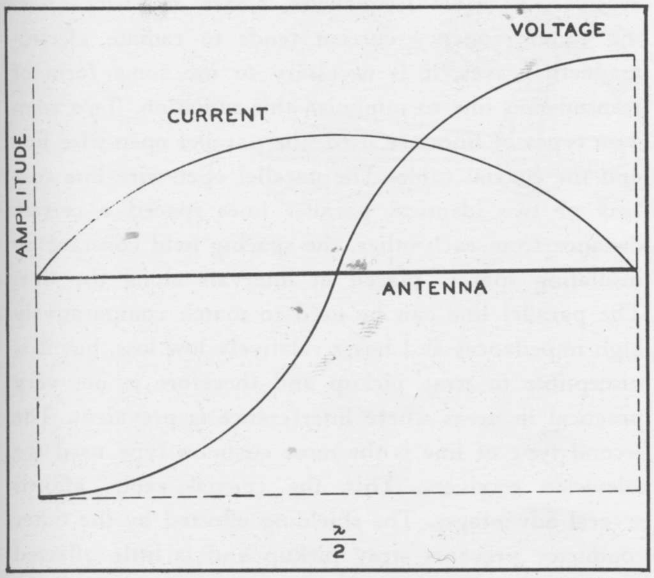

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Figure 42. Voltage and Current Distribution of a Half-Wave Dipole Antenna.

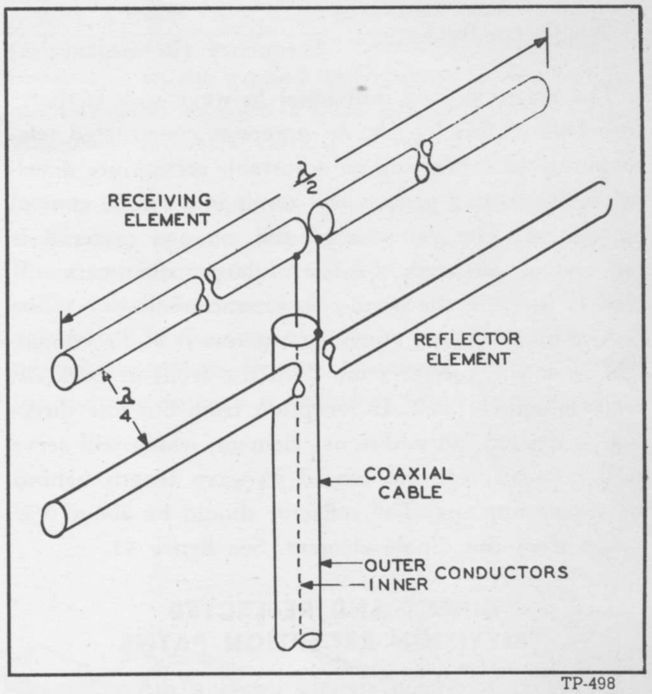

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Figure 43. A Half-Wave Dipole Antenna.

it is desirable to use a receiving antenna best suited for reception of low-angle signals, and placed as high above the surrounding terrain as possible.

Impedance of an antenna at any point is the ratio of the current to voltage at that point. See figure 42. It is important in connection with feeding power to the antenna, since it constitutes the load resistance represented by the antenna. At high frequencies, this impedance consists chiefly of radiation resistance. As the height of the antenna increases, the impedance approaches free-space value. For a ½-wave dipole in free space, (that is, entirely removed from any objects which might affect its operation, including the earth) the radiation resistance is equal to about 73 ohms.

Directivity is the ability of an antenna to receive or to radiate more energy in one direction than in another. It must be viewed as two dimensional, as it exists in both horizontal and vertical planes. Thus directivity involves the wave angles as well as the "compass" direction in which the antenna is aimed.

The physical aspects concern, primarily, the length of television antennas, which is critical for optimum operation; therefore, it is necessary to cut the antenna to a length which is resonant with the frequency of the desired transmitted signal. This length can be determined for a ½-wave dipole antenna by applying the following formula:

$$\text{Length (in feet)} = \frac{468}{\text{Frequency (in megacycles)}}$$

The length of one individual $\frac{1}{4}$-wave stub is therefore half of this length. As antennas constructed telescopically or containing an adjustable section are developed, this cutting process will result in a simple manual adjustment. The diameter of the antenna material is not critical, although the use of larger diameters will tend to increase the band-pass characteristic.

A normal $\frac{1}{2}$-wave receiving antenna is bi-directional, that is, it will receive from both the front or back directions equally well. If reception from but one direction is desired, an additional element, which will serve as a reflector, can be placed $\frac{1}{4}$-wave length behind the dipole antenna. The reflector should be about 5% longer than the dipole element. See figure 43.

DIRECT AND REFLECTED TELEVISION RECEPTION PATHS

Normally, television signals travel a direct line-of-sight path from the transmitter to the receiver. However, this path is often blocked by such objects as hills and buildings, causing weakened signals or no signals at the receiver. Another characteristic of television signals is that of reflection from large buildings and hills, and, by such a reflected path, to reach the receiver. Often this occurs in addition to the direct signal and results in two or more signals from the same transmitter being received by the television receiver. Inasmuch as these signals travel via different paths varying in length, their arrival at the receiving antenna has a slight time difference, the reflected signals being slightly delayed in arrival. This characteristic results in a visual pattern of interference known as a "ghost" or image upon the receiver picture screen. The reflected signal may be white or black, depending upon its polarity, and it may vary in intensity from almost equal that of the direct signal, to a point where it is just noticeable. Differences in relative intensities are caused by the attenuation they may encounter in their transmission paths. Obviously, in congested urban areas, there may be multiple signal paths that will create multiple images or "ghosts," resulting in very unsatisfactory reception. In some cases, reflections, hardly noticeable in themselves, may cause the direct signal pattern to appear fuzzy. Methods to eliminate or reduce the unwanted signal patterns resulting from reflected signals will be dealt with at length in the servicing section of this publication.

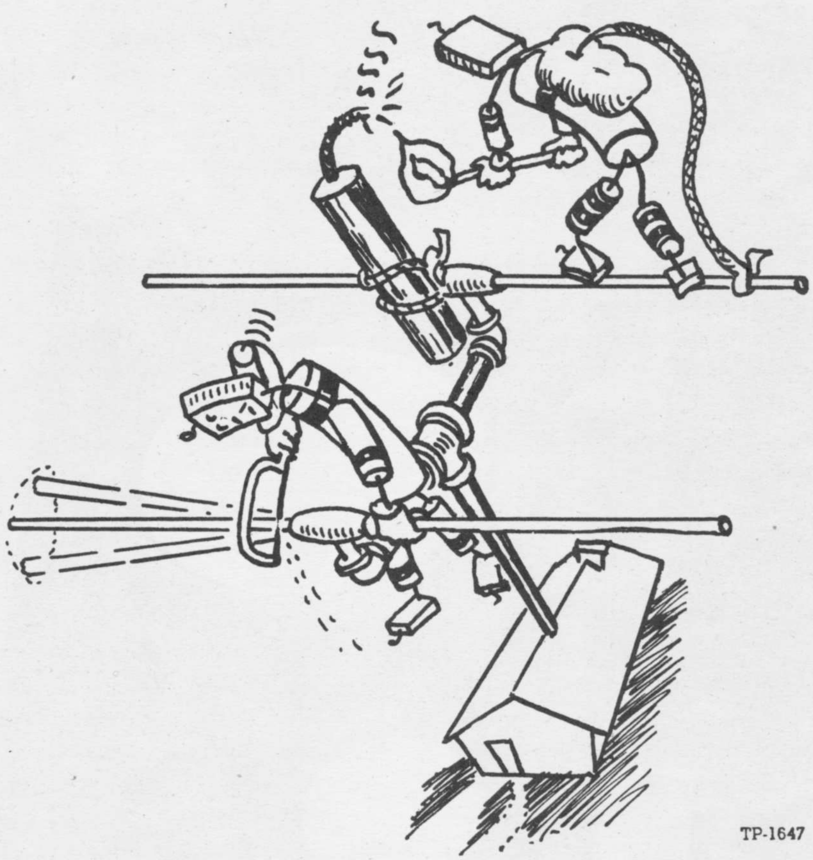
TELEVISION RECEIVER ANTENNA ORIENTATION

Because of the directive feature of television receiving antennas, it is highly advantageous to attempt to point the antenna as accurately as possible directly at the transmitting antenna. Note that pointing a receiving antenna involves pointing the *broad* side of the antenna and *not* the ends toward the transmitter. This orientation can be achieved in several ways. First, by reference to a map, the direction of the transmitter from the receiver must be determined, and then by use of a compass, and by manual rotation, the antenna can be easily aimed at the transmitter. However, the most advantageous method of pointing the antenna can be achieved by reference to the receiver screen during the process of rotation. By this procedure, the optimum position for the antenna can be determined by the greatest signal strength, the absence of ghost images, and the absence of extraneous interference patterns. Signal strength, however, is the major factor. Specific details of orientation will be reviewed in the service section of this book.

TRANSMISSION LINES FOR RECEIVING ANTENNAS

Transmission lines are used to transfer signals, with a minimum of loss, from the receiving antenna to the receiver. At radio frequencies, where any wire carrying radio-frequency current tends to radiate electromagnetic waves, it is necessary to use some form of transmission line to minimize this radiation. Two common types of lines are used, the parallel open-wire line and the coaxial cable. The parallel open-wire line consists of two identical parallel lines spaced a certain distance from each other, the spacing held constant by insulating spacers placed at intervals along the line. The parallel line can be used to match comparatively high impedances and has a relatively low loss, but it is susceptible to stray pickup and therefore is not very practical in areas where interference is prevalent. The second type of line is the most common type used for television receivers. This, the coaxial cable, affords several advantages. The shielding effected by the outer conductor prevents stray pickup and is little affected by its proximity to other surfaces. It matches relatively low impedances making it adaptable for use with dipole antennas. Several kinds of coaxial cable are usable at television frequencies; rigid coaxial cable of copper conductor with ceramic-bead spacers, flexible coaxial cable with copalene dielectric, coaxial cable with spun-glass dielectric, and coaxial cable with low-loss-rubber dielectric. The first type of cable is of best quality and the last of the poorest. Inasmuch as interference reduction and signal strength are in direct relationship to the quality of coaxial cable used, the use of the better quality is advisable. Although no definite length limitations are imposed upon television-receiver transmission lines, normal installations will vary between 25 and 125 feet. As the length increases, the need for good quality coaxial cable increases. The coaxial cable is coupled directly to the center ends of the dipole elements and to the ground and antenna connections on the television receiver. Figure 43 illustrates a dipole antenna with coaxial cable attached.

It is obvious from the preceding discussion of antennas and antenna installations, that the use of television receivers in apartment houses will present peculiar installation problems. Although this problem is not critical at the time of writing, it is evident that, as television receivers become household articles, devices for multiple antenna installations will be available.



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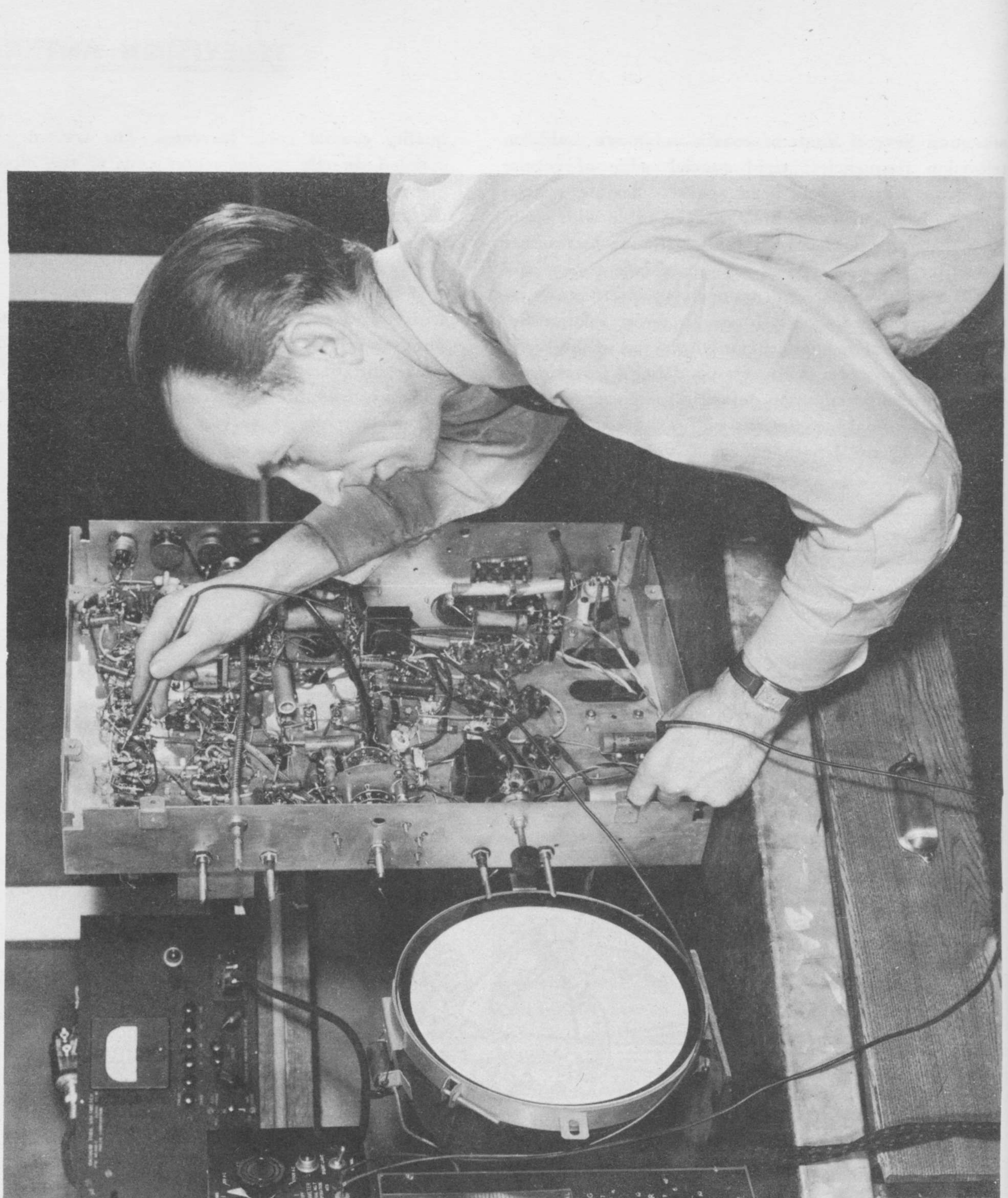
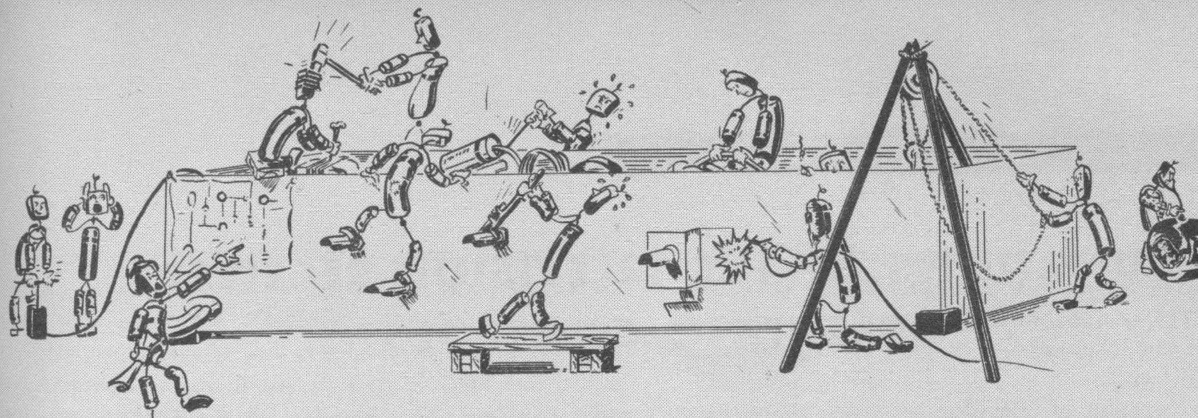


CENTERING
AMPLIFIER
FOCUS
BRILLIANCE
CENTERING
AMPLIFIER
INPUT

TP-926



SERVICING THE TELEVISION RECEIVER

A well-organized and logical service procedure is important for servicing television equipment efficiently. The service procedure is designed to give the maintenance man a quick and efficient method of locating and remedying trouble. The proper use of the service information and equipment described in this publication should prove helpful in coping with the majority of service problems that arise in connection with the television equipment. Most servicemen will find it highly desirable to establish routine service checks of the television receivers being maintained. Although the time intervals of these routine checks of the customers' receivers will vary with the troubles encountered for any specific set, it may prove advisable to make a check of receiver operation every three months in order to insure the customer the best performance from the set. This section of this book contains data that will aid in servicing the television receiver both in the home or office, and in the serviceman's shop. The following paragraphs outline installation procedures, alignment and adjustment procedures, and specific trouble-shooting data. All information refers specifically to the particular receiver used for reference in the preceding sections, but, in general, applies to other television receivers.

TELEVISION-RECEIVER DATA

FREQUENCY RANGES

Selector-Switch Channel Position	Channel Frequency
1	44-50 mc.
2	54-60 mc.
3	60-66 mc.
4	66-72 mc.
5	76-82 mc.
6	82-88 mc.

Intermediate Frequency:	I-F Band Pass:
Video — 19.5 mc.	6.0 mc.
Audio — 15 mc.	0.25 mc.

POWER SUPPLY

High-Voltage Supply: Supplies both the high-voltage potentials necessary to operate the cathode-ray tube and the filament voltage for the high-voltage rectifier tube.

Low-Voltage Supply: Supplies filament voltages to all tubes, except the high-voltage rectifier tube, also supplies all d-c voltages used in the equipment, except that used in the picture tube.

Power Consumption: 240 watts.

Audio Output: 3.4 watts.

Picture Size: 6½″ x 8½″. Produced by masking a 10″ picture tube to obtain the largest 4:3 aspect ratio picture.

Front Panel Controls
OFF-ON VOLUME
TONE
FOCUS
CONTRAST
VERTICAL HOLD
HORIZONTAL HOLD
VERNIER TUNING

Rear Chassis Controls
BACKGROUND

Rear Chassis Adjustments
HORIZONTAL LINEARITY
VERTICAL LINEARITY
VERTICAL HEIGHT
HORIZONTAL WIDTH
BENDING COIL

FUNCTIONS OF THE TELEVISION-RECEIVER OPERATING CONTROLS

In the development of television receivers, simplicity of controls has been an essential factor in order to permit the layman to operate the equipment with understanding and efficiency. The average receiver will have 5 or 6 controls for operation by the owner, and an equal number of controls available for adjustment by the serviceman. The former controls are generally located on the front of the receiver, and the latter on the rear of the chassis. Of those controls on the front of the receiver, three involve adjustments of the volume, tone, and focus. The VOLUME and TONE controls will not likely present difficulties of operation for the customer, as they are similar to controls on modern radio receivers. The function of the FOCUS control should also be readily comprehensible to the owner. However, the remaining three controls, the CONTRAST control, and the VERTICAL and HORIZONTAL HOLD controls, need explanation if the average owner is to operate them for optimum receiver performance. For the location of these controls on a typical receiver, refer to figure 44. The following paragraphs contain a brief summary of the function of the four controls with which the customer will be least familiar, the FOCUS, CONTRAST, and the HOLD controls.

By variation of the FOCUS control, the picture on

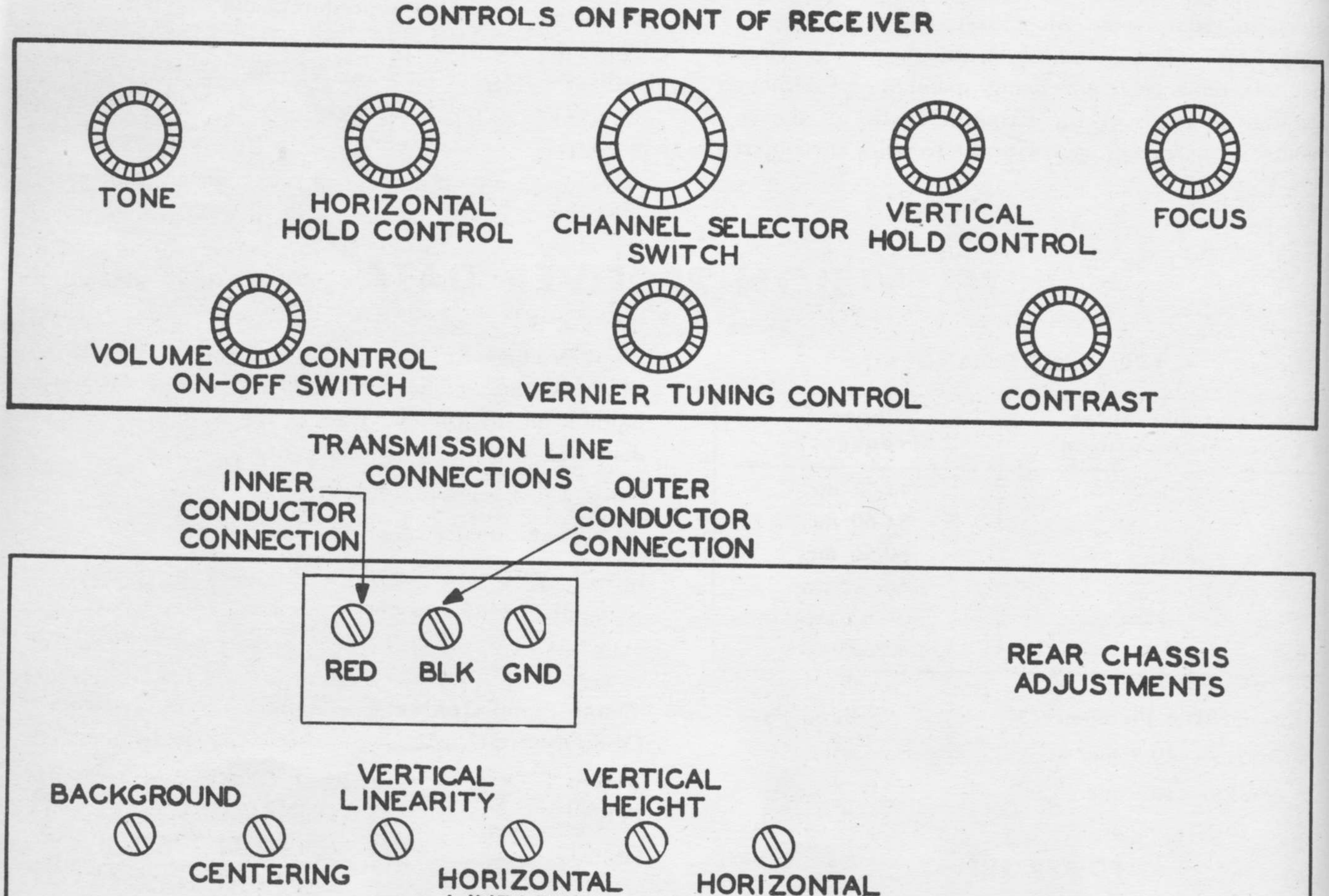


Figure 44. Typical Operating Controls and Adjustments of a Television Receiver.

the screen can be focused to the satisfaction of the viewer. Improper focus is generally caused by variations in the d-c or electrode voltages; since power supplies are generally well regulated, it is unlikely that frequent adjustment of the FOCUS control will prove necessary.

By variation of the CONTRAST control, the intensity of the elements of the picture can be increased or decreased as necessary. Advancing the control increases the contrast between the dark and light portions of the picture with a general increase in illumination of the screen. This is often a necessary step in rooms where the general illumination is higher than average. Inasmuch as the variation of the CONTRAST control is associated with the gain of the receiver, the control is a potentiometer placed in the receiver circuit in the grid-bias circuit of a tube. Changing the negative potential on the tube effects a change of the gain in this certain stage. Operation of this control will vary with the user, and the setting will likely prove subject to the individual's personal choice as determined by the quality of his vision.

The HORIZONTAL and VERTICAL HOLD controls can cause confusion and uncertainty in the mind of the customer, as their variation frequently results in weird and fantastic patterns on the screen. However, with instruction, the customer can be shown how to vary these controls until the picture "locks-in." Normally these controls should require little adjustment; however, since extraneous noises sometimes throw the receiver out of sync, it may occasionally be necessary to vary the settings of these controls. These controls regulate the free-running frequency of the blocking oscillator, thus determining the amount of sync voltage necessary for proper synchronization. Maximum stability occurs when the tips of the sync voltage are used. This point of stability can best be determined by "locking-in" the picture during the reception of strong noise signals. Although the customer will not think of the variations of these controls in these terms, it should be relatively easy to demonstrate the way to observe the unstable position of the control, and the procedure of determining the "lock-in" position from this point.

Another control of importance to the serviceman is the BACKGROUND or "brightness" control. Usually located on the rear of the chassis, it should not be disturbed by the customer. The purpose of this control is, through biasing of the grid of the cathode-ray tube, to prevent visible retrace. During the retrace period, the video signal is cut off and it is necessary to adjust the BACKGROUND control so that no retraces are visible. Another effect, with a too-greatly advanced setting of this control, is a decrease in the contrast and reduction of the details of the picture. The procedures for adjusting the BACKGROUND and CONTRAST controls in relation to one another are outlined later in this section.

The final operating control is the VERNIER TUNING control. This is usually located in the center of the receiver face just below the screen, and is used to "tune-in" the specific station. When it is adjusted to the strongest and clearest audio signal, the receiver will automatically be accurately tuned to the video-signal frequency of the specific station.

AN ABBREVIATED TELEVISION-RECEIVER OPERATING PROCEDURE

1. Turn the BACKGROUND and CONTRAST controls fully counterclockwise. (Dark-screen position.)
2. Turn the OFF-ON-VOLUME control about half-way clockwise.
3. Allow a reasonable warm-up period.
4. Select a desired station with the channel-selector switch.
5. Tune the station in by adjustment of the VERNIER TUNING control for best sound reception.
6. Turn the BACKGROUND control slowly clockwise until the screen is barely illuminated.
7. Advance the CONTRAST control until the picture on the screen appears with light and dark areas in pleasing contrast.
8. If the picture on the screen requires "locking-in," adjust the HORIZONTAL and VERTICAL HOLD controls (either or both).
9. Adjust the FOCUS control for best detail or best picture clarity.
10. Readjust the BACKGROUND and CONTRAST controls as needed to improve the picture.
11. Readjust the HOLD controls as necessary, after selecting a different station.
12. Adjust the VOLUME and TONE controls for best sound reception.

FIELD SERVICING THE TELEVISION RECEIVER

Installing the Television-Receiver Antenna

The multiplicity of factors involved will necessarily result in a wide variety of installations. The location of the antenna on a home, apartment house or office building will be determined by the convenience of the installation and the signal strength obtainable. Many antennas placed in convenient locations will have to be moved to improve signal strength or to avoid sources of interference. The trial and error method of installation seems inevitable. However, certain installation considerations can be noted that will result in fewer trials and less errors. The primary consideration is locating the antenna in a line-of-sight with the transmitting station, or as near this as possible. When the transmitter and receiver are separated by rough terrain, containing hills or mountains, and there is doubt as to the receiver location being in line-of-sight and range with the transmitter, it is advisable to refer to an accurate topographical map of the area to determine the advisability of locating the receiver at the specific point being considered. For calculation of the distance of the receiving antenna to the horizon, the following approximate formula can be used. Distance $= 2 \times \sqrt{\text{Height}}$. (Using a measurement of height in feet gives a distance measurement in miles.) When both the height of the receiving antenna and the transmitting antenna are known, the line-of-sight distance can be determined by the formula: Distance $= 2 \times \sqrt{H} + 2 \times \sqrt{h}$, where h equals the height of the receiving antenna in feet, and H equals the height of the transmitting antenna in feet, distance resulting in miles.

The greatest possible height must be sought to avoid intervening hills or buildings. If the house is surrounded by trees or wooded areas, it is, of course, desirable to keep clear of the trees and if possible to raise the antenna above their general height. On apartment buildings or office buildings, placing the antenna at a height is generally possible and line-of-sight easily observed. In urban areas, however, danger exists from reflecting surfaces between, beyond, or near the line-of-sight from the transmitter. When installations are made upon any type of building, it is advisable to keep the antenna as far as possible from metal roofing, gutters, or framing. On apartment buildings and offices, similar caution must be observed to avoid installations near penthouse points where interference from elevator relays may exist.

Antenna masts of some height are generally constructed of steel tubing while ordinary pipe is used for shorter lengths. Pyramidal open-section or four-sided steel towers can be used where strength and unusual height are needed. From these considerations, it can be seen that the serviceman must exercise sound judgment in his efforts to place the receiving antenna in the location giving optimum reception. Figures 45 and 46 show examples of antenna installations. Specific installation details emphasizing elimination of interference patterns and reflected signals will be considered later.

The final installation problem of servicemen will be the matter of orienting, or aiming, the antenna. This requires that the antenna be placed *broadside* to the transmitting station as shown in figure 47, in order to obtain the optimum video signal. It is necessary to do

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Figure 45. A Dipole Antenna Mounted on a Window Frame.

this very accurately, viewing the screen during actual reception while at the same time turning the antenna. Some means of instantaneous communication between the man at the antenna and the man operating the receiver must be used. Philco intercommunication systems are excellent for this purpose and can be readily used, as they can be plugged into any convenient 115-volt a-c outlet and a speaker-microphone combination placed at the end of an extension cord for use by the man at the antenna. Orientation of the antenna for optimum signal strength should be measured and determined by relative a-v-c readings, and by the absence of "ghosts" upon the test pattern.

Although most manufacturers of television receivers will likely produce antennas to be purchased and used with their specific receivers, it will be the work of the serviceman to cut or adjust the antenna to the resonant frequency of a specific transmitting station.

With the development of multiple-channel television receivers, it will be necessary to install an antenna that will give optimum performance for all frequencies or

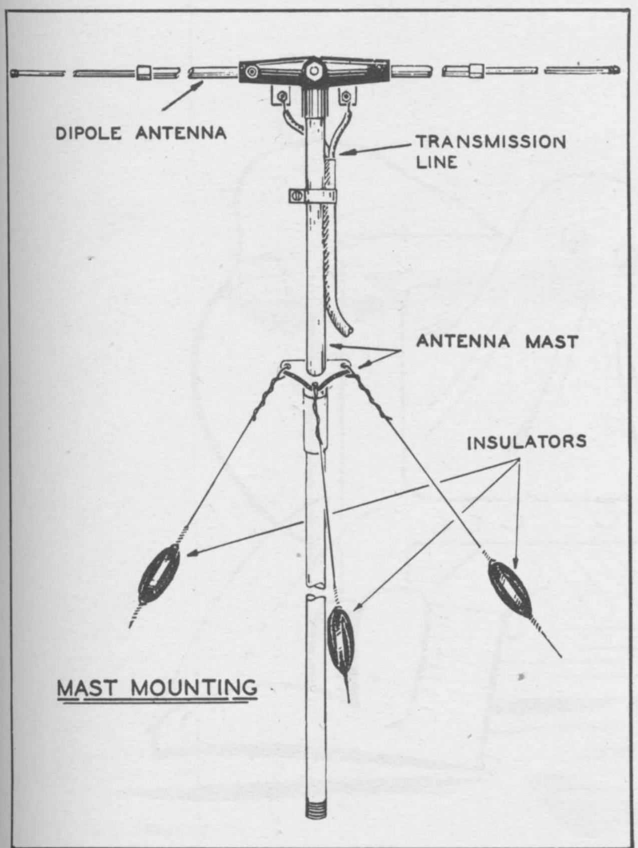

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Figure 46. A Dipole Antenna Mounted on a Mast.

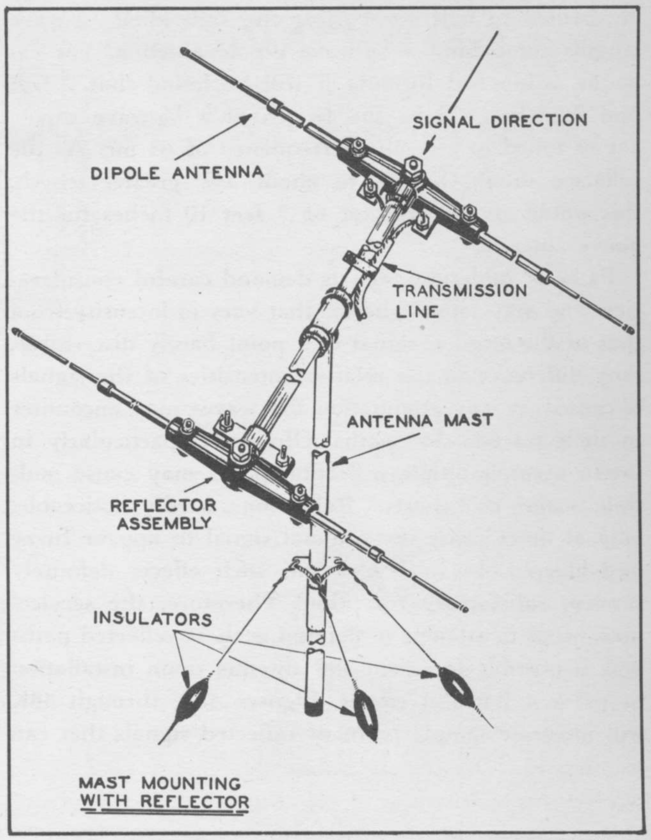

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Figure 47. A Dipole Antenna and Reflector Element Mounted on a Mast.

channels involved. The best policy at the moment seems to be the cutting of an antenna to the resonant frequency of the weakest station.

In case of an installation where two stations of approximately the same signal strength are received and their frequencies are several channels apart, a compromise on antenna length can be made by cutting the antenna to a frequency midway between the two station frequencies. If the receiver is located between two transmitting stations bearing 180 degrees apart from the receiver, a single-element dipole antenna cut to the frequency of the weaker of the two stations, may be used. Again, it appears a matter of trial and error in determining the best antenna length for reception under these circumstances.

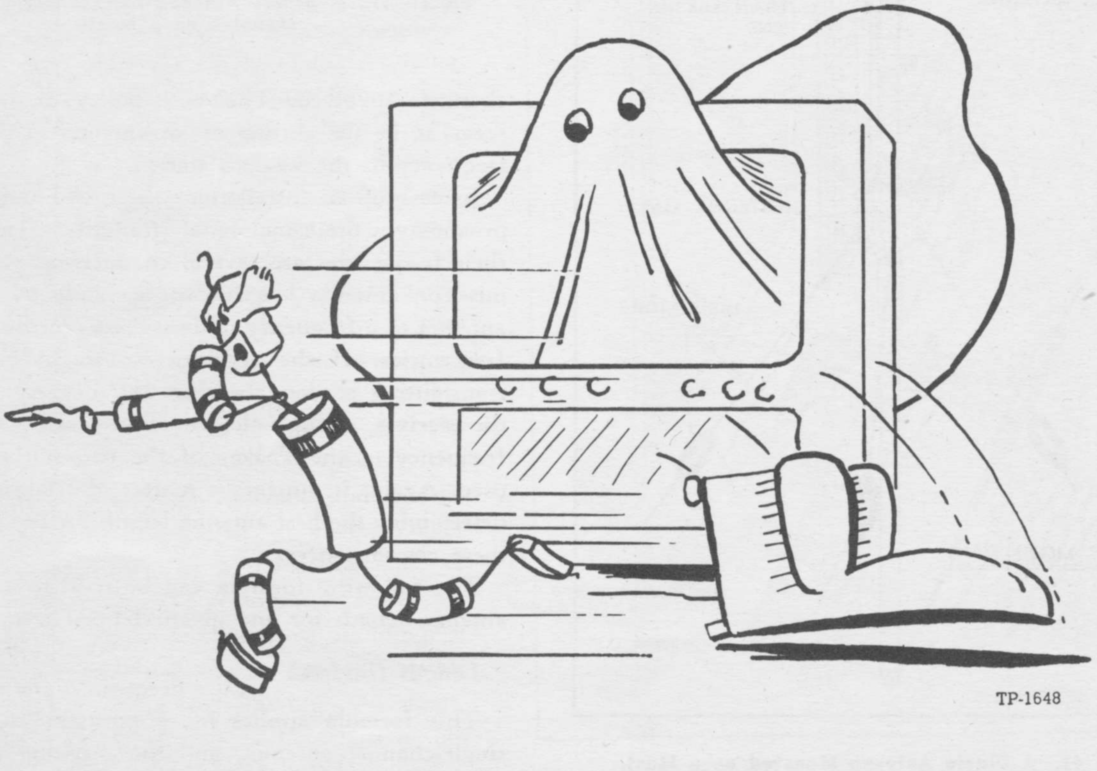
The following formula can be used to calculate the antenna length for any given channel frequency.

$$\text{Length (in feet)} = \frac{468}{\text{Frequency (in megacycles)}}$$

This formula applies for a normal $\frac{1}{2}$-wave dipole single-channel antenna, and the resulting figure must be divided in half for cutting the individual ¼-wave lengths comprising a ½-wave dipole antenna. For example, using this formula it will be found that 7 feet and 7 inches will be the length of a ½-wave dipole cut or tuned to a resonant frequency of 63 mc. As the reflector should be cut to about 5% greater length, this would give a reflector of 7 feet 10 inches for the above antenna.

Paths of undesired signals demand careful consideration, and may cause "ghosts" that vary in intensity from that of the original signal to a point barely discernible. Any difference in the relative intensities of the signals is caused by any attenuation the waves may encounter in their transmission paths. Obviously, particularly in urban areas, multiple reflection paths may cause multiple images or "ghosts." Reflections, hardly noticeable, may at times cause the original signal to appear fuzzy and blurred. In some locations such effects definitely prevent satisfactory reception. Therefore, the serviceman needs to attempt to determine these reflected paths and if possible to orient the antenna upon installation to prevent harmful effects. Figures 48A through 48K will illustrate sample paths of reflected signals that can be partly or wholly eliminated by antenna orientation. The exception to these cases is that in which the reflected and original signal arrive at the receiver in phase, giving an additive effect to the signal strength, or in the case where intervening objects in the path of the original signal so weaken it that the reflected signal is the stronger of the two. Needless to say, in the latter case the antenna is oriented towards the reflected signal. When the direct and reflected signals reach the receiver electrically out of phase, the signal strength may be materially weakened, and an apparently good receiving antenna location may be useless. This can be remedied by a change of the antenna position to a place where signal strength is satisfactory. A change of only a few feet may result in in-phase reception of the two signals.

In the following illustrations, figures 48A through 48K illustrate the various problems which may arise from reflected or blocked signals, while figures 49A through 49K show sample antenna installations. These installations are intended only as suggestions, not as standards, for those servicemen who may be faced with antenna installation problems.



