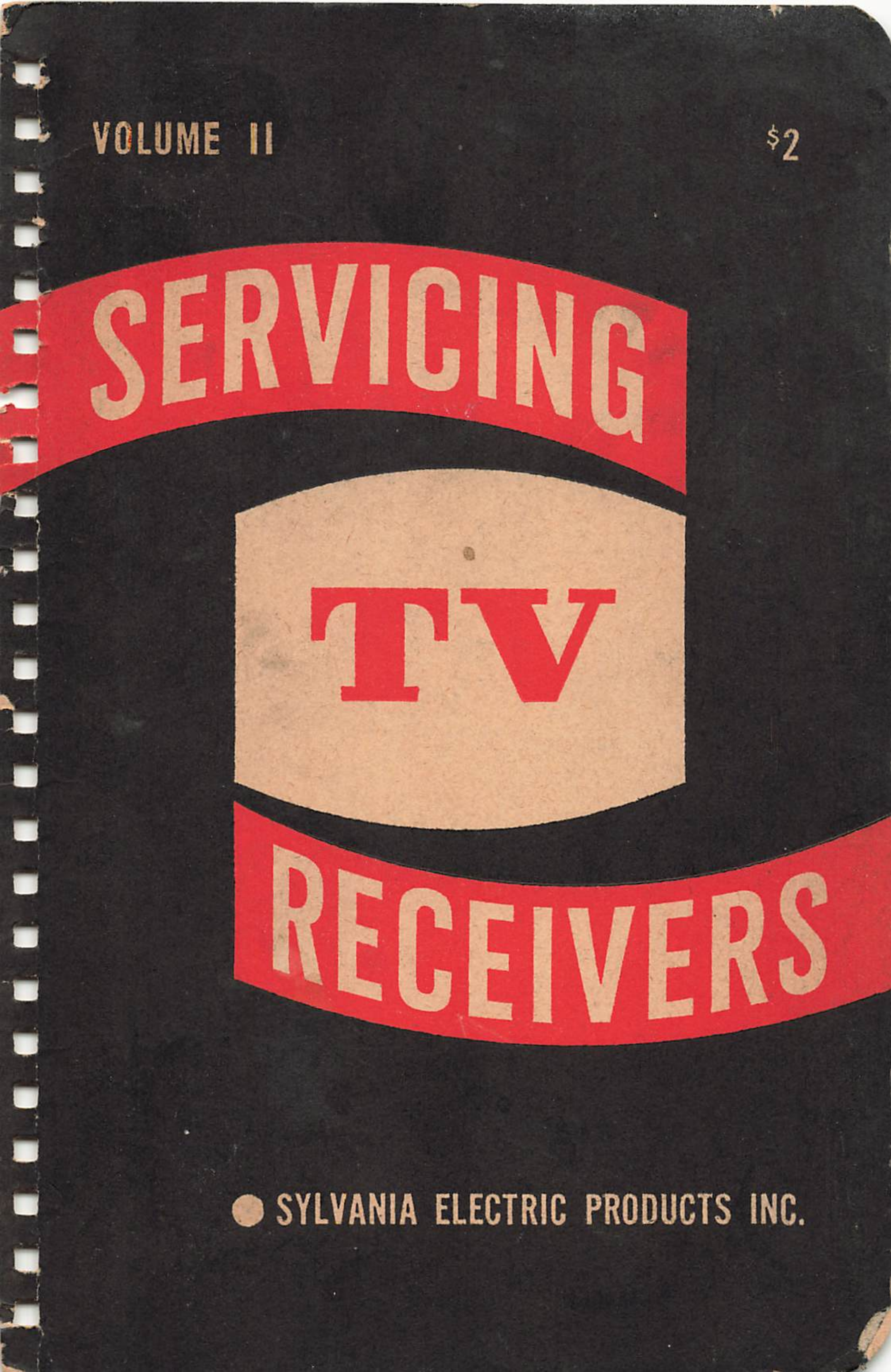


VOLUME II

$2

SERVICING TV RECEIVERS

● SYLVANIA ELECTRIC PRODUCTS INC.

SERVICING
TV
RECEIVERS

VOLUME TWO

SYLVANIA

1740 Broadway New York 19, N. Y.

FIRST EDITION
First Printing
Printed in U. S. A.

PREFACE

SERVICING TELEVISION RECEIVERS is intended for the practicing television serviceman. For this reason, it is organized to serve two purposes:

1. To provide readily usable information on typical television receiver troubles:

2. To establish and guide the serviceman in the use of systematic trouble localization techniques.

Of the two, the second purpose is the more important. The modern television receiver is a complex instrument. Haphazard servicing procedures that were successful with the small ac-dc radio set are impractical if not impossible as far as application to television receivers is concerned. On the other hand, involved servicing procedures requiring elaborate servicing equipment that is expensive and needlessly complicated are also impractical.

The problem of servicing complicated electronic equipment with sensible servicing methods was neatly solved by the armed forces during the last war. How effective they were can be deduced by realizing that within a few months of entering the service, previously non-technical personnel were successfully maintaining and repairing complicated electronic equipment such as radar, sonar, and other automatic devices. It is these methods specifically adapted for television receivers that are made use of in this book.

Since practical examples are an excellent means of illustrating any explanation, a commercially available television receiver, the Sylvania 7100 series, model 1-366, has been chosen for some specific examples. All the information in this book is applicable, however, in general, to almost all television receivers on the market today.

TABLE OF CONTENTS

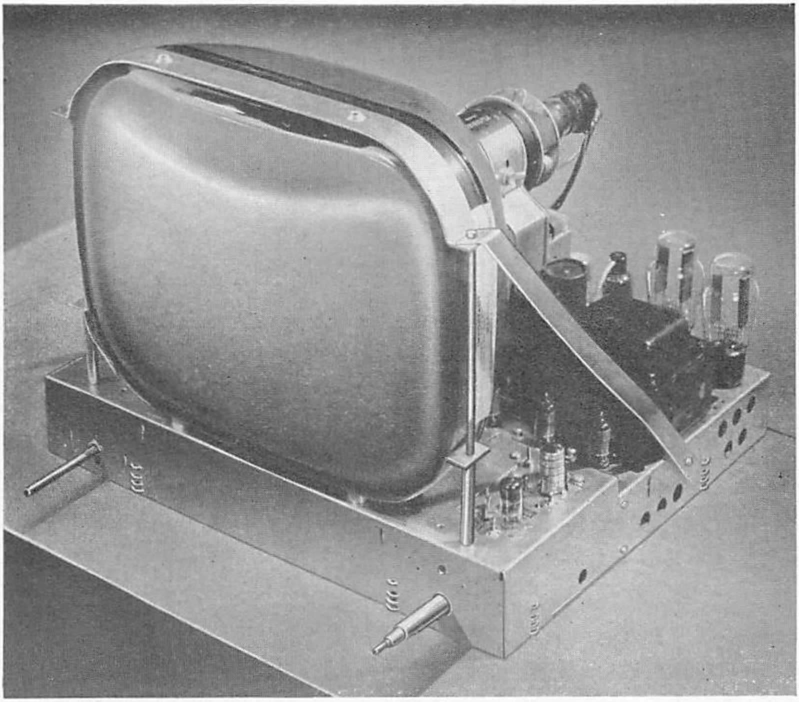
LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS—Continued

ACKNOWLEDGEMENTS

Grateful acknowledgement is made to WCBS, WPIX, WABD, and WJZ-TV for their assistance and cooperation, and for their permission to use the test patterns illustrated.

The photographs of the test patterns used in this book exemplify improper functioning of television receivers and they do not in any way reflect upon the operation of the television broadcast stations whose test patterns are used for purposes of illustration.



1-1. Typical Television Receiver Chassis

CHAPTER I

THE PRESENT STATE OF TELEVISION

I-I. INTRODUCTION

Essentially, television is the transmission and reproduction of the events occurring before a television camera. Consequently, the viewer is enabled to see and hear what is going on at great distances from his television set.

A television system includes a transmitter and a receiver. At the transmitter, the events that are "looked at" and "listened to" are converted into electrical signals which are impressed upon high frequency radio waves and radiated into space. These radio waves are picked up by the receiver antenna and converted by circuits within the set into electrical signals corresponding to those transmitted by the station. These signals are then used to reproduce the pictures and sound that were televised.

Today, the receiver of the type discussed in this book can reproduce pictures in black and white only. However, television receivers that can produce color pictures are already in the production planning stage. This additional feature adds to the complexity of the receiver and, therefore, will require more skill from the serviceman.

I-2. FREQUENCY ALLOCATIONS

In contrast to AM radio stations, which occupy only a narrow portion of the radio frequency spectrum and are assigned narrow frequency bands, television stations require so much of the spectrum that they are assigned channels that contain a "spread" of frequencies. While the complete frequency-spread allocated to conventional radio stations (the "broadcast band") is approximately one megacycle wide and accommodates 106 separate channels, each television channel is *six megacycles wide* and accommodates only *one television station.* The FCC (Federal Communications Commission) allocated twelve channels, numbered from 2 to 13, to television. These allocations are separated into three bands; one extending from 50 to 72 megacycles, the second from 76 to 88 megacycles, and the last from 174 to 216 megacycles. (See table 1-1.) The gaps between the bands are necessary because of previous allocations to frequency-modulation radio stations, government and airline communications, amateur radio stations, and various other users.

downward motion of the horizontal lines starts a new cycle.