TP-1648

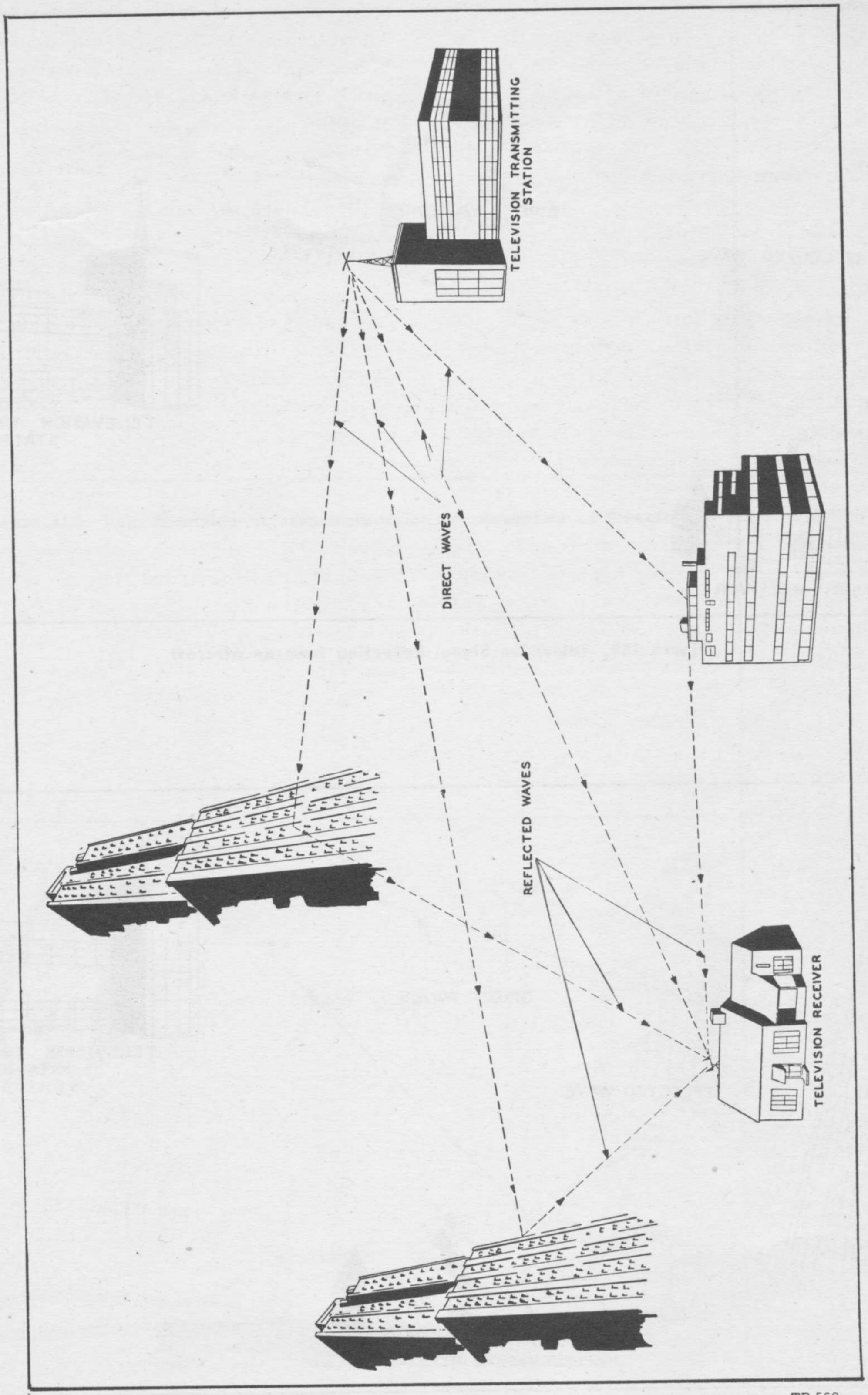
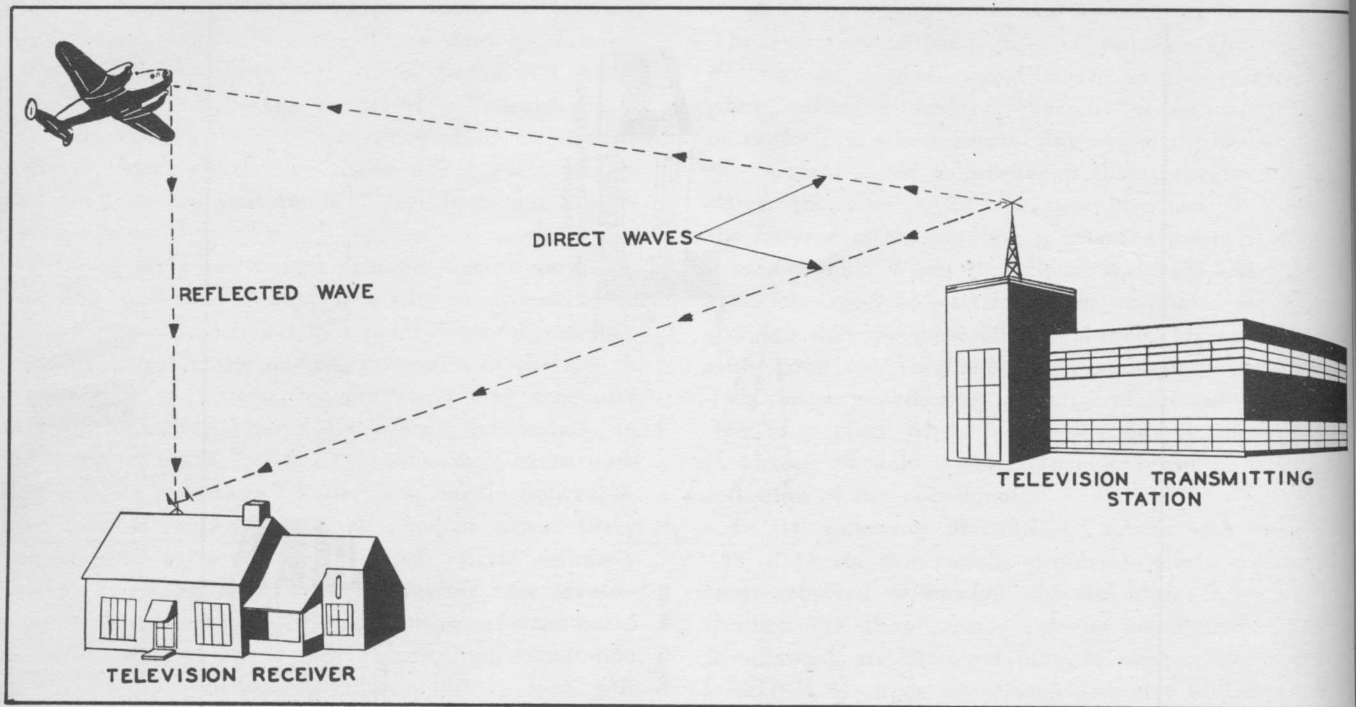
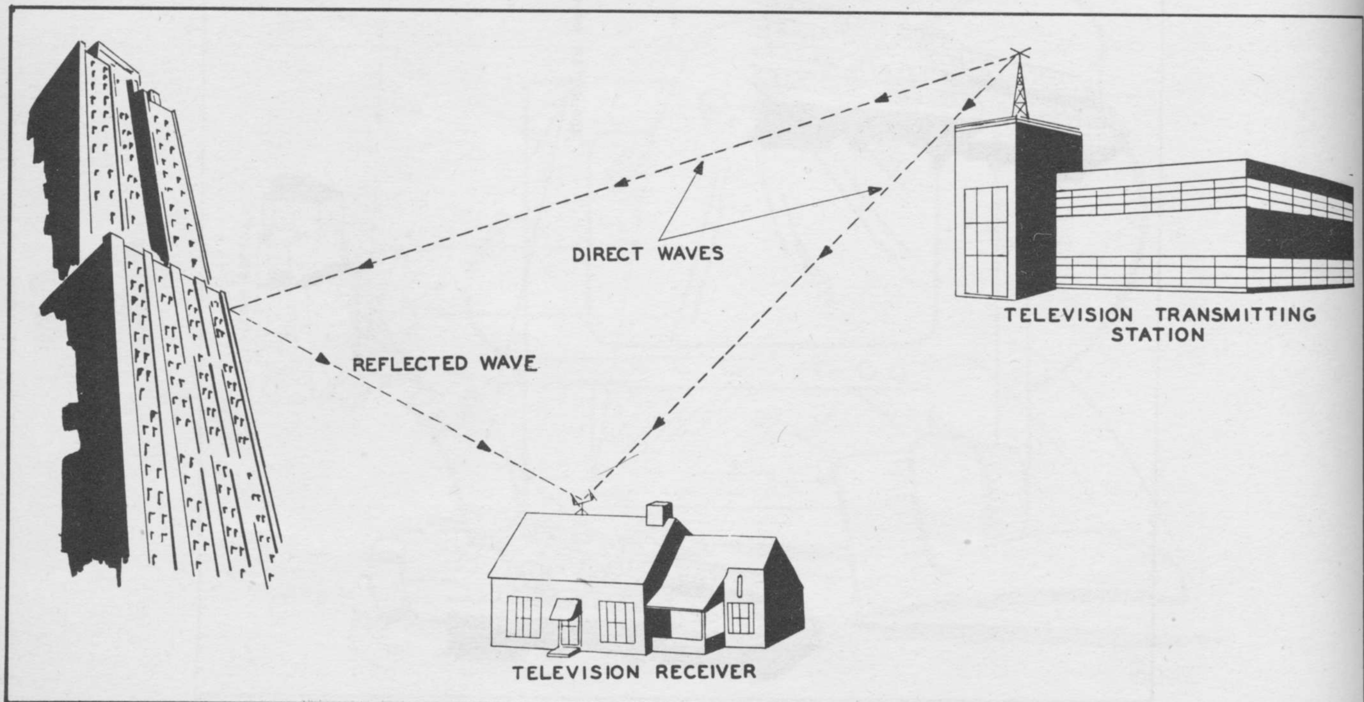


Figure 48A. Television Receiver with Multiple Signal Paths.



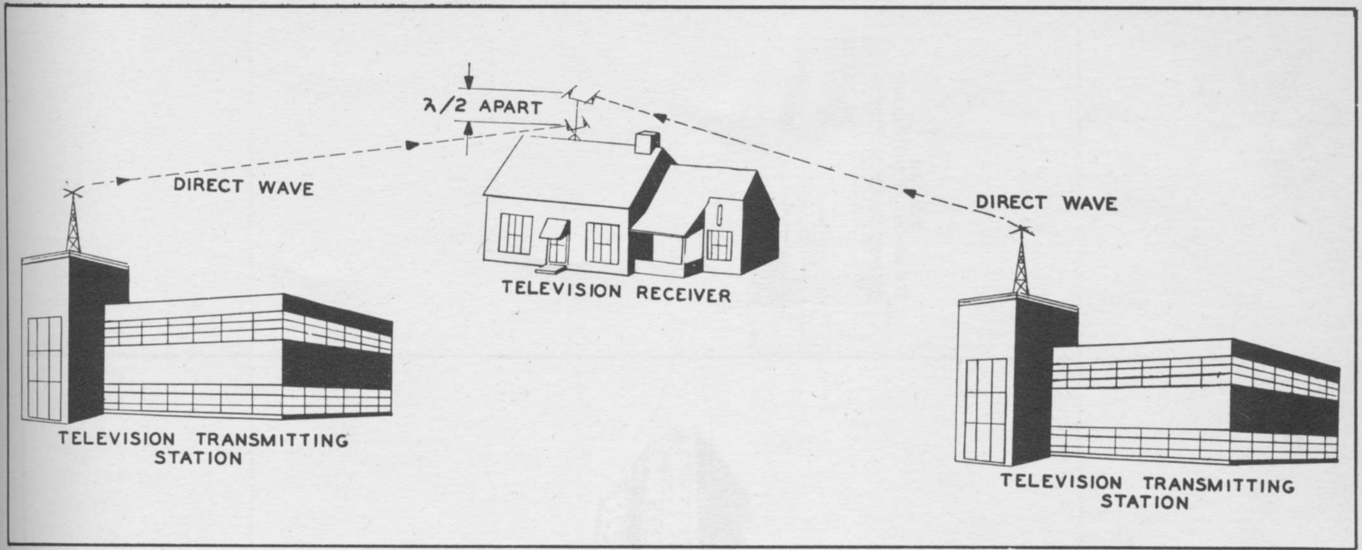
TP-560D

Figure 48B. Television Signal Reflecting from an Aircraft.



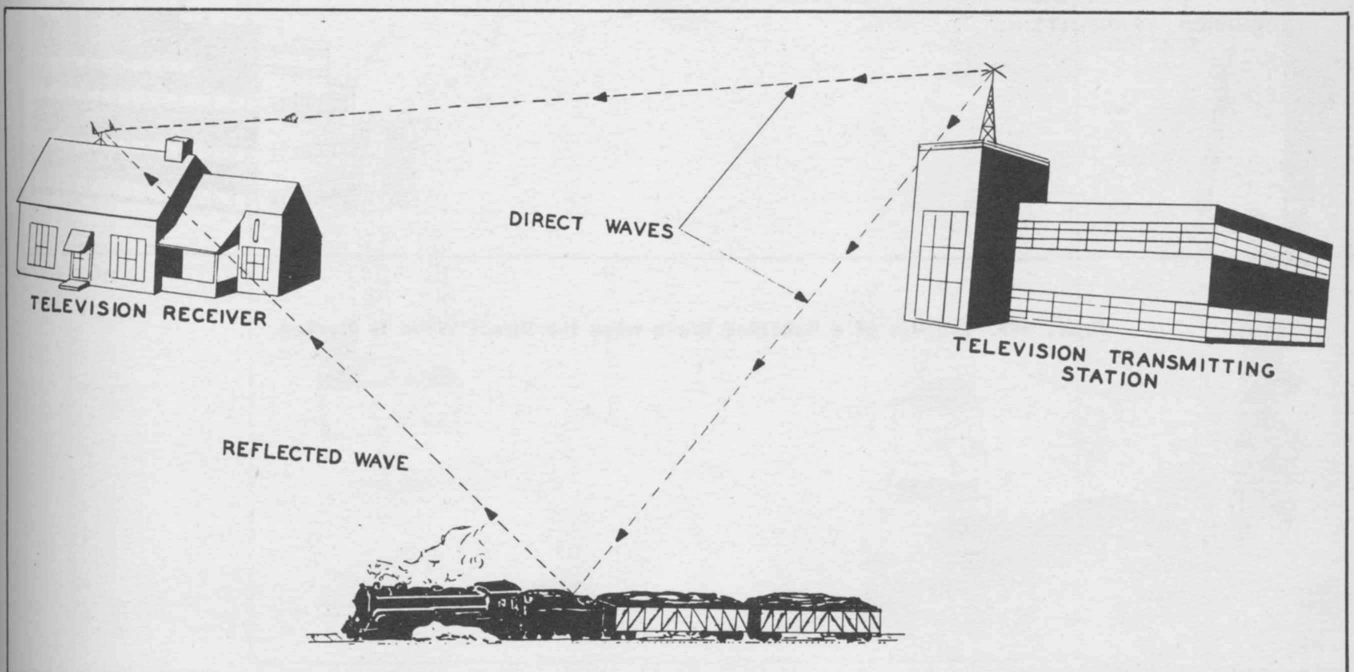
TP-560C

Figure 48C. Television Signal Reflecting from a Building.



TP-560F

Figure 48D. Dual Receiving Antenna Installation for Reception of Signals from Two Directions.



TP-560E

Figure 48E. Television Signals Reflecting from a Moving Train.

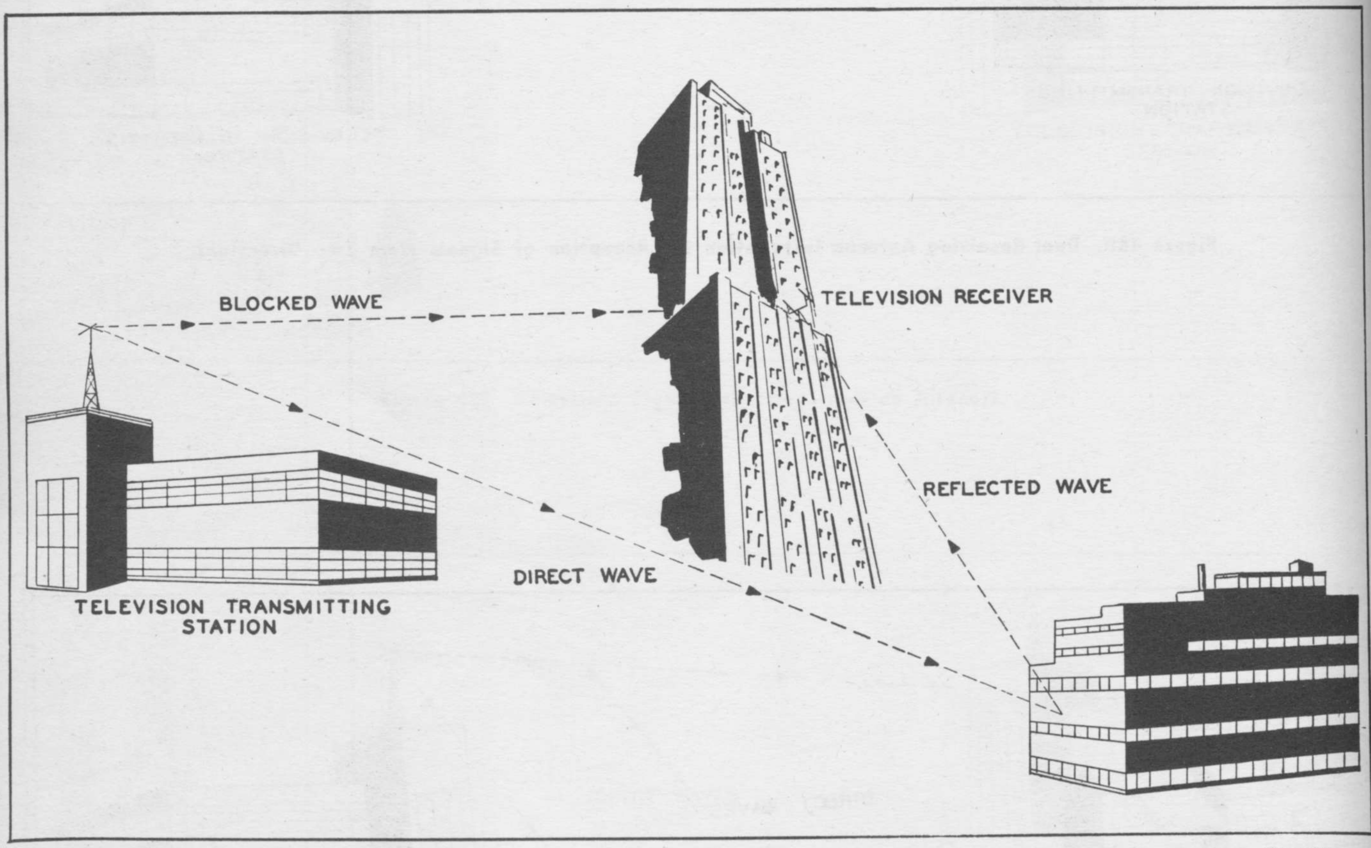
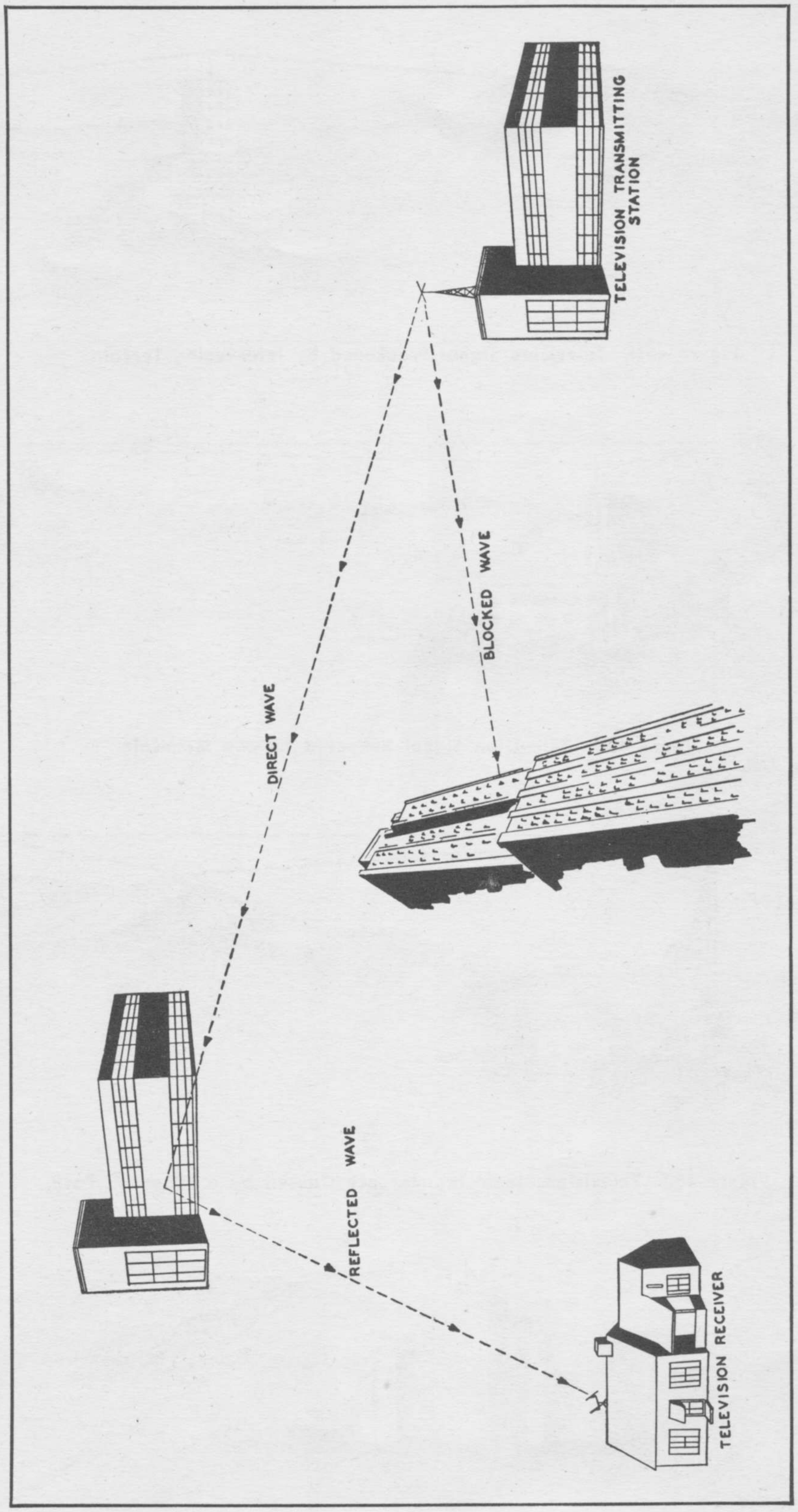
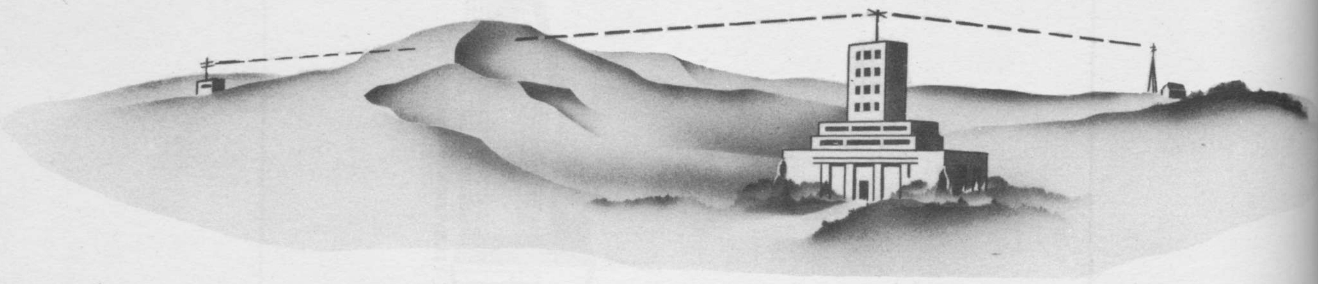


Figure 48F. The Use of a Reflected Wave when the Direct Wave is Blocked.



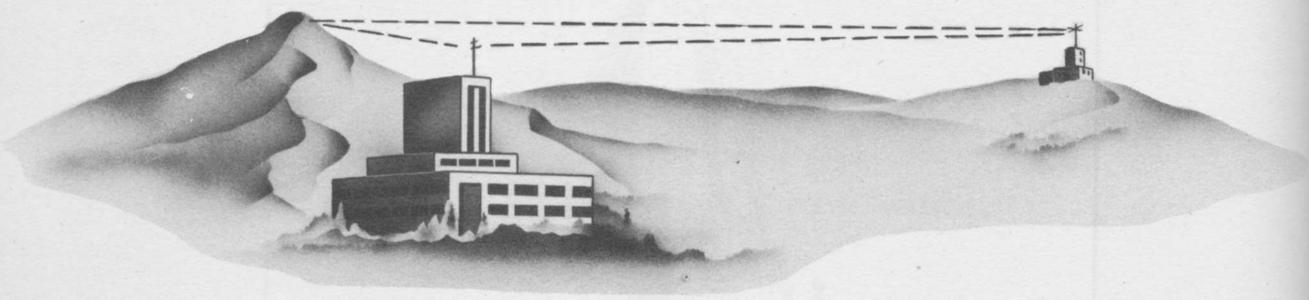
TP-560A

Figure 48G. Reception by Means of a Reflected Signal.



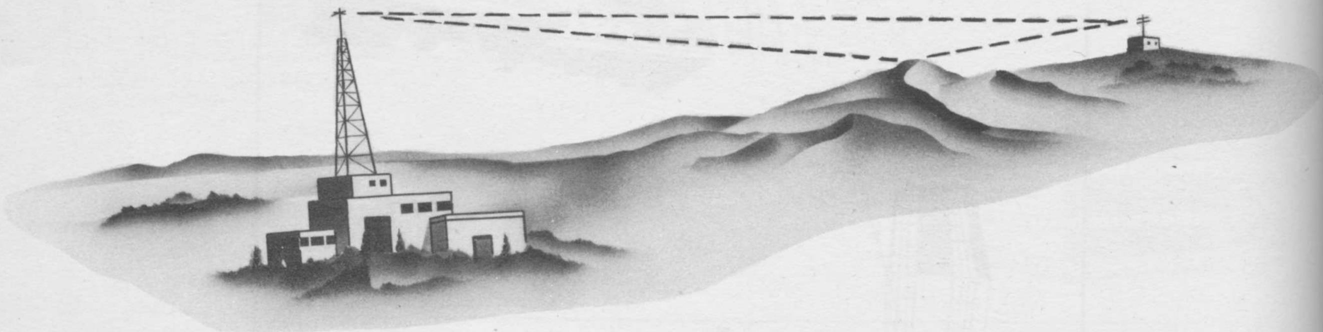
TP-556B

Figure 48H. Television Signal Weakened by Intervening Terrain.



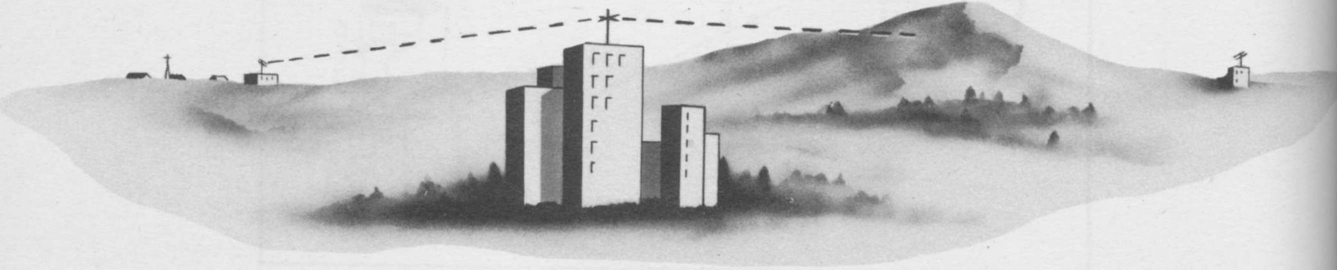
TP-556C

Figure 48 I. Television Signal Reflected from a Mountain.



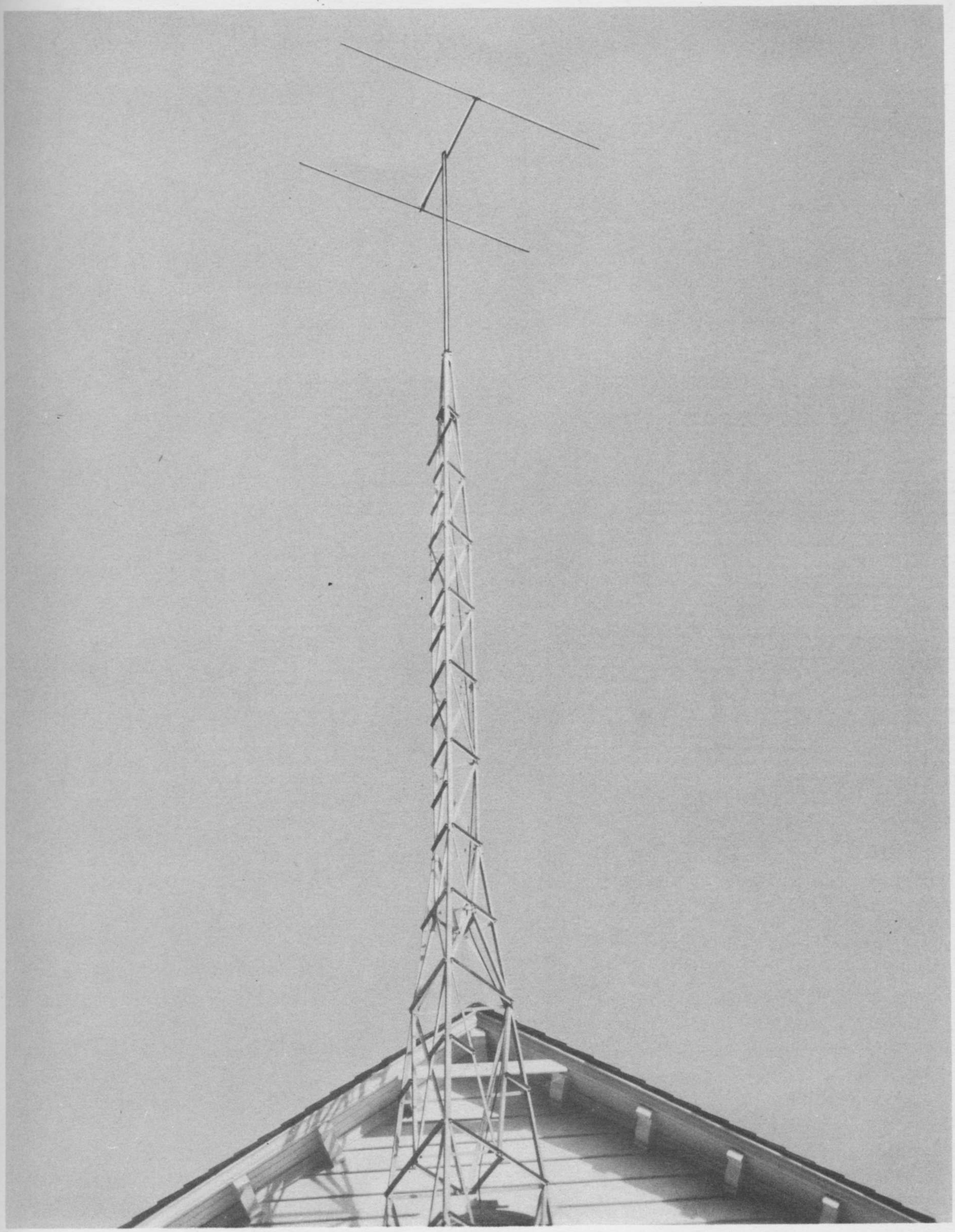
TP-556D

Figure 48J. Television Signal Interference Caused by a "Bounce" Path.



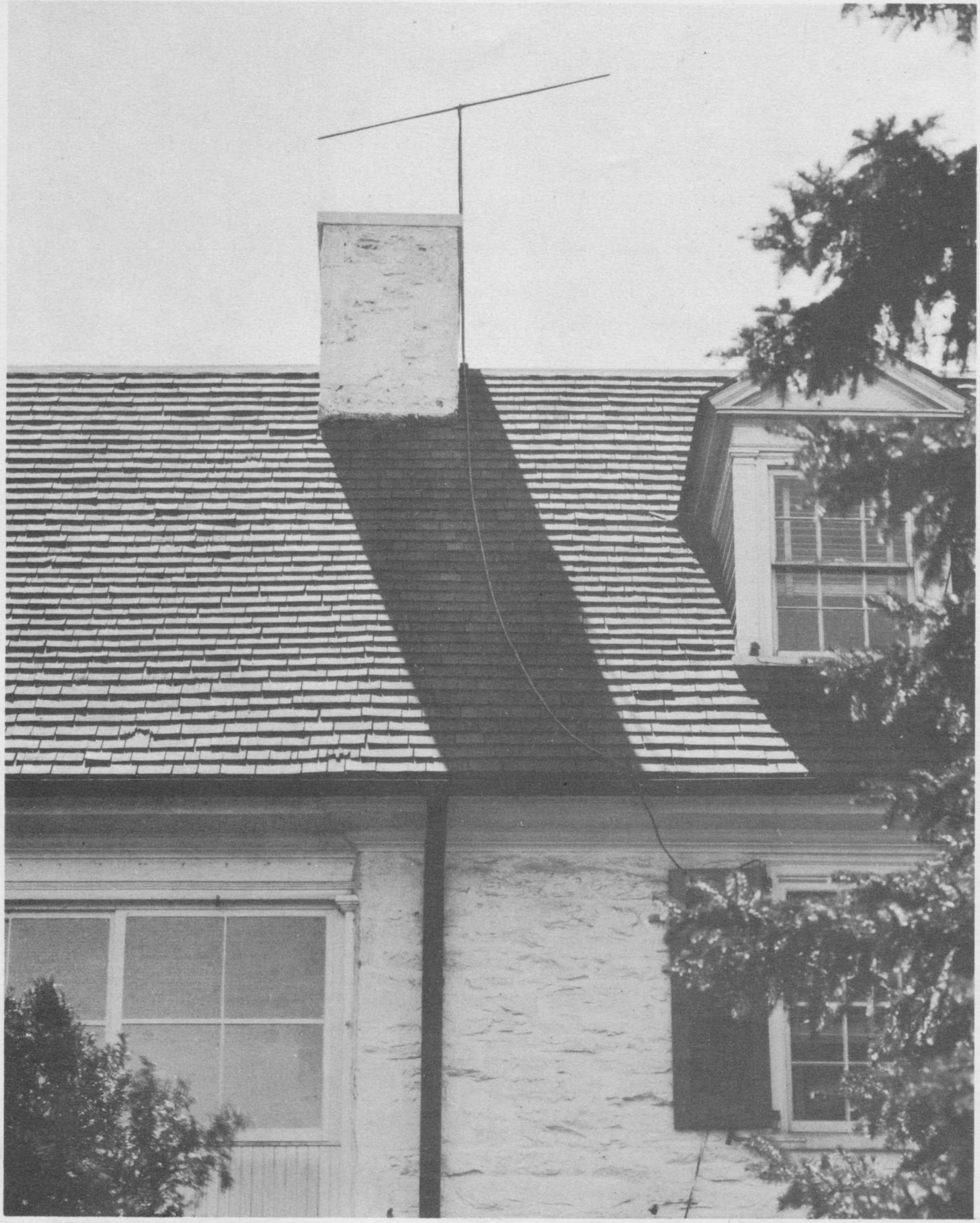
TP-556

Figure 48K. Television Signal Blocked by a Mountain.



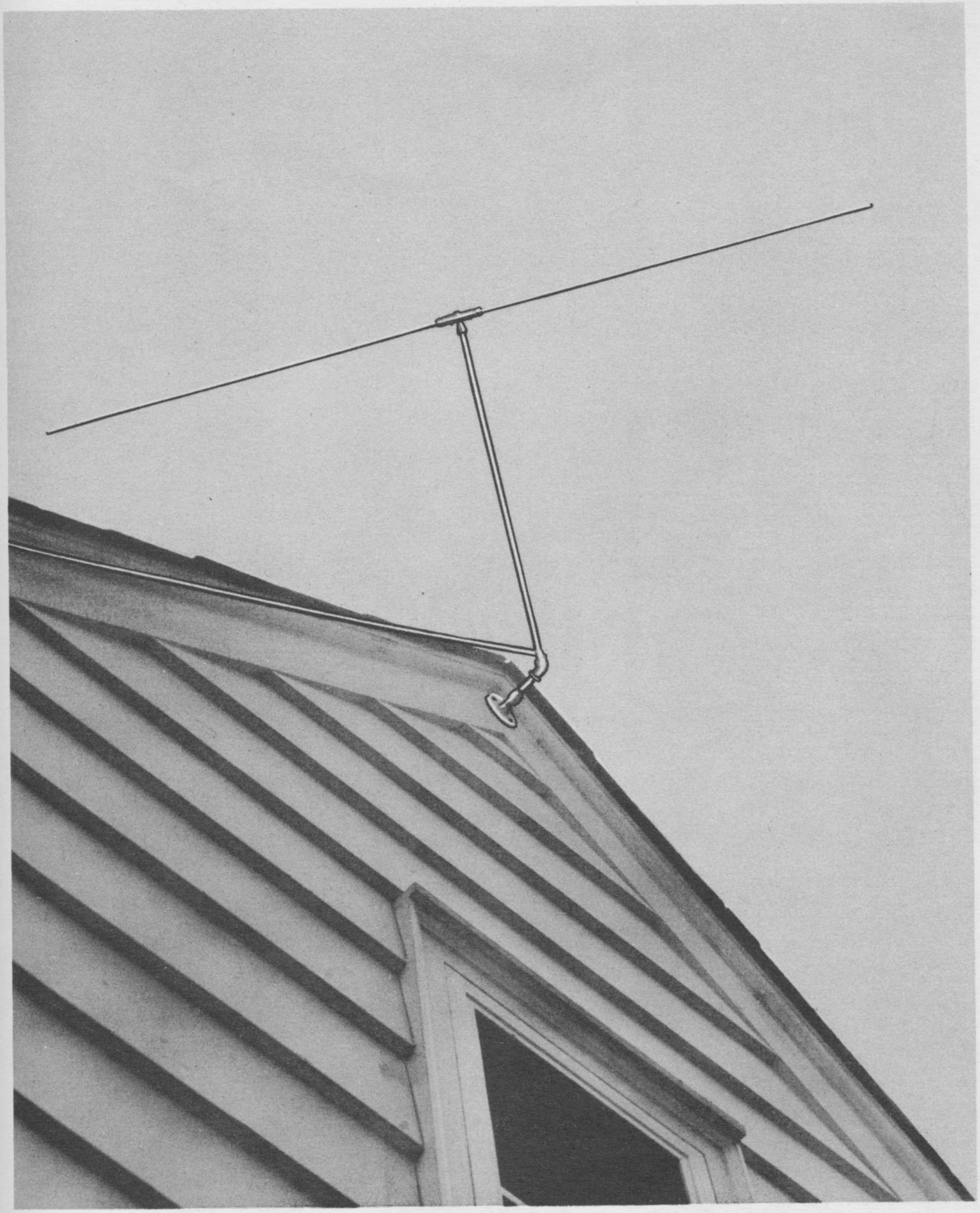
TP-843

Figure 49A. Dipole and Reflector Mounted on a Mast.



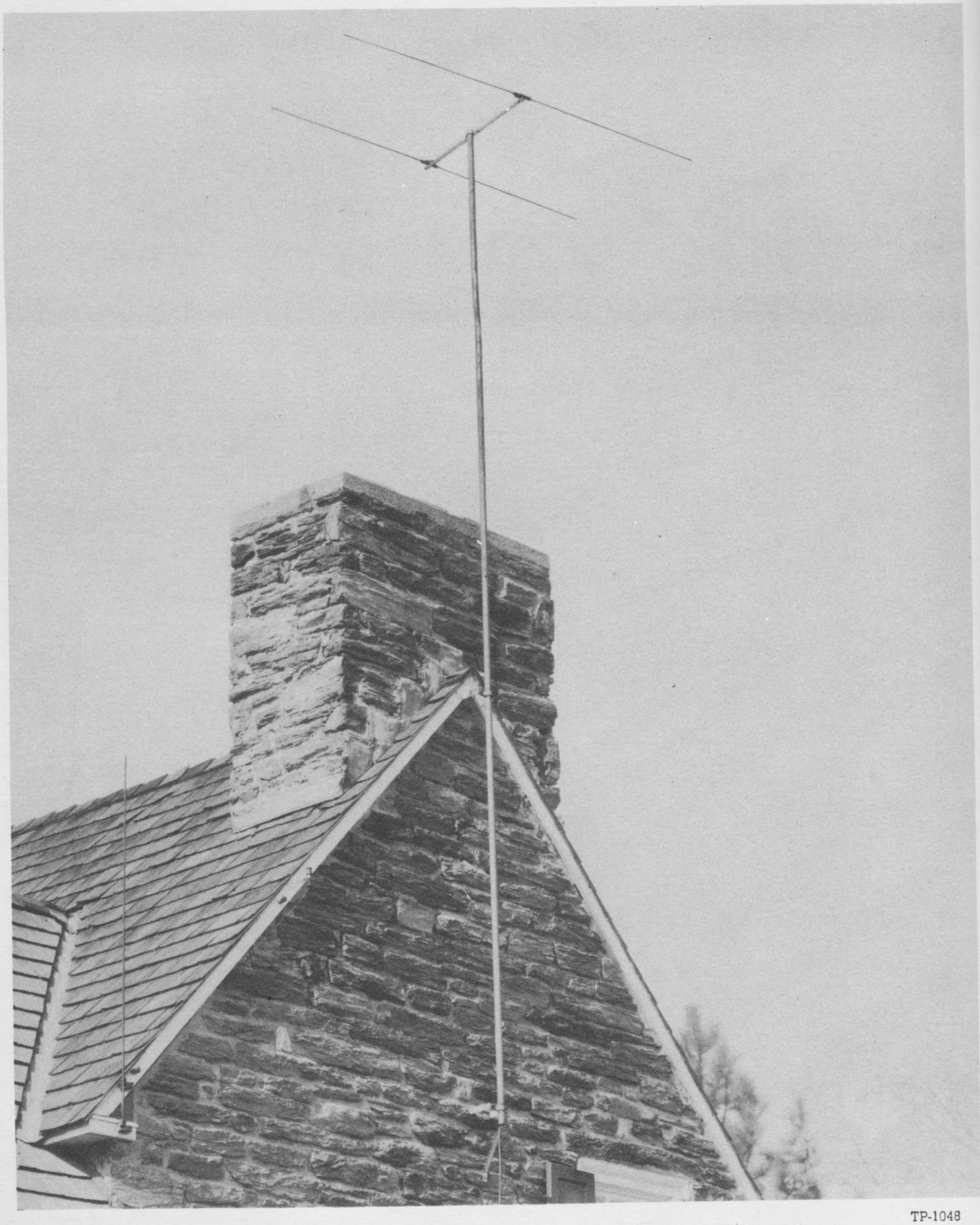
TP-1047

Figure 49B. Single Dipole Antenna Mounted on Ridge of Roof.



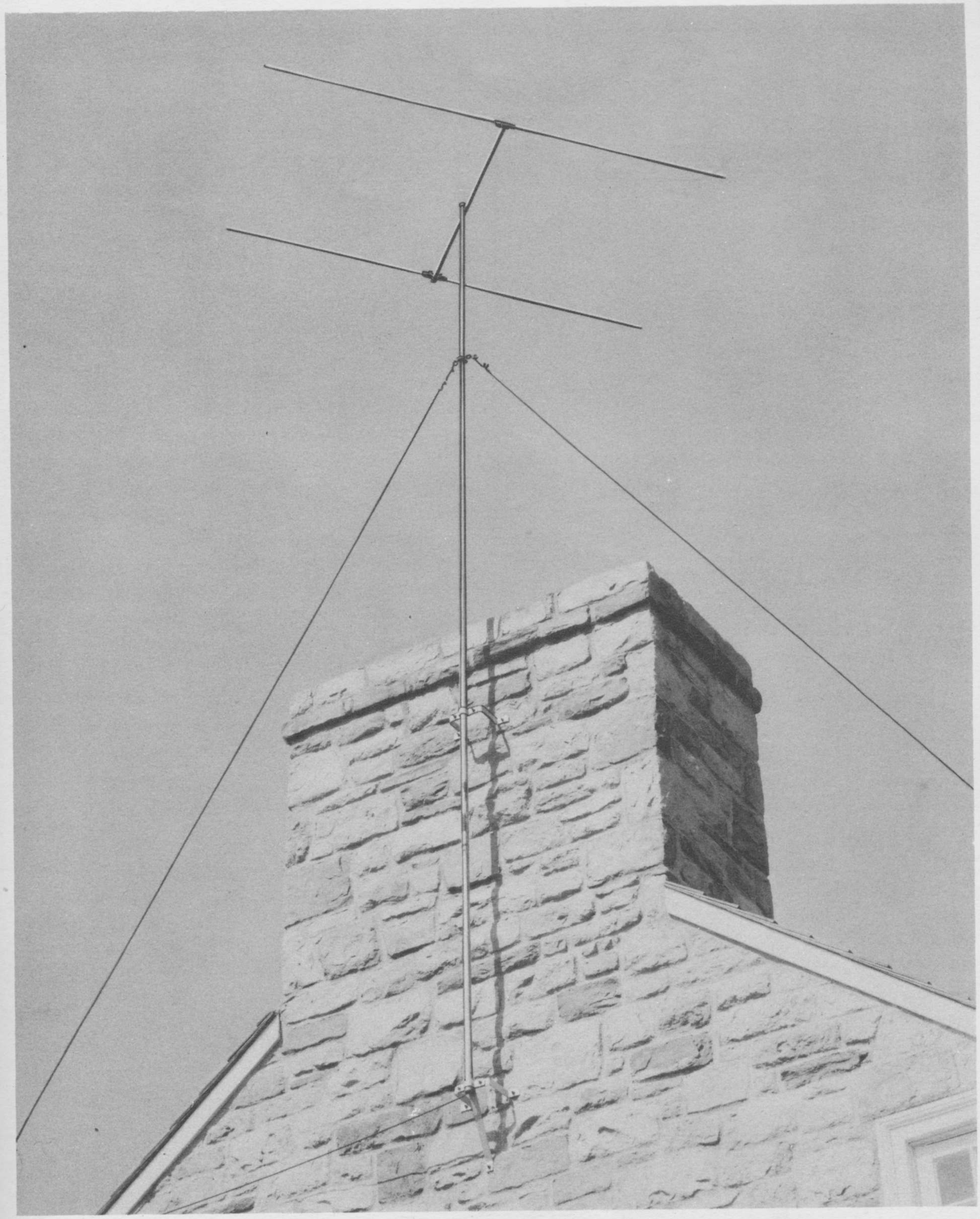
TP-1046

Figure 49C. Single Dipole Antenna Mounted on a Gable.



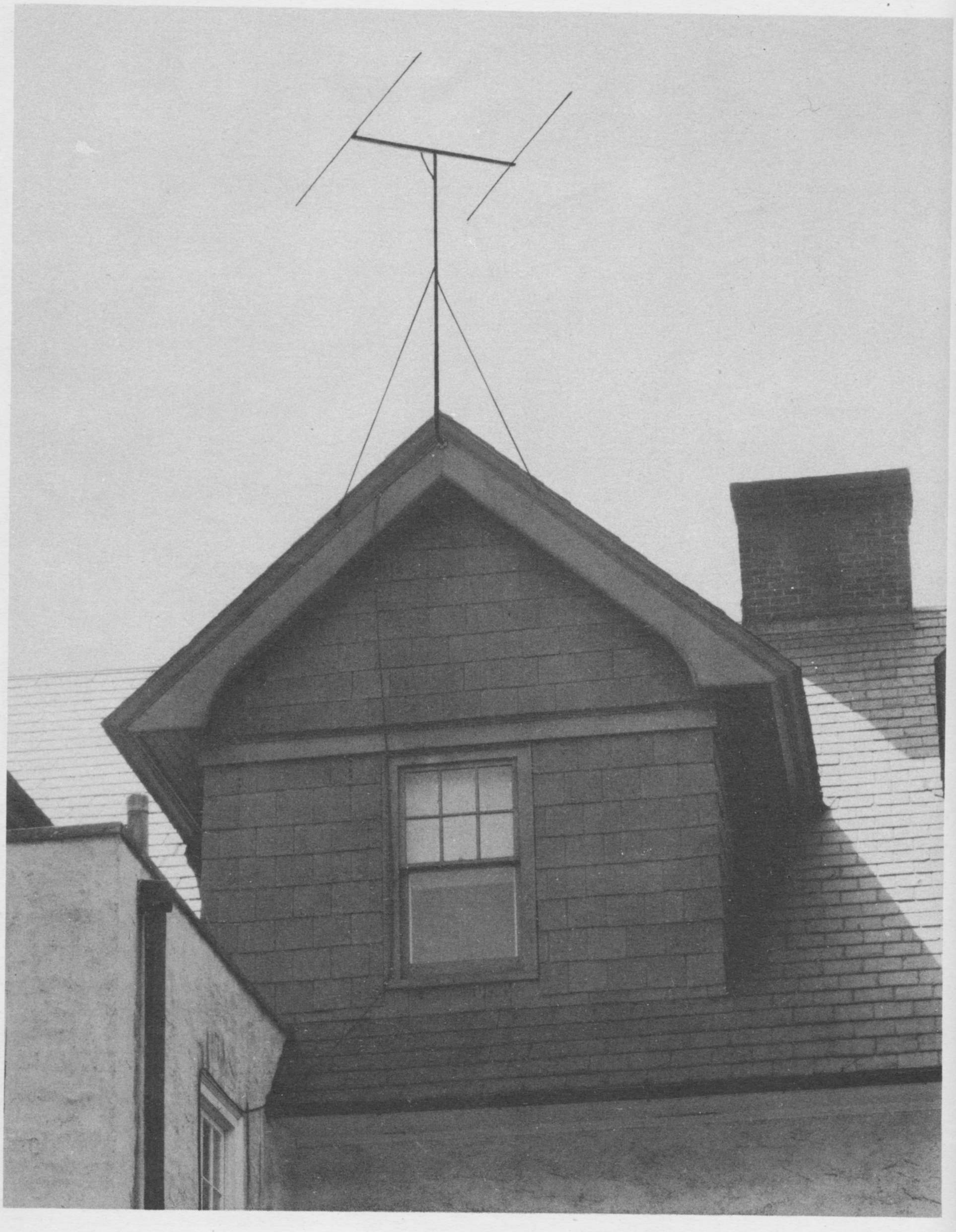
TP-1048

Figure 49D. Dipole Antenna and Reflector Mounted on the End of a House.



TP-1043

Figure 49E. Dipole Antenna and Reflector Mounted on a Chimney.

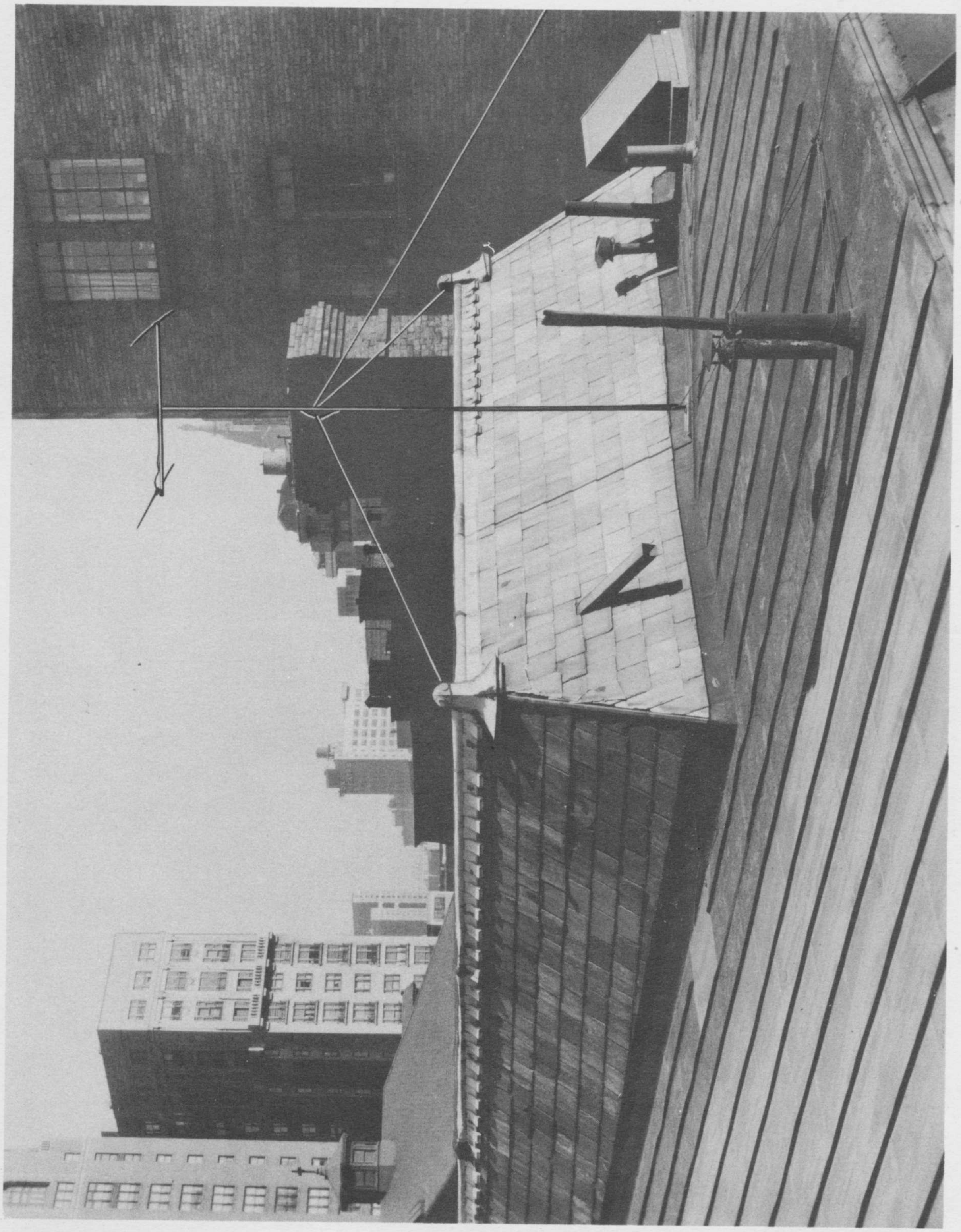


TP-1044

Figure 49F. Dipole Antenna and Reflector Mounted on a Dormer.

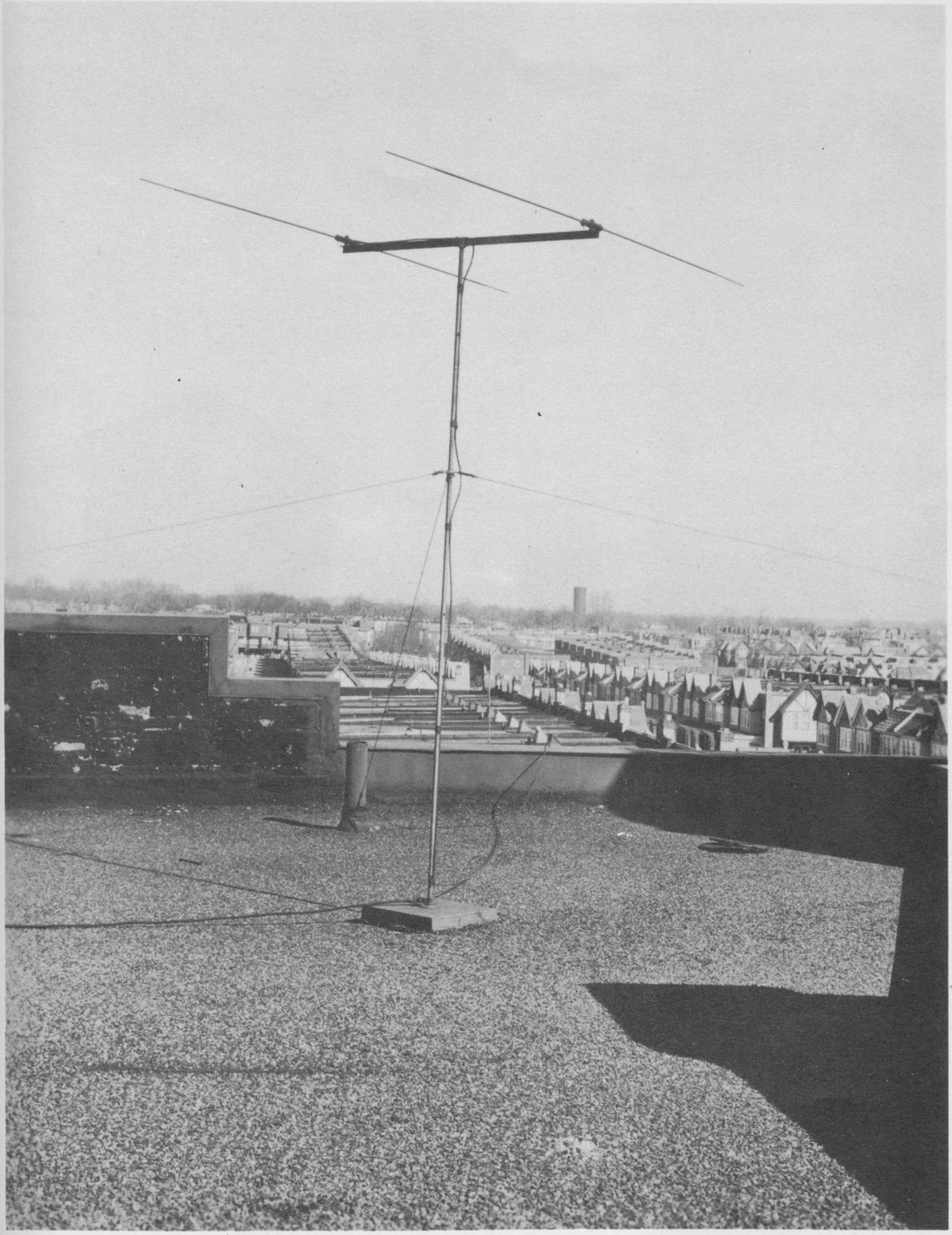
TP-868

Figure 49G. Dipole and Reflector Surrounded by Reflecting Surfaces.



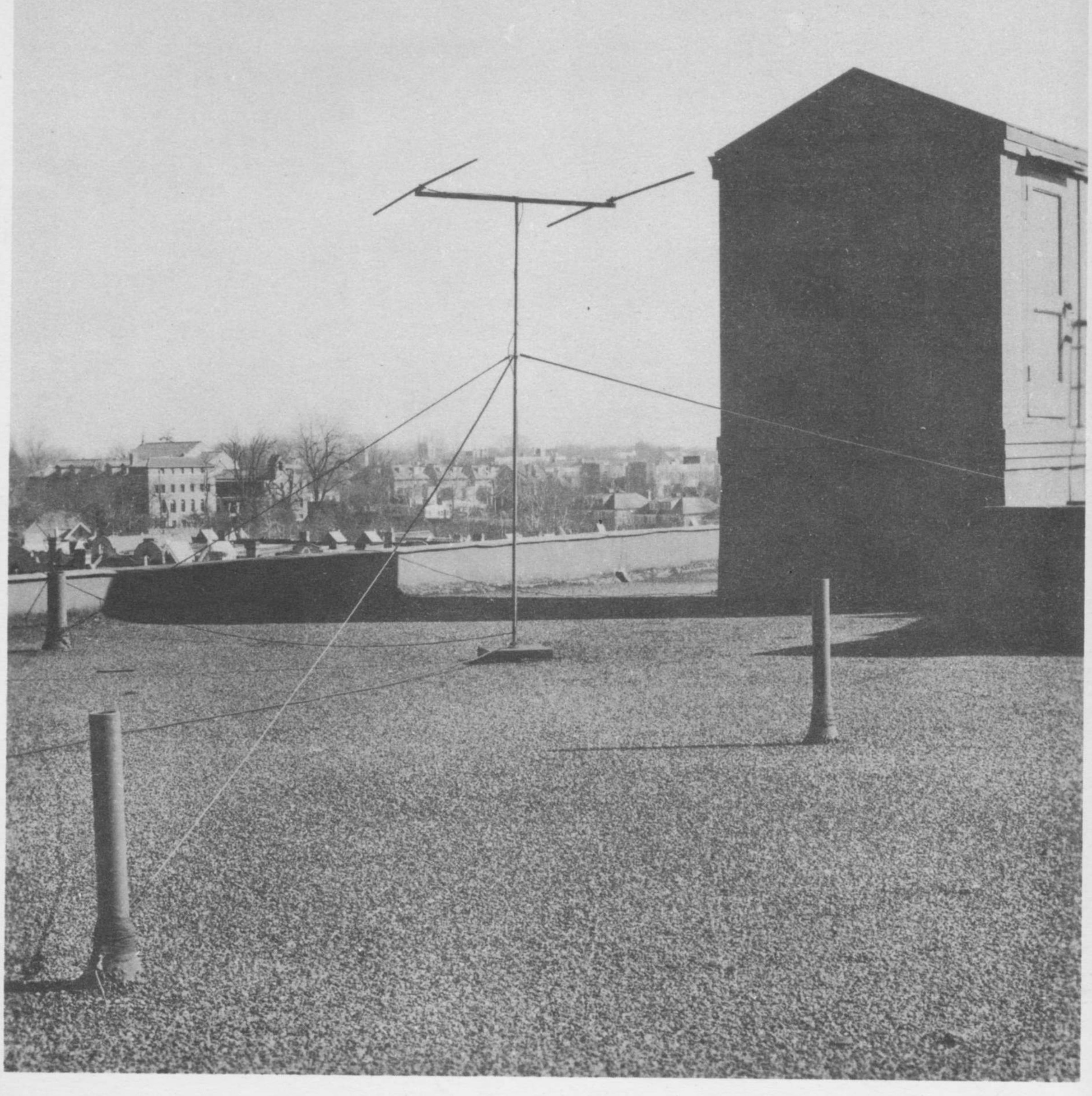
TP-901

Figure 49H. Dipole and Reflector Mounted in a Congested Area.



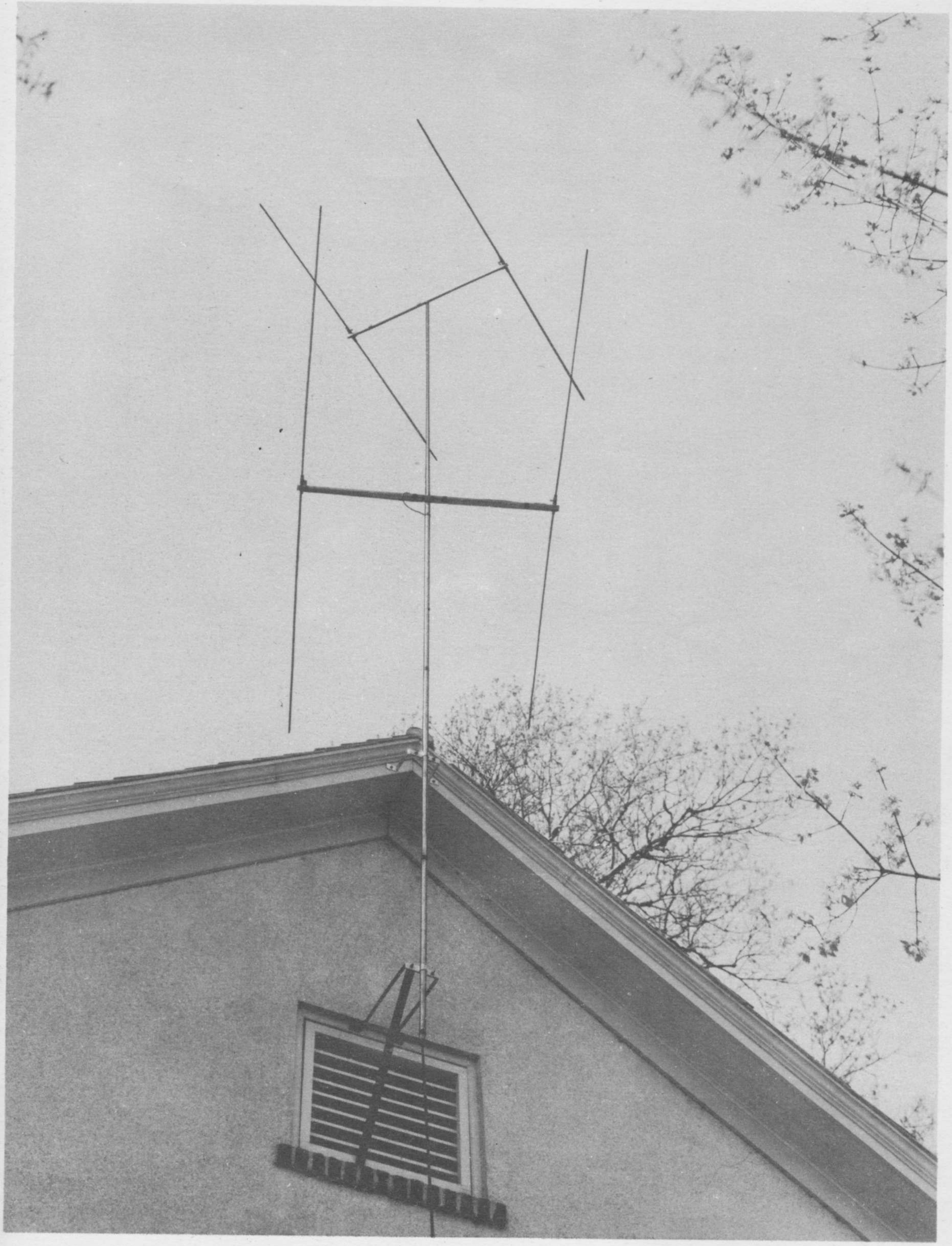
TP-869

Figure 49 I. Dipole Antenna and Reflector Mounted on an Apartment Roof.



TP-870

Figure 49J. Dipole Antenna and Reflector Mounted near an Elevator Penthouse.

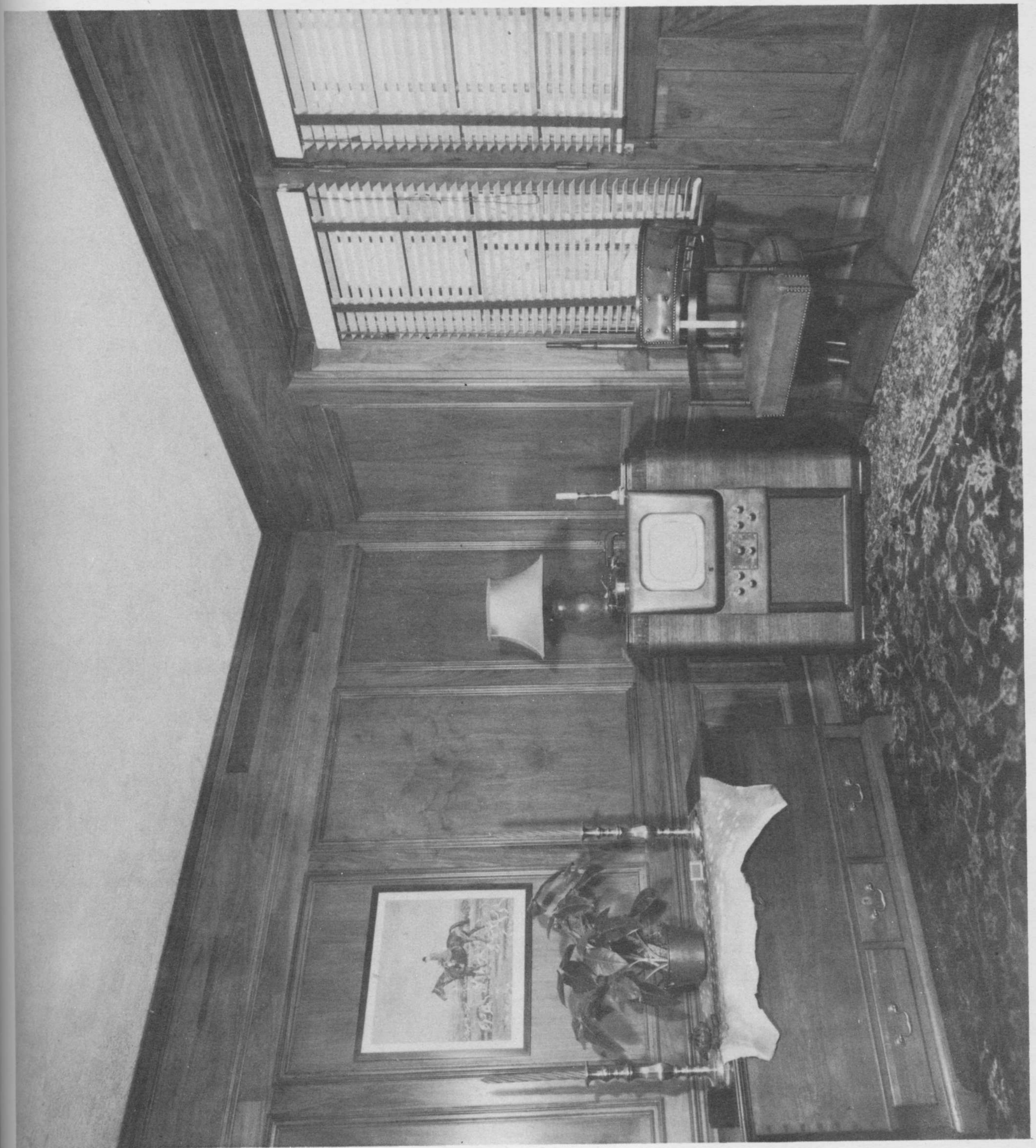


TP-1042

Figure 49K. Installation of Dual Dipole Antennas and Reflectors.

TP-910

Figure 50. A Normal Installation of a Television Receiver.



TP-930

Figure 51. An Exceptionally Well-Located Home Television Receiver.

Installing the Television-Receiver Transmission Lines.

With the antenna installed, the installation of the transmission line follows. Although several types of transmission lines can be used, it is generally considered most satisfactory for maximum gain and optimum picture reproduction to use coaxial cable. This type of line is advantageous because the inner wire is effectively shielded from stray fields and long lengths of transmission line are possible with little loss of signal strength. With the receiver under discussion, lengths of coaxial cable from 100 to 600 feet can be used. In order to have maximum signal strength, it is desirable to use the best quality coaxial cable to avoid the losses present in cheaper cables. The use of poor quality line, or too great lengths of line, can result in excessive losses, reducing the quality of the reception. Servicemen may be tempted to use low quality cable in order to reduce the expense of installation, but it must be remembered that there is a direct relationship between the quality of the cable and the quality of the picture. Different antenna locations will present wide variations in transmission-line installations. Each one will present its own problems, so no attempt will be made in this publication to give complete details on transmission-line installations. However, certain considerations may be noted as aids. It is of prime importance that the cable be well secured to the roofing or wall so that it cannot sway or move with the wind. Various types of clamps, insulators, or lashing can be utilized for this purpose. Care must be taken that clamps do not damage the cable. To obtain optimum signal strength, the transmission line should be as short as possible, but in many cases it may be found that the desire for neat installation and convenient location may necessitate using a long transmission line.

Coaxial cable is easily damaged, and any movement of the cable should be prevented if possible. Like furniture, the receiver cabinet is apt to be moved, and the point of connection of the cable at the receiver should be well secured. Where the cable is brought through walls or window framing, a standard porcelain tube insulator may be used, although, with coaxial cable, it is not absolutely necessary.

Locating the Television Receiver in the Home.

In general, the choice of location for the television receiver will be made by the owner. However, two considerations will be pertinent to the serviceman. First, if possible, guide the customer in his choice in order to avoid placing the receiver in rooms or parts of a room with excessively bright light. Second, locate the receiver in that part of the room giving the least reception of interfering signals from electrical appliances or units within the home. In connection with locating the receiver, it can be called to the attention of the owner that the optimum viewing distance is from 4 to 10 feet and that a cleared area of this size in front of the receiver is to his advantage. Figures 50 and 51 show television receivers in various room locations. Since this test-survey receiver has a flat viewing screen, it can be viewed from angles without distortion of the picture. For best possible viewing of the screen, make certain the viewing surface is free from dust, finger-prints or dirt. Having installed the television receiver in the home and having placed it in operation, it is imperative that the serviceman furnish the owner with operating instructions and aid him in the actual practice of operating the receiver.

Installation Adjustments of the Television Receiver.

Installing television receivers may also involve operating adjustments and alignments resulting from improper handling in transit. For this reason the following installation adjustment procedures are outlined. It is assumed that the receiver has been unpacked, unwrapped, inspected, and antenna connected, and the set plugged in to a 115-volt a-c power source. It is also assumed that the transmitting station is using a circular test pattern. For adjustments on the rear of the receiver chassis, it will be found necessary to locate a mirror in front of the receiver screen in order to view the screen while making the adjustments. (Refer to figure 52.) With these preliminary steps completed, the following procedure should be followed:

(a) Turn the ON-OFF VOLUME control to the ON position, and set the control at approximately the half-way point.

(b) With the VERNIER-TUNING control set at mid-point, adjust the oscillator tuning screw on the front of the chassis so that the station is in tune. This

TP-927

Figure 52. Use of Mirror in Making Rear-Chassis Adjustments.

is an adjustment whereby the station is in tune when the audio signal is at the middle volume peak. If the set has been correctly aligned, this adjustment assures proper tuning of the receiver video sections.

(c) Adjust the HORIZONTAL and VERTICAL HOLD controls until the test pattern locks-in. This should be near the center position of the controls.

(d) Adjust the FOCUS control until the test pattern appears in focus for normal vision. (Should be near center position.)

(e) Adjust the bending coil by turning it until maximum illumination of the screen is obtained. (206 in figure 53.)

(f) Adjust the bending-coil control until maximum illumination of the screen occurs.

(g) Turn the CONTRAST control fully counterclockwise.

(h) Adjust the BACKGROUND control until the test pattern is just barely visible.

(i) Turn the CONTRAST control clockwise until the test pattern has satisfactory shading.

(j) Center the test pattern by loosening the clamps on the focus coil and moving the coil until the pattern is centered in the mask.

(k) Adjust the HORIZONTAL WIDTH and VERTICAL HEIGHT controls until the test pattern height and width just touch the edges of the mask.

(l) Adjust the HORIZONTAL LINEARITY and VERTICAL LINEARITY controls until the circular test pattern is symmetrical.

If, after these adjustments, there are additional troubles, such as "shadow," a shadow effect on the screen around the edges of the screen mask; "pincushion," an effect caused by improper adjustment of the straightening coils causing lines or objects at the top and bottom of the pattern to curve concavely and convexly; or a tilted picture, refer to the alignment and calibration instructions for the television receiver. As a final precaution, check to see that all screws loosened in the process of making operational adjustments are well tightened.

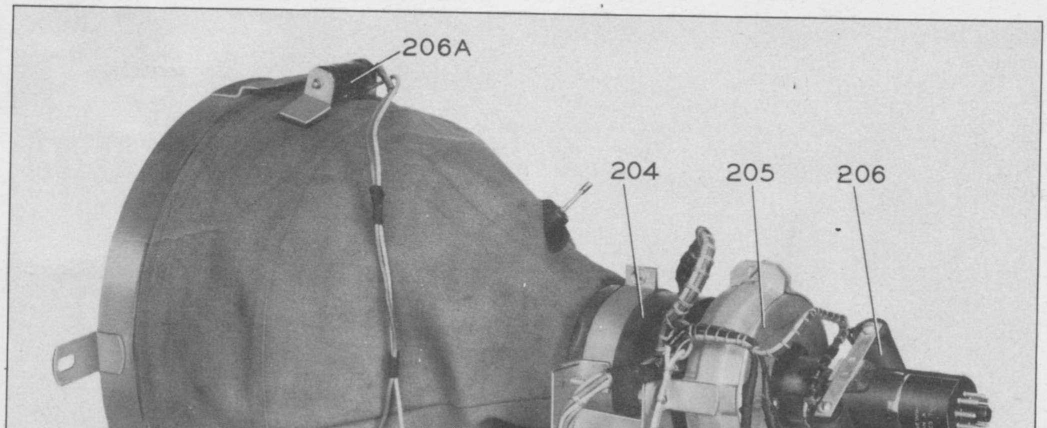


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Figure 53. Picture-Tube Adjustments.

Avoiding External Interference.

Unfortunately, it is often impossible to avoid reception of unwanted signals from external sources. Such sources are varied. They may be any type of electrical appliance, any kind of electrical unit, ordinary light bulbs, automobile ignitions, diathermy equipment (until diathermy is used on specific frequencies such that it can be trapped out of a television receiver, no remedy exists for this type of interference), or trees near or touching the antenna. Even aircraft in the immediate vicinity of the receiver will cause intermittent vibrations or variations of the television picture. Ordinarily, the means of eliminating or avoiding these types of interference are limited; however, an attempt can be made. First, if the source of interference is known, turn off the offending appliance, unit, etc. If the source is not known, it may be discovered by a process of elimination (turning off all possible sources of offense). In the modern home this may prove difficult. The usual remedy for this is the installation of filter units in the offending source. Filter units placed on offending units are the common type used in radio servicing, r-f chokes and by-pass condensers comprising the filtering system. Interference entering through the line to the receiver can also be stopped at times by this type of filter. Another aid is in the location of the antenna. When severe ignition interference patterns are noted, it is often possible to avoid them by re-orienting the antenna. Additional height can also aid in the elimination of offending signals. Adding directive elements to the antenna also helps to eliminate the offending source by reducing the strength of the unwanted signals, unless the signals arise between the transmitter and the antenna. These problems will confront most owners of modern television receivers, and it is the responsibility of the serviceman to educate the owner as to the sources of interference and the means of elimination in order to avoid owner dissatisfaction.

Grounding the Television Receiver.

The television receiver has a connection on the rear of the chassis for a ground. An external ground installation should be made as a safety measure. The outside connector or shield of the coaxial cable is also connected to the ground connection on the set. Another essential is a ground connection to the antenna mast. These grounds can be attached, at the discretion of the serviceman, to a pipe driven in the ground or to water pipes or similar grounded metal objects. Lightning arresters can be used but are not necessary and if used may provide difficulties through accompanying losses of signal strength.

SERVICING THE TELEVISION RECEIVER IN THE SHOP

Test Equipment.

The following test equipment used for servicing television receivers is only the equipment considered essential. With the present-day development of test equipment, the serviceman will have at his disposal increasingly better and more economical equipment with which to work. Most servicemen possess equipment that can be used to supplement this list in their work of servicing television receivers.

A mirror—this is an essential item for every television serviceman. It is used in viewing the front of the screen while making rear-chassis adjustments. It can be of pocket size, or if larger, can be mounted for convenient use.

A compass—a compass is necessary for orienting the television antenna. Used in conjunction with a map of the area which shows the transmitter and receiver locations, it will quickly show the direction in which the antenna must point. This, too, can be of pocket size.

Insulated alignment tool—any fibre type is satisfactory.

An oscilloscope—any reliable scope can be used, providing it contains a wide-band amplifier, making it possible to view the wide bands prevalent in television circuits.

A voltmeter—used in general servicing procedures, this should possess a resistance of 20,000-ohms-per-volt on d.c., normal high-voltage range; a-c voltage, resistance and amperage-measurement features.

A vacuum-tube voltmeter—this meter must have an r-f probe and provide for fairly high r-f voltage measurement.

An r-f signal generator—this is used in the amplitude-modulated signal-generator method of r-f and i-f alignment. It should cover a range from 10 to 100 megacycles, have a 400-cycle audio output, and possess a strong r-f signal output, measurable in microvolts.

A sweep-frequency signal generator—this should cover a range which is sufficient to cover the video i-f range, the audio i-f channel, the audio carrier, the video carrier, and the adjacent audio carrier. This generator is used in the sweep-signal-generator method of alignment of the i-f sections of the receiver.

A dynamic tester—this is used in aligning the r-f stages of the receiver and constitutes a probe made up of a grid-leak detector and high-gain audio amplifier. It should possess a jack for an output meter for visual indications and should cover a wide range of audio and radio frequencies. (As an alternative to the use of a dynamic tester, an electronic voltmeter and a signal generator with an output of 2 volts can be used.)

A vacuum-tube tester—types owned by most servicemen should prove adequate.

A bias battery, or other source, of 3 volts.

ALIGNMENT AND ADJUSTMENT PROCEDURES

CONTROL ADJUSTMENTS OF THE RECEIVER PICTURE TUBE.

CAUTION: AVOID CONTACT WITH HIGH VOLTAGE.

1. Connect the survey-test receiver for operation.

2. Turn power on and allow the set to operate for 10 minutes.

3. Turn the BACKGROUND control knob clockwise until the viewing screen is illuminated with the scanning field.

4. Place bending coil opposite the bend of the picture-tube electron gun and rotate the bending coil about the picture-tube axis for maximum brilliance of viewing screen. (206 in figure 53.)

5. Adjust the bending-coil control to maximum counterclockwise position, then rotate control slowly clockwise until the viewing screen reaches maximum brilliance. Stop at this point, as further increase of bending-coil current is not needed.

6. Loosen clamping bolts on the deflection coils (204) and the focus coil (205).

7. Rotate the deflection coils until the horizontal sweep is horizontal. Keep coil assembly close to the bulging or enlarged portion of the tube.

8. Amply tighten the clamping bolt on the deflection-coil assembly.

9. Shift the position of the focus coil in its holder until picture is centered inside the mask.

10. Turn the BACKGROUND control counterclockwise until all trace lines disappear from the viewing screen.

11. Tune in a station which is broadcasting a test chart, either a circle chart or a chart with squares down the right-hand side and across the bottom.

12. Adjust the FOCUS control for the clearest picture.

13. Reduce the vertical and horizontal size of the test-chart picture until it is approximately ¼ inch inside the tube mask. To reduce the size of the picture, adjust the VERTICAL HEIGHT control and the HORIZONTAL WIDTH control counterclockwise.

14. Adjust the HORIZONTAL and VERTICAL LINEARITY controls until the test chart appears to be correctly proportioned.

15. Increase the size of the picture horizontally and vertically until it is just inside the mask.

16. If "pin cushion" effect exists, correct by adjusting the straightening coils (206A).

Alignment of the Television Receiver. Alignment of the television receiver is an exacting task. For this reason, the serviceman will do well to make certain that re-alignment is necessary, before undertaking such adjustment. While the need for alignment of receiver circuits is usually indicated by a lack of sensitivity, poor tone, or poor picture quality, or combinations of these symptoms, circuit component failure may also produce these indications. Therefore, *always* check the circuit components *first;* then, if the check reveals that all parts are in good working order and all circuits are functioning properly, misalignment may be investigated.

Two procedures are outlined for alignment of the television receiver. The complete procedure for alignment of the radio-frequency, video i.f., audio i.f., and audio amplifiers, is detailed, utilizing an amplitude-modulated signal generator. If the symptoms do not indicate complete alignment, the second procedure may save the serviceman both time and trouble. Alignment of the radio-frequency amplifier is omitted, and the alignment of the other amplifiers is simplified. See figures 54 and 56 to locate adjustment points.

R-F AND I-F ALIGNMENT BY THE AMPLITUDE-MODULATED METHOD.

Equipment Required.

A vacuum-tube voltmeter with an r-f probe.

A signal generator with a frequency range of 10 to 100 mc., and modulated with a 400-cycle tone signal and an attenuated signal output strength measured directly in microvolts.

An oscilloscope of wide-band characteristics.

A 1000-mmf capacitor.

A 3-volt battery.

Insulated alignment tools.

PRELIMINARY PROCEDURE.

Place the chassis to be aligned on a clean metal test-bench.

Connect chassis for operation.

Place the signal generator adjacent to the receiver. Make certain a good electrical contact is established between the signal-generator chassis and the receiver chassis through the test bench. A metal bench is necessary to help maintain both pieces of equipment at the same r-f potential, preventing the circuits from oscillating during the alignment procedure.

Turn on both receiver and signal generator. Allow the equipment to operate approximately ½ hour before proceeding with the alignment. This warm-up period is necessary to prevent the introduction of adjustment errors, which would result if the circuits were adjusted when the parts are cold.

Keep all leads between the signal generator and the receiver as short as possible.