To summarize: A television picture or "frame" is composed of horizontal lines that are varied in tone or shade to correspond to the image of the scene. The generation of the horizontal line on the face of the picture tube by moving the pin-point electron beam across the face is called horizontal scanning. In order to reproduce an entire picture with the use of horizontal lines, the horizontal lines must be vertically stacked. This is accomplished by causing the beam that is scanning horizontally to move slowly down the face of the picture tube. This downward motion of the beam is accomplished by a process called vertical scanning.

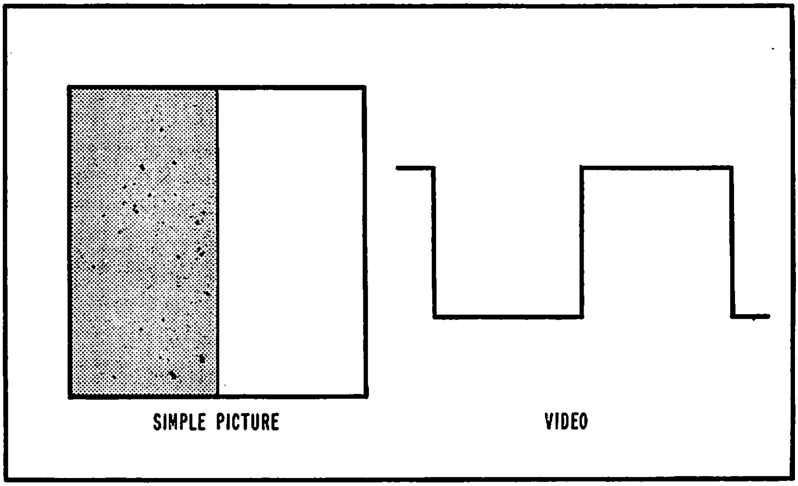
The reproduction of an image on the face of a picture tube by the combination of horizontal and vertical scanning would be sufficient to produce an acceptable television picture. However, because of certain technical problems, the actual technique used in contemporary television is more complicated. The actual method used is called interlaced scanning.

1-5. INTERLACED SCANNING

A television picture is created by presenting a series of changing "stills" to the eye. Unless the "stills" occur in rapid succession, the eye distinguishes between the individual "stills" and the image appears to flicker. Experiments performed by moving-film technicians indicate that at least 24 images a second are required to create the illusion of an action picture free from annoying flicker. To provide a steady image, thirty images or frames a second are transmitted by present-day television stations. It was decided to establish the transmission of 30 frames a second as the television standard in this country because the most commonly used power frequency is 60 cycles per second.

Each frame is transmitted in two portions, each called a field. Sixty fields are transmitted per second. Making the field frequency equal to the power-line frequency (60 cycles) reduces the disturbing effect of ripple in the plate voltage supply caused by imperfect filtering and other 60 cycle pickups. Transmitting each frame as two fields further reduces the picture flicker problem.

Each field is generated by scanning alternate lines, as shown in figure 1-3. The scanning electron beam starts at the upper left-hand corner and scans line 1. At the end of line 1, the beam is blanked out. While it is blanked out, the beam is rapidly returned to the left side of the screen. This is the horizontal retrace. The next line scanned is line 3, followed by line 5, and so on until about 250 odd lines are scanned. At the bottom of the field, the electron beam is quickly returned to the top of the image during the remainder of the 262.5 lines of the odd scan. Then the even lines are scanned. When about 250 even lines have been scanned, the second field is completed. These two fields of approximately 250 lines and the retrace lines combine



1-4. Formation of Video Signal

to make one frame of 525 lines. When viewed on the screen, the lines interlace to form one image. This is accomplished by the eye, which blends the odd-line fields and the even-line fields into a 525-line image occurring 30 times a second.

The problem of controlling the electron beam so that the odd lines are scanned first and the even lines afterwards is accomplished by synchronizing signals sent along with the picture signal. The circuits causing the electron beam in the picture tube to scan the screen in the proper pattern are called the deflection circuits. The synchronizing signals are applied to these circuits so that the electron beam scanning the screen of the picture tube is kept in step with the electron beam scanning the screen of the camera tube. The beam automatically skips successive lines.

1-6. THE PICTURE SIGNAL

As explained above, the camera tube at the studio converts the optical image corresponding to the televised scene into an electrical signal. This signal is called the video signal.

The video signal is generated as the electron beam of the camera tube scans the image focused on its screen. It is a voltage that varies in accordance with the light and dark tones encountered by the beam as it scans a line across the screen. The video signal corresponds to voltage waveform that would be obtained if a very small photo-electric cell with an aperture no wider than the thickness of a line were rapidly scanned across a focused image of the studio scene. For one image, 525 separate groups of video signals are obtained, one for each line.

During a one-second interval, 15,750 horizontal lines are scanned. This result is obtained by multplying the number of lines in one frame (525) by the number of frames in one second (30). Assume that the picture being scanned consisted of one vertical black bar covering half the screen. This is illustrated in figure 1-4. With only one difference in shading, this is probably the simplest picture that could be transmitted except for a completely black or completely white scene. The video signal corresponding to this simple image is shown in figure 1-4. It consists of one complete square wave. The negative excursion represents the black portion or area of no light, the positive excursion represents the white portion or area of maximum light. To reproduce the entire image, 15,750 of these square waves would have to be transmitted each second, one for each horizontal line. As the picture becomes more complicated, the frequency range of the video signal increases. Even a pattern as simple as that shown in figure 1-4 requires more bandwidth than that allowed for conventional radio signals. For the television receivers in use today, four megacycles is the maximum video bandwidth permitted by the present FCC regulations.

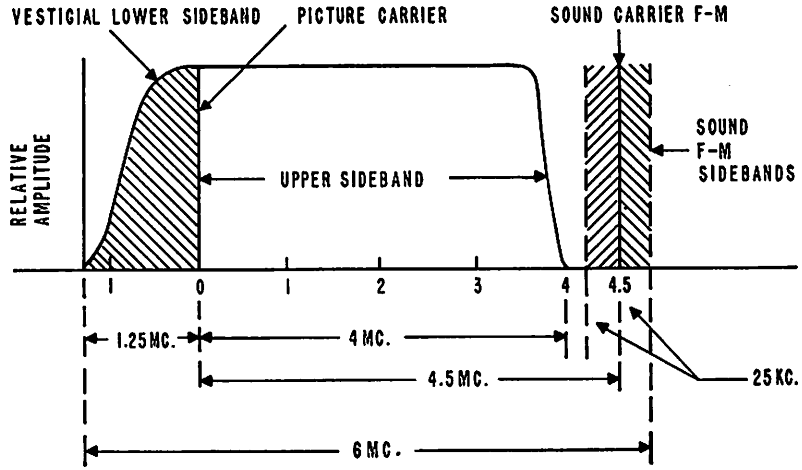
1-7. VESTIGIAL SIDEBAND TRANSMISSION

The video signal is impressed on the transmitter carrier by means of amplitude modulation. Conventional amplitude modulation such as is used in radio transmission results in sidebands on either side of the carrier frequency. Each sideband covers a frequency range equal to the frequency of the modulating signal. In the case of a four-megacycle signal, the sidebands would extend four megacycles above and below the carrier. Without including the audio component of the complete television signal, the total bandwidth required for a television station would then have to be eight megacycles.

If each television station were to occupy a channel eight megacycles wide, the interval between channels would have to be ten megacycles, in order to minimize interference. At present, the FCC allocation on the lower band covers 72 megacycles. Therefore, if ten megacycles were required between adjacent carriers, only seven channels could be used. Actually, however, 12 channels occupy the 72-megacycle spread. Each channel occupies only six megacycles of the spectrum, yet each television station manages to transmit four megacycles of picture information.

When the transmitter carrier is amplitude modulated in accordance with the picture information, equal sidebands below and above the carrier are developed. However, both the lower and upper sidebands convey the same information. By suppressing the lower sidebands, the channel width required for the television channel is reduced. Since the remaining upper sideband is capable of supplying all the picture detail, no loss in picture quality results. Because of the difficulty of completely eliminating the lower sideband, the FCC regulations allow only partial elimination of the lower sideband. Since part of the lower sideband is still present, this process is called vestigial sideband transmission.

The sound accompanying the picture signal is transmitted via a



1-5. Vestigial Sideband Transmission

frequency-modulated carrier located 4.5 megacycles above the picture carrier. Figure 1-5 is a diagram of the frequency coverage of a transmitted television signal. The picture carrier is located 1.25 megacycles above the lower limit of the channel. The space between the lower frequency of the channel and the carrier is used for the partially suppressed lower sideband. Four megacycles of the spectrum on the high side of the picture carrier are used to convey the picture information. Filters in the transmitter cause the picture signal to cut off sharply above the four-megacycle point. The audio carrier is located 4.5 megacycles above the picture carrier. The frequency swing of the audio carrier is confined to 25 kilocycles on either side of the carrier. This leaves an 0.5 megacycle gap between the picture and the audio sidebands. Because of this gap and the fact that the picture carrier is amplitude modulated while the audio carrier is frequency modulated, the problem of interference between the video and audio components of the television carrier is reduced. Separation of the video and audio signals in the receiver is also simplified by these provisions.

1-8. COMPOSITE VIDEO SIGNAL

The scene viewed by the camera at the studio is transmitted a line at a time, in accordance with the procedure described in paragraph 1-5. Within the receiver, the lines must be arranged in the proper order to reproduce the picture.

To keep the electron beam of the camera tube and the receiver locked in step, the transmitter includes synchronizing signals along with the picture signal. Within the receiver, the synchronizing circuits extract the synchronizing signals and apply them to the deflection circuits which control the position of the electron beam.

The synchronizing signals consist of short pulses called sync pulses. Two types of these sync pulses are generated by the transmitter: the horizontal sync pulses and the vertical sync pulses. One horizontal sync pulse is supplied to mark the end of each horizontal line scanned by the camera tube and one vertical sync pulse is supplied to mark the end of each field. Thus 15,750 horizontal sync pulses and 60 vertical sync pulses are transmitted each second. The great difference in frequency between the horizontal and vertical sync pulses enables the receiver to distinguish between them. To further differentiate the two sync pulses, the vertical sync pulse is made about three times as long as the horizontal.

The horizontal sync pulse is added to the video signal at the end of each line; the vertical sync pulse at the end of each field. Thus, the sync pulses occur during the retrace intervals. In addition to the sync pulses, the transmitter adds blanking pulses to the picture signal.

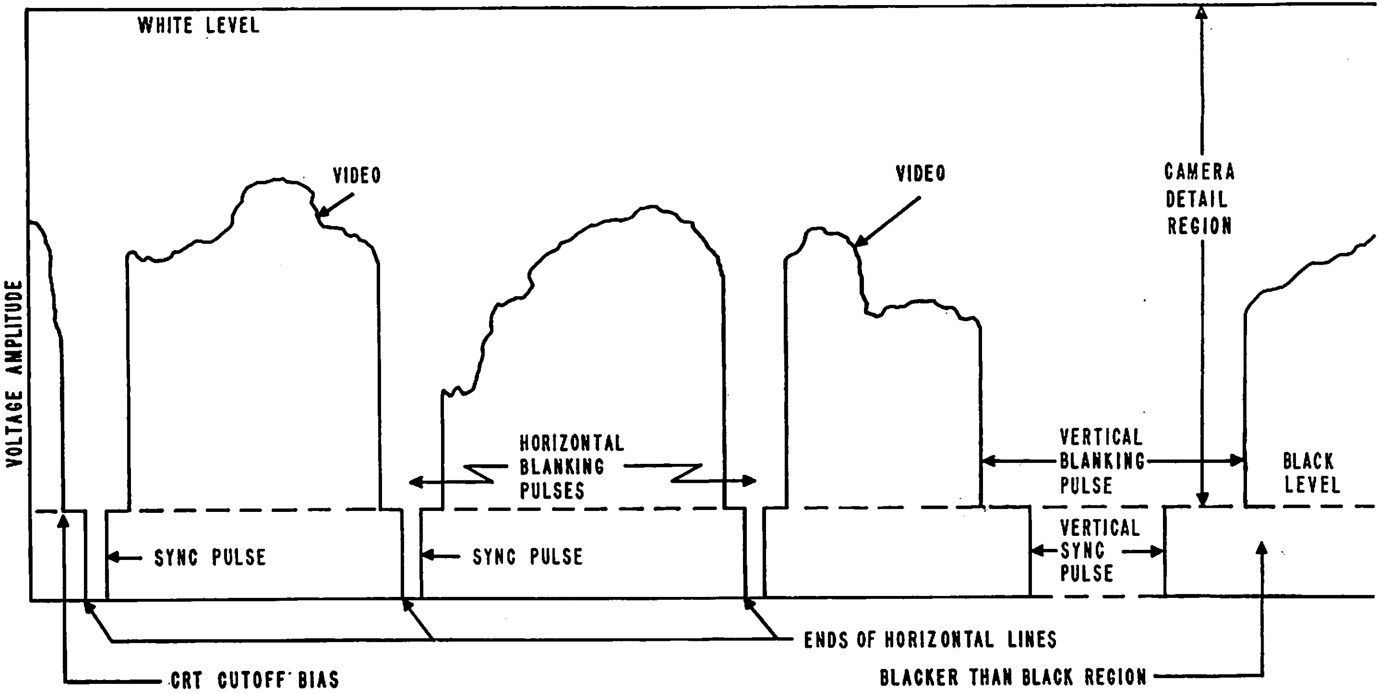
The purpose of these blanking pulses is to shut-off the scanning electron beam during the interval when the beam is returning to the left side of the screen (retrace) to begin another horizontal line and when it is returning to the top of the screen to begin another field. This blanking action is accomplished by the horizontal and vertical blanking pulses, respectively. In effect, the blanking pulses make the screen blacker than black. When the beam comes to the end of a horizontal line, the blanking pulse is applied to the control grid of the picture tube. The blanking pulse is of such a polarity that the beam is cut off. Just after the blanking pulse is applied to the picture tube, the horizontal sync pulse is applied to the horizontal deflection circuits. The horizontal line immediately ends and rapidly returns to the left side of the screen to begin another horizontal line. At this instant, the horizontal blanking pulse ends and the beam turns on again. The beam can now sweep out a horizontal line in the normal manner. Each horizontal line is controlled in this manner.

At the bottom of the field, the vertical blanking pulse is applied to the cathode-ray tube. Consequently, the electron beam is cut off. Just after the beam is cut off, the vertical sync pulse is applied to the vertical deflection circuits, ending the downward vertical sweep of the electron beam. The beam is then rapidly returned to the top of the screen, ready to begin another field.

The composite video signal contains five separate components:

1. The video signal.
2. The horizontal sync pulse
3. The vertical sync pulse
4. The horizontal blanking pulse
5. The vertical blanking pulse.

The manner in which these are combined together is illustrated in figure 1-6. Seventy-five percent of the transmitter signal amplitude is allotted to the video signal. Minimum signal amplitude represents white, and 75% of maximum amplitude represents black. With the polarity indicated in figure 1-6, the video signal would be applied to



I-6. Composite Video Signal

the cathode of the picture tube. If the polarity were reversed, the video could be applied directly to the grid of the picture tube. The last 25% of signal amplitude, the so-called blacker-than-black region, is devoted to the blanking and synchronizing pulses. The blanking and sync pulse region is called the blacker-than-black region because the function of the blanking signal is to reduce the intensity of the electron beam to the point where no visible light is produced. It is during the period of the blanking pulses that the sync pulses are applied to the receiver. Blanking the set during this interval prevents the display of video during sweep retrace. Superimposed on top of the blanking pulses are the sync pulses. Circuits that are sensitive to peak signals separate the sync pulses and apply them to the appropriate synchronizing circuits. The blanking and sync pulses are applied to the cathode-ray tube along with the video signal.

1-9. SUMMARY

Television is the art of transmitting pictures and sound to remote points. The heart of the television receiver is the picture tube, whose ability to convert electrical signals into visible light makes modern-day television possible. The television picture is transmitted one line at a time. The electron beam within the picture tube scans the screen in synchronism with the electron beam scanning the image at the studio. A complete image is reproduced by scanning successive lines in a vertically downward direction. To keep the electron beam at the studio and camera in step, synchronizing signals are transmitted together with the video signal.

Because of the large amount of detail that must be combined to form a television signal, the television channel is six megacycles wide. This is almost six times the space occupied by the entire broadcast band. Confining the television channel to six megacycles requires the use of vestigial sideband transmission; i.e., the partial suppression of the lower sideband. The audio signal is a frequency-modulated signal situated at the upper end of the six-megacycle channel.

CHAPTER 2

THE TELEVISION RECEIVER

2-1. FUNCTIONAL SECTION

From a servicing viewpoint, the television receiver is best considered as a group of distinct interconnected circuits. Together, these circuits or sections comprise a complex device performing the many different functions required for the reproduction of the television picture and sound. Individually, each section is relatively simple, and can be readily understood and repaired. The servicing procedures described in this manual are based on sectionalizing the trouble to one of these sections and then repairing the defective component within the section.