Keep the output of the signal generator as low as possible; this prevents overloading of the circuits being aligned.

DETAILED PROCEDURE.

The alignment procedure outlined below is for channel 3; the frequency of channel 3 is 60 to 66 mc.

AUDIO I-F CHANNEL.

1. Couple the signal-generator output through the 1000-mmf capacitor between pin 6, the grid connection on the audio i-f amplifier tube (7V7) socket, and chassis (ground).

2. Connect the oscilloscope vertical amplifier between pin 2, the plate connection on the audio-output tube (7B5) socket, and chassis (ground). If a 10-volt output meter is used in place of the oscilloscope, connect a capacitor in series with one lead, keeping the d-c voltage out of the meter.

3. Adjust receiver volume control to maximum clockwise position, and tone control to maximum counterclockwise position.

4. Regulate the signal-generator output to give a 400-cycle tone-modulated signal, with a radio frequency of 15 mc. (the audio intermediate frequency), and a signal strength of 20,000 microvolts.

BALANCING THE DISCRIMINATOR TRANSFORMER.

1. Insert the insulated (non-metallic) padding screwdriver into the center hole of the discriminator transformer, and adjust compensator (121D) for minimum indication on the voltmeter, or minimum deflection as shown on the oscilloscope. The correct minimum indication is located between two peak indications. See figure 54 for trimmer locations.

2. Insert the insulated padding screwdriver into the outside hole on the discriminator transformer and adjust compensator (121A) for equal amplitude of signal output, as indicated when the input frequency is varied

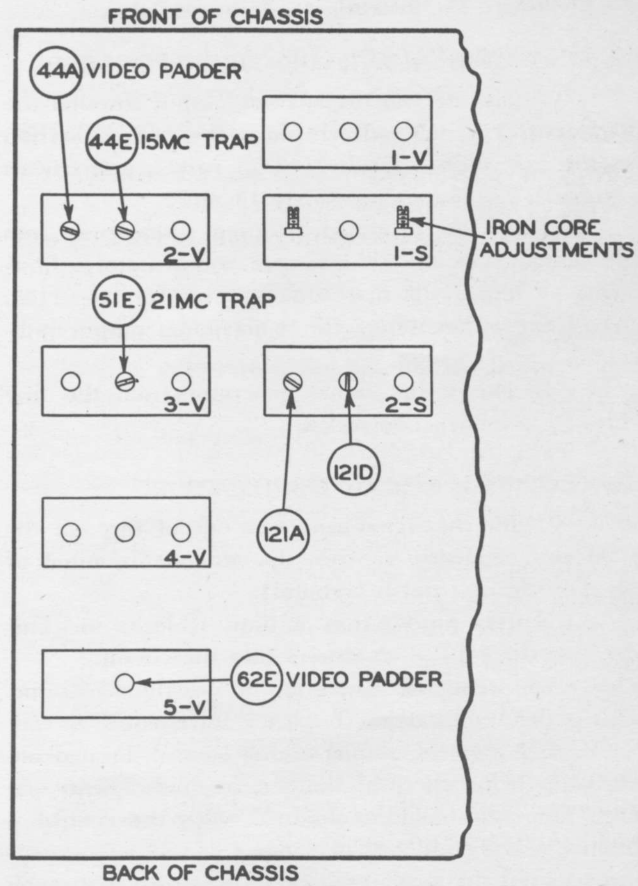

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Figure 54. Location of Circuit Trimmers.

from 14.75 mc. through the center frequency to 15.25 mc. Peak output should be obtained approximately 0.2 mc. either side of the 15-mc. center frequency. The output response curve may be plotted by recording the relative output as points on a graph and connecting the points with a line. This curve is called the discriminator "S," or response, curve. See figure 55. The peak above and below 15 mc. should be adjusted to equal amplitude.

3. Disconnect the signal generator from the audio i-f amplifier tube.

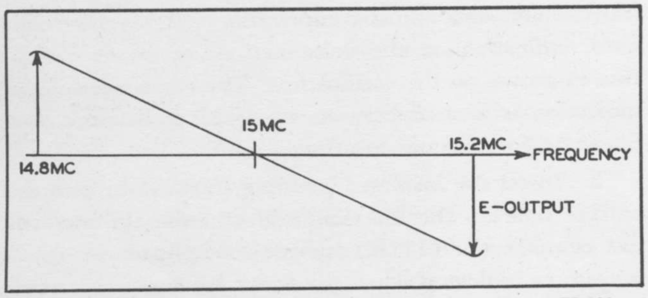

Figure 55. Discriminator-Response Curve.

TUNING THE AUDIO I-F TRANSFORMER.

1. Couple the signal-generator output through the 1000-mmf capacitor between pin 6, the grid connection on the first video i-f tube (1232) socket, and chassis (ground). Set output to exactly 15 mc.

2. Insert the insulated padding screwdriver into the slotted ends of the iron-core compensator adjustments on top of the first audio i-f transformer (114). Adjust the compensators for a maximum output indication.

3. Disconnect the signal generator from the first video i-f amplifier-tube socket.

TUNING THE LOCAL OSCILLATOR.

1. Couple the signal-generator output through the 1000-mmf capacitor between the antenna terminal of the receiver and chassis (ground).

2. Depress push-button 3 until it locks in. This connects the coils of channel 3 into the circuit.

3. Adjust signal generator to exactly 65.75 mc. This is the audio-carrier frequency for channel 3.

4. Adjust panel vernier-tuning control, located immediately below the push-buttons, for mid-capacity setting. This adjustment is obtained when the control is rotated to the middle of its range.

5. Insert the insulated padding screwdriver through hole (3) located above the push buttons, figure 56, and adjust the oscillator iron-core tuning slug for a minimum indication on the oscilloscope, or the voltmeter. This minimum indication is located between two peak indications. When it is obtained, the local oscillator is correctly adjusted. Thus, it will heterodyne with the incoming frequency of 65.75 mc. and produce the desired audio intermediate frequency of 15 mc.

6. To complete the alignment of the audio i-f amplifier, vary the frequency of the signal generator from 65.50 mc. to 66 mc. This will produce, as a result of heterodyne action with the local oscillator, a resultant frequency varying above and below the audio i-f. As the frequency is varied, readjust the iron-core tuning slugs located in the first audio i-f transformer (114), equalizing the amplitude of the peaks obtained as the signal-generator frequency is varied to each side of the 65.75-mc. frequency. When this is correctly performed, the ideal "S" curve will be obtained.

7. Disconnect the test equipment.

VIDEO I-F CHANNEL.

1. Couple the signal generator through a 1000-mmf capacitor to the grid (pin 6) of the mixer tube (1232) and to ground.

2. Remove the oscillator tube (7A4).

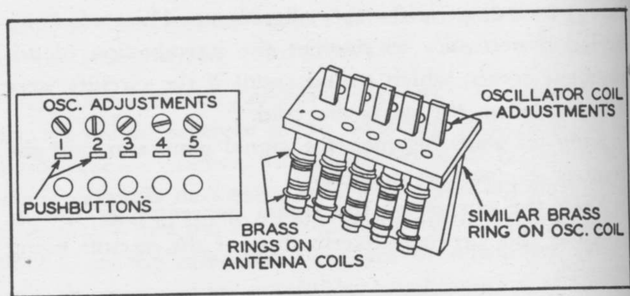

Figure 56. R-F and Local Oscillator Adjustment Locations.

3. Connect the oscilloscope or an output meter through a 1000-mmf capacitor to the picture-tube grid (pin 5 of picture-tube plug) and ground.

4. Adjust the signal generator to 15-mc. output.

5. Turn the attenuator on the signal generator to maximum output.

6. Adjust the 15-mc. audio trap to minimum reading on the output indicator.

7. Set the signal generator to 21-mc. output.

8. Adjust the 21-mc. audio trap to minimum reading on the output indicator.

9. Apply a 3-volt negative bias to the a-v-c lead at a point on the a-v-c filter condenser.

10. Sweep the signal generator through the channel from 15 to 21 mc. in steps of ½ megacycle. Assemble data, beginning at 15.5 mc., reading the output voltage of the signal generator for each ½-mc. step up to 21 mc., while keeping the output indication constant by changing the microvolt output from the signal generator.

11. Change these readings to percentages by taking the lowest microvolt reading as a constant, and dividing each reading into this figure. From the resulting percentage figures, which represent relative outputs, a graph can be plotted. (Figure 69 illustrates a convenient form of chart which can be used for recording these measurements.) Observe the form of the resulting curve. Note the 50% point (19.5 mc.). Compare with the idealized curve in figure 6. No sharp peaks or dips should occur in the curve. The slope should start about 20.5 mc. The mid-point (50%) should be at 19.5 mc. and 100% at 18.75 mc. The curve should be as flat as possible down to 16 mc., and should drop to a minimum at 15.75 mc.

If the curve does not approach this form, the set must be aligned by adjusting the padders, or by wire dressing (moving the wires of the grids and plates of the video i-f tubes closer to or farther from the chassis). Refer to figure 54 for the location of these padders (44E) and (62E).

AUDIO AND VIDEO R-F CHANNELS.

1. Connect the signal generator through a 1000-mmf capacitor to the antenna connection on the receiver and to ground.

2. Remove the plate load from the r-f tube in the receiver and substitute a resistor of 330 ohms.

3. Connect a vacuum-tube voltmeter from the plate of the r-f tube to ground, using a 1000-mmf capacitor to isolate the B+ voltage from the meter, or use the dynamic tester with an output meter.

4. Load the tertiary winding of the antenna coil with a 150-ohm resistor.

5. Set the signal generator to mid-frequency of the channel to be aligned.

Note: For channel 3, 60-66 mc., this would be 63 mc.)

6. Increase the output of the signal generator to obtain an indication on the voltmeter.

7. Tune the secondary (grid) winding of the antenna coil, by means of the rings, to maximum reading on the voltmeter.

8. Remove the load from the tertiary winding and place the load resistor of 150 ohms across the grid winding of the antenna coil.

9. Tune the tertiary winding by the shunt padding capacitor to maximum reading on the voltmeter.

10. Remove the load from the grid winding.

11. Tune the signal generator through the channel frequencies from 60 to 66 mc., and as this coil is over-coupled, two peaks should be noted. One should be at 66 mc. and one at 60 mc. with an approximate 30% dip at the center of 63 mc. If this does not occur, these coils should be realigned.

12. Remove the 330-ohm resistor from the plate of the r-f tube, restoring the normal plate load.

13. Remove the plate load of the mixer tube and substitute the 330-ohm resistor.

14. Connect the vacuum-tube voltmeter from the plate of the mixer tube to ground through a 1000-mmf capacitor.

15. Disconnect the signal generator from the receiver antenna post and reconnect it direct to the r-f tube grid and to ground, after removing condenser (6).

16. Leave the signal generator set at 63 mc.

17. Tune the r-f coil to maximum output reading by the ring adjustment. As this is a single-tuned coil, one peak only should result, at 63 mc. It should be about 30% higher than the curve at 60 and 66 mc.

18. Leave the voltmeter as connected and disconnect the signal generator from the r-f tube grid and reconnect it to the receiver antenna post. By rotating the signal generator through the 60-66 mc. channel, the overall response of the antenna and r-f stages can be observed.

Sweep the generator across the channel and take output readings at every ½ mc. From the readings plot a curve. This curve should be almost flat. The dip at the center of the antenna-stage curve is filled by the peak of the curve of the r-f stage. The result is an overall flat response. If this is not the resulting curve, these two stages must be realigned, as this response curve must be attained for good television reception.

Band	Signal Generator	Response Wanted
1	45.25 mc. — 49.75 mc.	See Figure 57
2	55.25 mc. — 59.75 mc.	
3	61.25 mc. — 65.75 mc.	
4	67.25 mc. — 71.75 mc.	
5	77.25 mc. — 81.75 mc.	

SENSITIVITY DATA.

The audio i-f sensitivity is such that a 50% modulated 500-microvolt signal applied at the first audio i-f grid will give a 20-volt peak-to-peak output as measured at the plate of the 7B5 tube to ground.

The video i-f sensitivity is such that a 50% modulated 250-microvolt signal applied at the first video i-f grid will give a 20-volt peak-to-peak output as measured at the plate of the 6V6 video-output tube to ground.

The overall sensitivity of the receiver is such that a 50% modulated, 50-microvolt signal applied to the antenna input will give a 20-volt peak-to-peak output as measured at the plate of the 6V6 video-output tube to ground.

VIDEO-AMPLIFIER TEST.

The high-frequency response of the video amplifier can be checked with a standard signal generator and a vacuum-tube voltmeter equipped with a vacuum-tube probe to minimize high-frequency degeneration through lead capacity. A procedure for making a video-amplifier response chart follows:

1. Attach the output of the signal generator between diode plate (pin 3) of the detector and ground through a series capacitor and a resistor; the resistor should have a resistance at least four times the value of the diode-load resistor.

2. Attach the vacuum-tube-voltmeter probe between picture-tube grid and ground.

3. Apply a 1-volt unmodulated 80-kc. signal from the signal generator and record the voltage indicated on the vacuum-tube voltmeter.

4. Apply a constant 1-volt signal at various frequencies over the range of the signal generator up to five megacycles. Record the voltage indicated on the vacuum-tube voltmeter for each frequency measured, and compile readings in chart form.

5. Defects in the response curve, which should be reasonably flat or constant up to 3½ megacycles, are indicated by dips, sharp rises, or an early falling off of the voltages indicated on the vacuum-tube voltmeter.

6. Sharp rises or dips are indications of unwanted resonant circuits, or a tendency to go into oscillation at certain frequencies.

7. A gradual falling off of the voltage, beginning at a relatively low frequency, one megacycle for example, indicates unwanted shunt capacity between plate, or grid, and ground, or a change in the characteristics of the various peaking coils.

The low-frequency response of the video amplifier can be checked by using an audio-signal generator in place of the standard signal generator. In case the audio-generator output is not calibrated, the vacuum-tube voltmeter can be used to adjust the generator output to 1 volt for all frequencies.

8. An early falling off of the low frequencies, at 120 cycles for example, indicates an open or leaky compensating, or interstage, coupling capacitor. Low-frequency motor-boating generally indicates an open decoupling capacitor.

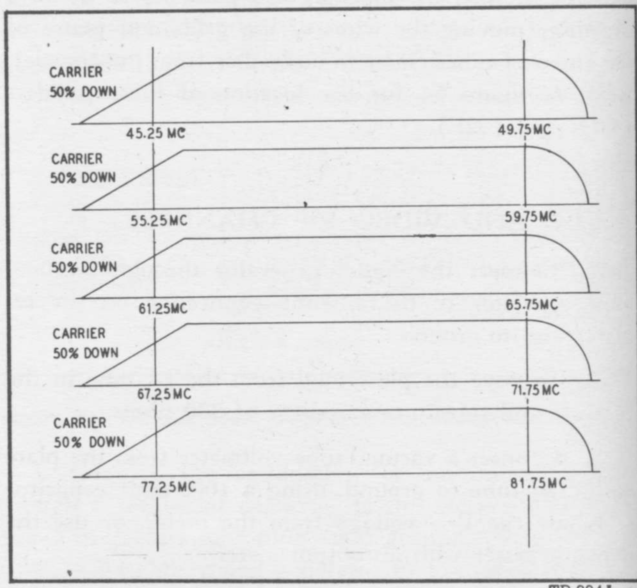

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Figure 57. Idealized R-F Response Curves.

I-F ALIGNMENT (SWEEP-SIGNAL-GENERATOR METHOD). Alignment of the television receiver will be accomplished with a minimum of trouble and effort, if the serviceman will carefully observe and follow all instructions.

EQUIPMENT REQUIRED.

A sweep-frequency signal generator capable of covering continuously and repeatedly the frequency range of 14 mc. to 22 mc. This range will cover the video i-f channel, audio i-f channel, and the adjacent audio i-f channel.

A vacuum-tube voltmeter.
An oscilloscope.
A 1,000-mmf capacitor.
Insulated alignment tools.

PRELIMINARY PROCEDURE.

1. Place the chassis to be aligned on a clean metal test-bench.

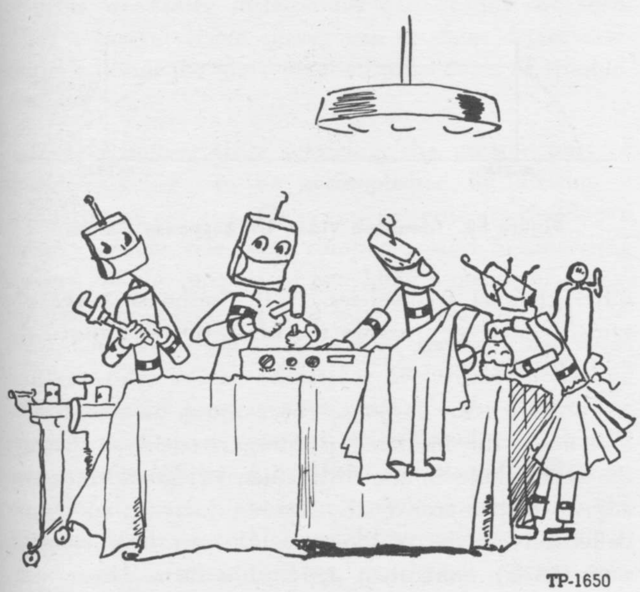
2. Connect chassis for operation.

3. Place the signal generator adjacent to the receiver. Make certain a good electrical contact is established between the signal-generator chassis and the receiver chassis through the test bench. This is necessary to help maintain both pieces of equipment at the same r-f potential, preventing the circuits from oscillating during the alignment procedure.

4. Turn on both receiver and signal generator. Allow the equipment to operate approximately ½ hour before proceeding with the alignment procedure. This warm-up period is necessary to prevent the introduction of adjustment errors, which would result if the circuits were adjusted when the parts are cold.

5. Keep all leads between the signal generator and the receiver as short as possible.

6. Keep the output of the signal generator as low as possible; this prevents overloading of the circuits being aligned.



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DETAILED PROCEDURE.

Audio I-F Channel.

1. Connect the oscilloscope between pin 2, the plate connection on the audio-output tube (7B5) socket, and chassis (ground).

2. Couple one lead of the sweep-signal generator, set to sweep the 14.5-mc. to 15.5-mc. frequency range, through a 1000-mmf capacitor, to pin 6, the grid connection of the audio i-f amplifier tube (7V7) socket, and the other lead to chassis (ground). Also connect the synchronizing signal, developed in the sweep generator, to the oscilloscope.

3. Place marker on signal generator to 15 mc.

4. Adjust receiver volume control to maximum clockwise position, and tone control to maximum counterclockwise position.

5. Increase output of the signal generator to approximately 10 volts, r.m.s., until a half-scale deflection is obtained on the oscilloscope screen.

NOTE

The sweep generator will cause the trace on the oscilloscope screen to be deflected a distance proportional to the amplifier gain at the frequency being swept. This trace, being produced many times per second, appears to the eye as one trace. The amplitude of the trace at any one point immediately indicates the response of the amplifier at that frequency, in comparison to its response at other frequencies. Thus, a response curve is continuously obtained, indicating the exact overall gain of the circuit being adjusted. The marker from the sweep generator will indicate the exact frequency at any point on the trace response curve.

6. Insert the insulated (non-metallic) padding screwdriver into the center hole on the discriminator transformer, and adjust compensator (121D) for minimum marker indication at midpoint of "S" curve. See figure 54 for trimmer locations.

7. Insert the insulated padding screwdriver into the outside hole on the discriminator transformer and adjust compensator (121-A) so that the negative and positive peak on either side of the marker will be of equal amplitude.

NOTE

If the sweep generator used sweeps upward through the frequency range, it will produce a single trace and the trace will appear as an "S" curve. Superimposed upon the center of the "S" curve will be the 15-mc. marker. When compensator (121-A) is correctly adjusted, the size of the "S" on each side of the marker will be equal. If the sweep generator used sweeps upward and downward through the frequency range, it will produce a double trace.

8. Disconnect the signal generator from the audio i-f amplifier-tube socket.

9. Couple one lead of the signal-generator output, through the 1000-mmf capacitor, to pin 6, the grid connection of the first video i-f tube (1232), and the other lead to chassis (ground).

10. Insert the insulated padding screwdriver into the slotted ends of the iron-core compensator adjustments on top of the first audio i-f transformer (114); regulate the compensators for maximum and for an equal amount of signal on each side of the marker.

11. Disconnect the test equipment.

VIDEO I-F CHANNEL.

Adjusting the Audio I-F Reject Circuit.

1. Connect the oscilloscope vertical amplifier between the grid of the picture tube and chassis (ground); this connection may be made on pin 5 of the picture-tube plug. Snap plug cover back and terminal will be exposed, or the connection may be made at the point of grid-lead termination on the chassis.

2. Remove the heavy conductor from pin 6 on the socket of the mixer tube (1232). This conductor connects the grid of the mixer tube to the wave-band coil assembly. Leave the a-v-c bus connected to pin 6; this connection supplies the mixer tube with grid bias.

3. Couple one lead of the sweep-signal generator, which covers the 14.5-mc. to 21.5-mc. range, to pin 6, the grid connection of the mixer tube (1232), and the other lead to chassis (ground).

4. Set marker on signal generator to 15 mc.

5. Turn CONTRAST control all the way on, maximum clockwise position.

6. Increase signal-generator output to approximately 10 volts, r.m.s., to give half-scale deflection on oscilloscope.

7. Insert the insulated padding screwdriver into the center hole in the top of the second video i-f transformer and adjust padder (44E), part of the 15-mc. audio trap, for minimum deflection of the 15-mc. marker on the oscilloscope. This adjustment is made to reject the 15-mc. audio carrier.

Adjusting the Adjacent Audio I-F Reject Circuit.

1. Adjust the marker to 21 mc., the frequency of the adjacent audio channel.

2. Insert the insulated padding screwdriver into the center hole in the top of the third video transformer and adjust padder (51E), part of the 21-mc. audio trap, for minimum deflection of the 21-mc. marker on the oscilloscope.

Aligning the Video I-F Amplifier.

1. Adjust the marker to 19.5 mc. This is the video intermediate frequency.

2. The next step is extremely important, because the adjustments performed in it will determine the response characteristics of the video i-f amplifier. Therefore, before making the adjustments given in this step, the response of the video i.f. should be compared with the ideal response curve shown in figure 58. Note that the video intermediate frequency of 19.5 mc. is 50% down, i.e., ½ as strong as the average output for the

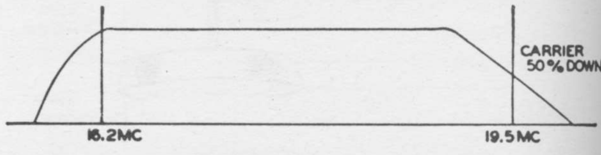

Figure 58. Idealized Video I-F Response Curve.

other channel frequencies. If the response curve obtained closely approaches the ideal, do not disturb the adjustments.

3. When the response curve shows an undesirable dip, insert the insulated padding screwdriver through the center hole in the fifth video i-f transformer and adjust compensator (62E) for an increase in output deflection on the oscilloscope. Do not turn compensator (62E) more than 1/16 of a turn. Then insert

the insulated padding screwdriver through the outside hole in the top of the second video i-f transformer and adjust compensator (44A) for an increase in output deflection of the oscilloscope. Do not turn compensator (44A) more than 1/16 of a turn. Check response of video i-f amplifier and repeat procedure until the desired response is obtained. A typical response curve of the receiver under discussion is shown in figure 59.

4. Disconnent signal generator from the mixer-tube socket. Replace the grid lead previously removed.

5. Disconnect oscilloscope.

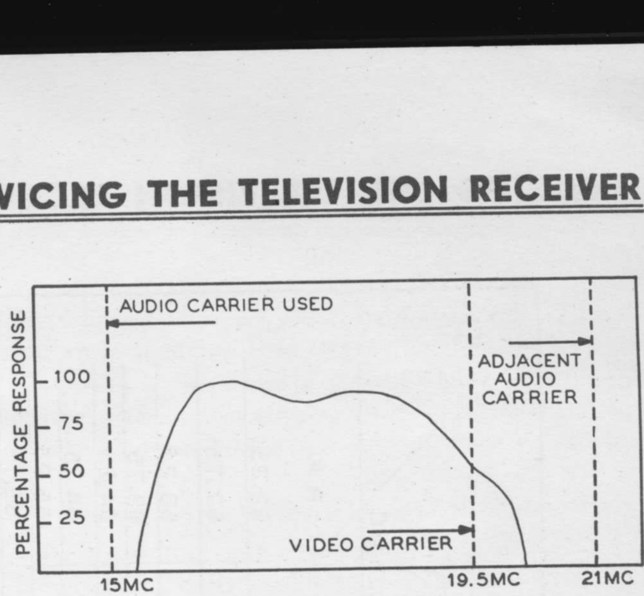

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Figure 59. Typical I-F Response Curve of the Test Receiver.

TROUBLE-SHOOTING DATA

METHODS OF TROUBLE-SHOOTING — Although the majority of servicemen have well-defined trouble-shooting procedures developed through years of experience, the following outline can aid as a review of the various methods of trouble-shooting that can be employed in servicing television receivers.

By Visual Analysis.

Experienced servicemen have generally developed this technique to a high degree. Observation of the physical aspects of a television receiver involve checking for obviously broken connections either in the receiver, or transmission line and antenna. Burnt and defective parts are frequently easily discerned. Broken or noisy controls or faulty installations can readily be seen. Thus a careful visual survey can at times detect difficulties without the more detailed procedures of trouble-shooting.

In television-receiver servicing, the greater part of trouble-shooting can be accomplished by viewing a standard test pattern. These test patterns are developed by the various television companies and broadcasting systems for the purpose of providing a means of checking receiver alignment and adjustment. The test patterns, with slight variations, are all basically the same, and generally are broadcast for 15 minutes preceding each television program. For analysis, the Philco test pattern (sometimes referred to as "resolution chart") is used throughout this book. All servicemen must acquaint themselves thoroughly with the television test pattern, and learn to interpret its variations in terms of misalignment, misadjustment, or defects of the television receiver. For checking overall bandwidth and r-f, i-f, and video-amplifier responses, it is possible to construct a chart to use with the normal test pattern that will apply to any one channel of frequencies desired. See figure 60 for a sample chart designed for use on channel 3. The development of these charts is a responsibility of the serviceman, and they are essential for accurate servicing of television receivers.

The television test pattern can be of service to both the customer and the serviceman. The former can use it in determining proper picture size, linearity of the picture (i.e., the picture symmetry and aspect ratio), and proper shading. The serviceman can utilize the test pattern for the same purposes, and in addition can use it as a check on the receiver performance, with reference to bandwidth, analysis of interference, and peaks and dips in the i-f, r-f, and video-amplifier responses.

By Signal Substitution.

One efficient method of trouble-shooting is that of signal substitution. This consists of substituting a signal, from a signal generator, for the normally received signal at various points in the circuit, and carefully observing the results in the picture or sound. Normal substitution of a signal should be from the output stages toward the antenna stage. This method is of special benefit in localizing the trouble in a certain section or stage of the receiver.

By Point-to-Point Resistance and Voltage Measurement.

After utilizing the signal-substitution method to localize the trouble in a certain section or stage of the receiver, it will generally be necessary to use ordinary

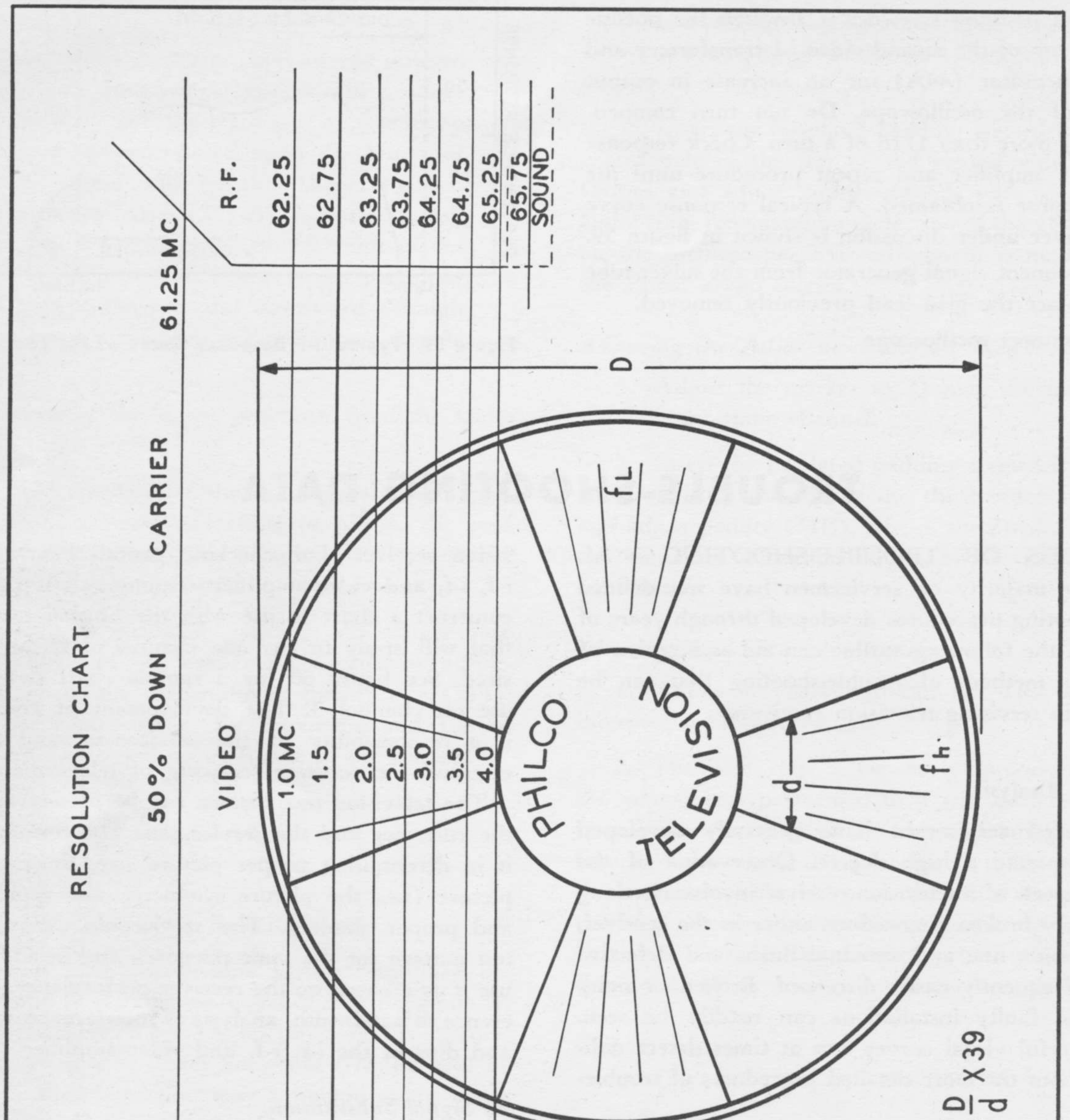

Figure 60. A Resolution Chart for Channel Three.

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point-to-point measurements of resistance and voltages, thus further localizing the trouble in a unit or part of a certain stage of the receiver. For this purpose figures 66, 67, and 68, showing these types of measurement are included in this section.

By Tube Checking.

Another trouble-shooting procedure is that of checking the tubes of the receiver. Inasmuch as a large percentage of receiver trouble can be traced to tubes, this procedure must not be overlooked, and it can be made advantageously early in the process of trouble-shooting.

Although the review of trouble-shooting procedures has followed a specific order, serviceman can vary it to suit their habit or preference. The subsequent material in this section consists of trouble-shooting data and charts to facilitate analyzing troubles commonly found in television receivers.

By Overall Response Checks by the Resolution Chart.

By visual inspection of the normal test pattern (resolution chart) it is possible to analyze the r-f, i-f, and video responses of any certain channel, as well as the overall bandwidth of the receiver. Figure 60 illustrates video response curves superimposed upon a drawing of the test pattern.

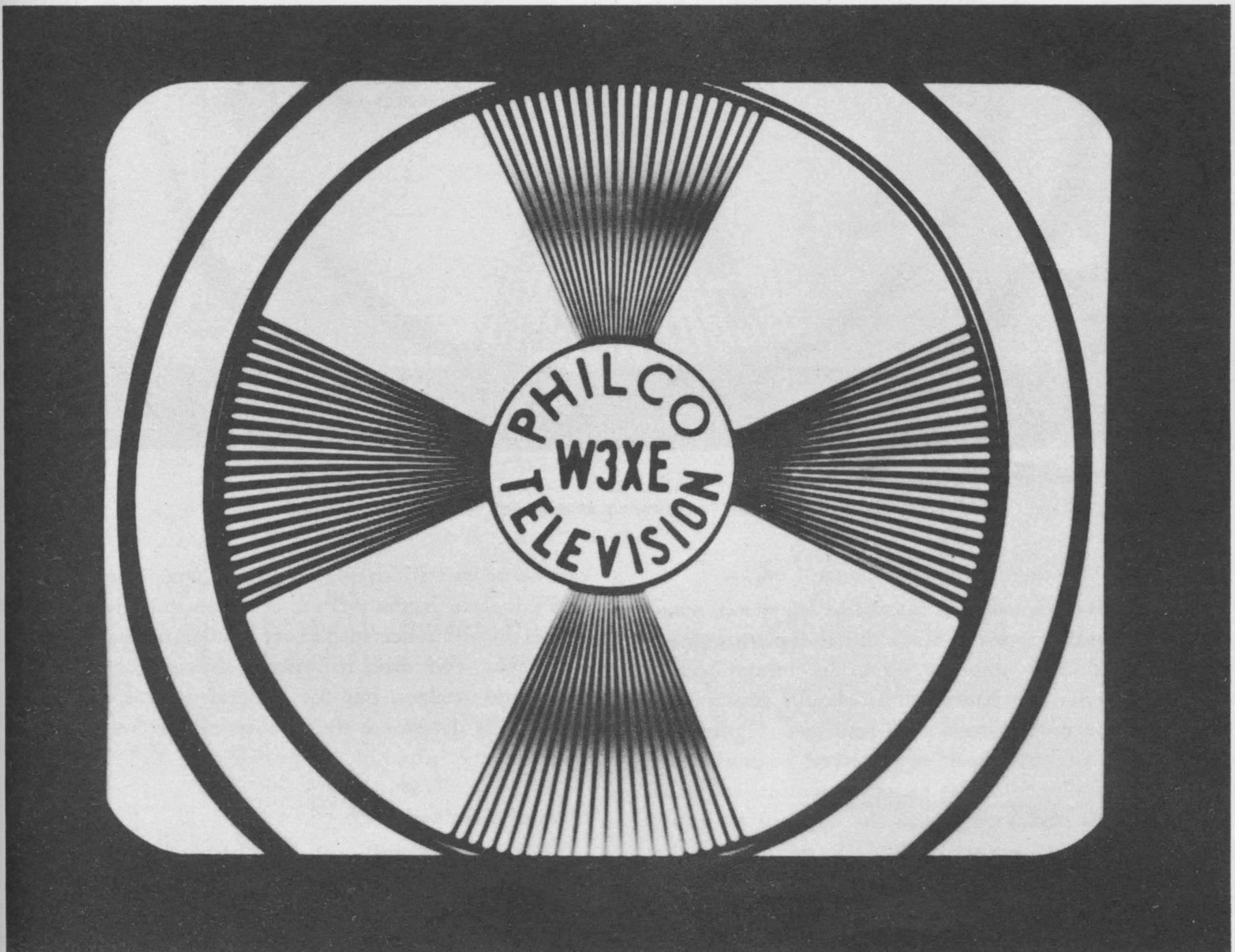

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Figure 61. A Test Pattern Showing Peak in Receiver Response.

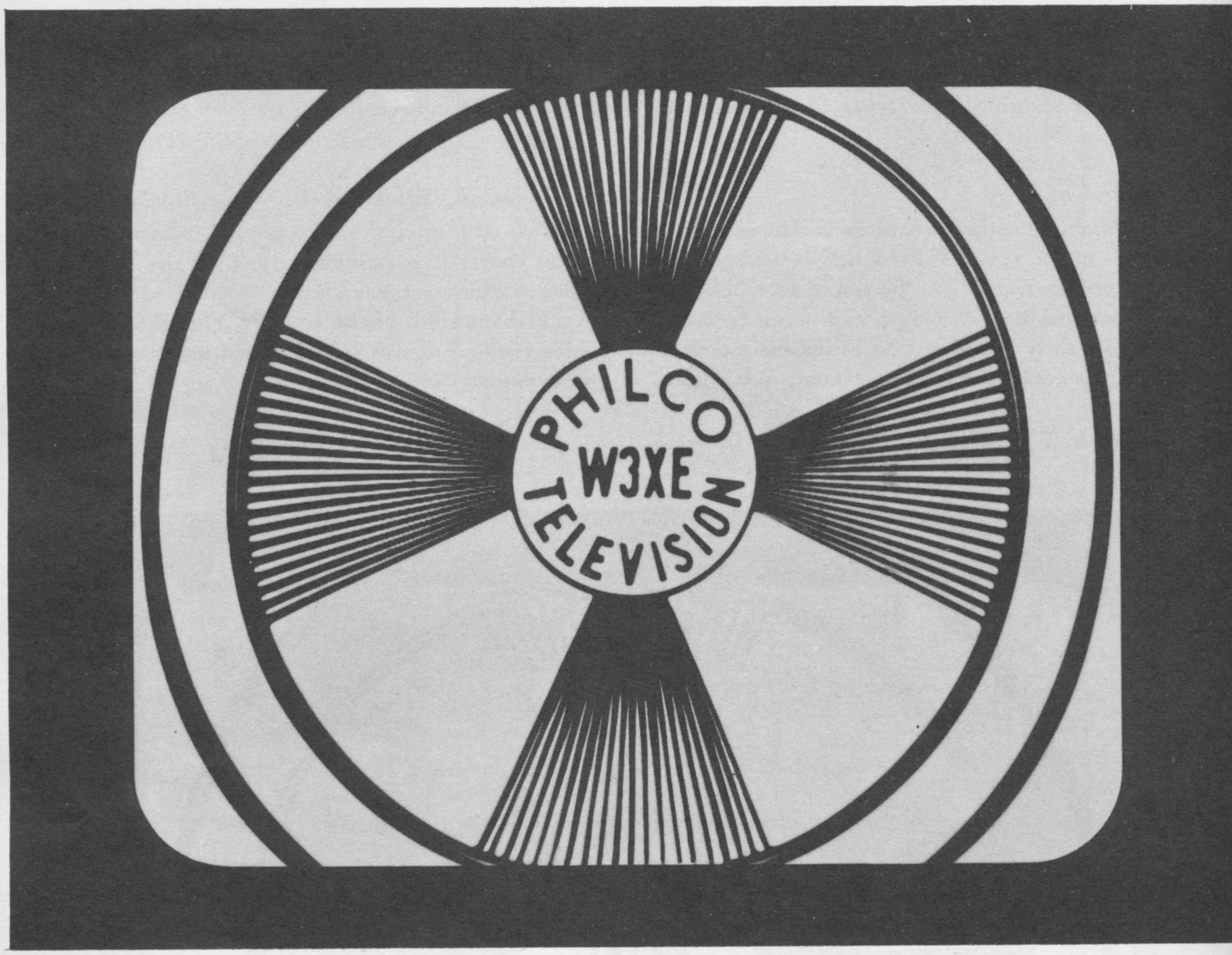

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Figure 62. A Test Pattern Showing Insufficient Receiver Bandwidth.

R-F, I-F, and Video-Amplifier Response Checks.

Since negative transmission is used in television, maximum modulation appears black in the picture, and minimum modulation appears white. In normal reception, the televised resolution chart should contain no black or white areas, streaks or smudges. Figure 60, prepared for use in checking receiver responses on channel 3, is similar to charts for other channel-response checking. (It is necessary to use the appropriate chart for each separate channel.) A black smudge in the vertical (high-frequency) wedge at about mid-point would indicate a peak in the r-f response curve at about 63.75 mc., in the i-f response curve at about 17 mc., or in the video-amplifier response curve at about 2.5 mc. Refer to figure 61 to see this indication. These smudges can occur at various places on the wedges and can be easily located in the r-f, i-f, or video-amplifier response curves by reference to a chart similar to that of figure 60. Peaks and dips will rarely be indicated on the horizontal wedges, but the general appearance of the wedge will determine the quality of the low-frequency response.

Overall Bandwidth Check.

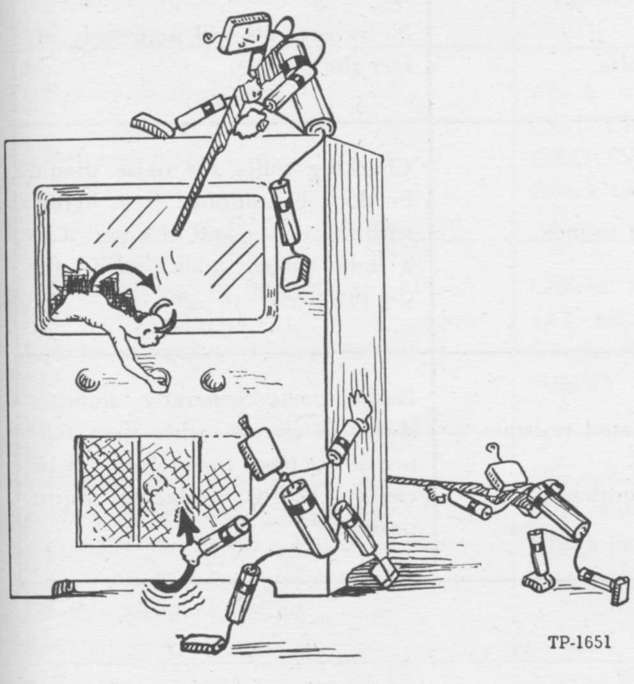
Overall bandwidth can be observed by noting the place on the vertical wedge where the black and white lines converge. See figure 62. When the receiver frequency response covers the desired bandwidth, the black and white lines should converge almost exactly at the edge of the inner circle. Reference to the formula on the resolution chart, figure 60, will show how to determine the number of lines the set is capable of reproducing properly, or in other words, the bandwidth of the set. Normally, the vertical wedge is composed of 20 black and 19 white lines. The overall response of a particular set is no better than the poorest response. That is, if the r-f response is 6 mc., the i-f response is 2.5 mc., and the video-amplifier response is 3.5 mc., the overall response is limited to the least of these, 2.5 mc.

MISCELLANEOUS SERVICING DATA and CHARTS

When replacing parts of a receiver, use identical parts made by the set manufacturer. It is extremely important that a replacement part be installed in the exact position formerly occupied by the original part. When moving leads to install parts, be careful to dress the leads back to their former placement. Failure to observe this precaution may result in severe circuit interaction and necessitate considerable experimental lead rearrangement and circuit realignment to re-establish original performance.

REMOVAL OF PICTURE TUBE

CAUTION: THIS SET DEVELOPS AND OPERATES WITH POTENTIALS AS HIGH AS 6000 V. BEFORE ATTEMPTING TO REMOVE PICTURE TUBE, DETACH RECEIVER FROM POWER OUTLET, AND GROUND THE HIGH-VOLTAGE CAPACITOR.



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CAUTION: HANDLE PICTURE TUBE WITH CARE. DO NOT GRASP TUBE BY ITS NECK, FOR A SMALL STRAIN ON ITS NECK MAY CAUSE THE TUBE ENVELOPE TO CRACK.

1. Detach deflection-coil cable plug from socket on chassis.

2. Detach plug from base of picture tube. (See figure 64.)

3. Remove high-tension cable from anode by gently pulling cable away from tube.

4. Remove wing nuts holding picture-tube assembly in cabinet, and lower assembly out of cabinet.

5. Place tube assembly on flat surface, upside down, on its mounting board.

6. Loosen centering-coil assembly and slide it off the tube neck.

7. Loosen bolt in front clamping ring.

8. Gently slide tube forward and out of tube-mounting assembly.

9. To replace, reverse procedure.

Removal of Deflection Coil.

1. Remove picture-tube assembly as outlined above.

2. Remove coil leads from deflection-coil cables.

3. Loosen coil clamping ring and remove coil from mounting.

4. To replace, reverse procedure.

GENERAL TROUBLE-SHOOTING CHARTS

VISUAL INSPECTION

SUSPECTED TROUBLE	SUGGESTED CHECKS	SPECIAL NOTES
Antenna cabling	Check antenna lead-in for shorts or opens; also for poorly soldered or corroded joints.	Also check antenna proper for defects.
Power-line cabling	Check power cable for breaks. Check for loose or broken plug in power socket. Check fuses for looseness in holders or blown-out condition.	A fuse may sometimes pass visual inspection and yet be defective. Check with continuity meter or substitute new fuse.
Defective tubes	Check tubes for lighting. Check tubes for correct location. Check tubes for microphonics.	A tube may often fit in the wrong socket and will light but will not function.
Miscellaneous (video)	Check controls for noise. Check push buttons for noise.	Noisy controls will noticeably affect the picture.
Miscellaneous (audio)	Check tubes for noise. Check for tone quality. Check for arcing or frying sounds.	Checking tubes for noise should be done by tapping them lightly with the eraser end of a pencil or a light rubber mallet made for the purpose.
Miscellaneous (burnt odors)	Check for burnt wires. Check for burnt or overheated resistors. Check for burnt capacitors. Check for burnt-out transformers.	Burnt parts generally indicate shorts in circuit rather than failure of the parts themselves. Check circuit before replacing burnt parts.

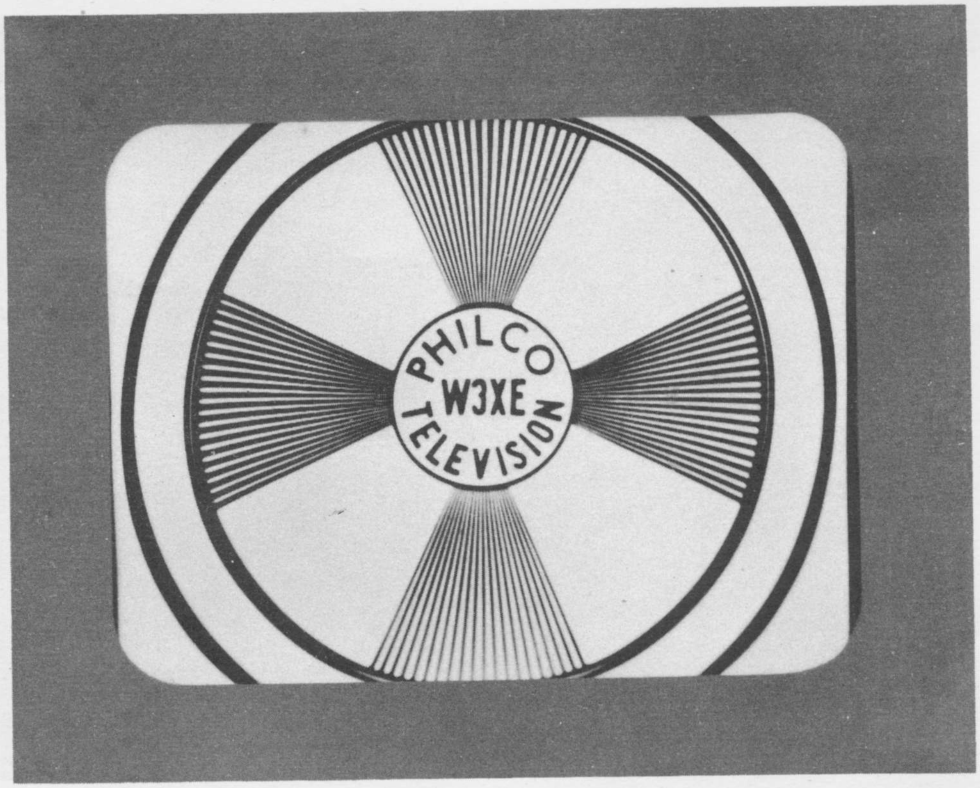
TEST-PATTERN INSPECTION

EFFECTS ON PICTURE	SUGGESTED CHECKS	SPECIAL NOTES
Picture lines blurred and hazy. Refer to figure 63A.	Check FOCUS control setting. Check r.f. and i.f. for alignment.	If FOCUS control will not regulate picture, a circuit defect is indicated.
Picture hazy and hard to keep synchronized.	Check for weak received signal. Check for weak tubes. Check alignment of r.f. and i.f.	A check for weak received signal can be made by comparison with another receiver, if available. If not, check antenna and lead-in.
Picture washed-out. Refer to figure 63B.	Check BACKGROUND control setting. Check for gassy picture tube.	Substitute picture tube.
Picture has wrong aspect ratio and wrong size. Refer to figures 63C and 63D.	Check VERTICAL HEIGHT control setting. Check HORIZONTAL WIDTH control setting.	Correct aspect ratio is 4:3.
Picture too dark. Refer to figure 63E.	Check CONTRAST and BACKGROUND control settings.	
Picture shading poor. Refer to figure 63F.	Check for improper setting of CONTRAST and BACKGROUND controls. Check receiver alignment.	
Picture has poor linearity. Refer to figures 63G and 63H.	Check VERTICAL LINEARITY adjustment. Check HORIZONTAL LINEARITY adjustment.	
Picture has poor horizontal linearity accompanied by a bright bar of light in, or to the extreme left of picture. Refer to figure 63CC.	Check for defective HORIZONTAL SWEEP circuits. Check output transformer.	Refer to electrical-checks chart.

EFFECTS ON PICTURE	SUGGESTED CHECKS	SPECIAL NOTES
Picture has poor vertical linearity accompanied by a bright bar of light in, or toward the top of, picture.	Check for defective VERTICAL SWEEP circuits. Check 6K6 tube.	Refer to electrical-checks chart. *Rarely occurs.*
Picture has no horizontal sweep, only bright vertical bar of light.	Check for defective HORIZONTAL SWEEP circuits.	Refer to electrical-checks chart.
Picture has no vertical sweep, only bright horizontal bar of light.	Check for defective VERTICAL SWEEP circuits.	Refer to electrical-checks chart.
No video, but audio is good. Picture tube lighted. Refer to figure 63FF.	Check for video-output trouble.	Refer to electrical-checks chart.
Same as above with picture tube unlighted.	Check for defective high-voltage power supply. Check bending current.	Refer to electrical-checks chart.
Set completely dead. (No video or audio.)	Check for defective r-f, mixer, or first i-f stages. Check low-voltage power supply.	Refer to electrical-checks chart.
Picture lines appear with "herring-bone" pattern. Refer to figure 63DD.	Diathermy equipment in vicinity causing interference.	No remedy except to turn off equipment.
Picture lines appear rippled. Refer to figure 63EE.	Beat-frequency interference.	Seek equipment in vicinity operating near television-receiver frequency.
Picture shows following or leading white back-lighting. Refer to figure 63M.	Check for improper receiver alignment causing phase shifting in i-f, r-f, or video stages.	

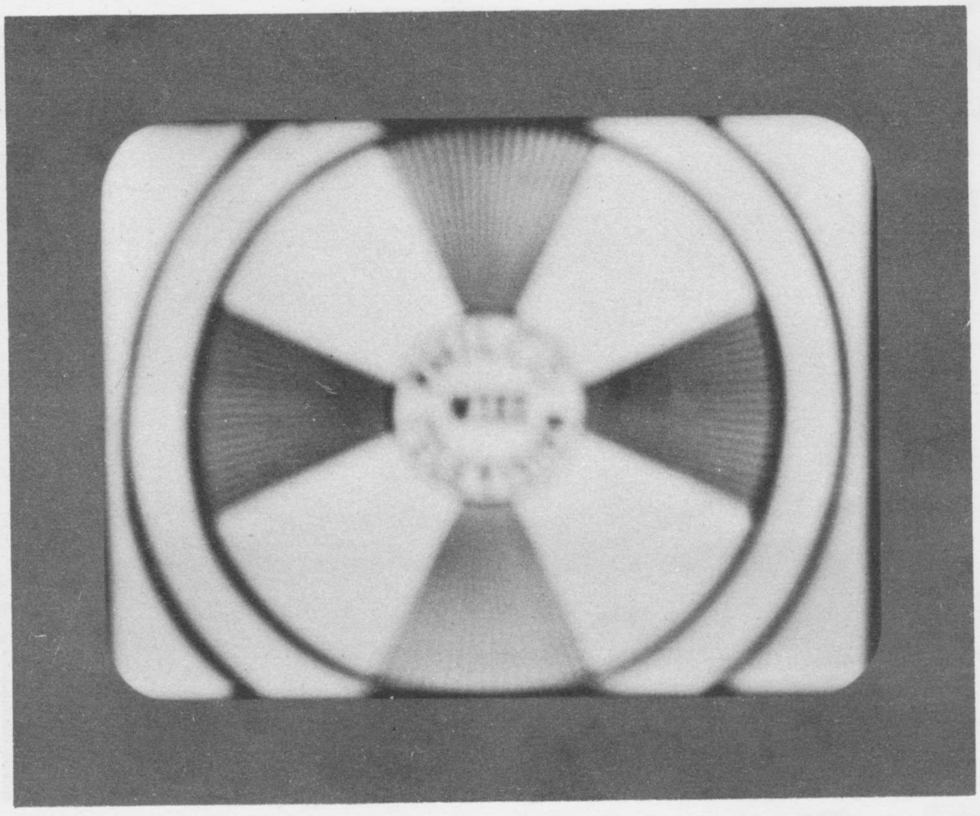
EFFECTS ON PICTURE	SUGGESTED CHECKS	SPECIAL NOTES
Picture shows black horizontal bars running throughout in unison with sound. Refer to figures 63N and 63P.	Audio signal leaking into video section.	Check audio traps.
Picture shows black and white bars stationary in picture. Refer to figure 63Q.	Check power-supply filter system.	Only one black and white bar indicates 60 cycles and shorted tube. Two bars indicates 120 cycles and trouble in the power-supply filter.
Picture is "S" shaped on sides. Refer to figure 63R.	Hum in horizontal-deflection coils.	Check power-supply filters.
Picture shows "pairing" of lines indicating improper interlace.	Check sync separator and vertical-deflection circuits.	
Picture appears thin and contains lots of "snow." Refer to figure 63S.	Too weak signal. Check for defective antenna or transmission line or improper receiver alignment or defective set.	
Picture very dark and distorted from over-syncing. Refer to figure 63T.	Too strong signal. Place short wire across transmission line at receiver. Vary length from 6″ down for proper signal strength.	
"Ghosts" in picture. See figure 63U.	Check antenna orientation and placement. Check for improper setting of audio trap. Check i-f alignment.	
Scanning raster incorrectly illuminated. Refer to figure 63F.	Check BACKGROUND control setting.	Reduce if necessary.

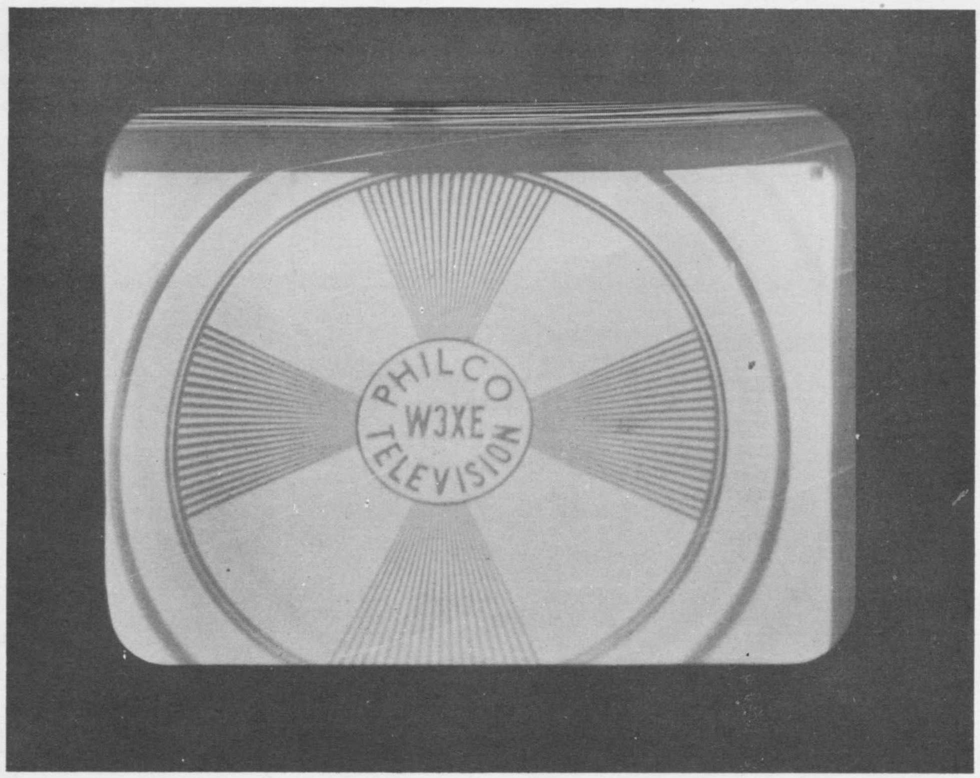
EFFECTS ON PICTURE	SUGGESTED CHECKS	SPECIAL NOTES
Horizontal sweep out of sync. (Sweep is very slow.) Refer to figures 63W and 63X.	Check HORIZONTAL HOLD control setting.	Change control as necessary.
Horizontal sweep out of sync. (Sweep is less slow.) Refer to figure 63Y.	Check HORIZONTAL HOLD control setting.	Change control as necessary.
Horizontal sweep out of sync. (Sweep is approaching sync.) Refer to figures 63Z and 63AA.	Check HORIZONTAL HOLD control setting.	Change control as necessary.
Vertical sweep out of sync. (Sweep is slow.) Refer to figure 63BB.	Check VERTICAL HOLD control setting.	Change control as necessary.
Picture appears tilted. See figure 63GG.	Check position of deflection coils.	Rotate deflection coils about the picture-tube axis for proper orientation.
Picture appears incorrectly centered. Refer to figures 63J, 63K, 63L.	Check CENTERING control setting.	Adjust CENTERING control if necessary. Adjust FOCUS coil position about the picture-tube axis for proper centering of the picture.
Picture shows fine white streaks intermittently flashing across it. See figure 63V.	None.	Usual cause is ignition interference. Refer to antenna-installation data.
Video signal from signal generator. Refer to figures 63HH and 63JJ.		Signal-generator patterns used in checking the video channel. Pattern 63HH is a high, and 63JJ a low modulating frequency.



TP-1962

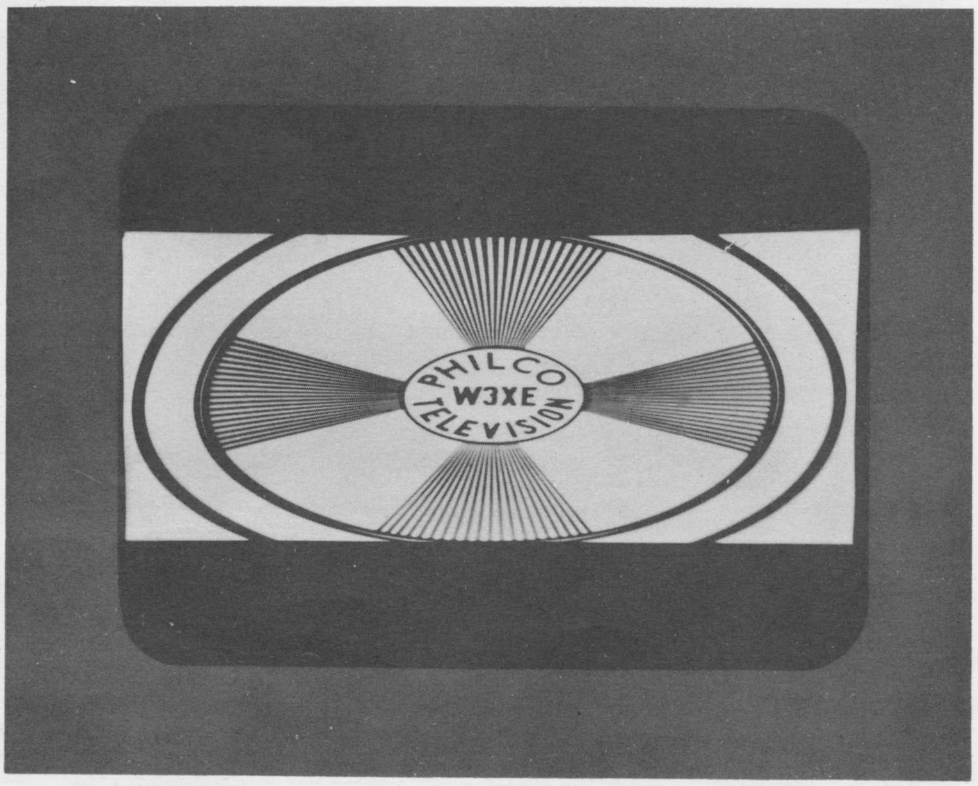
Figure 63. A Normal Test Pattern.





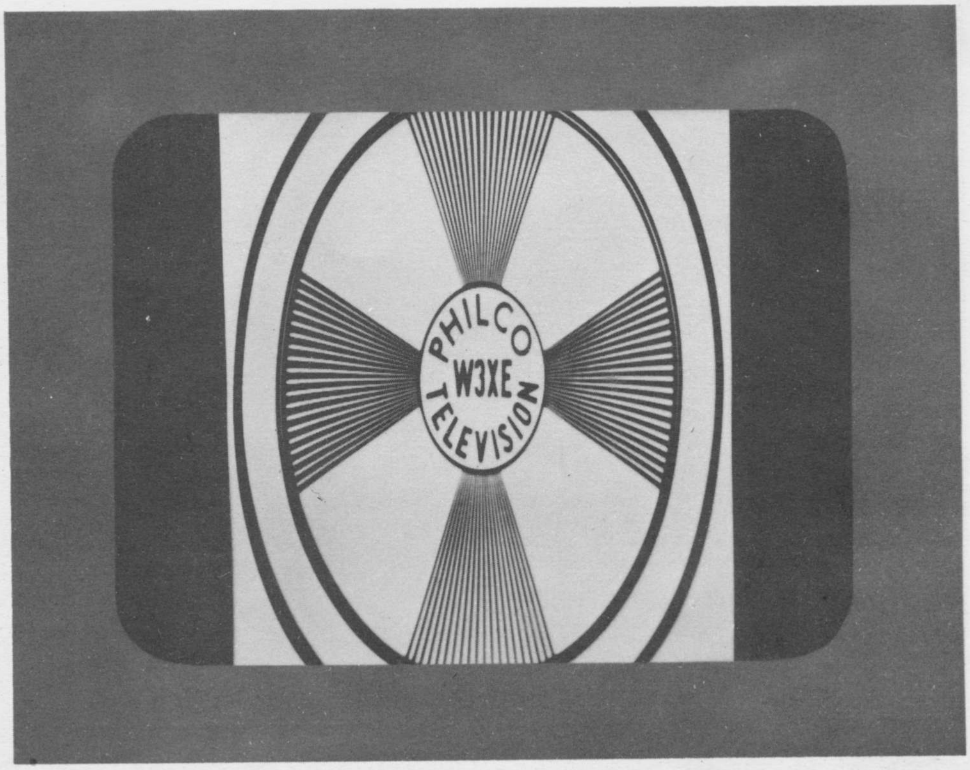
TP-1964

Figure 63B. Background Control Improperly Adjusted.



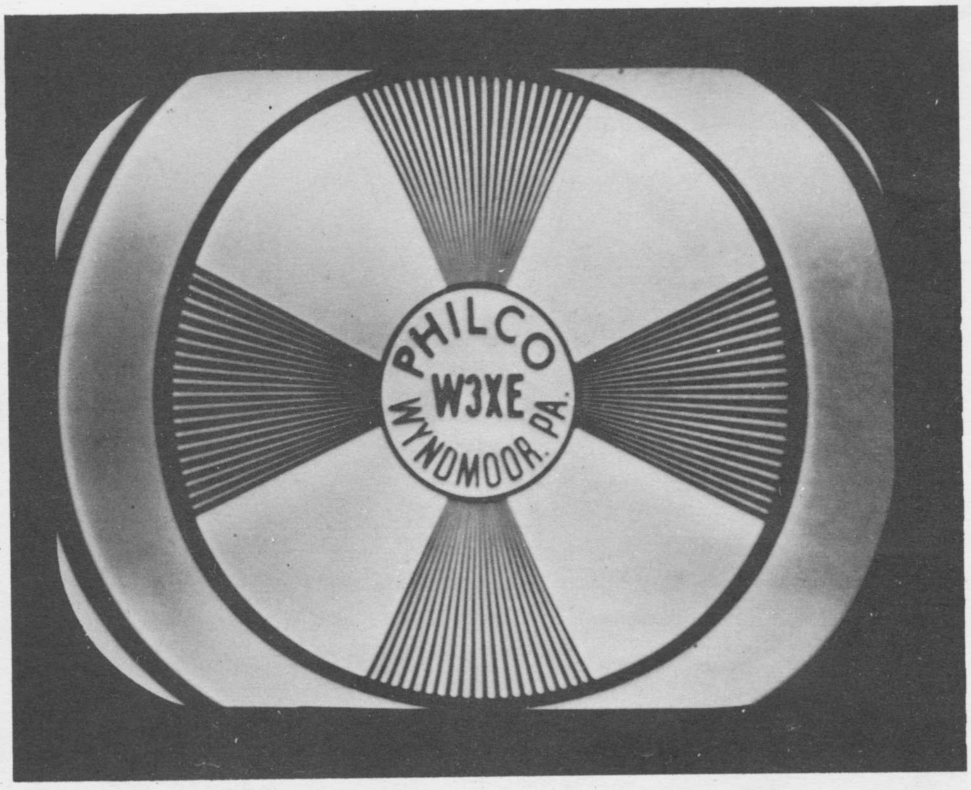
TP-1965

Figure 63C. Incorrect Aspect Ratio (Vertical).



TP-1966

Figure 63D. Incorrect Aspect Ratio (Horizontal).



TP-1012

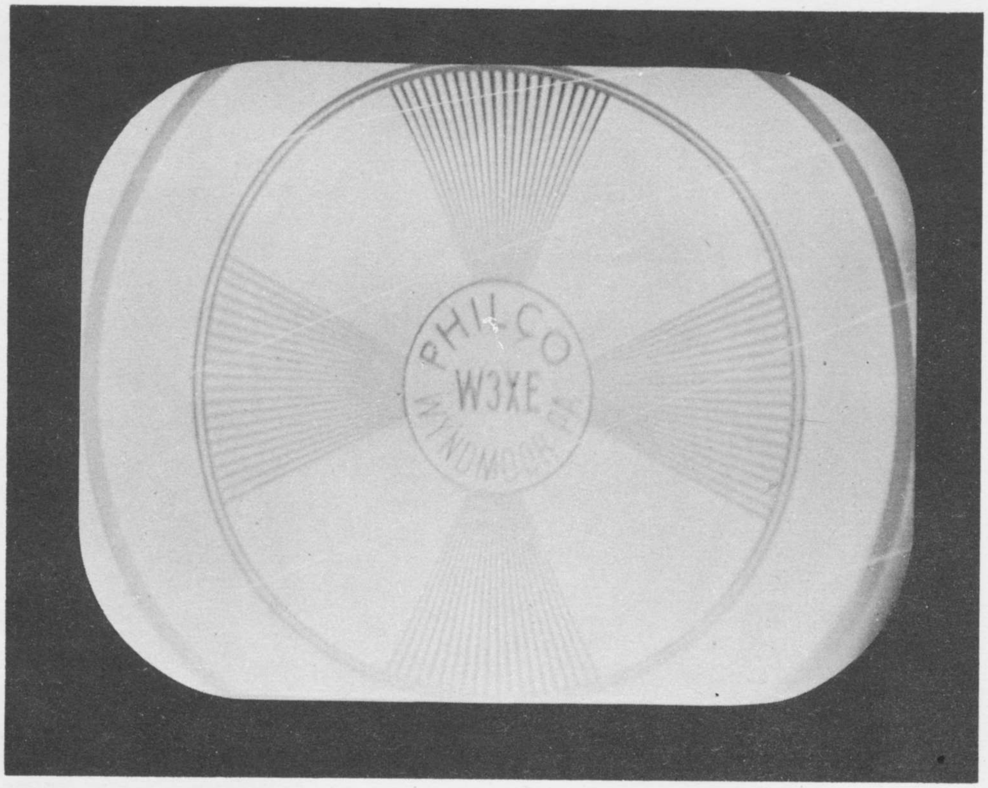


Figure 63F. Background Control Improperly Adjusted (Too Light). TP-1016

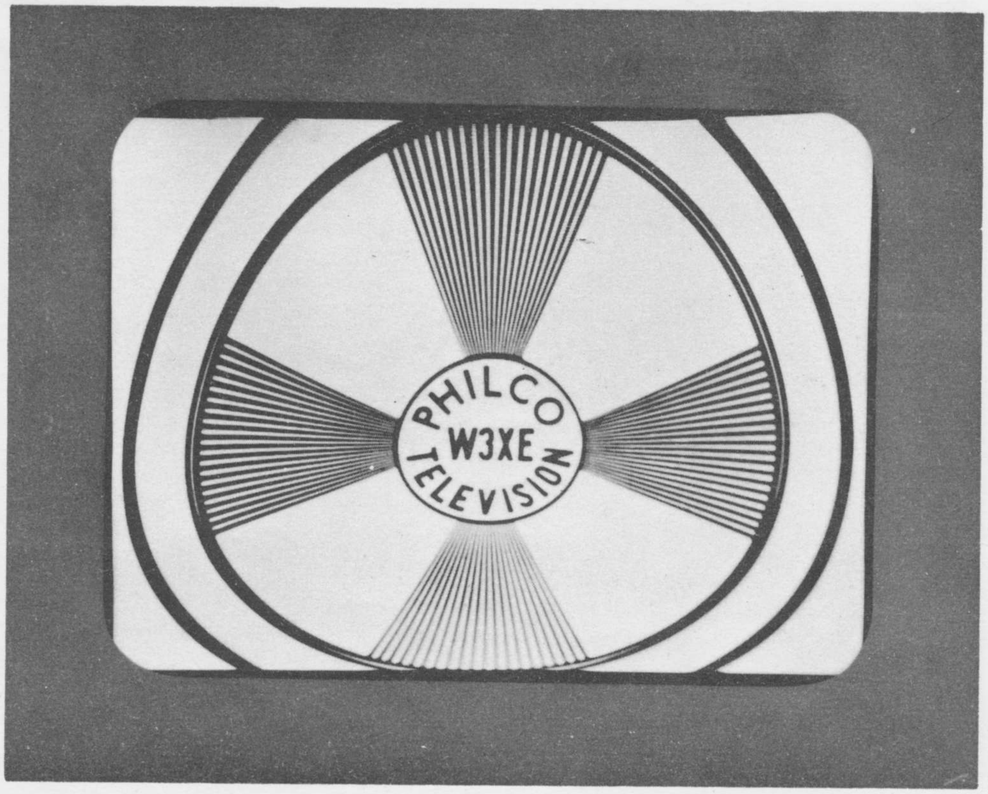
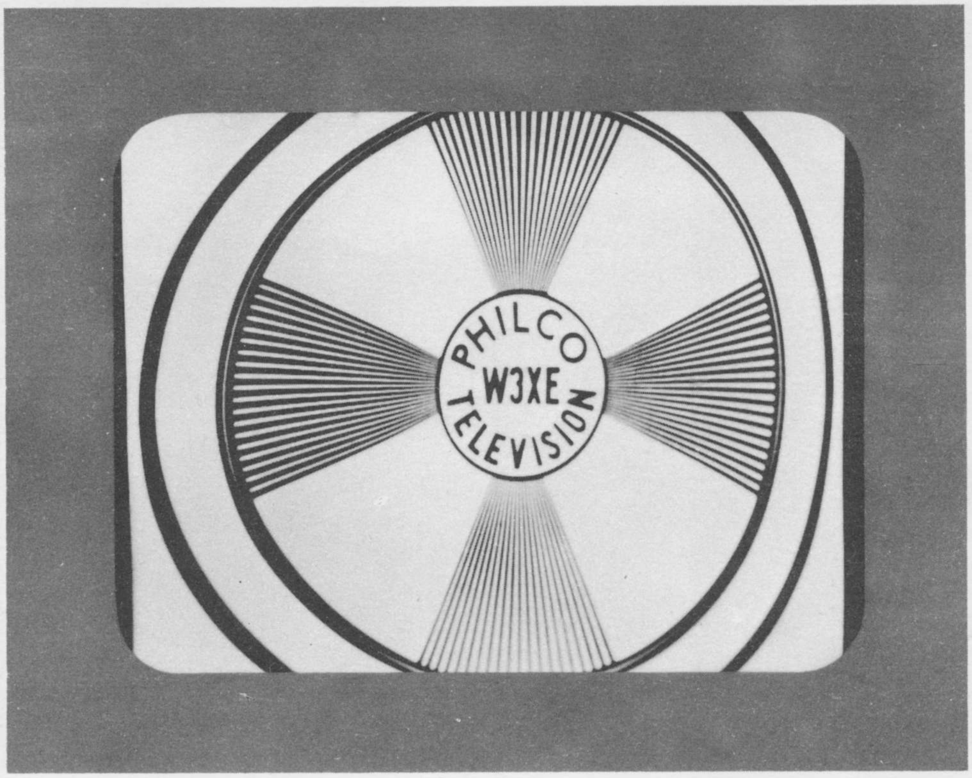
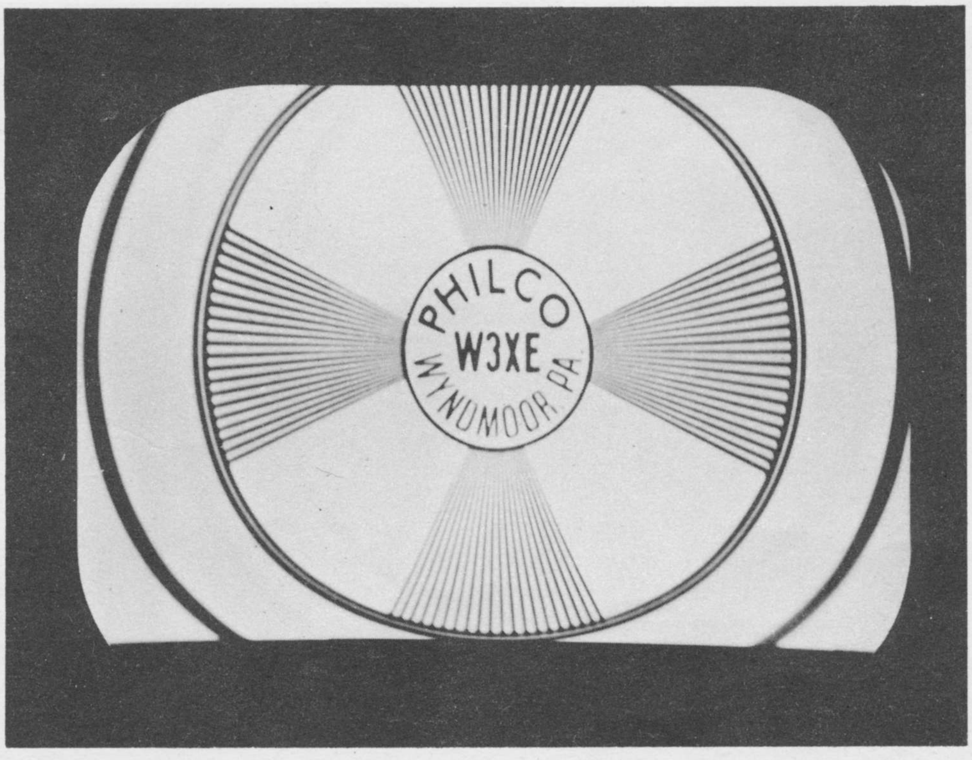


Figure 63G. Vertical Linearity Improperly Adjusted. TP-1967

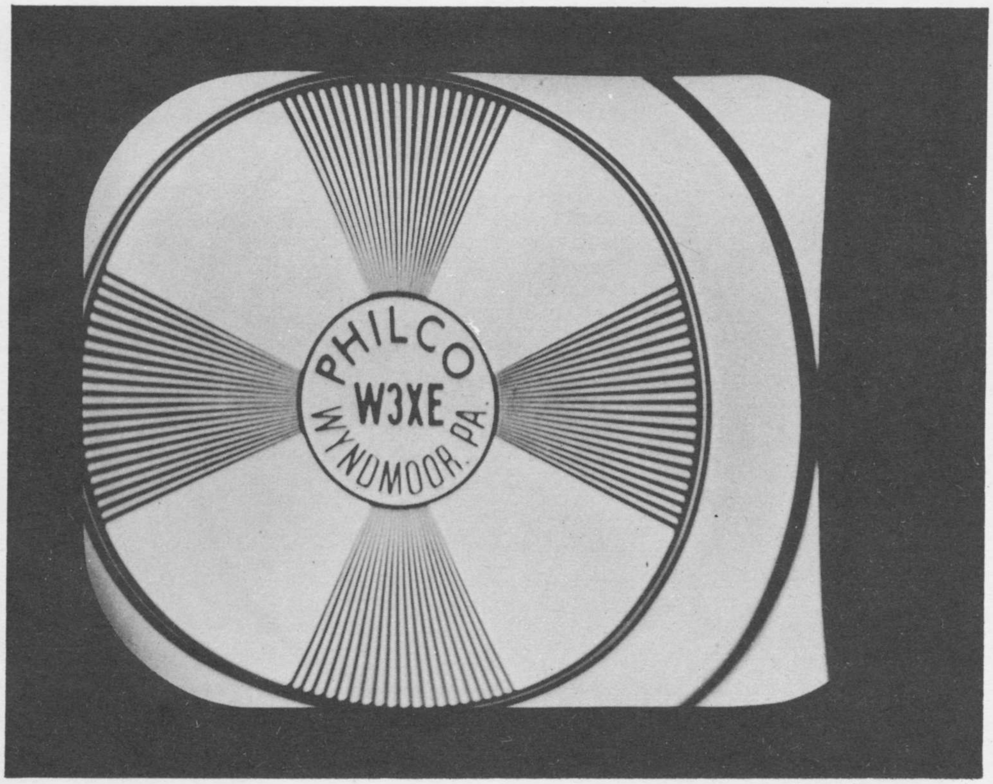


TP-1968

Figure 63H. Horizontal Linearity Improperly Adjusted.

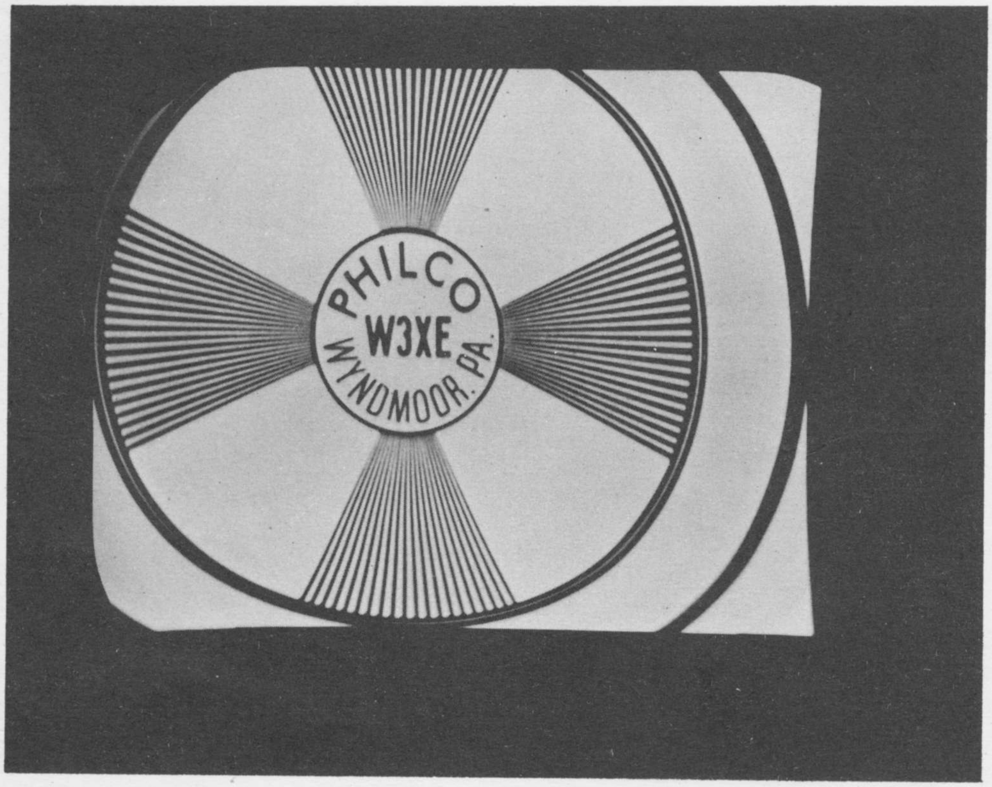


TP-1018



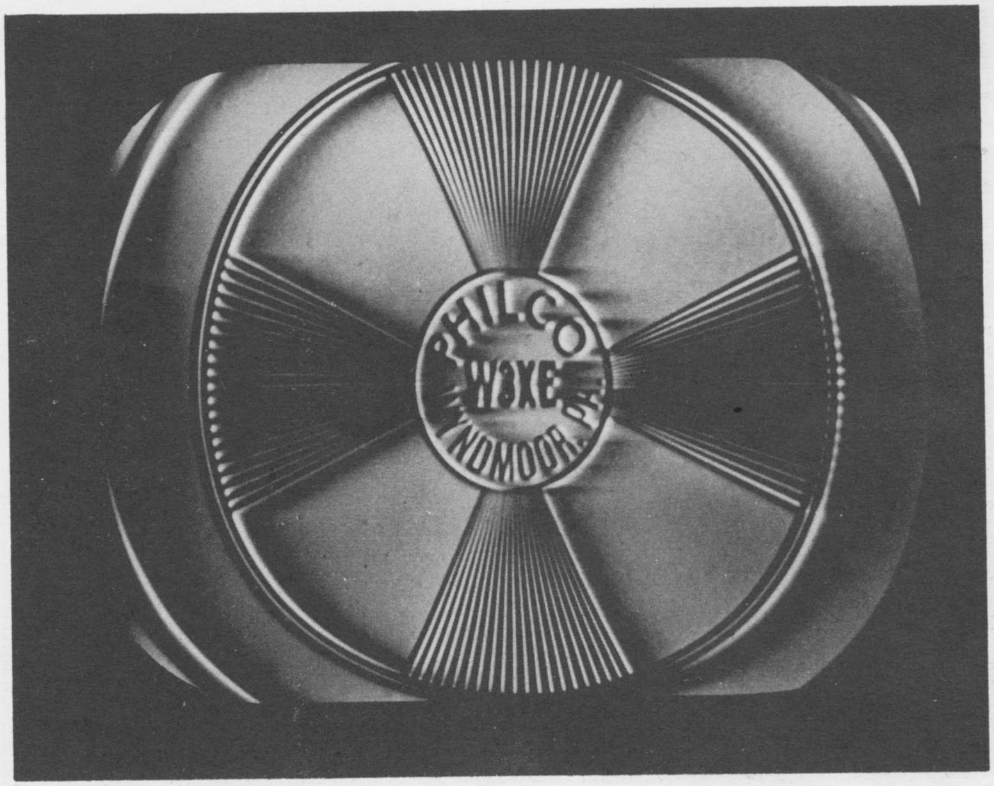
TP-1014

Figure 63K. Test Pattern Improperly Centered (Horizontally).