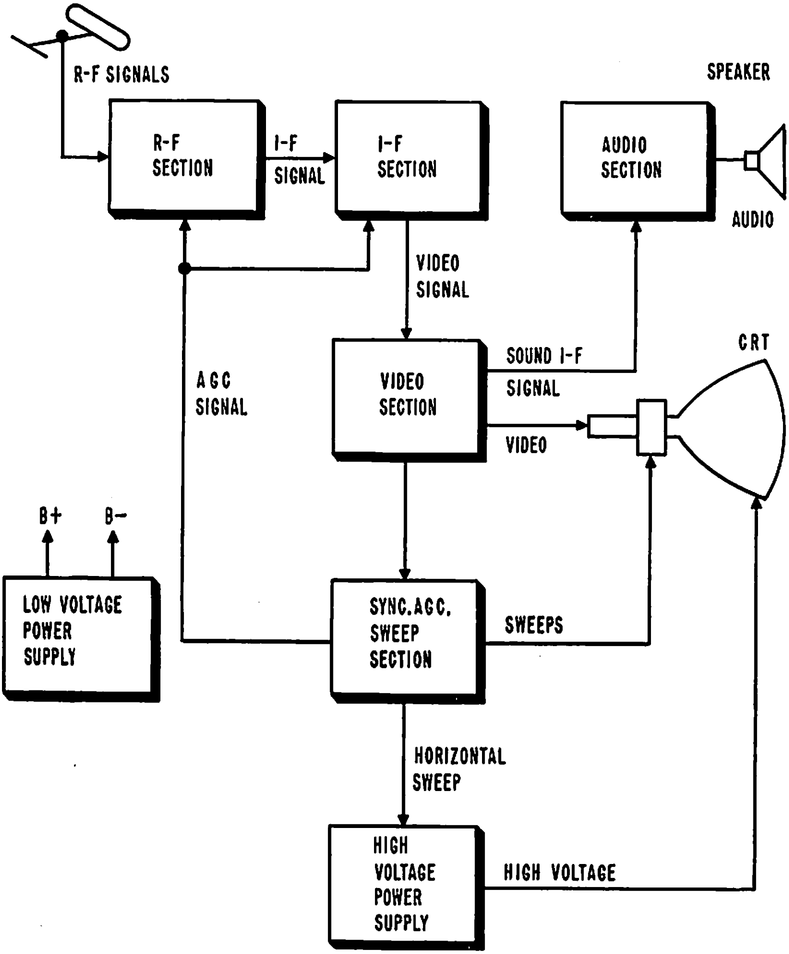
A typical television receiver is divided into eight functional sections (figure 2-1). These sections are the:

1. RF section
2. IF section
3. Video section
4. Audio section
5. Sync and sweep section
6. Picture tube assembly
7. High voltage power supply
8. Low voltage power supply

The rf section is sometimes called the "front end" or "rf head" of the receiver. This section performs three functions: the selection of the desired channel, the amplification of the signal of the desired channel, and the conversion of the rf signal to a lower-frequency if signal. Generally, the rf section consists of three stages: an rf amplifier, a local oscillator, and a mixer or converter. Selection of the carriers of the desired channel occurs in tuned rf circuits (it must be remembered that each television signal consists of two carriers, i.e. the picture carrier and the sound carrier.) After the desired channel is selected, the signals are amplified. The amplified signal and the output of the local oscillator are combined in the mixer, producing an if signal whose frequency is much lower than that of the original signal. Note that this signal consists of two if signals. One corresponds to the picture carrier and the other to the sound carrier.

The if section amplifies the picture and sound if carriers. In most modern receivers, the picture and sound if carriers are amplified in the same if amplifier channel. The two carriers are detected together, resulting in the video signal and a signal that is the beat between the two carriers. This beat signal, which is always at a frequency of 4.5 mc (the frequency difference between the picture and sound transmitter carriers), contains the fm sound components. Such receivers are called intercarrier type.

In other receivers, the picture and sound if carriers are separated at the output of the rf section or after the first if amplifier, and amplified



2-1. Television Receiver on a Functional Basis

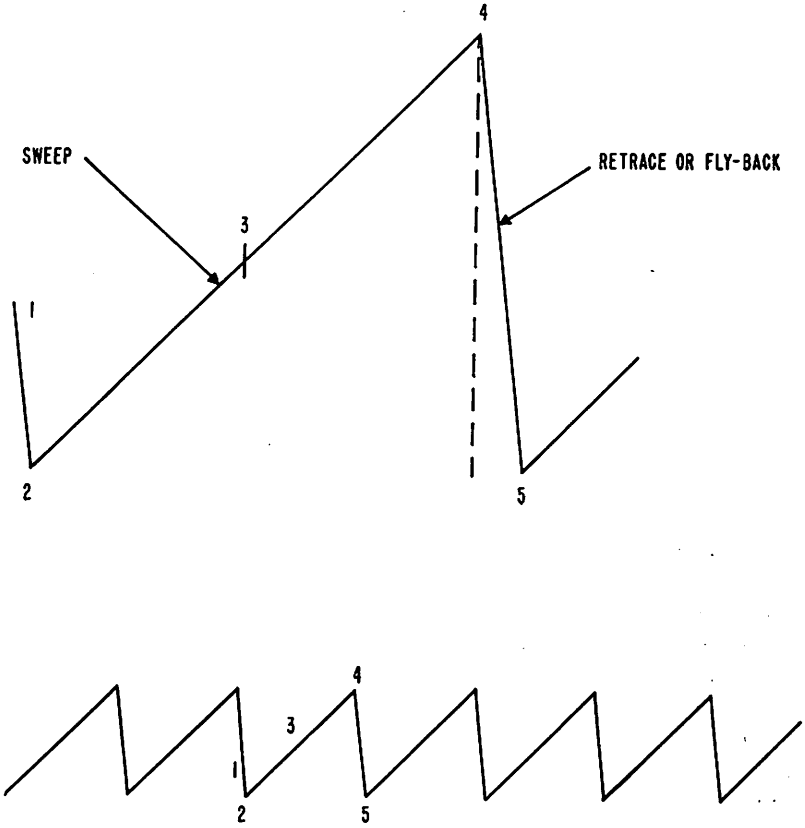
in separate if amplifier strips. Because the intercarrier is the most commonly used if system, this manual emphasizes this type of receiver. The output of the if section is detected or demodulated, forming the video signal such as shown in figure 1-4. In addition, the heterodyne beat between the video carrier and the audio carrier produces a 4.5 megacycle frequency-modulated audio carrier. In intercarrier-type receivers, this audio carrier is applied to the sound section; in receivers using a separate audio if section, it is suppressed by the use of low-pass filters.

The video section amplifies the video signal and applies it to the picture tube. Since the video signal has components ranging from about 60 cycles to 4 megacycles, the video section must be able to amplify this wide frequency band without distortion.

The audio section of the intercarrier-type receiver amplifies the frequency-modulated 4.5 megacycle sound carrier, detects it in a detector that can demodulate frequency-modulated signals, amplifies the audio output signal of the detector and drives the loudspeaker of the set.

Contained in the video signal applied to the cathode ray tube are the synchronizing pulses needed to keep the scanning beam of the receiver in step with the beam in the camera tube. In order to separate the synchronizing pulses, the video signal is also applied to the sync and sweep section. After separation from the video signal, the horizontal and vertical sync pulses are applied to the horizontal and vertical sweep generators. The sweep generators generate voltages that are applied to the deflection yoke on the neck of the cathode ray tube. The currents flowing in the yoke as a result of the sweep voltages deflect the electron beam, causing it to scan the screen a line at a time, one line beneath the other until the entire field is scanned. The sync and sweep section is also used to generate an AGC signal. The AGC or automatic gain control signal automatically adjusts the gain of the receiver to compensate for changes in rf signal strength due to lower input signal fading, airplane "flutter", atmospheric conditions, etc. The AGC signal is analogous to the AVC signal of a radio receiver.

The picture tube assembly consists of the cathode ray tube, the focus coil or focus magnet, and the deflection yoke. The picture tube, described in paragraph 1-3, consists of an electron gun that directs a narrow beam of electrons against the fluorescent material forming the screen. The focus coil or magnet forms the beam into a very narrow spot by magnetic means. The focusing action depends on the fact that an electron stream is shaped or deflected by the action of a magnetic field. The deflection yoke consists of two sets of coils mounted on a single cylindrical form designed to slip over the neck of the cathode ray tube. One set of coils causes horizontal motion of the beam (line scanning), the other set causes vertical motion of the beam (field scanning). The set of coils that cause the beam to scan a horizontal line are mounted above and below the tube. When a current flows through these coils the electron beam moves to the right or left depending on the direction of current through the coil. The amount of deflection depends on the amount of current flowing through the deflection coils. The greater the current in the coils, the greater is the deflection. If a current of 20 milliamperes deflects the beam one inch to the right, 200 milliamperes is needed to deflect the beam ten inches. To cause the beam to trace out a horizontal line at constant speed, the current applied to the horizontal deflection coils must increase at a constant rate in order to bring the beam from the left hand side of the screen to the right. When the beam reaches the right hand side of the screen, the current must rapidly drop back to the value that permits the beam