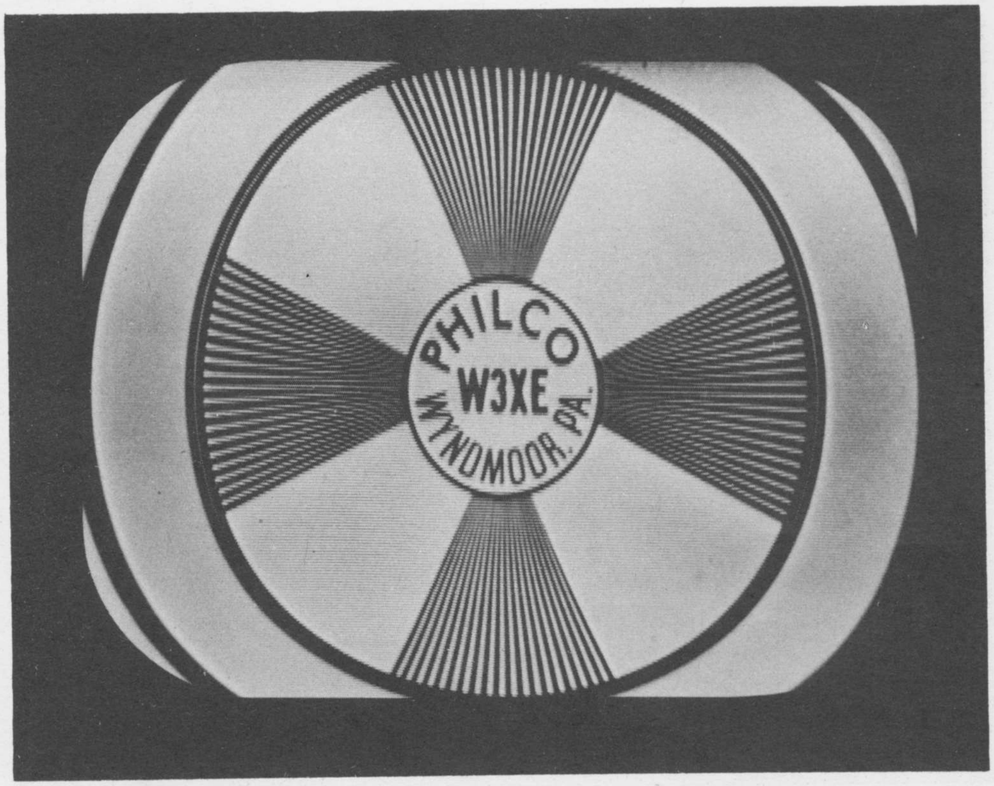
TP-1006

Figure 63L. Test Pattern Improperly Centered (Both Off).

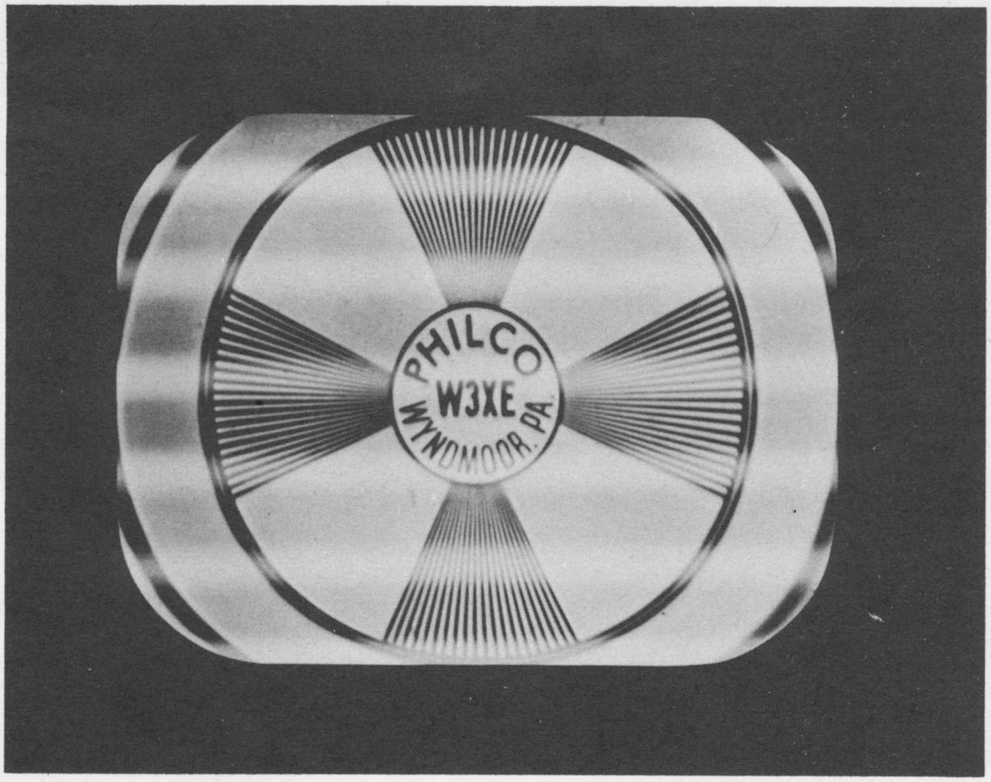


TP-1020

Figure 63M. Phase Shifting.

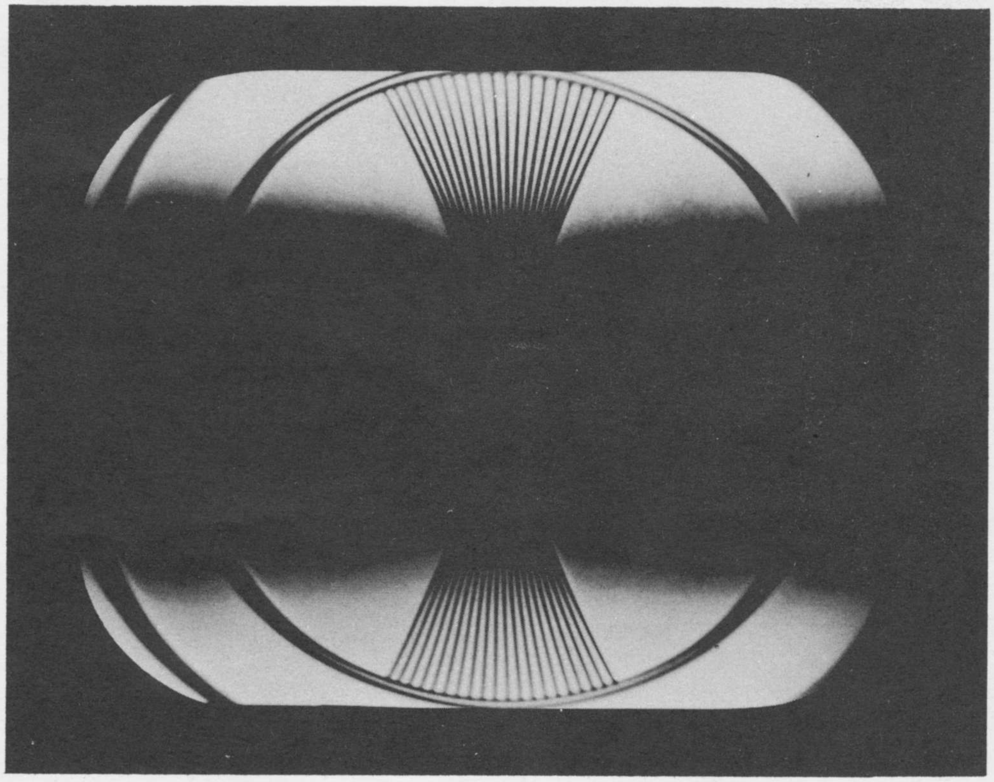


TP-1017



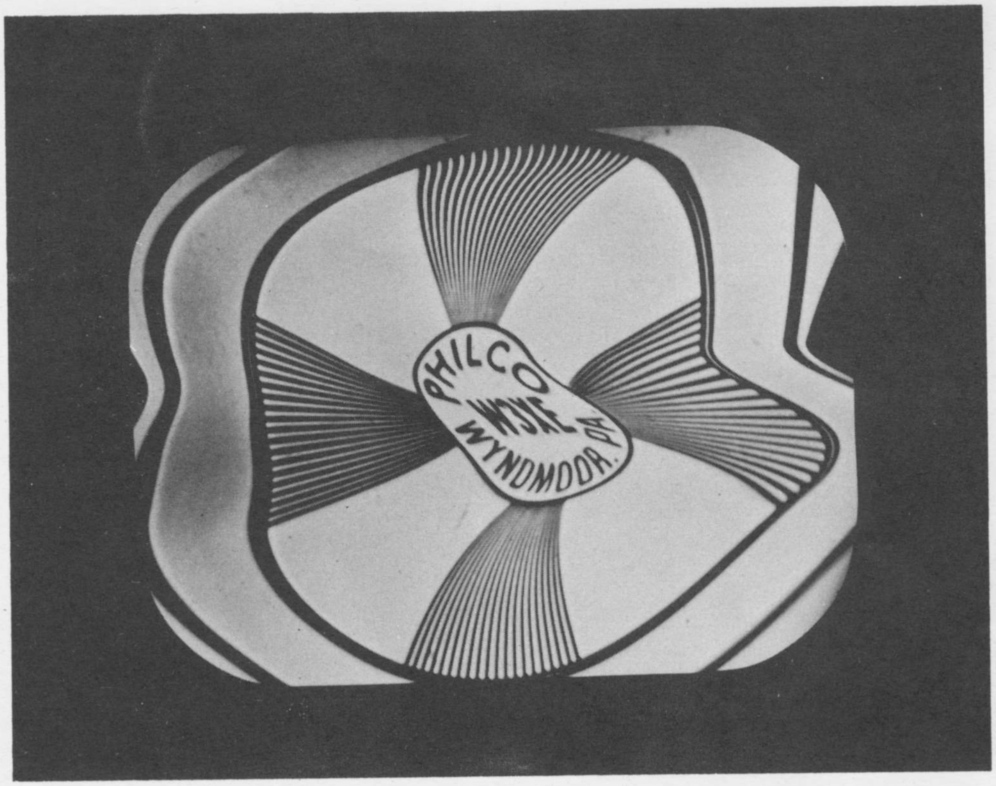
TP-1021

Figure 63P. Audio Signal (400-cycle) in Video Output.



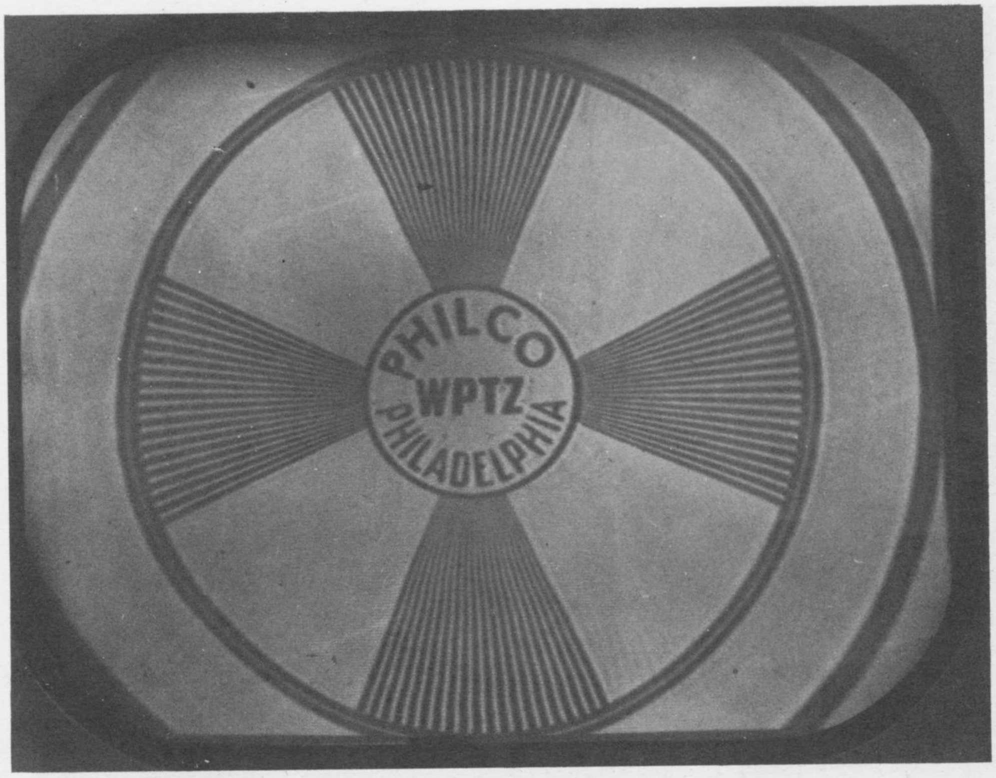
TP-1010

Figure 63Q. 60-Cycle A.C. in Video Output

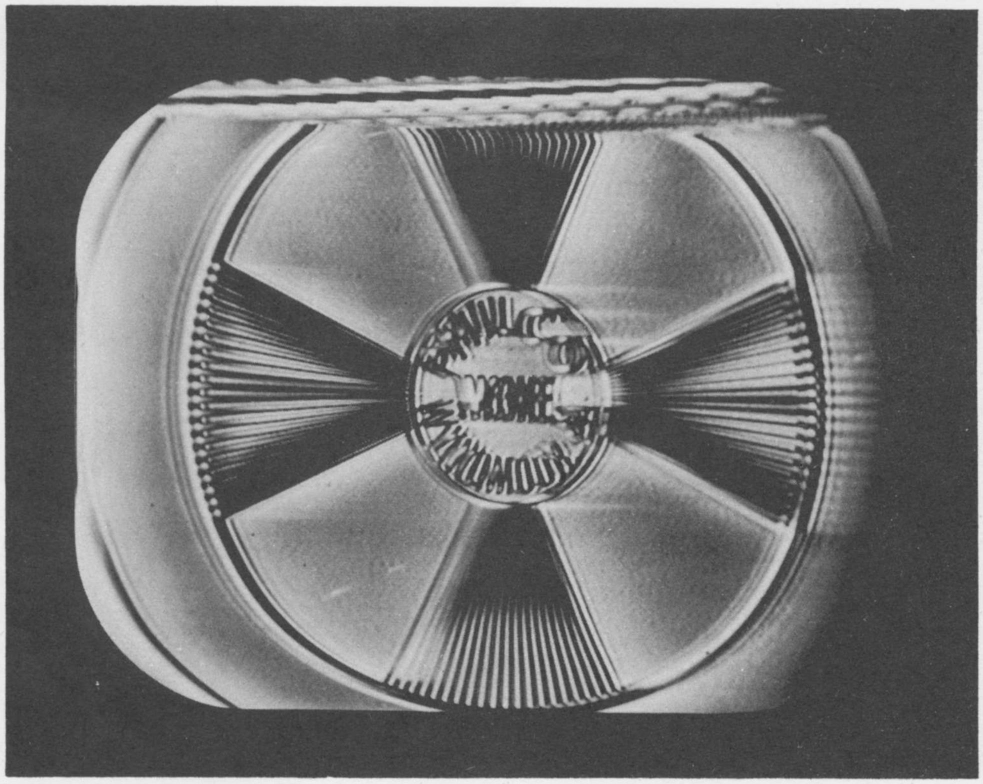


TP-1022

Figure 63R. Hum in the Horizontal-Deflection Coils.

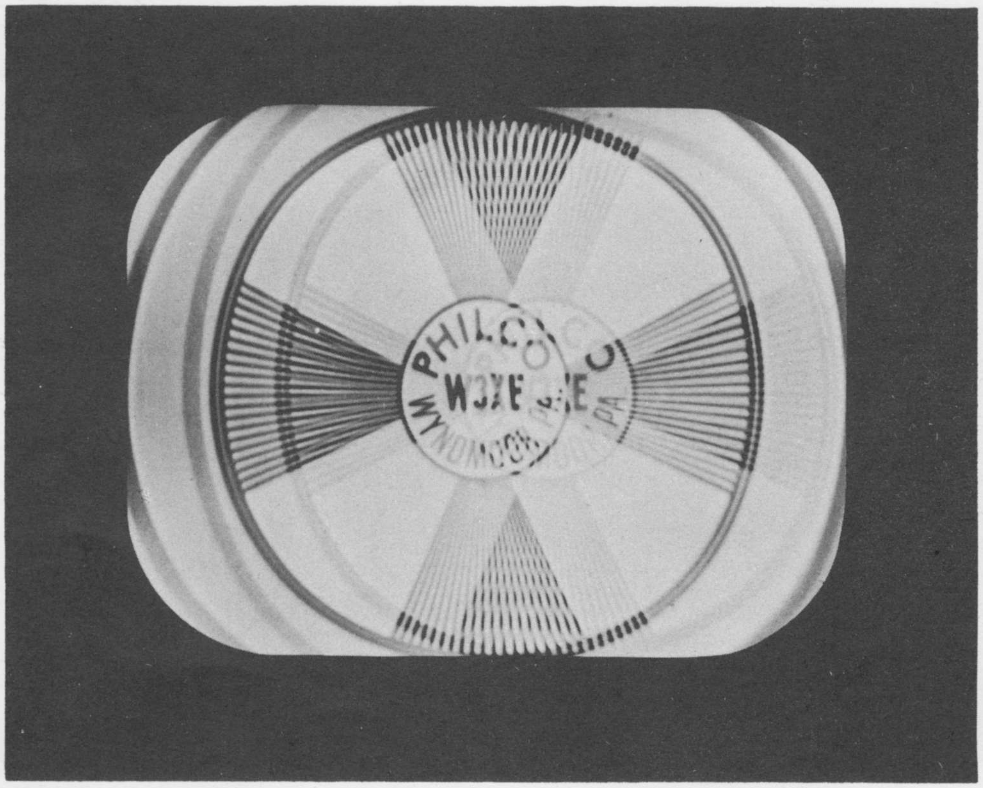


TP-1811



TP-1008

Figure 63T. Video Signal Too Strong.



TP-1023

Figure 63U. "Ghosts."

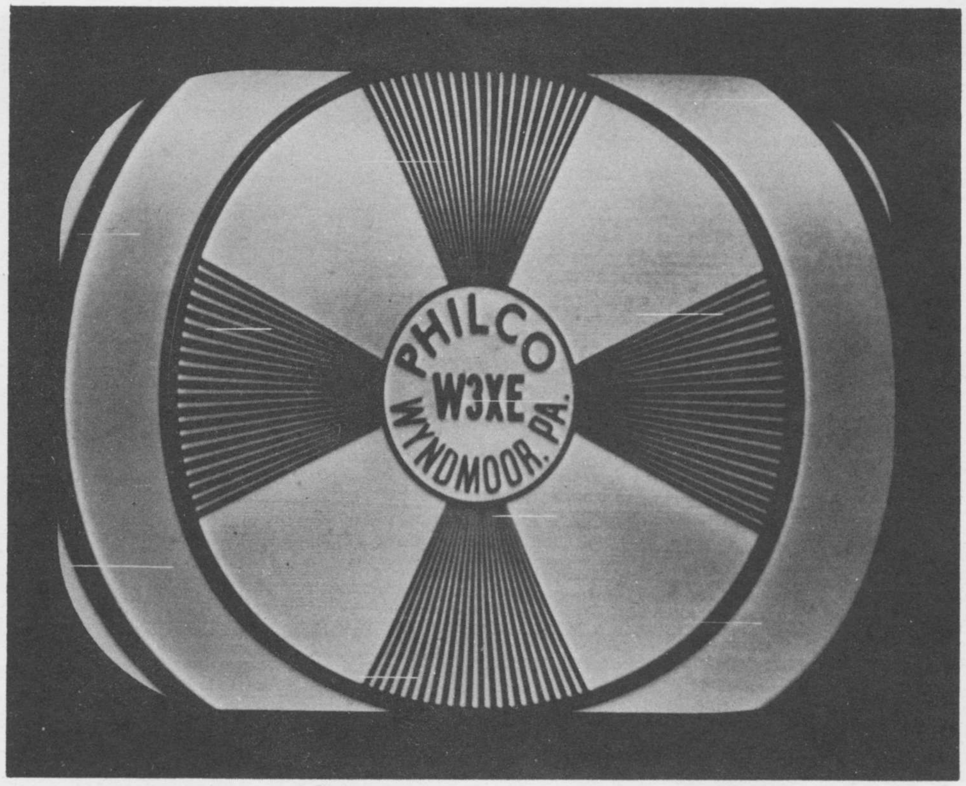
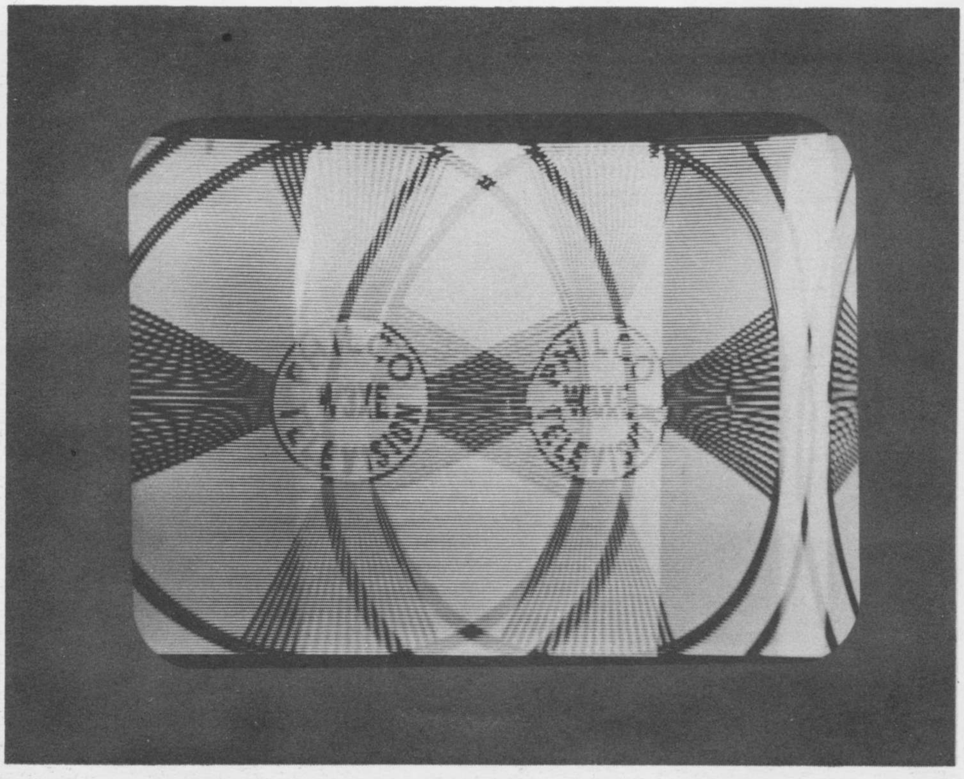
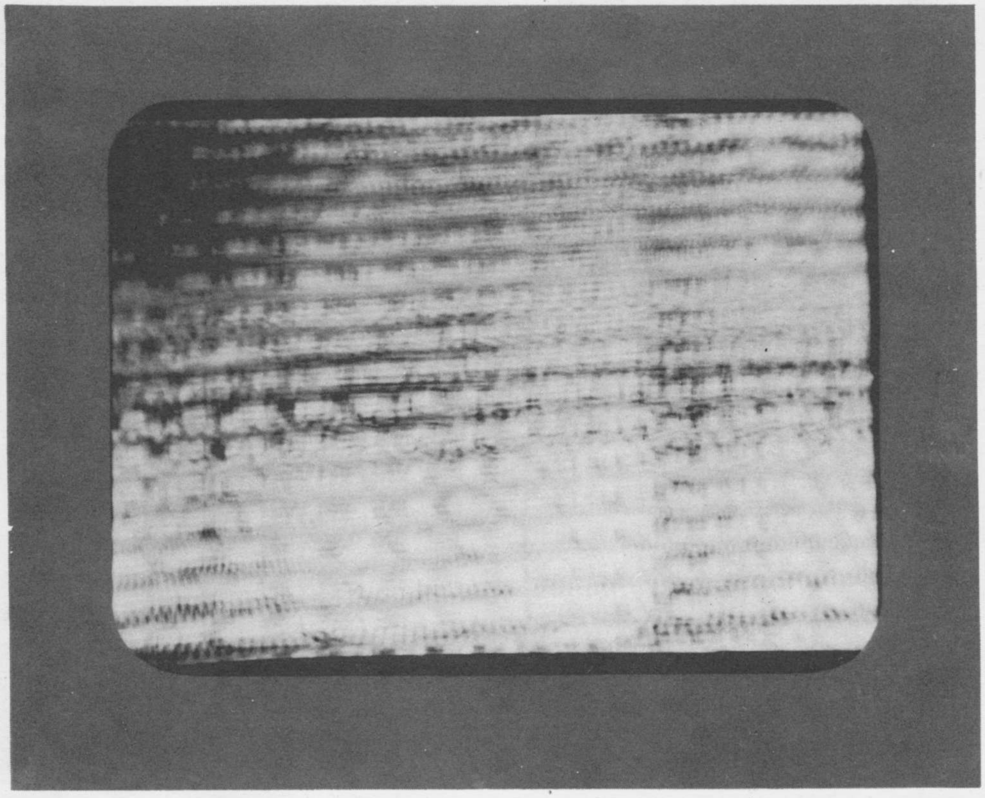


Figure 63V. Ignition Interference.

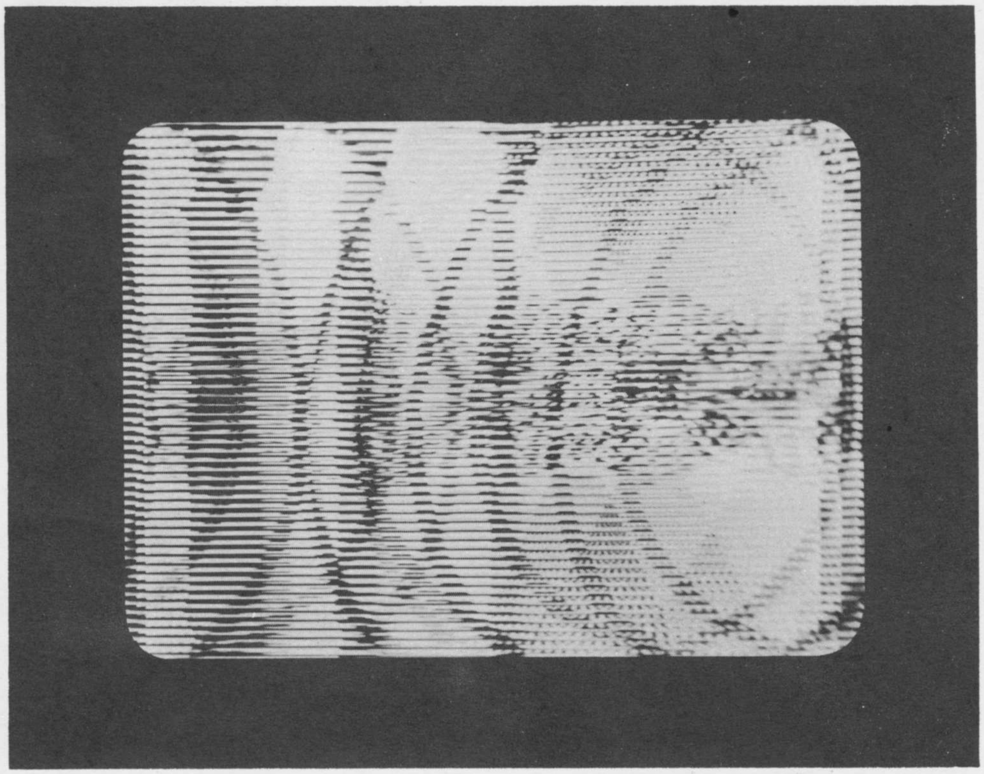
TP-1024





TP-1970

Figure 63X. Loss of Horizontal Sync (Moderately Slow Sweep).



TP-1971

Figure 63Y. Loss of Horizontal Sync (Slow Sweep).

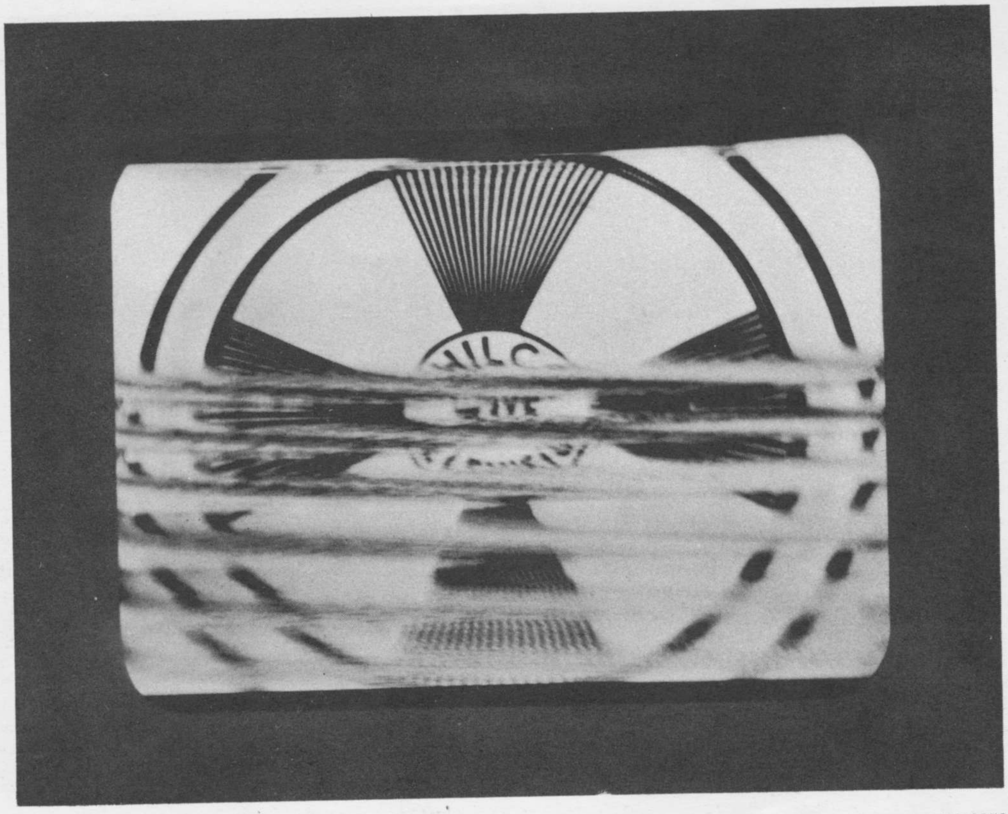
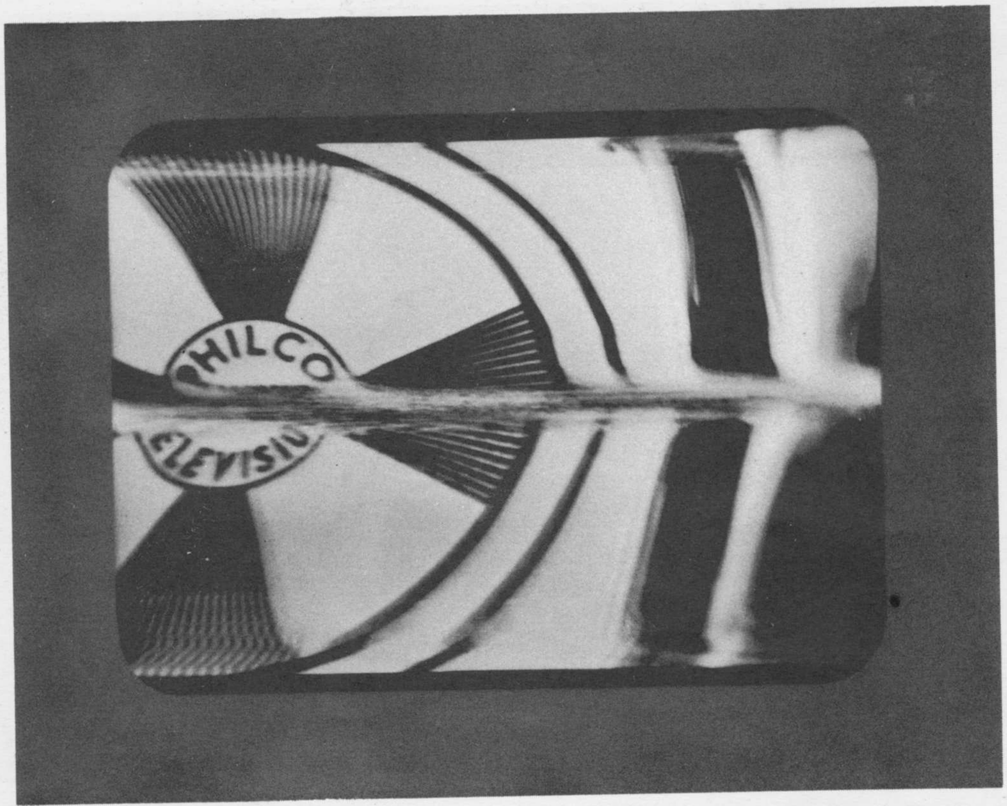


Figure 63Z. Loss of Horizontal Sync (Sweep Slowly Approaching Sync).



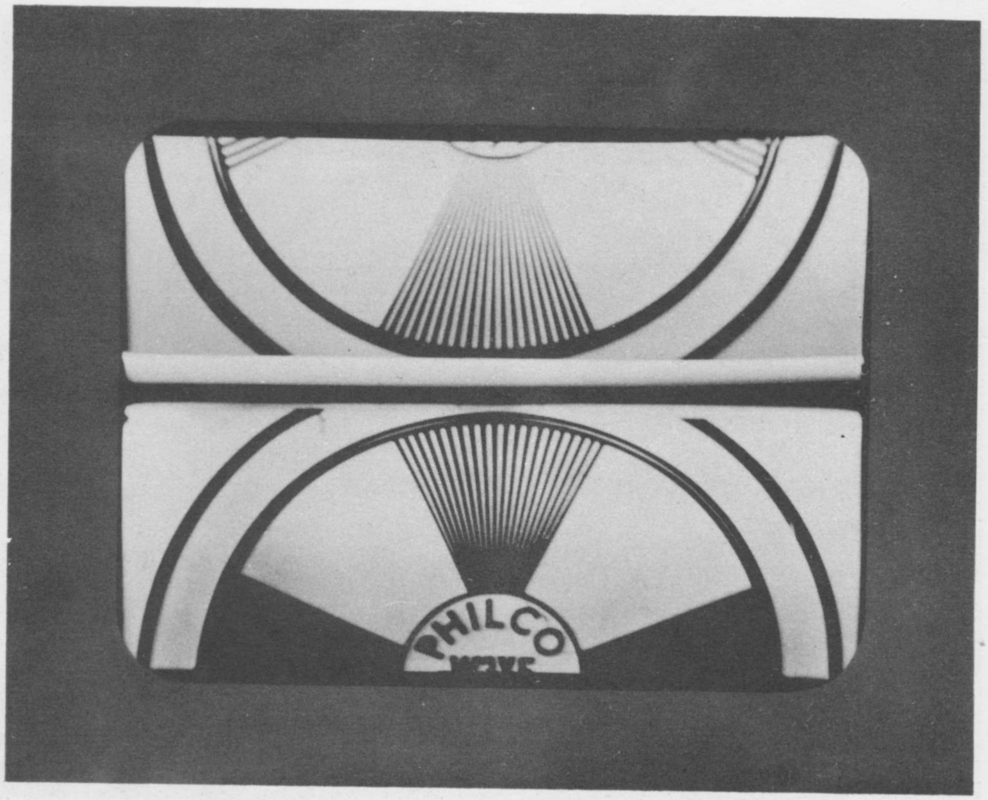


Figure 63BB. Loss of Vertical Sync.

TP-1974

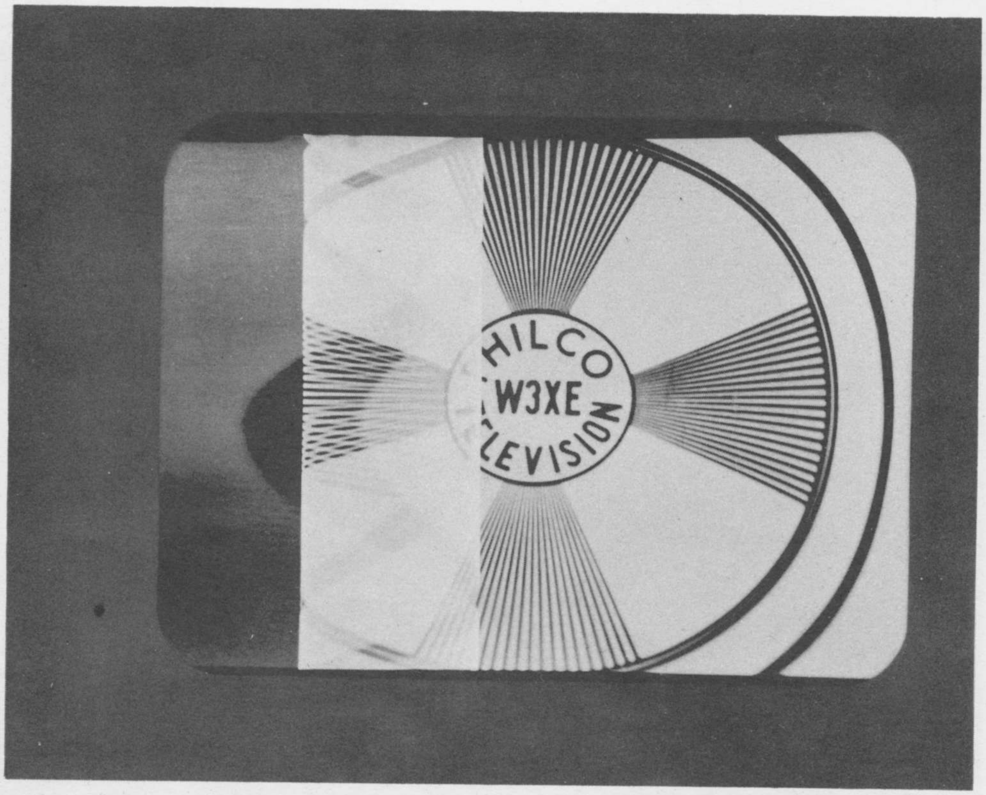
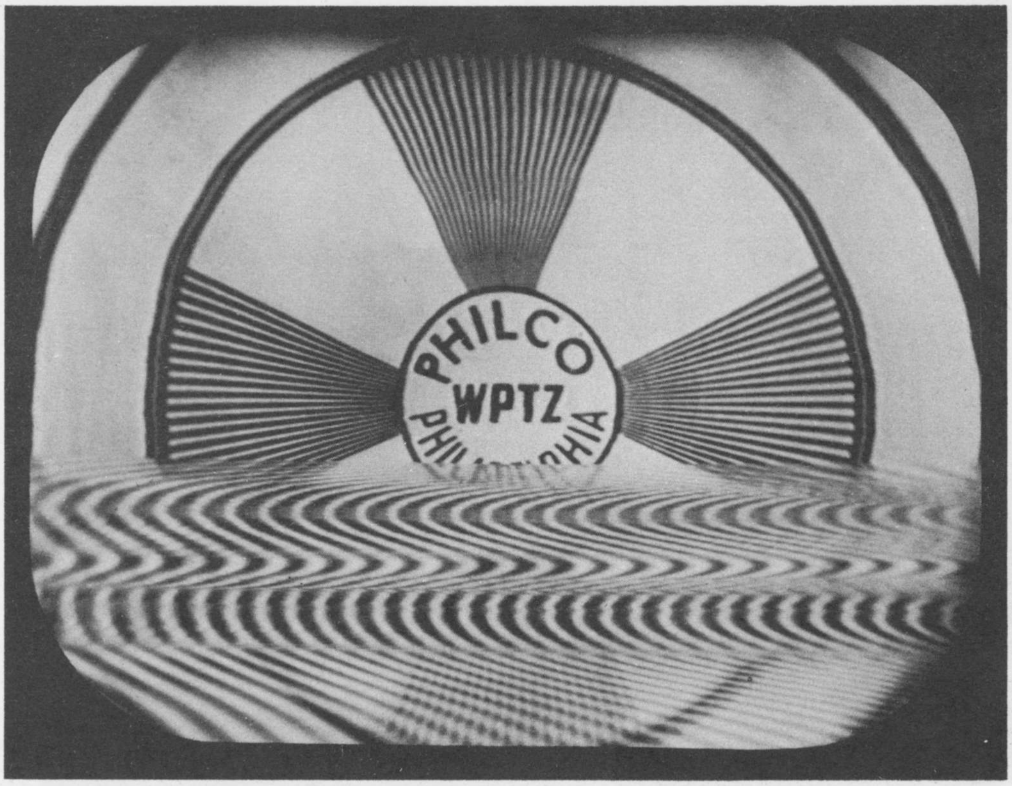


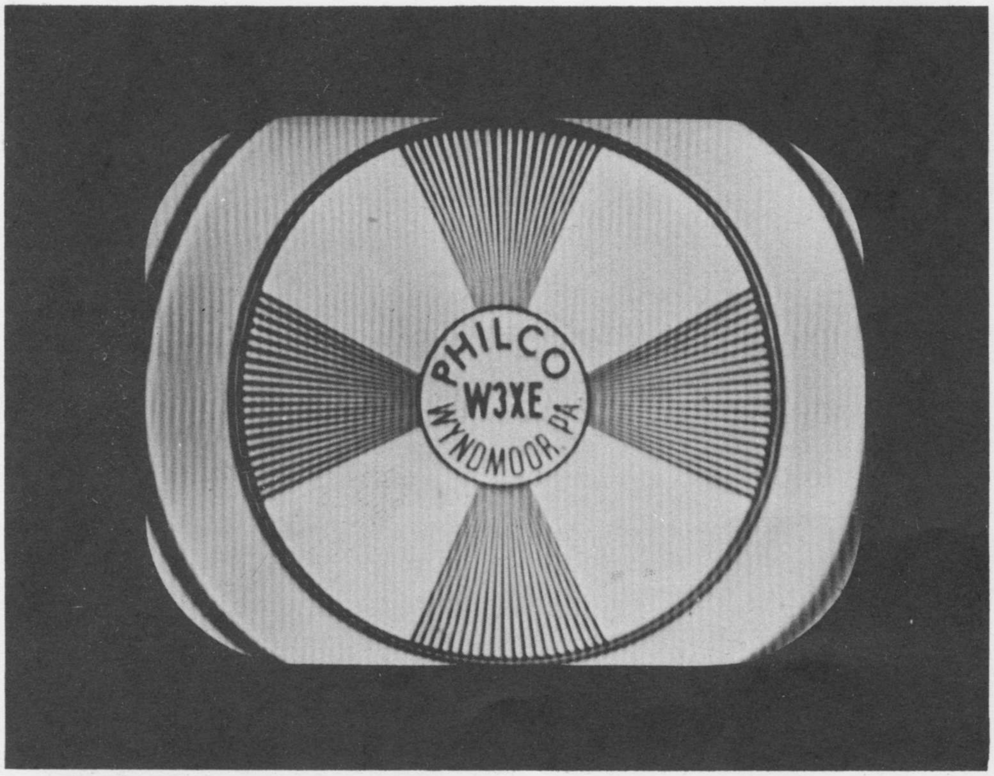
Figure 63CC. Defective Horizontal Sweep.