2-2. The Shape of the Sweep Current

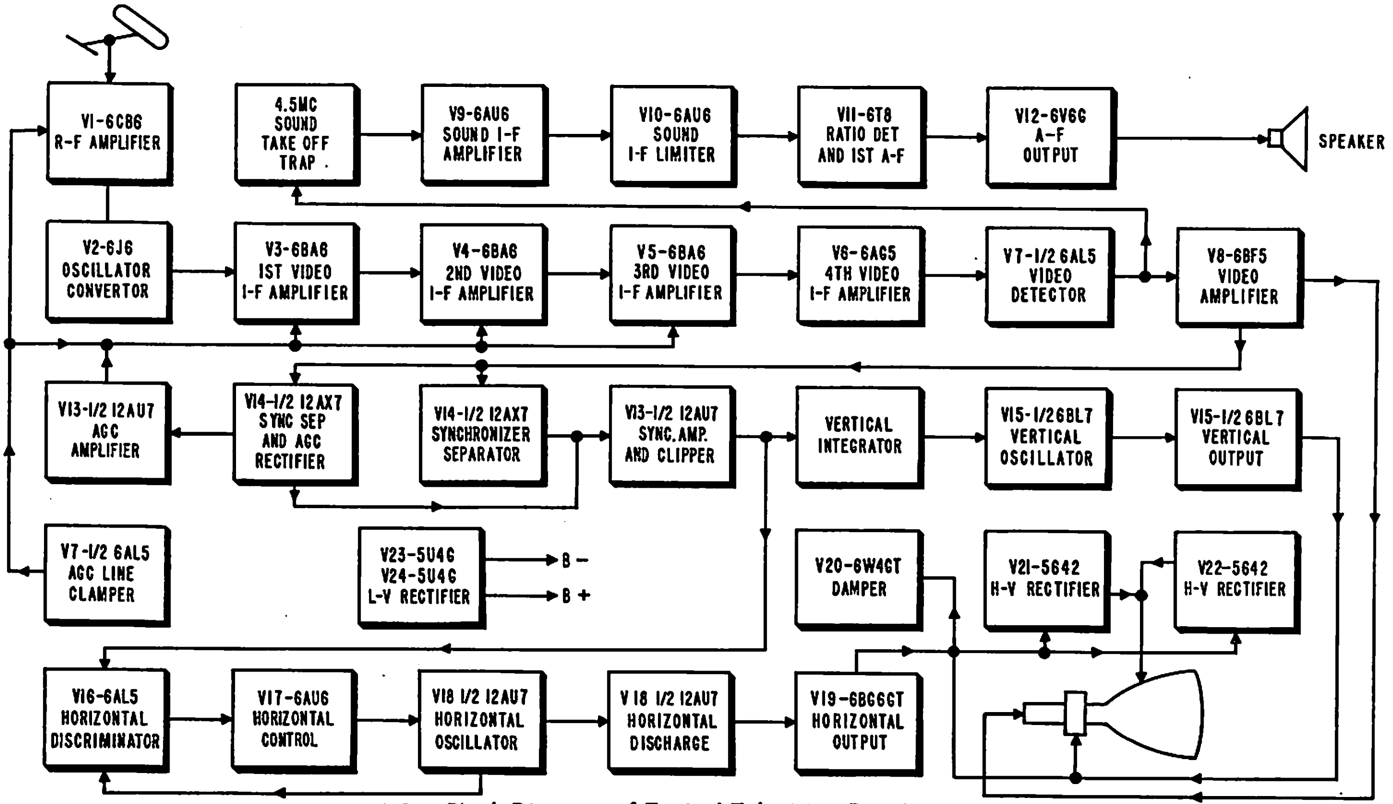
to return to the left hand side of the screen. Figure 2-2 is a diagram of the shape of the current passed through the horizontal deflection coil to cause the beam to scan one horizontal line. Between points 1 and 2, the beam is returning to the left from the previous sweep. At point 2, the current starts to increase causing the beam to begin scanning to the right. As the current increases until it reaches point 3, the beam will have scanned to the middle of the line. The increase of current to point 4 brings the beam to the extreme right hand side of the screen. It is now necessary to quickly return or retrace the beam to the left so that a new line can be swept out. This is accomplished by causing the current to quickly drop to point 5. Point 5 corresponds to point 2: i.e., the beam is at the left hand side of the screen. The current now starts to increase again, and the scanning of a new line begins. The slant vertical portion of the current waveform is called the trace; the steep downward return is called the retrace or fly-back. The cycle of trace and retrace is repeated 525 times for each frame or a total of 15,750 times a second. At the same time that the horizontal scanning current is being applied to the horizontal deflection coils, the vertical scanning current is being applied to the vertical deflection coils. However, only 60 vertical trace portions are applied to the deflection yoke each second. The vertical trace and retrace have essentially the same shape as their horizontal counterparts.

The high voltage power supply provides the voltage necessary to accelerate the electrons from the electron gun to the fluorescent screen. Without this high voltage to accelerate them, the electrons would not have enough energy to produce a bright image. Very little current is required from the high voltage power supply, hence the expense of using a 60-cycle high voltage transformer can be avoided by resorting to more economical methods of generating high voltage. In most conventional receivers, "fly-back" power supplies are the source of high voltage. In the fly-back power supply, the horizontal trace and retrace are applied to the primary of a fly-back transformer, inducing a voltage in the high voltage winding. The induced voltage is very high during the retrace because of the rapid current change occurring in a short time interval through the many turns of wire in this winding. This process is similar to the "inductive-kick" used to generate high voltage in the ignition coil of an automobile. The high pulse voltage is rectified and applied to the high-voltage terminal of the cathode-ray tube. Because the frequency of the signal applied to the transformer is 15,750 cycles per second, the filter components are much smaller than those found in conventional low voltage power supplies. A distinct advantage of the fly-back power supply is the high voltage failure that accompanies failure in the horizontal sweep circuits, thus preventing the screen from being burned.

The low voltage power supply customarily consists of a conventional full-wave rectifier with special filters and voltage dividers. This power supply furnishes the plate and screen voltage for all the tubes of the receiver.

2-2. BLOCK DIAGRAM

In the preceding paragraph, the television receiver was analyzed on a functional basis. For the purposes of this explanation, the television receiver was reduced to eight sections. Each section, which consists of one or more tubes and associated electronic components, performs a definite operation in the reproduction of the sound and image of the television scene. In the paragraphs that follow, typical present day television receiver circuitry is described on a stage by stage basis. Figure 2-3 is a complete block diagram of a typical receiver. In this diagram, a block is used to represent every tube or stage in the receiver. This diagram has been provided to facilitate the understanding of the



2-3. Block Diagram of Typical Television Receiver position and function of each stage in the overall signal flow in the receiver. Reference should be made to this diagram as the reader progresses through the explanation of the operations of each stage.

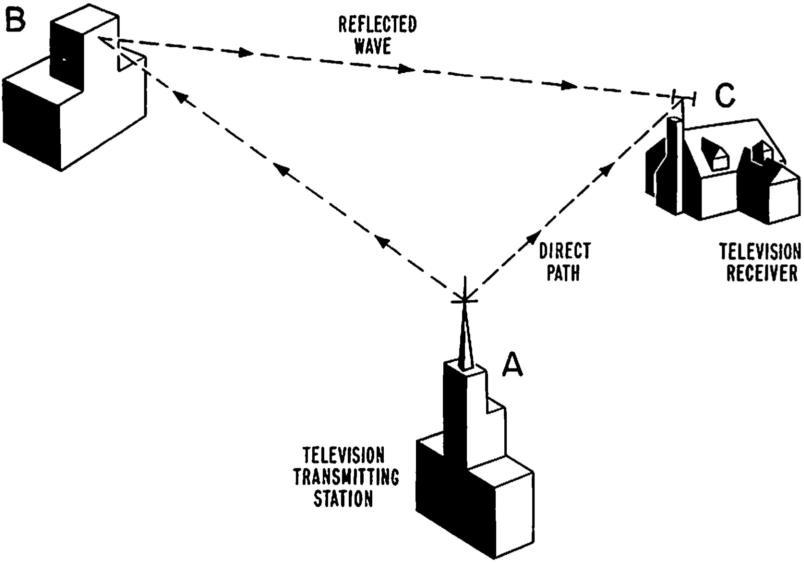
2-3. THE ANTENNA

The television antenna is the first link in the electronic "chain" between the rf signal radiated by the television station and the eyes and ears of the TV viewer. The function of the antenna is to "extract" sufficient radio frequency energy from the air to enable the television receiver to produce an acceptable picture and sound.

In addition to the requirement for high gain, the television antenna must also have a broad bandpass. The necessity for broad bandpass arises from the fact that the 12 television channels presently allocated cover a frequency interval of approximately 160 megacycles. For the purpose of the television technician, the theory behind the design of the practical television receiving antenna is unnecessary. But one rule must be stressed: the best antenna is useless if it is not properly applied. It is therefore imperative that the technician become familiar with the effective characteristics and use of the antenna.

Several characteristics distinguish the television antenna. The first is high-gain and directivity. Since gain is proportional to directivity, high gain and high directivity are synonymous. Because of its directive characteristics, the orientation of the antenna is critical. This means that the antenna must be correctly pointed with respect to the television station if the station signal is to be successfully picked up. If the receiver is located so that the television stations in the vicinity are in different directions, then an antenna of low directivity, or more than one antenna of high directivity, will be necessary, with each antenna pointed at one of the stations.

One of the major advantages of the directive characteristics of the television antenna is its ability to discriminate against "ghosts." Ghosts in a television picture can be compared to sound echo. A sound echo results when the original sound is followed a short interval later by the same sound reflected from the surface of some distant object. On the television screen, a ghost appears as a weaker outline to the right of every object in the picture. The ghost is the result of a reflection (fig. 2-4) of the transmitter signal to the receiver antenna from the wall of a building or the side of a hill. Because the time required for the reflected signal to reach the receiver antenna is greater than that required for the direct signal, the image corresponding to the reflected signal appears to the right of the image produced by the direct signal. By proper orientation of the antenna, the directive characteristics of the antenna can usually be used to discriminate against the reflection causing the ghost. In the event that more than one antenna is being used, and ghosts are a problem, the technician should remember that the ghost on one channel might be caused by a reflected signal picked up by the antenna erected to receive the signals of another channel.