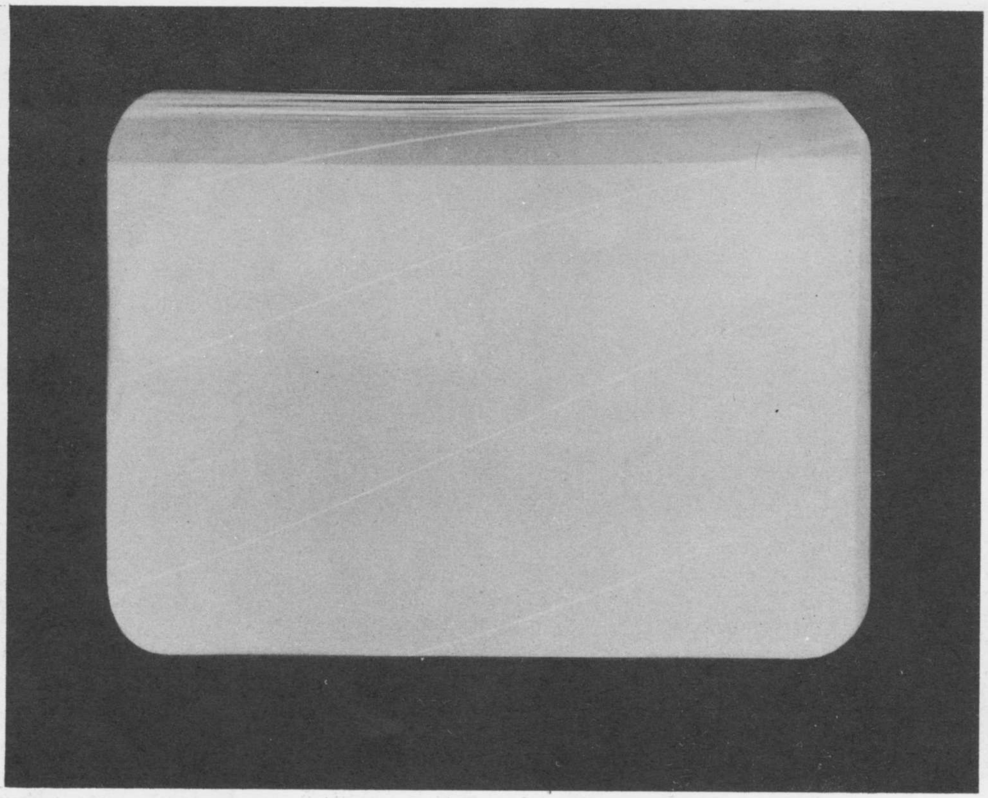
TP-1975



TP-1812

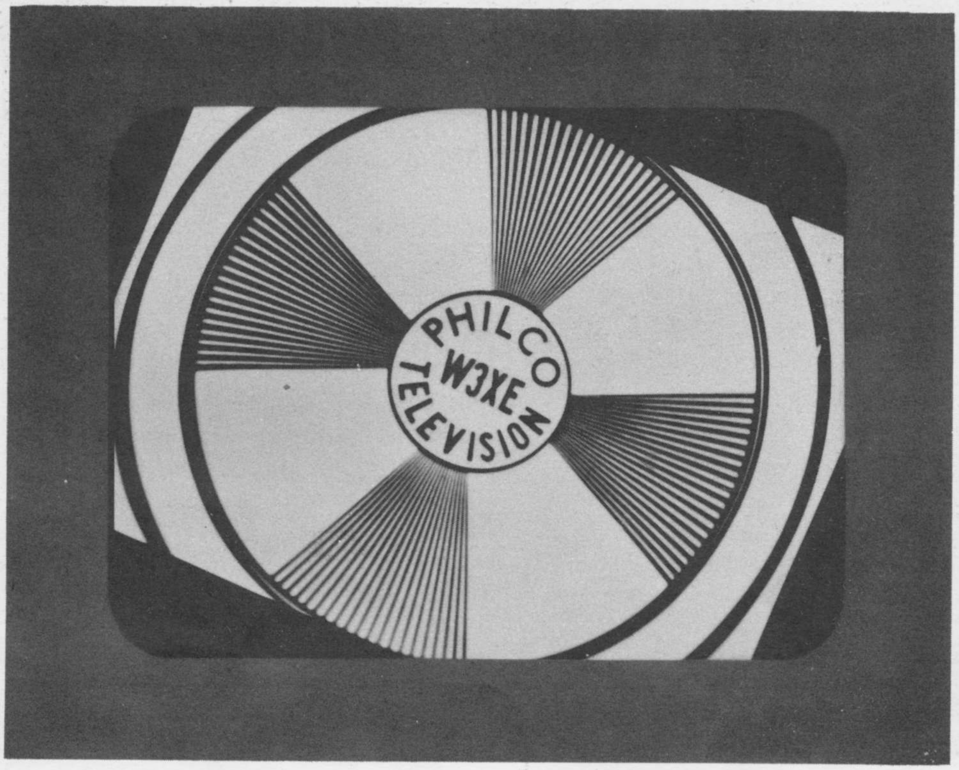
Figure 63DD. Diathermy Interference.





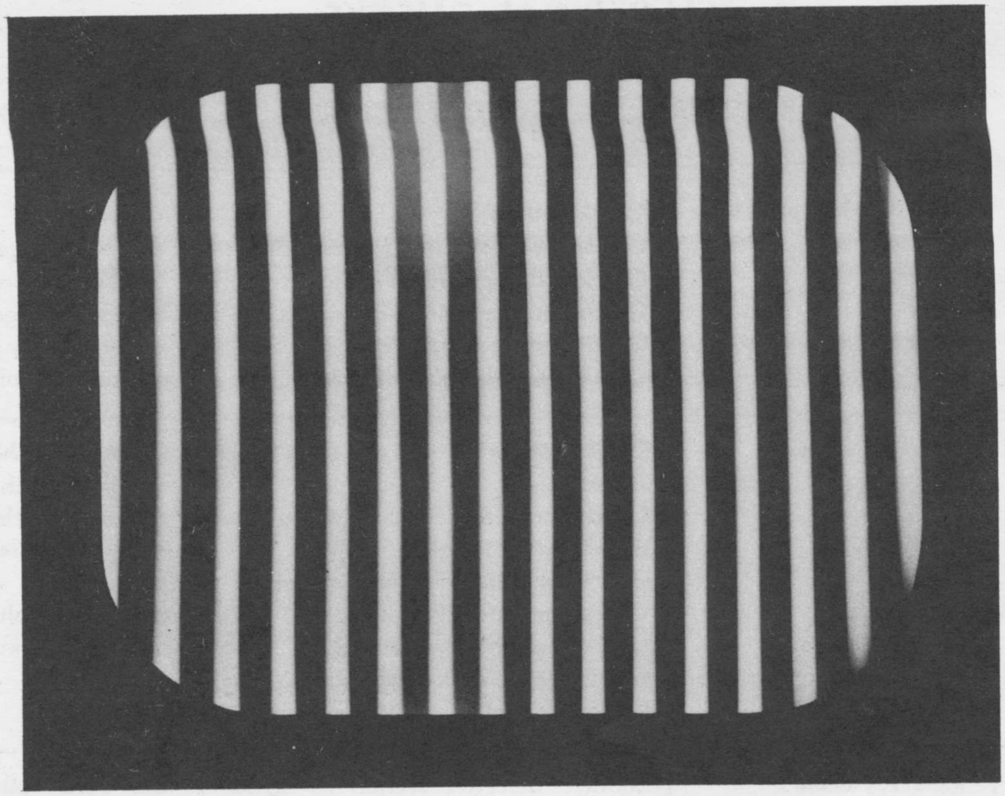
TP-1976

Figure 63FF. Defective Video Channel (Scanning Raster Correctly Oriented).



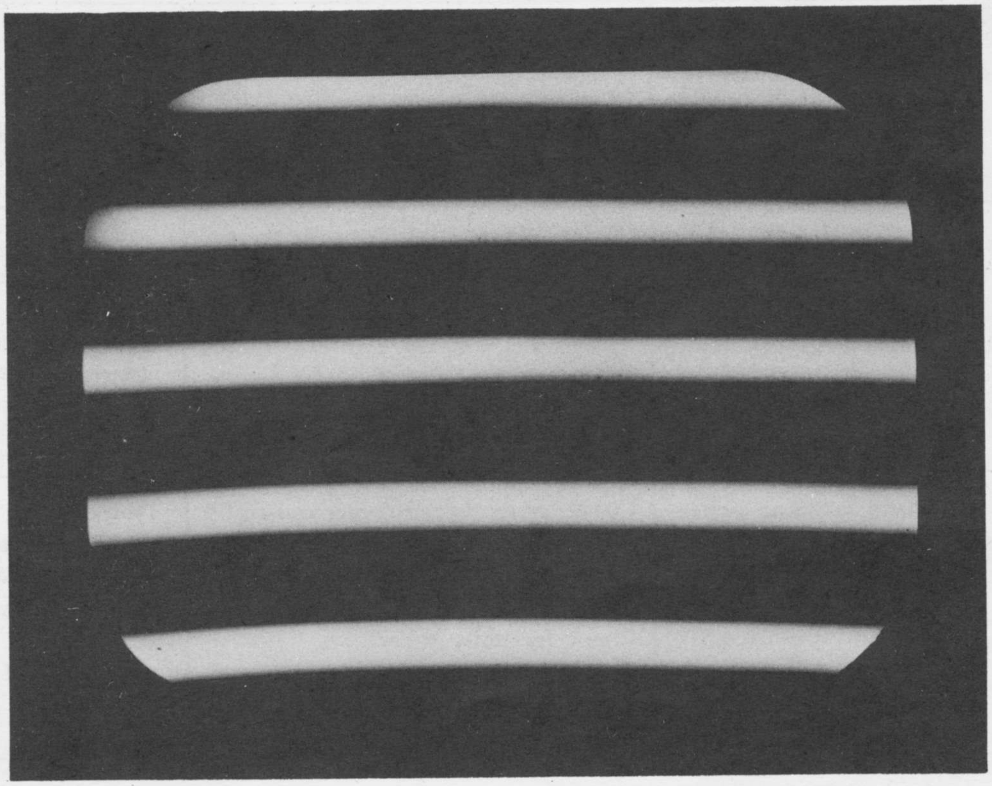
TP-1977

Figure 63GG. Improper Orientation of Picture.



TP-1011

Figure 63HH. Signal-Generator Pattern (Vertical).



TP-1009

Figure 63JJ. Signal-Generator Pattern (Horizontal).

ELECTRICAL CHECKS

LOCATION	EFFECT ON RECEIVER	SUGGESTED CHECKS	SPECIAL NOTES
Audio channel.	Receiver has poor tone quality.	Check tubes. Check for open coupling capacitor. Check for open by-pass capacitor. Check for open filter capacitor. Check tuning adjustment. Check audio i-f alignment.	Check tubes in tube tester or preferably by substituting tubes known to be good. Discriminator is common source of trouble.
Audio channel.	Receiver noisy.	Check for noise pickup from sync circuits. Check for defective contacts on tube sockets. Check for defective channel switch. Check for defective tubes. Check for defective resistors. Check for defective capacitors. Check for peaks in response curve.	Capacitors should be checked, both electrically and mechanically. To eliminate noise pickup from sync circuits, dress volume-control leads away from sync circuits.
Audio channel.	Receiver dead.	Localize defective section by signal-substitution method. Isolate defective part in section.	Use both voltage and resistance analyses.
Video channel.	Picture poorly defined (with CONTRAST, BACKGROUND and TUNING controls set correctly).	Check for weak received signal. Check for incorrect alignment of video i-f stage. Check for incorrect tuning.	
Video channel.	Picture contains dark lines.	Check for interference caused by diathermy or other high-frequency radiating machinery. Check for heterodyning of r-f carriers. Check for hum. Check for audio modulation.	Automobile ignition interference can be very troublesome, especially if the antenna is located in radiation areas of passing automobiles.
Video channel.	Picture contains noise. Noise signal energy in the picture channel results in patterns of splotches appearing in picture and is referred to as noise in picture.	Check for local interference caused by diathermy machine, electrical equipment, or automobile ignition. Check for noisy tube-socket contacts. Check for noisy tubes. Check for noisy resistors and capacitors.	Noisy tubes, resistors, and capacitors can usually be located by tapping with a light object such as the eraser end of a pencil.

LOCATION	EFFECT ON RECEIVER	SUGGESTED CHECKS	SPECIAL NOTES
Video channel.	No picture.	Localize defective section by signal-substitution method. Isolate defective part in section.	Use voltage and resistance analyses, and signal-generator method.
Horizontal-sweep circuits.	Poor linearity of picture with LINEARITY control properly set but defects still existing.	Check for changed value of grid and plate resistors. Check for changed value of coupling and by-pass capacitors. Check for defective deflection coils. Check for defective matching transformer. Check for defective tubes.	If defective deflection coils or matching transformer are suspected, replace with new assemblies.
Horizontal-sweep circuits.	Insufficient sweep amplitude (WIDTH control properly adjusted).	Check for changed value of grid and plate resistors. Check for changed value of coupling and by-pass capacitors. Check for defective deflection coils. Check for defective matching transformer. Check for defective tubes.	If defective deflection coils or matching transformer are suspected, replace with new assemblies.
Horizontal-sweep circuits.	No synchronization of horizontal sweep.	Check for lack of synchronizing signal. Check for insufficient sync signal supplied to sync amplifier. Check for weak video signal. Check for insufficient gain in video i-f amplifier. Check for defective sync separator. Check for dead horizontal-sync amplifier. Check for defective horizontal-oscillator stage. Check tubes.	Amplitude of sync pulse can be observed with oscilloscope.
Horizontal-sweep circuits.	No horizontal sweep.	Localize defective section by signal-substitution method. Isolate defective part in circuit.	Use both voltage and resistance analyses. Check for cause of part failure.

LOCATION	EFFECT ON RECEIVER	SUGGESTED CHECKS	SPECIAL NOTES
Vertical-sweep circuits.	Poor linearity of picture with LINEARITY control properly set but defects still existing.	Check for changed value of grid and plate resistors. Check for changed value of coupling and by-pass capacitors. Check for defective deflection coils. Check for defective matching transformer. Check for defective tubes.	If defective deflection coils or matching transformer are suspected, replace with new assemblies.
Vertical-sweep circuits.	Insufficient sweep amplitude (HEIGHT control properly adjusted).	Check for changed value of grid and plate resistors. Check for changed value of coupling and by-pass capacitors. Check for defective deflection coils. Check for defective matching transformer. Check for defective tubes.	If defective deflection coils or matching transformer are suspected, replace with new assemblies.
Vertical-sweep circuits.	No synchronization of vertical sweep.	Check for lack of synchronizing signal. Check for insufficient sync signal applied to sync amplifier. Check for weak video signal. Check for insufficient gain in video i-f amplifier. Check for defective sync separator. Check for dead vertical-sync amplifier. Check for defective vertical-oscillator stage. Check tubes.	Amplitude of sync pulse can be observed with oscilloscope.
Vertical-sweep circuits.	No vertical sweep.	Localize defective section by signal-substitution method. Isolate defective part in section.	Use both voltage and resistance analyses.
Picture tube.	Poor brightness.	Check for "soft" picture tube.	Check by substituting new picture tube.
Picture tube.	Poor focus.	Check for "soft" picture tube.	High current also indicates "soft" tube.
Picture tube.	Lack of normal effect of BACKGROUND control.	Check for gassy picture tube. Check for partial short from cathode to grid. Check for open 6V6.	Substitute picture tube.

LOCATION	EFFECT ON RECEIVER	SUGGESTED CHECKS	SPECIAL NOTES
Picture tube.	Bright tube.	Check for partial short from cathode to grid. Check for gassy tube.	Substitute picture tube.
Picture tube.	Poor picture contrast.	Check for partial short from cathode to grid.	Substitute picture tube.
Picture tube.	Poor viewing screen.	Check for scratched fluorescent coating. Check for burnt fluorescent coating.	Substitute picture tube.
Picture.	No operation.	Check for burnt-out tube. Check for cracked envelope. Check for shorted elements. Check high-voltage supply.	
Power supply.	Hum in receiver.	Check for open filter capacitor. Check for shorted filter choke.	
Power supply.	Low power.	Check for low line-voltage. Check for open filter capacitor. Check for leaky filter capacitor. Check for weak rectifier tubes.	
Power supply.	No voltage.	Check for open filter choke. Check for dead rectifier tube. Check for open primary or secondary of power transformer. Check for short circuit.	

TROUBLE-SHOOTING CHARTS FOR SPECIFIC CIRCUITS

VIDEO CHANNEL		
TROUBLE	CAUSE	REMEDY
Noise in video and not in audio. Noise signal energy in the picture channel results in patterns of splotches appearing in picture and is referred to as noise in picture.	Microphonic tube (1232) in the video i-f amplifier circuit.	Replace defective tube.

AUDIO CHANNEL

TROUBLE	CAUSE	REMEDY
Hum in audio at high volume-control settings.	Volume-control leads in strong a-c field.	Dress volume-control leads away from a-c leads.
Distortion of audio; video is bright and clear.	Audio i-f amplifier out of alignment.	Realign audio i-f amplifier. Be careful to obtain correct discriminator waveform.
Noise in audio, but not in video.	Audio circuit is picking up interfering signals from sync circuits. Audio i-f amplifier is not correctly aligned.	Dress audio circuit leads away from sync-circuit leads. Realign audio i-f amplifier, being careful to obtain correct discriminator response curve. If discriminator is incorrectly adjusted, it will cause the audio to be distorted.
Noisy audio reception and weak audio output.	Microphonic tube (7V7) in audio i-f amplifier. Weak audio-output tube (7B5). Gain in audio i-f stage low.	Replace bad tubes. Realign audio i-f amplifier.
Noisy volume control.	Volume control is worn out.	Replace volume control and switch.
Picture is bright and clear but there is no audio.	(7B5) audio output plate by-pass capacitor (.006 mf) is shorted.	Replace defective capacitor.

COMBINATION AUDIO AND VIDEO CHANNEL

TROUBLE	CAUSE	REMEDY
Weak audio and weak video on all channels.	Low gain in mixer tube (1232).	Replace defective tube.
Noise in video and audio. Noise is still present when antenna is disconnected.	Poor electrical connection to the high-voltage anode on the picture tube.	Repair connection.
Unstable picture, i.e., video sync controls intermittently lose complete control and station carrier seems to shift.	The unstable condition can be due to a poorly soldered connection on the oscillator vernier.	Resolder connection.

TROUBLE	CAUSE	REMEDY
Set dead, no audio and no video.	Shorted .01-mf plate filter capacitor in first video i-f transformer.	Replace defective capacitor. Also replace 3,300-ohm dropping resistor. This resistor is always damaged when the capacitor shorts.

SYNC SEPARATOR

TROUBLE	CAUSE	REMEDY
Horizontal and vertical sweep circuits will not synchronize with incoming picture signal.	Trouble is lack of synchronizing pulses, indicating trouble must be in the sync-separator circuit.	Replace defective screen-grid by-pass capacitor (10 mf) on sync-separator tube (6Y6G). Also due to interference from electrical appliances, units, autos, light bulbs, etc., taking over the sync.

HORIZONTAL-SWEEP CIRCUITS

TROUBLE	CAUSE	REMEDY
Picture is only ¾ normal width and white vertical bar appears at left of picture.	Horizontal-sweep circuits may not be producing a linear sweep voltage. Horizontal-control tube (6V5G) may be defective.	Replace tube, if defective.
Picture width cannot be increased enough by regulating external controls.	Horizontal-deflecting circuits are not producing enough deflection voltage.	Check for defective horizontal-output transformer. Check horizontal-sweep tube. Check for changes in resistor values.
Vertical bar of light on picture-tube screen when the set is first turned on.	Bright bar appears because the horizontal-deflection circuits are not working.	The fact that they start to work several minutes after set has been turned on indicates a defective horizontal-oscillator tube.
Vertical bar of light on picture-tube screen. Does not disappear.	The result of horizontal-sweep circuit not functioning. Trouble is usually in horizontal oscillator. Check for shorted .01-mf capacitor in the grid circuit of the (884) oscillator.	Replace shorted capacitor.

TROUBLE	CAUSE	REMEDY
Arcing sound and the intermittent appearance of a vertical bar of light on the picture-tube screen.	High-voltage breakdown between cathode resistor of horizontal-control tube 6V5 and shielded volume-control cable.	Dress lead away from socket of tube 6V5.

VERTICAL-SWEEP CIRCUITS

TROUBLE	CAUSE	REMEDY
When set is jarred, the vertical-synchronizing circuits lose control.	Dirty contacts on tube pins in vertical-deflection circuits. Noisy tubes in the vertical-deflection circuits.	Clean contacts. Replace defective tubes.
Intermittent horizontal white bar in picture accompanied by tearing of picture.	Intermittent breakdown of .25-mf coupling capacitor to grid of vertical-sweep-output tube (6K6).	Replace defective capacitor.
Picture height can be increased, but when the height is increased the test chart picture is vertically non-linear. This fault cannot be corrected by adjusting the vertical-linearity control.	Time constant in the plate circuit of the vertical discharge tube, (6C8) has changed. The 1-megohm plate-dropping resistor has increased in value.	Replace defective 1-megohm resistor.
White horizontal line or lines across picture.	Static discharge from tube envelope.	Replace 6K6 vertical-amplifier tube.

PICTURE-TUBE CIRCUITS

TROUBLE	CAUSE	REMEDY
Background control does not regulate brightness of picture. Picture screen is so bright that the picture appears to be washed out.	Failure of background control to regulate brightness of picture tube indicates lack of grid-control voltage. This is usually the result of leakage between grid and cathode of the picture tube.	Replace defective picture tube.
No video when station is tuned in. Audio is reproduced with good quality.	Observation discloses burned-out 10AP4 picture tube.	Replace defective tube.
Spot on picture tube.	Viewing screen defective.	Replace tube.

HIGH-VOLTAGE SUPPLY

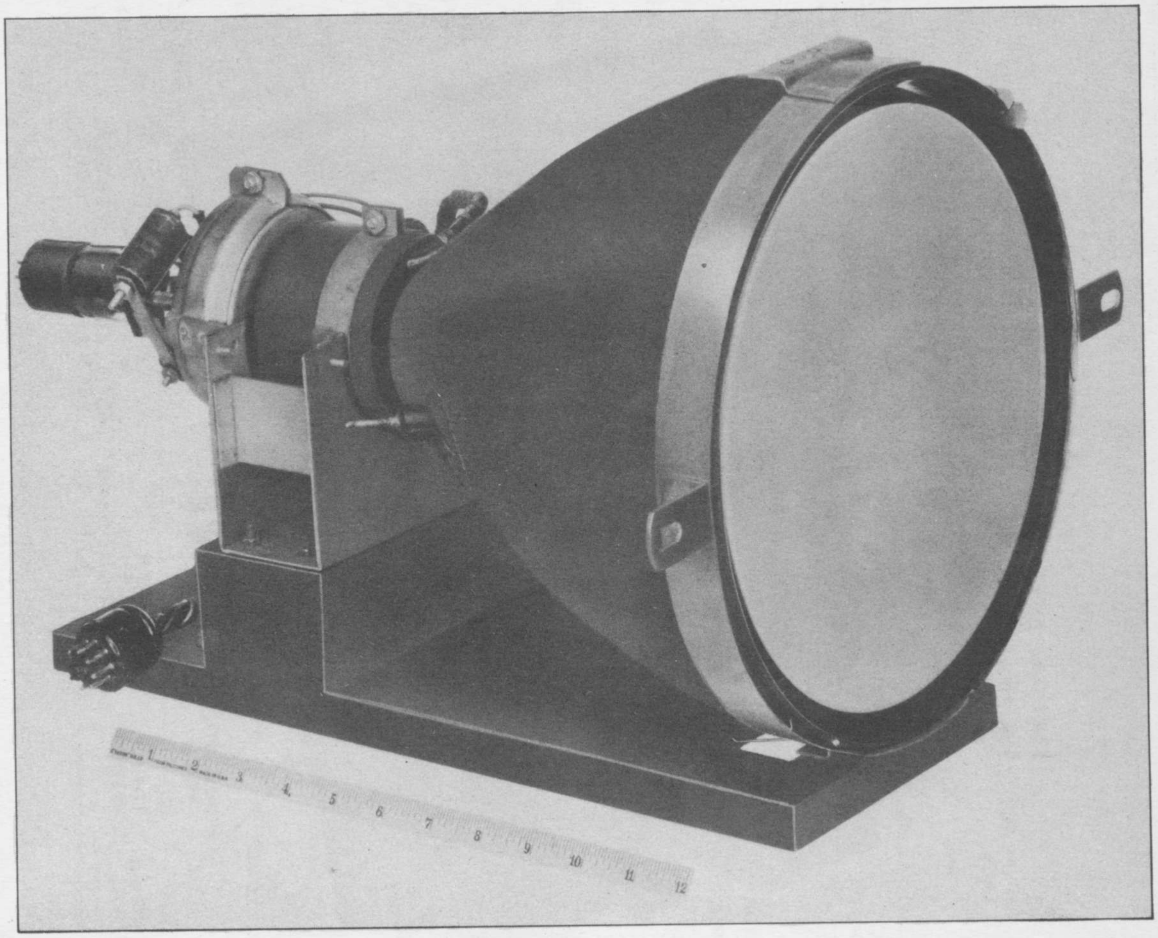
TROUBLE	CAUSE	REMEDY
No video but audio is reproduced with good quality.	Dirty contacts on safety switch on tube socket. Removing tube opens safety switch in primary circuit of high-voltage transformer.	Clean contacts.
No light on picture tube when station is tuned in. Audio is clear.	High-voltage-rectifier tube burned out or gassy. If gassy, check filter resistors.	Replace defective tube. Replace resistors if necessary.
High-voltage breakdown accompanied by odor.	Rectifier tube has loose seal on high-voltage cap.	Replace rectifier tube.
High-voltage breakdown in wiring of the power-supply shield.	Opening for leads through high-voltage shield too small, causing the insulation to be weakened.	Increase size of wire opening in high-voltage shield and replace burned wiring.

CONTROL ADJUSTMENT

TROUBLE	CAUSE	REMEDY
No video when station is tuned in. Audio is reproduced with good quality.	Observation discloses (10AP4) picture tube is not burned out, but that centering coil is not correctly positioned. This trouble is frequently due to someone dusting inside cabinet and bumping coil with duster.	Readjust centering coil.
Picture stretched either horizontally or vertically.	Indicates incorrect aspect ratio. Correct ratio is 4:3.	Regulate width and height controls to obtain correct aspect ratio.
Lines of images which are known to be straight, either vertically or horizontally, appear bent or curved.	Indicates incorrect adjustment of vertical and horizontal linearity controls.	Regulate vertical and horizontal linearity controls until linearity is obtained. A test pattern must be used to make this adjustment.

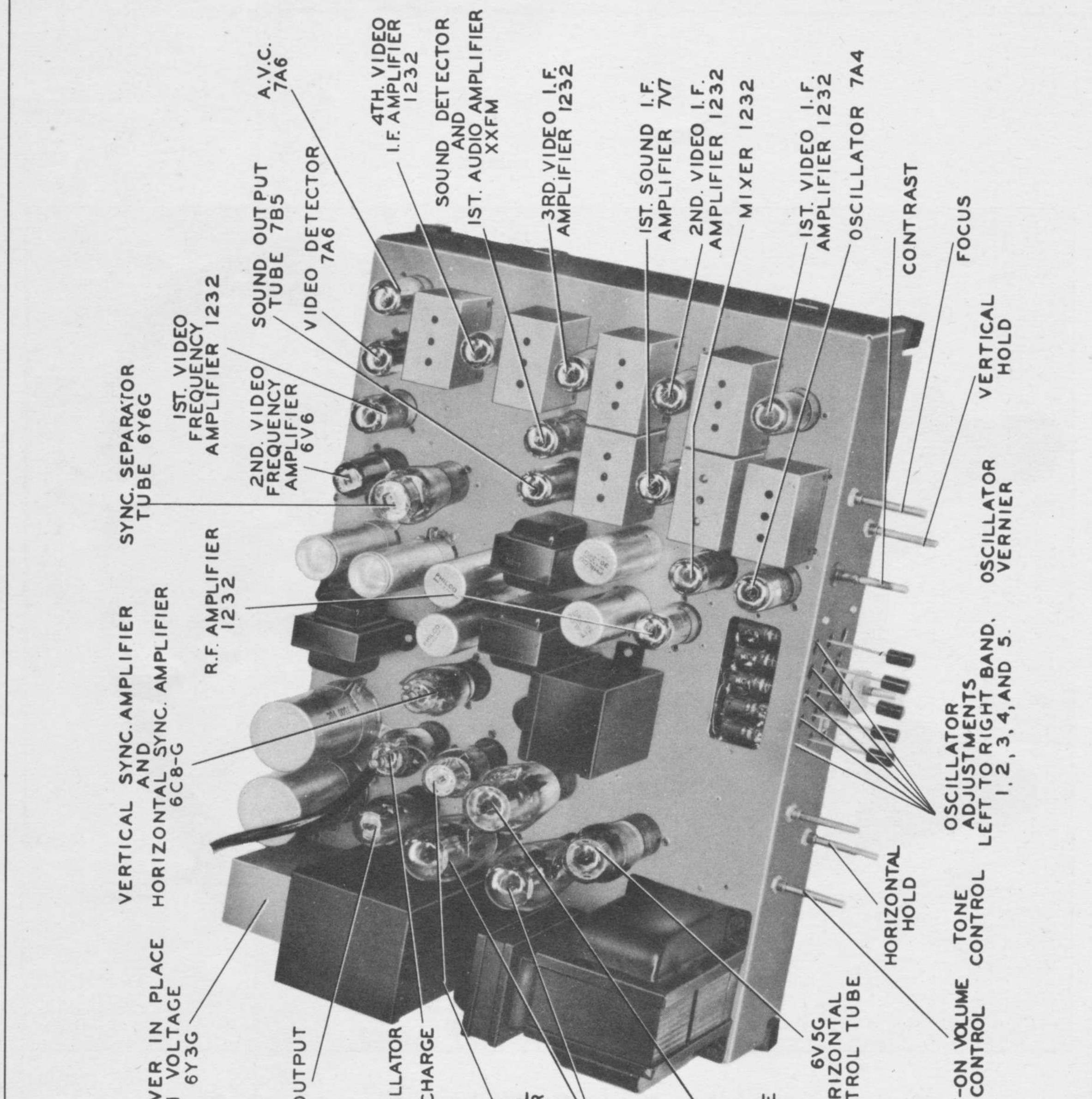
TUBE-FUNCTION CHART

TUBE TYPE	FUNCTION
1232	R-F Amplifier
1232	Mixer
7A4	Local Oscillator
1232	1st Video I-F Amplifier
1232	2nd Video I-F Amplifier
1232	3rd Video I-F Amplifier
1232	4th Video I-F Amplifier
7A6	Detector
7A6	A.V.C.
1232	1st Video-Frequency Amplifier
6V6	2nd Video-Frequency Amplifier
10AP4	Picture Tube
6Y6G	Synchronizing-Pulse Separator
6C8	{ Horizontal-Synchronizing-Pulse Amplifier { Vertical-Synchronizing-Pulse Amplifier
884	Horizontal Oscillator
6AH5GT	Horizontal Output
6V5G	Horizontal Control
6C8	{ Vertical Oscillator { Vertical Discharge
6K6G	Vertical Output
7V7	1st Audio I-F Amplifier
XXFM	Audio Detector and Amplifier
7B5	Audio Output
5X4G	Low-Voltage Rectifier
6X3G	High-Voltage Rectifier



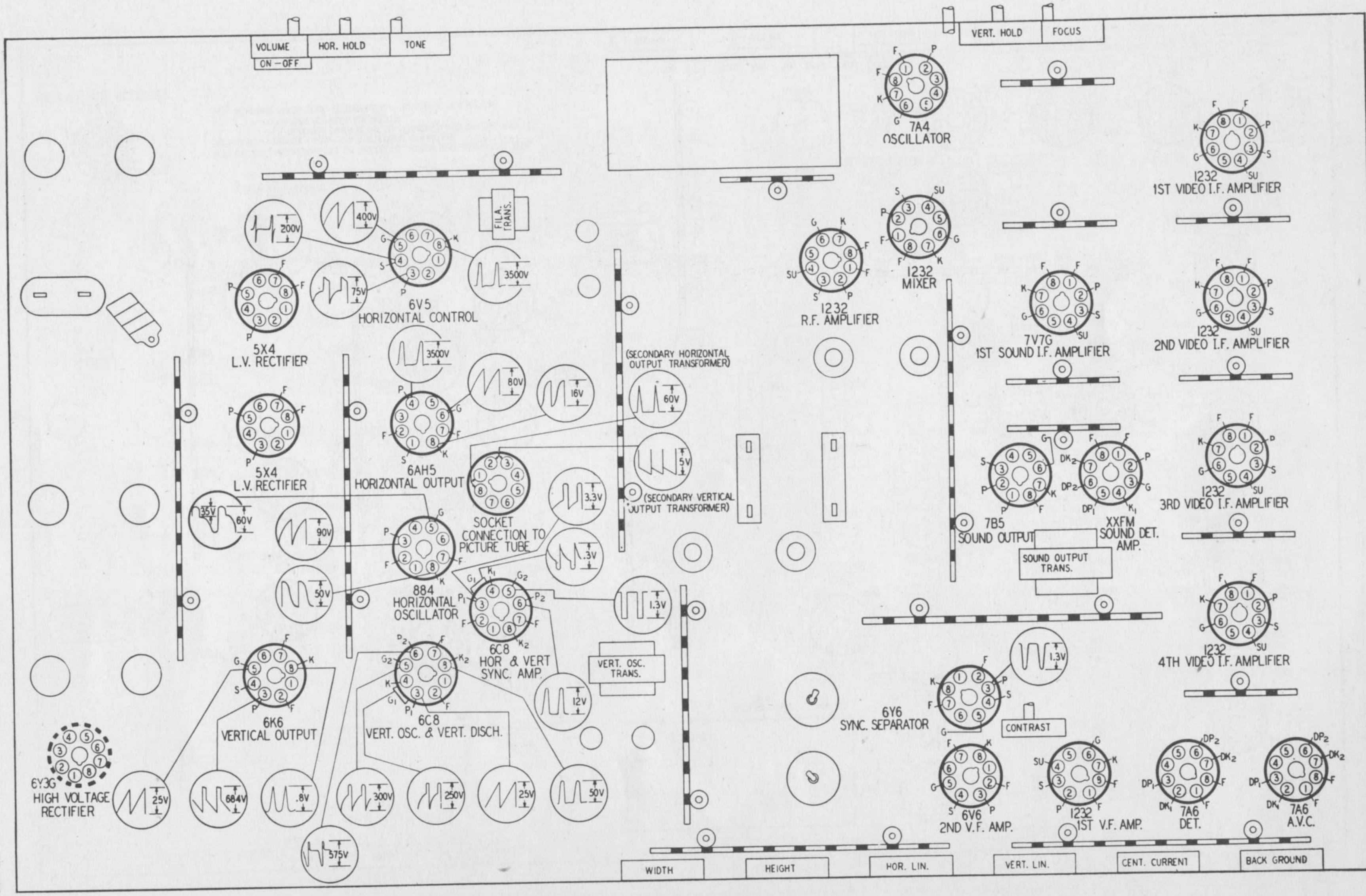
TP-914

Figure 64. A Picture Tube Showing Flat Viewing Surface and Canvas Cover.



TP-401

Figure 65. Top View of a Typical Television-Receiver Chassis.



TP-405

Figure 66. Tube-Socket Waveform Chart.

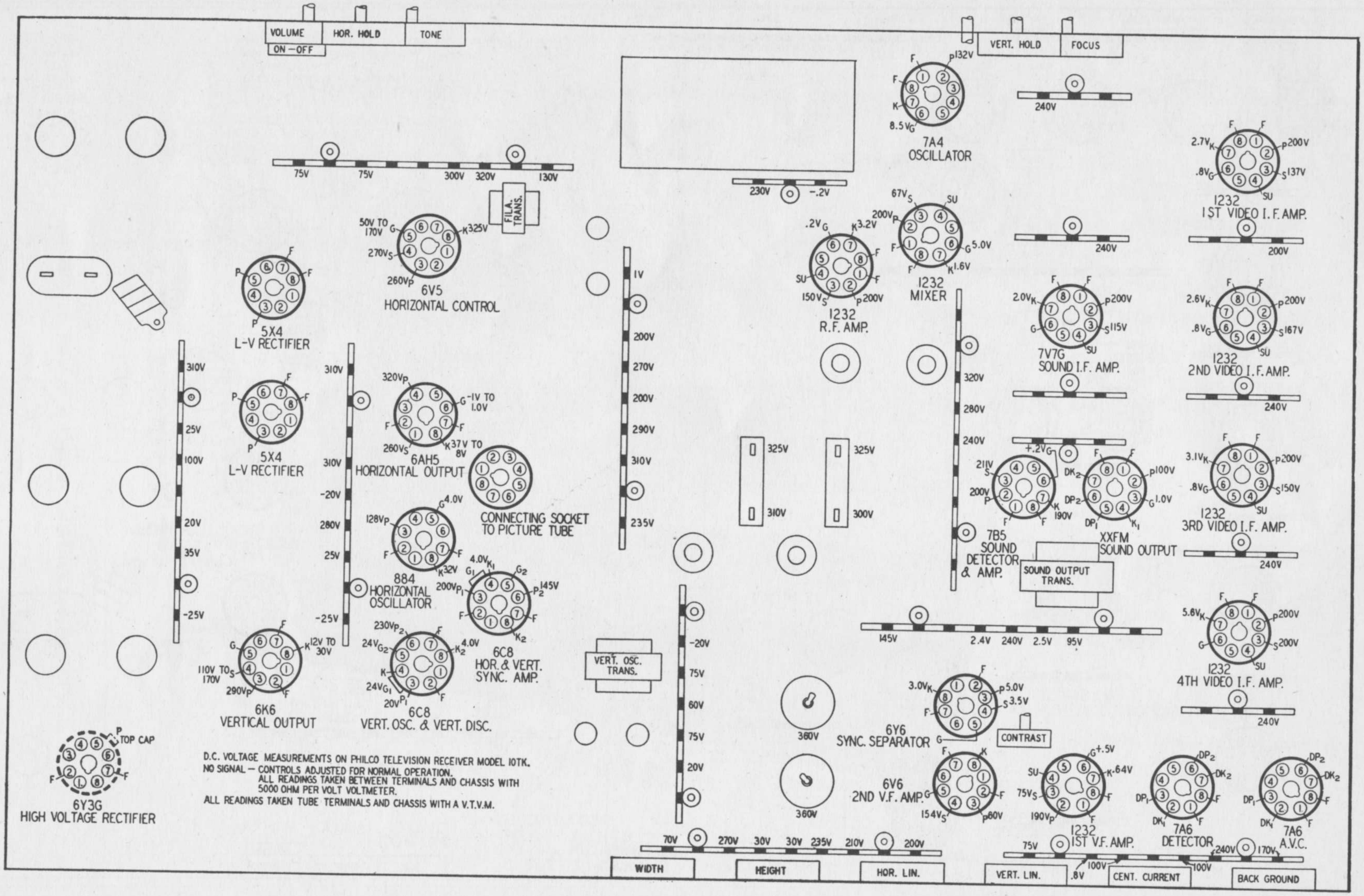


Figure 67. Tube-Socket D-C Voltage, Measurements Chart.