2-4. How Ghosts are Created

The transmission line that connects the antenna to the receiver is as important as the antenna itself. In the final analysis, only the signal carried by the transmission line from the antenna can be used by the receiver. The antennas and transmission lines available on the commercial market today are carefully designed and manufactured. However, the results obtained are porportional to the quality of the installation. The technician must use extreme care when installing the antenna and transmission line. Shoddy techniques can only result in a poor installation and therefore a poor picture. The best rule to follow is to adhere to the methods recommended by the manufacturer of the antenna and receiver. Do not use splices in the transmission line when they can be avoided. Use the type of transmission line recommended. Secure the line so that it does not swing with the wind. Do not depend on the connections to the antenna members to support the entire weight of the transmission line. Avoid piercing the plastic web between the two conductors of a two-wire transmission line with staples or nails. When the plastic web is damaged, the characteristics of the line are affected and its efficiency reduced. Twist the line 1/4 turn every 3 or 4 feet to reduce local electrical interference caused by pick-up in the transmission line.

2.4. THE RF SECTION

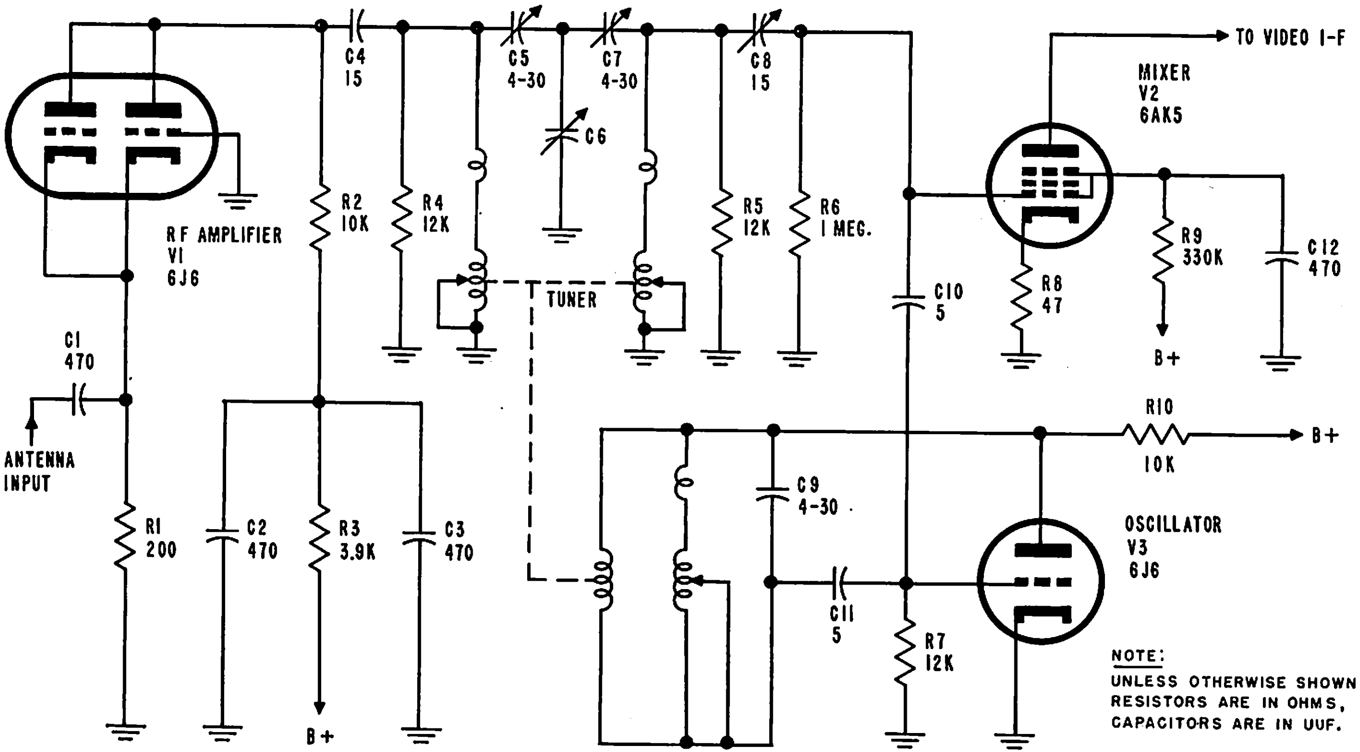
The major function of the rf section of the receiver is the selection of the carriers of the desired channel and the conversion of these carriers to if signals. The rf section generally consists of antenna input circuits, an rf amplifier, a mixer, and a local oscillator. The antenna input circuit matches the transmission line to the input of the rf amplifier. The rf amplifier serves to increase the signal-to-noise ratio and image rejection ratio of the receiver. It also isolates the local oscillator from the antenna. This reduces radiation interference between television receivers in crowded localities.

Figure 2-5 is a simplified schematic of a typical rf tuner or "front-end". This tuner is a continuous tuning front end, i.e., a continuously varying tuning dial is used to select the desired channel. V1, the 1st rf amplifier, is basically a grounded-grid, tuned-plate amplifier. The antenna circuit drives the cathode circuit of V1 through capacitor C1. The plate circuit is ganged to the tuning control so that the resonant frequency of the plate circuit can be tuned to the desired channel. The plate circuit consists of a band-pass filter. The bandwidth of this filter is 6 mc wide so that it can admit all the components of the composite rf signal. To ensure that the tuning control tracks properly, trimmer capacitors C5, C6 and C7 are provided. During factory alignment, these trimmers are adjusted so that the plate circuit and grid circuit of the rf amplifier and mixer respectively are tuned to the proper frequencies at all positions of the tuning control. The output of the filter is applied to the grid of the mixer. Also applied to the grid of the mixer is a voltage from the oscillator.

The oscillator frequency of the receiver being used as an example is always 26.4 mc above the received video carrier frequency, when in tune. When the oscillator signal beats with the rf signal in the mixer, two if signals result. one at 26.4 megacycles for the picture carrier and one at 21.9 megacycles for the sound carrier. The two carriers are applied to the if section for further amplification. The output of the oscillator is coupled to the mixer by C10.

The function of the mixer is the combining of the incoming rf carrier with the receiver oscillator signal to produce the lower if or intermediate frequency.

Except for the picture tube, all the tubes in a television receiver draw their power from a common source: the low voltage power supply. This means that every stage in the receiver has a connection to a common point: the B+ supply line. This common connection could enable signals from various stages in the receiver to couple to one another, resulting in oscillation and motorboating. A set that is oscillating or motorboating may cause odd patterns on the picture tube, or, in some cases, a completely black tube without a raster. When heard through the loudspeaker, the oscillation or motorboating manifests itself as a howl, whistle, or "put-put". In order to prevent undesired coupling, special decoupling networks are incorporated in the plate and screen leads of those stages in the receiver that would tend to oscillate because of feedback through the power supply. Their function is to isolate the affected stage from the power supply in such a manner that the d-c voltage of the power supply is properly coupled to the plate or screen but the ac signals that have entered the power supply from other



2-5. Simplified Schematic of Typical RF Head

NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS,
CAPACITORS ARE IN UUF.

stages are blocked. The decoupling network in the plate of V1 is composed of capacitors C2 and C3 and resistor R3. Decoupling of the filament circuits is also necessary because all the tubes draw their filament power from two windings on the transformer. Since coupling through the common filament connection can also be a source of troublesome feedback, decoupling networks or filters are also found in filament circuits (see figure 5-1). The serviceman should be particularly aware of the function of the decoupling filters. In the event that any of the capacitors of the decoupling networks were to open, the immediate result could be oscillation among several stages. A good indication of the presence of oscillation in a stage is an abnormally high negative voltage on the grid of a stage as measured with a Polymeter. Thus if a serviceman encounters a set in which all the tubes are good and which exhibits a raster (even one which may be distorted), one of the checks the serviceman should make is a check of the grid potential of tubes in the rf and if sections with a Polymeter. If one of the tubes has too negative a grid potential, look for an open decoupling capacitor.

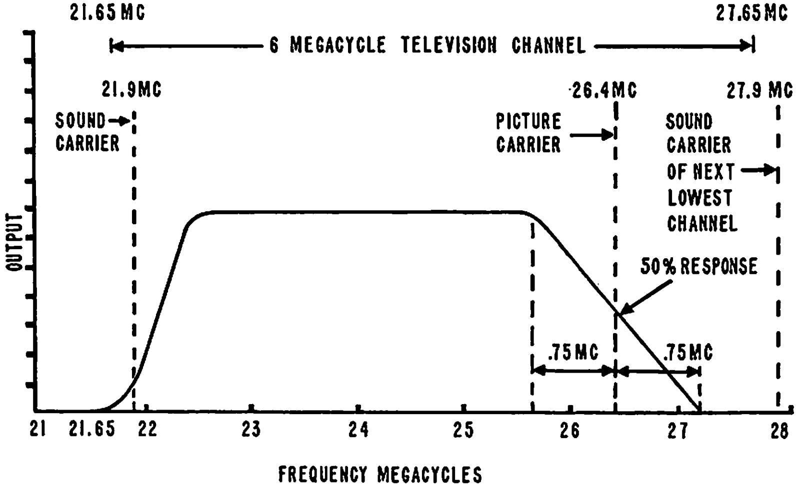
Because of the frequencies involved, the mechanical construction of the rf section or "front end" is very critical. Disturbing the position of a single wire can seriously effect the performance of the tuner.