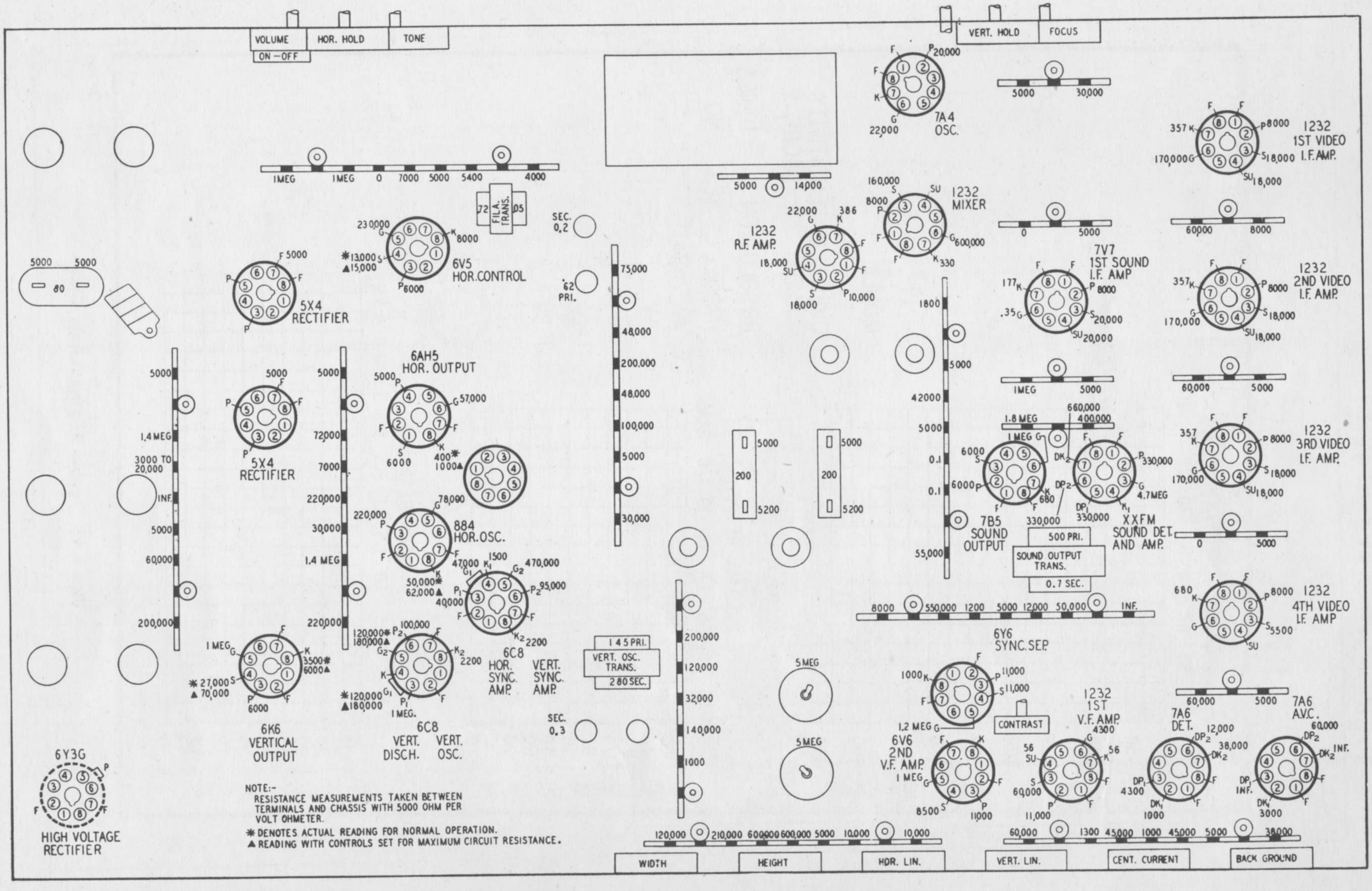


Figure 68. Tube-Socket Resistance, Measurements Chart.

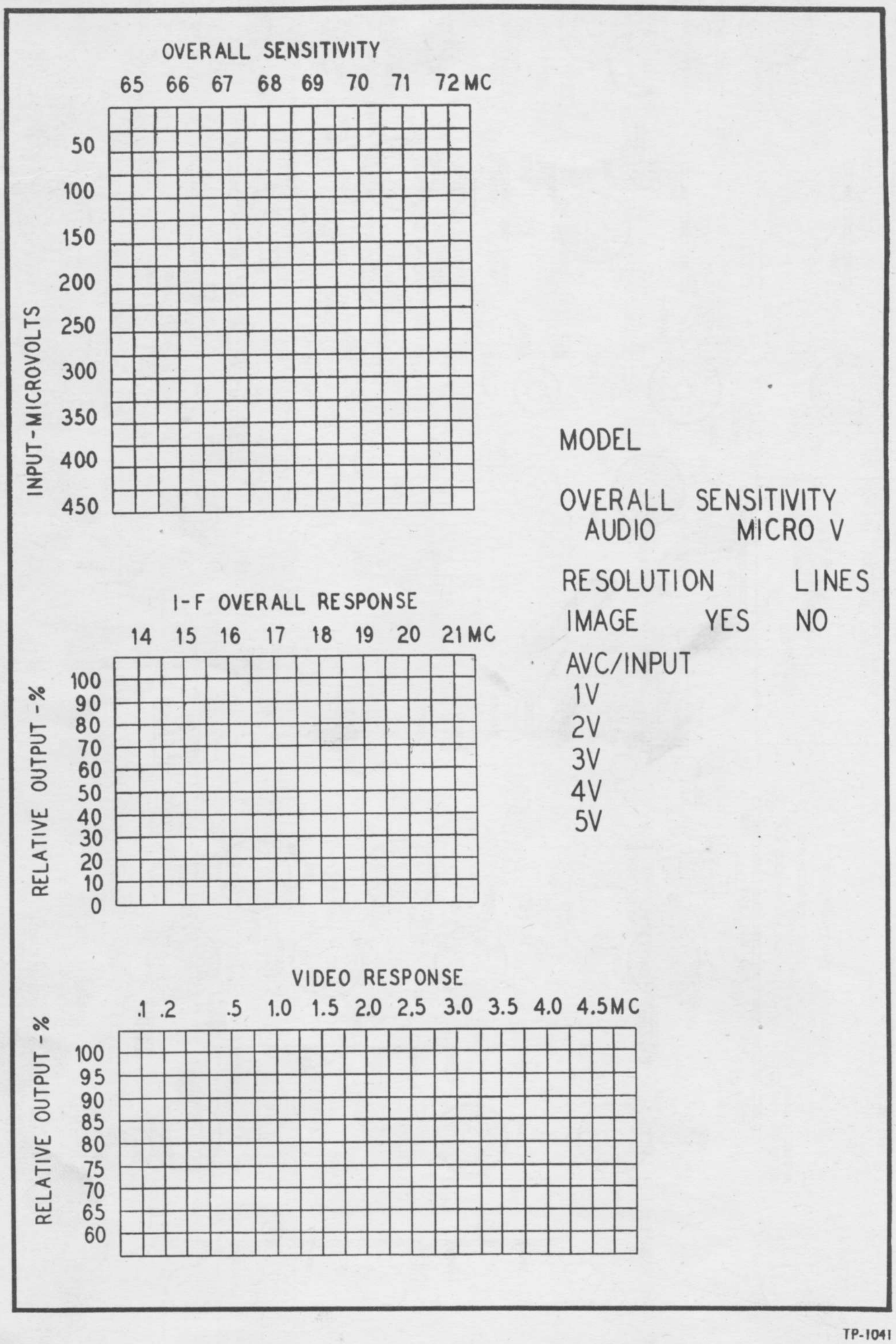
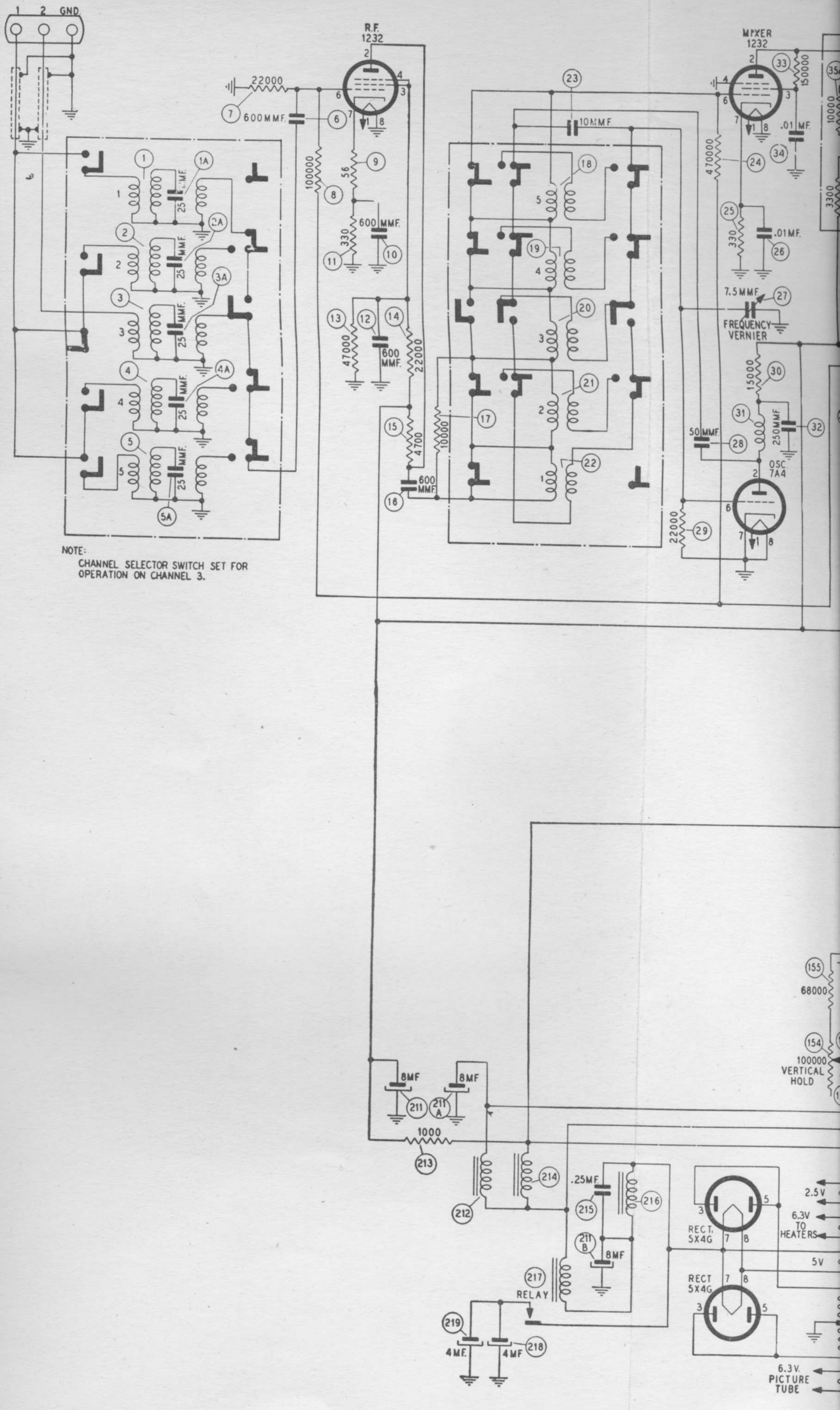
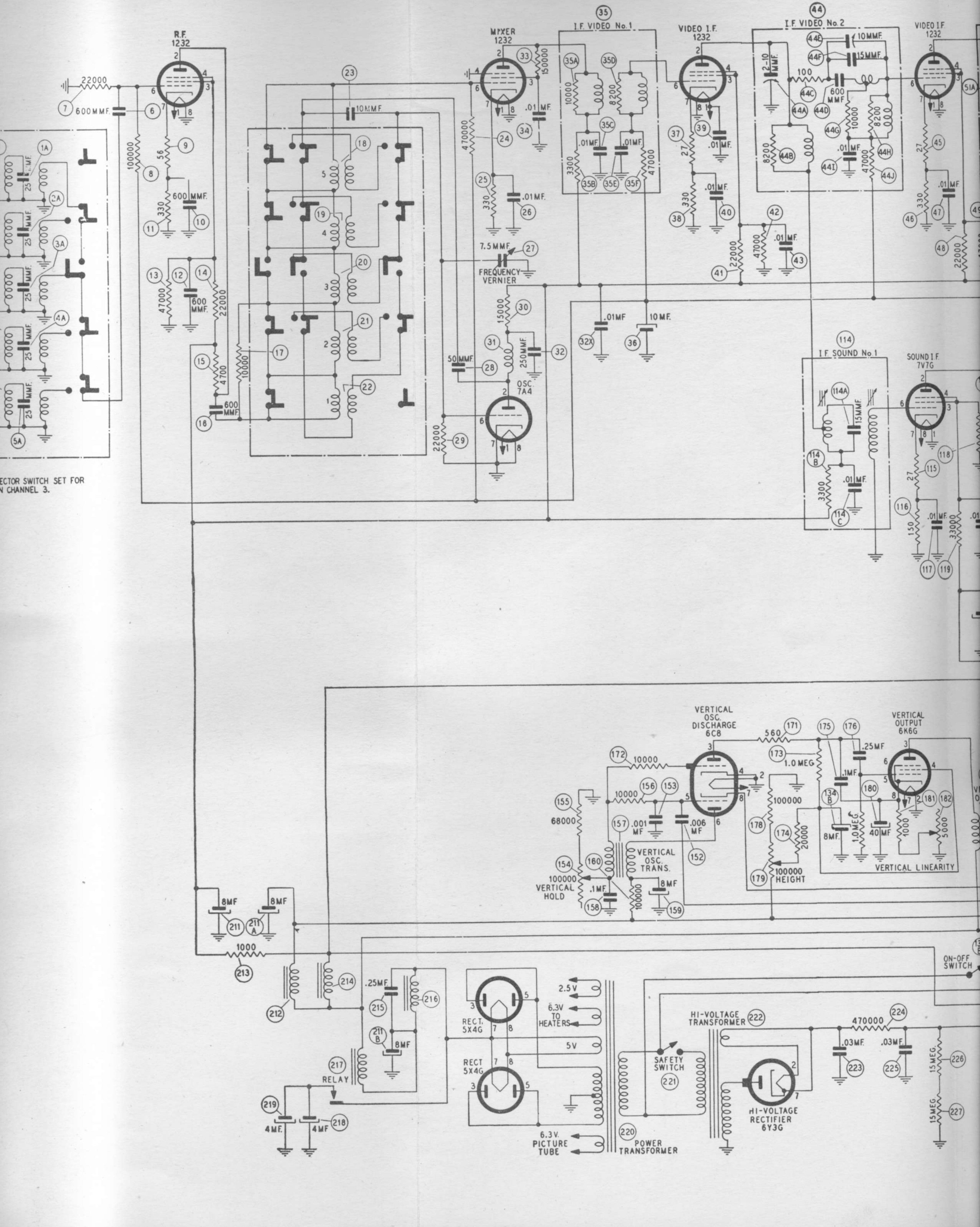


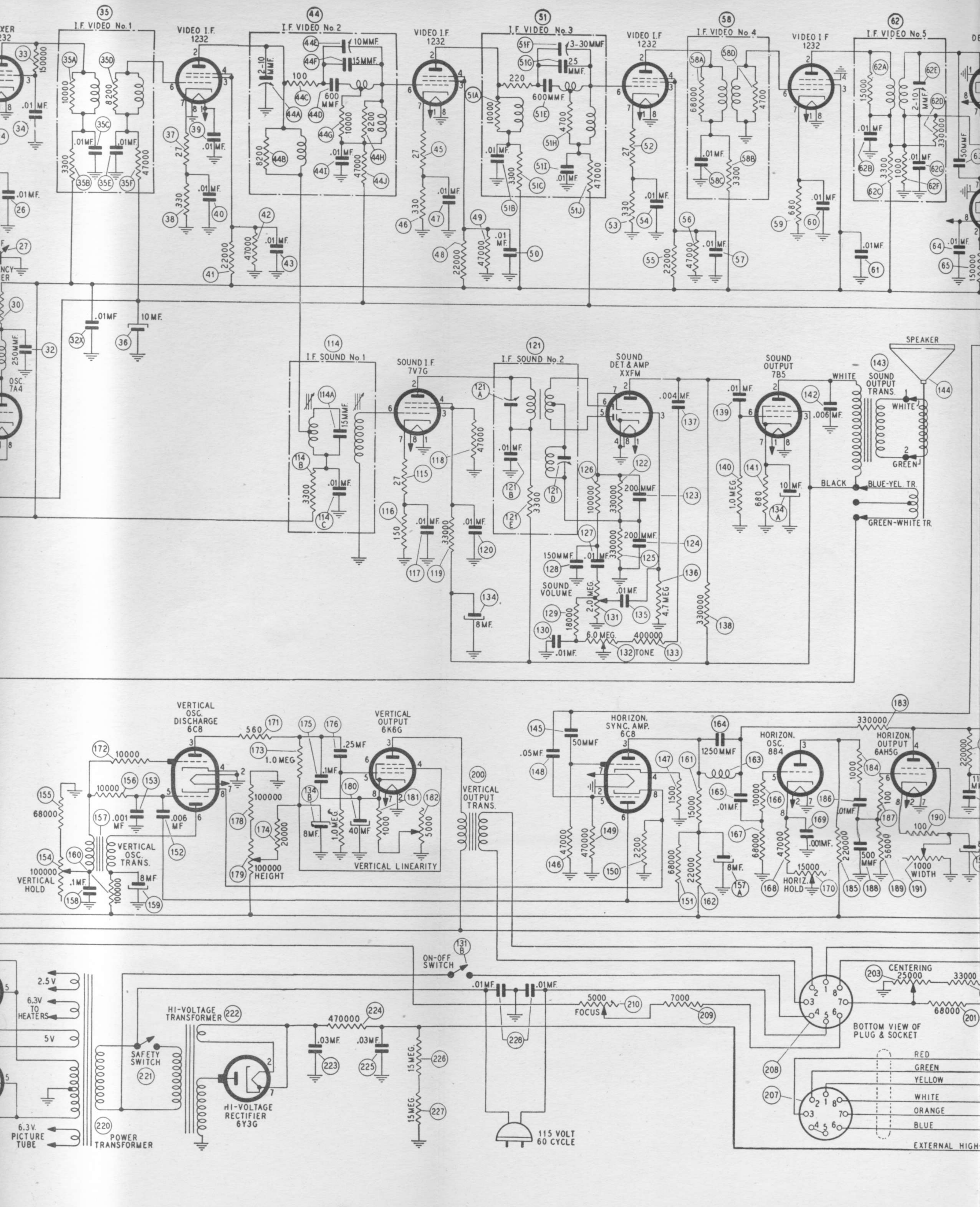
Figure 69. Sample Alignment-Data Chart.



1 2 GND
R.F. 1232
MIXER 1232
OSC. 7A4
22000
600 MMF.
100000
56
330
600 MMF.
47000
22000
4700
10000
600 MMF
10 MMF.
470000
150000
.01 MF.
10000
3300
.01 MF.
7.5 MMF.
FREQUENCY VERNIER
15000
250 MMF.
50 MMF.
22000
25 MMF.
NOTE:
CHANNEL SELECTOR SWITCH SET FOR OPERATION ON CHANNEL 3.
68000
100000 VERTICAL HOLD
8MF
8MF
1000
.25MF
8MF
RELAY
4MF
4MF
RECT. 5X4G
RECT 5X4G
2.5V
6.3V TO HEATERS
5V
6.3V. PICTURE TUBE



R.F. 1232
22000
600 MMF.
100000
56
330
600 MMF.
47000
600 MMF.
22000
4700
10000
600 MMF.
MIXER 1232
10 MMF.
470000
150000
.01 MF.
330
.01 MF.
7.5 MMF.
FREQUENCY VERNIER
15000
250 MMF.
50 MMF.
OSC. 7A4
22000
I.F. VIDEO No. 1
10000
8200
.01 MF
.01 MF
3300
47000
.01 MF
10 MF.
VIDEO I.F. 1232
27
330
.01 MF.
.01 MF.
22000
47000
.01 MF.
I.F. VIDEO No. 2
10 MMF.
15 MMF.
2-10 MMF.
100
600 MMF
8200
10000
8200
.01 MF
47000
VIDEO I.F. 1232
27
330
.01 MF
22000
I.F. SOUND No. 1
15 MMF.
3300
.01 MF.
SOUND I.F. 7V7G
27
150
.01 MF.
33000
ECTOR SWITCH SET FOR
N CHANNEL 3.
VERTICAL OSC. DISCHARGE 6C8
560
1.0 MEG
.25 MF
.1 MF.
VERTICAL OUTPUT 6K6G
10000
10000
68000
.001 MF
.006 MF
100000
20000
8 MF.
1.0 MEG
40 MF
1000
5000
VERTICAL OSC. TRANS.
100000 VERTICAL HOLD
.1 MF.
8 MF
100000 HEIGHT
VERTICAL LINEARITY
8 MF
8 MF
1000
.25 MF.
8 MF
RELAY
4 MF.
4 MF
RECT. 5X4G
RECT 5X4G
2.5 V
6.3 V TO HEATERS
5 V
6.3 V. PICTURE TUBE
POWER TRANSFORMER
HI-VOLTAGE TRANSFORMER
SAFETY SWITCH
HI-VOLTAGE RECTIFIER 6Y3G
470000
.03 MF.
.03 MF.
15 MEG.
15 MEG.
ON-OFF SWITCH


I.F. VIDEO No. 1
VIDEO I.F. 1232
I.F. VIDEO No. 2
VIDEO I.F. 1232
I.F. VIDEO No. 3
VIDEO I.F. 1232
I.F. VIDEO No. 4
VIDEO I.F. 1232
I.F. VIDEO No. 5
OSC. 7A4
I.F. SOUND No. 1
SOUND I.F. 7V7G
I.F. SOUND No. 2
SOUND DET & AMP XXFM
SOUND OUTPUT 7B5
SPEAKER
SOUND OUTPUT TRANS.
WHITE
GREEN
BLACK
BLUE-YEL. TR
GREEN-WHITE TR.
SOUND VOLUME
TONE
VERTICAL OSC. DISCHARGE 6C8
VERTICAL OUTPUT 6K6G
VERTICAL OSC. TRANS.
VERTICAL HOLD
HEIGHT
VERTICAL LINEARITY
VERTICAL OUTPUT TRANS.
HORIZON. SYNC. AMP. 6C8
HORIZON. OSC. 884
HORIZON. OUTPUT 6AH5G
HORIZ. HOLD
WIDTH
ON-OFF SWITCH
2.5V
6.3V TO HEATERS
5V
6.3V. PICTURE TUBE
POWER TRANSFORMER
SAFETY SWITCH
HI-VOLTAGE TRANSFORMER
HI-VOLTAGE RECTIFIER 6Y3G
FOCUS
115 VOLT 60 CYCLE
CENTERING
BOTTOM VIEW OF PLUG & SOCKET
RED
GREEN
YELLOW
WHITE
ORANGE
BLUE
EXTERNAL HIGH-

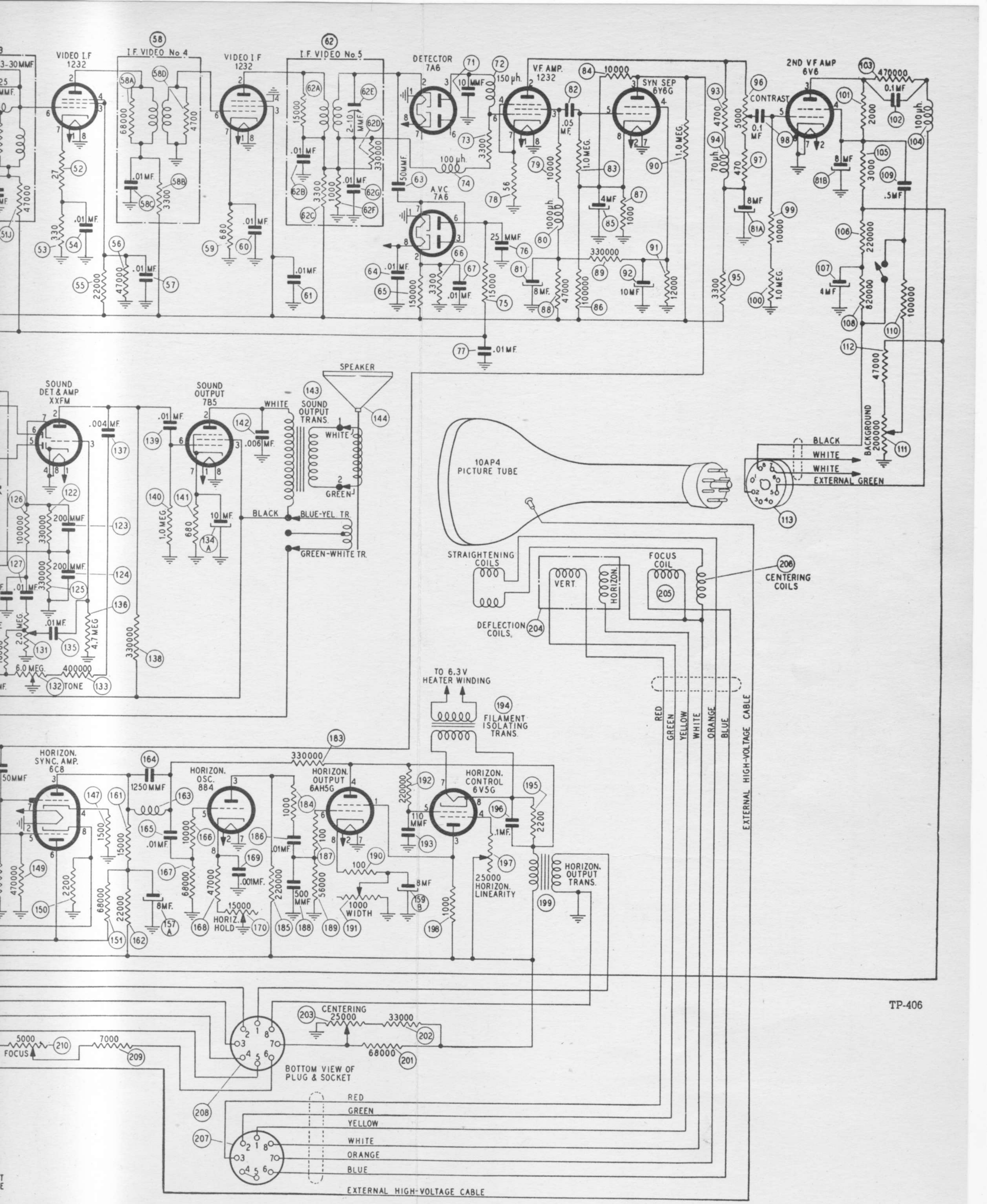


Figure 70. Schematic of Complete Television Receiver.

GLOSSARY OF TELEVISION TERMS

ACTIVE LINES—The unblanked portion of the scanning sweeps.

ADJACENT AUDIO (SOUND) FREQUENCY—The carrier frequency of the audio (sound) component of the television channel next below that under consideration.

AMPLITUDE MODULATION (AM)—A system of transmitting intelligence by radio involving changing the amplitude of the carrier oscillation.

APERTURE—When applied to cathode-ray tubes, it is the size of the scanning element; i.e., the size of the spot generated by the electron beam striking the fluorescent screen.

ASPECT RATIO—The numerical ratio of frame width to frame height. In television it is 4:3.

AUDIO CHANNEL—A band of frequencies used for transmission of audio intelligence. In television this band occupies a portion of the television channel.

AUTOMATIC VOLUME CONTROL—A system of regulation of receiver amplification factor, whereby weak signals are more greatly amplified than strong signals, thus, within operating limits, yielding a constant output regardless of incoming signal strength. (Also referred to as automatic gain control.)

AVERAGE BRIGHTNESS—The average light value of the picture.

BACKGROUND CONTROL—A potentiometer which regulates the average, or background, illumination of the received picture. When properly set, the retrace of the beam is just below the level necessary to appear on the screen.

BANDWIDTH—The difference in cycles per second between the lowest and the highest frequency of the transmitted band. A television channel is 6 mc. wide.

BLACK LEVEL—The amplitude of the modulating signal corresponding to the scanning of a black area in the transmitted picture.

BLACKER-THAN-BLACK REGION—That portion of the demodulated signal which is above the amplitude necessary to prevent the electron beam from reaching the screen.

BLANKING PULSE—A pulse used to blank out the electron beam during the return time of the beam to its starting point.

CAMERA—The picture-pickup tube and its associated sweep circuits.

CARRIER FREQUENCY—The specific frequency at which a radio-frequency signal is generated and radiated.

CATHODE-RAY TUBE—A device which converts electrical energy into light by causing an electron beam to strike a fluorescent screen.

CENTERING CONTROLS—The circuit components which locate the operating point of the electron beam so that normal deflection causes the picture to appear properly oriented about the center of the screen.

COAXIAL CABLE—A type of transmission line consisting of a conductor located inside a hollow conductor so that both conductors have a common axis.

CONTINUOUS SCANNING—The operation of scanning a picture or scene at a uniform velocity.

CONTRAST CONTROL—A potentiometer which regulates the degree of difference between the light and dark portions of the picture.

CROSS-OVER AREA—That region in the first lens system in a cathode-ray tube where the electrons converge as a result of the influence of the magnetic or electrostatic fields.

DAMPING TUBE—An electronic device used to momentarily short-circuit a circuit component to prevent undesired transient oscillations.

D-C REINSERTION—The combining of the video component with a d-c component to re-establish the average light value of the picture or scene.

DEFINITION—The sharpness of detail in the reconstructed picture.

DIPOLE—A type of antenna which is divided in the middle and is employed to transmit or receive high-frequency signals.

DISCRIMINATOR — A frequency-sensitive circuit which converts frequency variations into amplitude variations. The second detector of an FM superheterodyne receiver.

ELECTRON GUN—The structure which emits and accelerates a beam of electrons in the cathode-ray tube.

GLOSSARY OF TELEVISION TERMS (Continued)

ELECTRON LENS—Magnetic or electrostatic lines of force arranged so as to act upon a flow of electrons in a manner similar to the action of an optical lens upon light.

ELECTRON MULTIPLIER—A device used in electronic circuits, such as the image-dissector camera tube, wherein controlled secondary emission is utilized to amplify electron emission.

EQUALIZING PULSES—A series of pulses, contained in the composite video signal, which causes the vertical deflection to start at the same time in each interval.

FIDELITY—Faithfulness of reproduction.

FIELD—The term applied to one complete scanning operation.

FIELD FREQUENCY—The number of times per second the frame area is fractionally scanned in interlaced scanning; in television, 60 times per second.

FLICKER—The objectional variation of the light value of a picture.

FLUORESCENT SCREEN—The fluorescent coating on the inside surface of the viewing end of the cathode-ray tube.

FOCUSING CONTROL—A potentiometer which regulates the amount of focusing field, which in turn determines the point at which the converging electrons form a concentrated beam.

FRAME—The complete single picture of a televised sequence.

FRAME FREQUENCY—The repetition rate of the complete picture; in television, 30 times per second.

FREQUENCY MODULATION—A system of transmitting intelligence by radio involving the changing of the carrier frequency.

GHOST IMAGE—A shadow or echo picture on the television screen, usually caused by the reception of a reflected and delayed wave along with the direct wave.

HEIGHT CONTROL—A potentiometer which regulates the length of the vertical displacement of the cathode-ray beam.

HOLD CONTROL—A potentiometer which varies the free-running frequency of the sweep oscillator, thus determining the amount of control exercised by the sync pulses.

ICONOSCOPE—A type of camera tube.

INTERFERENCE—Any undesirable signal entering the receiver circuits.

INTERLACE SCANNING—A type of scanning in which alternate strips of the televised scene are scanned in alternate fields, used to reduce apparent flicker.

LIMITER STAGE—A stage of amplification ahead of the FM discriminator so biased that all input signals, above a prescribed minimum, drive the stage to cutoff, thus eliminating variations due to amplitude modulation of the input signal.

LINE—See scanning line.

LINEARITY CONTROL—A potentiometer in the sweep circuit which varies operating characteristics of the sweep generator in order that the speed of the beam may be made uniform across the face of the picture tube.

LINE SCANNING FREQUENCY—The number of lines scanned per second. (Present systems scan 525 lines in 1/30 sec. = 15,750 per second.)

"LOCK-IN"—That condition when the sweep circuits of the television receiver are controlled by the sync pulses from the transmitter, resulting in a stationary, clearly defined picture.

MODULATION—The process by which the amplitude, frequency, or phase of a radio-frequency carrier is varied with a signal.

MOSAIC — A specially constructed light-sensitive screen located in the picture-pickup tube.

NEGATIVE MODULATION TRANSMISSION—A type of television modulation in which the percentage of modulation is inversely proportional to the amount of light on the picture element.

ORIENT—To aim, direct, fix the position of.

PICTURE ELEMENTS—In transmission, the separate photosensitive globules or groups of globules that combine to form an image. At the receiver, the picture elements are the light emitting particles of the fluorescent screen activated by the electron beam.

PICTURE RECEIVER—A device used only to receive and reconstruct pictures from electrical waves.

PICTURE TRANSMITTER—See visual transmitter.

POLARIZATION—The direction of electrostatic lines of flux of a radio wave.

GLOSSARY OF TELEVISION TERMS (Continued)

POSITIVE MODULATION TRANSMISSION—A system of television modulation wherein the percentage of modulation is proportional to the amount of light on the picture element.

RASTER—A field, or one set of scanning lines in a frame.

RETENTIVITY OF VISION—The ability of the human eye to see light after the light stimulus is removed.

RETURN TRACE—A line of light which is traced upon the fluorescent screen each time the electron beam is returned to the starting point on the fluorescent screen to begin another sweep.

SCANNING—The process of analyzing successively, according to a predetermined method, the light values of picture elements constituting the total picture area.

SCANNING LINE—A single continuous narrow strip whose dimensions and properties are determined by the process of scanning.

SCANNING RASTER—See RASTER.

SCREEN—See fluorescent screen.

SCREEN PERSISTENCE—The property of continuing to radiate light for a short period of time after the exciting stimulus is removed.

SHOT EFFECT—An interfering electrical disturbance generated in radio tubes, particularly detrimental when they are used as high-frequency amplifiers.

SIDE BANDS—Radio frequencies adjacent to an amplitude-modulated carrier and composed of the modulating frequencies.

SWEEP VOLTAGE—A voltage generated by the sweep generator and used to deflect the electron beam of a camera, or a picture tube.

SYNCHRONIZATION—The maintaining of one operation in step with another.

SYNC PULSES—Voltage pulses superimposed upon the video signal to synchronize the receiver scanning with the scanning of the camera tube at the transmitter.

TELEVISION—The transmission and reproduction of a picture or scene by any device which converts light rays into electrical waves and reconverts them into light rays.

TELEVISION CHANNEL—A band of frequencies employed in the transmission of the composite video signal and its accompanying audio signal. At the present time a band of 6-mc. width is employed.

TELEVISION RECEIVER—A device which receives audio and video information and reconstructs it into duplicates of the original.

TELEVISION TRANSMITTER—The radio transmitter or transmitters for the transmission of both video and audio signals.

TEARING—A term applied to a picture fault; it means that the picture appears as if it were being torn apart.

USED AUDIO FREQUENCIES—The band of frequencies encompassed in the transmission of audio intelligence accompanying a specific video signal.

VERTICAL SCANNING—The vertical up-and-down motion of the electron beam.

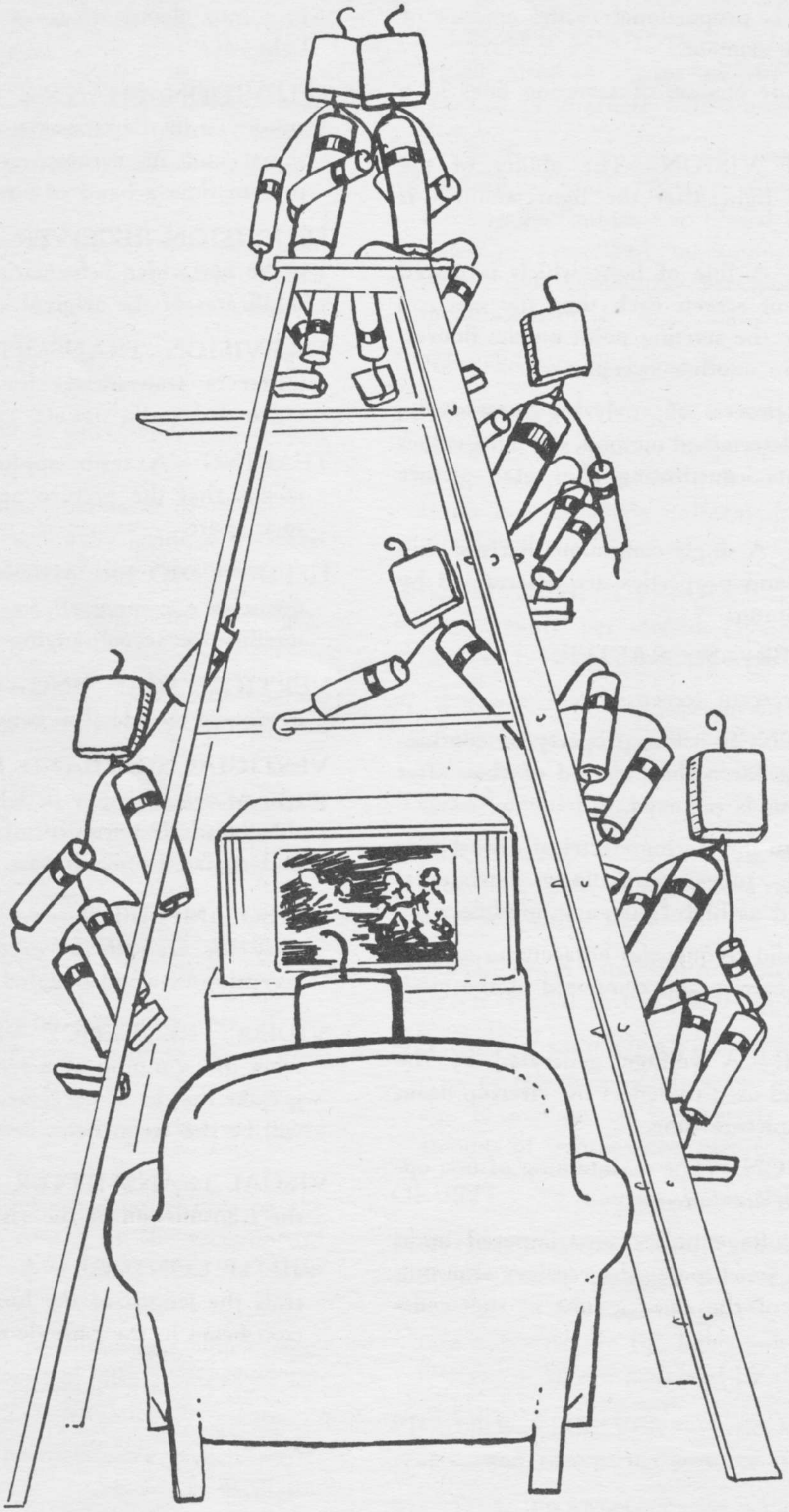
VESTIGIAL SIDE-BAND TRANSMISSION—A system of transmission in which one of the generated side bands is partially attenuated at the transmitter and radiated only in part.

VIDEO AMPLIFIER—An amplifier designed to amplify the frequencies necessary for transmission or reception of a video signal.

VIDEO FREQUENCY—Any frequency obtained from the scanning of a scene by a camera tube. The greater the detail necessary in the picture, the higher will be the frequencies involved.

VISUAL TRANSMITTER—The radio equipment for the transmission of the visual signal only.

WIDTH CONTROL—A potentiometer which controls the length of the horizontal sweep of the electron beam in the cathode-ray tube.



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