2-5. THE IF SECTION

The if section consists of the stages that amplify and detect the if carriers produced by the rf section and apply the result to the video and sound sections. Depending on the type of receiver, one or two if amplifier channels may be used. In the dual channel type of receiver, separate if amplifier strips are used to amplify the picture or video if signal and the sound or audio if signal. In the intercarrier type of receiver, both if signals are amplified in the same amplifier channel. Then the video and 4.5 mc sound if frequencies are separated and applied to the appropriate sections of the receiver. It may be noted that, in contrast, the dual if channel receiver is more difficult to tune and hold in tune, and is therefore falling into disuse. In addition, the intercarrier sound receiver requires fewer parts since only one if amplifier channel is used. It is usually more reliable, and easier to tune, than the dual channel receiver. For these reasons most of the receivers designed and produced today are of the intercarrier type.

The amplifier that handles both if signals is customarily referred to as the picture if amplifier in order to distinguish it from the amplifiers that handle only the sound if carrier. Three to five video if amplifiers are usually used to furnish the required gain and bandpass. The bandpass of the picture if amplifier strip is very important, since it directly determines the quality of picture detail.

As explained in paragraph 1-7, the complete signal transmitted by a television station is six megacycles wide (fig. 1-5). As shown in

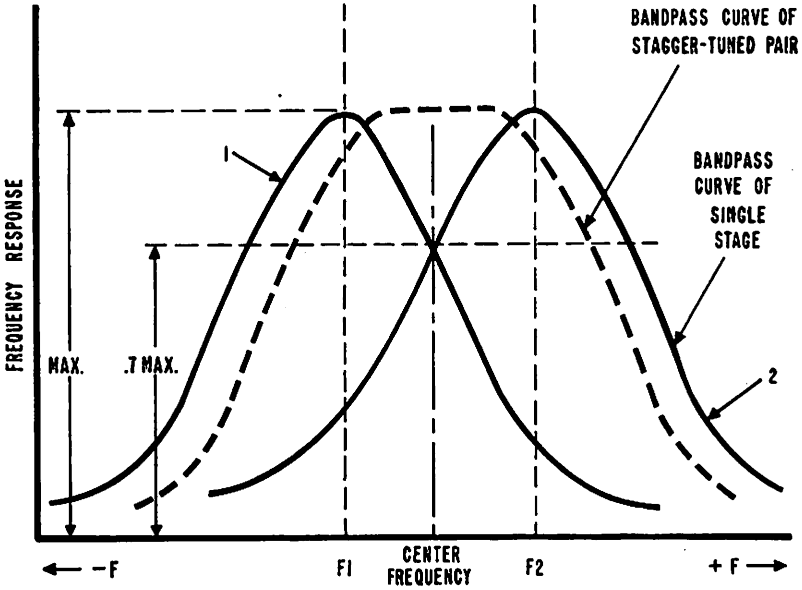


2-6. IF Bandpass

figure 1-5 the frequency distribution of the composite signal is as follows: 5.25 megacycles is used by the video component of the signal, a half-megacycle gap is provided between the video component and the audio carrier, then the audio carrier occurs, and finally, a quarter-megacycle safety band is provided between the audio component and the end of the television channel. As explained previously, the video or picture component of the television signal consists of two parts: the 4 megacycle upper sideband which contains all the picture information and the 1.25 megacycle vestigial lower sideband. All the information necessary to reproduce the picture is contained in the upper sideband. Because of the difficulty of completely eliminating the lower sideband at the transmitter, 1.25 megacycles of the lower sideband is also transmitted. The 1.25 megacycle vestigial sideband conveys the same picture detail contained in the first 1.25 megacycles of the upper sideband. In order to prevent over-emphasis of the detail carried by the lower video frequencies (i.e. 0 to 1.25 mc), the bandpass of the if amplifiers is deliberately reduced at the lower sideband frequencies.

Figure 2-6 is a graph of the correct bandpass or response of the picture if amplifier (i.e. the if section). By comparing this figure with figure 1-5, it will be noticed that the sound carrier is below the picture carrier in the if signal, whereas it is above the picture carrier in the rf signal radiated by the television station. This reversal in position results because the frequency of the oscillator in the rf tuner is above the incoming signal. Thus, for Channel 2 with a picture carrier frequency of 61.25 mc, the oscillator frequency is 61.25 + 26.4 mc or 87.65 mc. When the oscillator signal and the rf signal are mixed, the resultant picture if carrier signal has a frequency of 26.4 mc. The sound carrier for Channel 2 is 65.75 mc. When the sound carrier and the local oscillator signal are mixed, the resultant sound if carrier has a frequency of 21.9 mc, which is the difference between 65.75 mc and 87.65 mc. Since the oscillator is always tuned 26.4 mc above the picture carrier of the desired channel, the picture if carrier is always 26.4 mc and the sound if carrier is always 21.9 mc, regardless of the channel to which the receiver is tuned.

As indicated in figure 2-6, the flat portion of the if amplifier overall bandpass must be approximately 3.5 to 4 mc. In order to obtain this wide bandpass, special techniques must be resorted to in the design of the picture if amplifiers. Of the several methods possible, stagger tuning is the most popular today. Stagger tuning consists of peaking each of the if amplifier stages to a different frequency within the desired passband. In order to understand the basic operation of a stagger-tuned if amplifier strip, a simple two stage stagger-tuned amplifier is considered first. As with any stagger-tuned system, the two amplifier stages are connected in cascade. In figure 2-7, curve 1 plots the response of the first amplifier stage. The shape of the curve indicates that the amplifier stage is tuned to the frequency F_1. The frequencies on either side of the resonant frequency of the amplifier stage are not amplified as much as F_1 as indicated by the downward slope of curve 1. At the center frequency on figure 2-7, the signal receives only 70% of the amplification of a signal with a frequency of F_1. Curve 2 is a plot of the response of the second amplifier stage which is tuned to frequency F_2. As with the first amplifier stage, signals with frequencies either side of the tuned frequency are not amplified as much at F_2.



2-7. Effect of Stagger Tuning Two Amplifiers

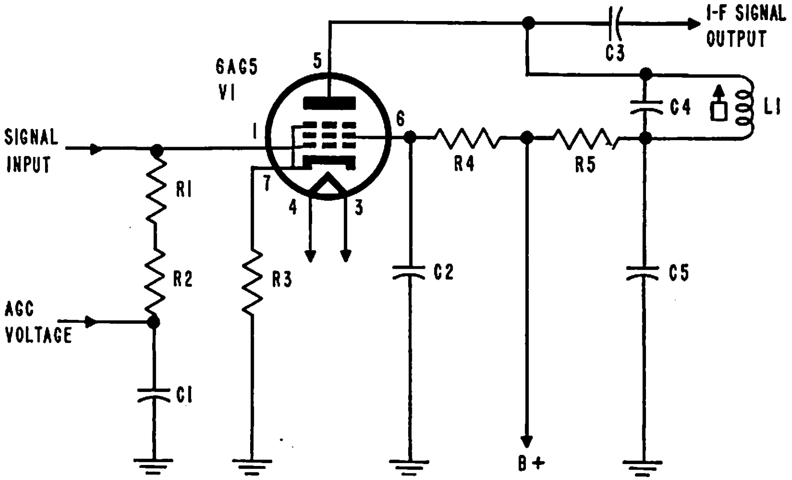
Again, at the center frequency, only 70% amplification is provided. Curves 1 and 2 combine to produce the dotted curve shown in figure 2-7 and signals applied to these stages will be affected by the overall response. Notice that the bandpass of the two amplifier stages together is much greater than that of either one. In the receiver being studied as a model (figure 5-1), four amplifier stages, tuned to four different frequencies, are used to obtain the bandwidth necessary to pass the frequencies indicated in figure 2-6.

The stagger-tuned if amplifier has several advantages. The first is that it is probably the easiest to align, since an ordinary signal generator can be used to check each tuned circuit. With a good signal generator, the serviceman can peak each circuit at the frequency called for by the manufacturer to aid in establishing the correct bandpass. Because the grid and plate circuit of each amplifier tube is tuned to a different frequency, the tendency for the amplifier stages to regenerate or oscillate is reduced, and thus their stability is increased.

As indicated in figure 2-6, the overall bandpass of the if section must fall off rapidly at the edges of the channel. The necessity for this arises from the fact that considerable interference with the picture and sound of the desired channel results if any of the signals of the adjacent channels enter the video or sound sections of the receiver. In particular, the sound carrier of the next lowest channel must be completely eliminated from the if signal applied to the video section, since this sound carrier is only 0.25 megacycles away from the edge of the vestigial sideband. With the 26.4 mc (picture carrier) if frequency, the edge of the vestigial sideband falls at 27.65 megacycles. The sound carrier of the adjacent channel is located at 27.9 megacycles. To attenuate this undesired sound carrier, tuned traps are used. An example of a trap is C136 in series with the parallel combination of L55 and C134 (see figure 5-1). Together, these components form a series resonant circuit, characterized by presenting a very low impedance at the frequency at which it is resonant. Since it is desired to eliminate the if signal corresponding to the sound carrier of the adjacent channel, the series trap is tuned to 27.9 megacycles. Because it is located in the grid circuit of the last video if amplifier stage, signals with a frequency of 27.9 megacycles are by-passed to ground. In this manner, the possibility of sound bars on the picture tube from an adjacent channel sound component is reduced.

Figure 2-8 is a simplified schematic of a typical if amplifier. Basically this stage is a tuned-grid tuned-plate amplifier, identical to the type used as if amplifiers in radio receivers. The main difference lies in the frequencies amplified and the fact that the grid and plate circuits are tuned to different frequencies in accordance with the stagger-tuning principle. Thus, to obtain the bandpass illustrated in figure 2-6, the four picture if amplifier stages are tuned to 25.5 mc, 23.6 mc, 25.0 mc and 25.9 mc.

The grids of the first three picture if amplifier tubes are supplied



2-8. Simplified Schematic of Typical IF Amplifier

with AGC (automatic gain control) bias voltage. This voltage controls the gain of the rf amplifier and picture if amplifier stages to compensate for varying changes in signal strength at the antenna due to changing climactic conditions and fading. The AVC bias voltage used in ordinary radio receivers is analogous to AGC except, as is necessary in television, it operates on the peaks of the signals. The effect of these changes in signal strength is a continual shift in the brightness in the image on the picture tube. Since the eye is very sensitive to changes in light intensity, an image whose intensity varies erratically is very annoying. The AGC bias avoids this by reducing the gain of the receiver when the signal strength momentarily increases and increasing the gain when the signal level drops. By varying the gain in this manner, the video signal applied to the picture tube is maintained relatively independent of rf signal amplitude fluctuations. The gain of the receiver is varied by the AGC bias applied to the picture if amplifier stages because the gain of the tubes used in these stages varies with the bias on the control grid. As the bias becomes more negative, the gain decreases; when the bias goes less negative the gain goes up. In order to obtain sufficient control of receiver gain, it is necessary to apply the AGC voltage to the rf amplifier and the first three picture if amplifier stages. However, the fact that the control grids are connected to a common source of AGC voltage makes the use of decoupling networks or filters necessary. As with the decoupling networks required for the plate and screen voltage supply, decoupling of the AGC line is required because the feedback between the various amplifier stages could result in oscillation of the if amplifier. The decoupling networks used in the AGC line are similar to those used in the plate and screen voltage line (capacitor C5 and resistor R5).

Although stagger-tuning is the most generally used method to obtain the necessary bandwidth for the picture if amplifier, over-coupled amplifiers are also used. In an over-coupled amplifier, the necessary bandwidth is obtained by using interstage transformers which are so tightly coupled that the bandpass curve has two peaks. The tuned circuits formed from the primary and secondary of the transformers are then loaded with resistors to flatten out the two peaks.

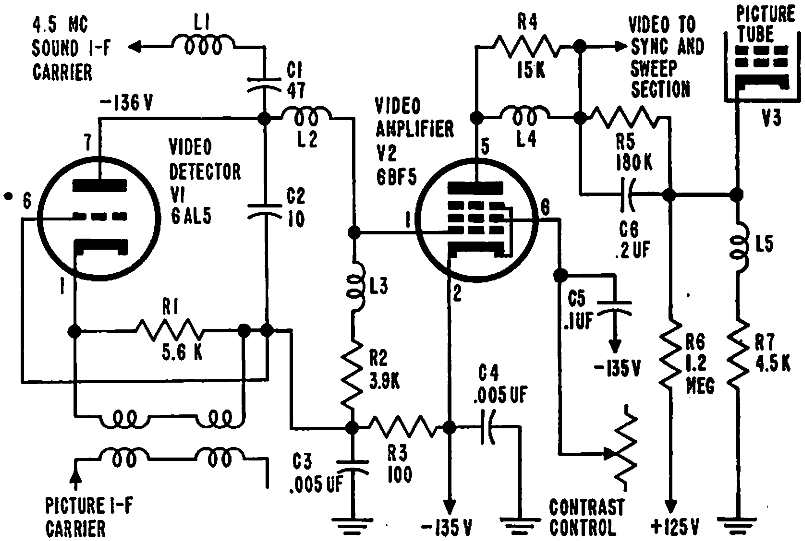
The output of the last if amplifier stage contains the picture and sound if carriers separated by 4.5 megacycles. When these are applied to the diode video detector (V1, fig. 2-9) two things occur. One is the reappearance of the video signal that is a replica of the signal generated at the camera tube in the studio as the electron beam scanned the image. The second is a mixing action between the picture and sound if carriers, identical to the mixing that occurs in the mixer tube of any superheterodyne receiver when the rf signal is mixed with the oscillator signal to produce a signal much lower in frequency. The frequency of the if signal produced by the mixing action equals the difference between the rf frequency and the oscillator frequency. In the video detector of the television receiver, the two signals that mix together are the picture and sound if carriers. Since the frequency difference is 4.5 megacycles, the result of mixing the two carriers is a signal with a frequency of 4.5 megacycles. This signal is frequency modulated with the sound accompanying the picture being transmitted. At the plate of the video detector, there is an auxiliary series resonant circuit tuned to 4.5 megacycles. This series resonant circuit provides the coupling between the video detector and the grid of the sound if amplifier and also tends to reduce the 4.5 megacycles going into the video amplifier.

In addition to separating the sound carrier from the if signal, the video detector also extracts the video signal from the picture carrier. In accomplishing this, the video detector functions exactly as the second detector in a radio receiver. First, the if signal is rectified. After rectification, the if signal components are filtered out, leaving only the envelope. This envelope is the video signal. Filtering the if component from the rectified signal is comparatively easy because the frequency of the if signal is 26.4 megacycles, whereas the highest video frequency is 4 mc. The video signal is coupled to the grid of the video amplifier.

2-6. THE VIDEO SECTION

The video section consists of the video amplifier that receives the video components of the television signal. It amplifies and applies the video signals to the grid or cathode of the picture tube and to the sync separating circuits of the sync and sweep section. It should be remembered that the video signal contains three components, the camera detail, the blanking pulses, and the sync pulses. All three are applied to the picture tube but only the camera detail appears on the screen.

As explained previously, the picture detail is caused to appear on



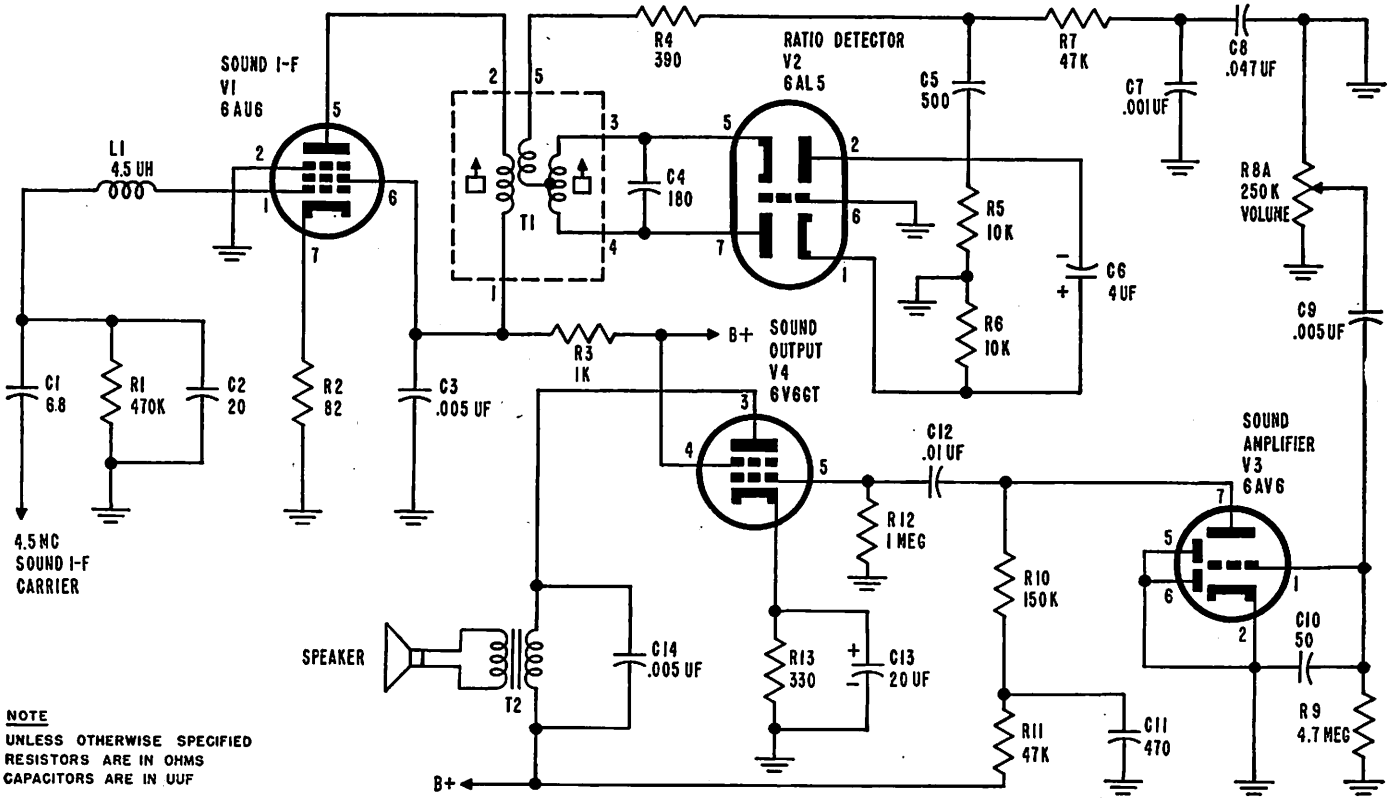
2-9. Simplified Schematic of Video Amplifier

the screen of the picture tube by varying the intensity of the electron beam. When the beam current is a maximum, the spot of light caused by the beam is brightest. When the beam current is minimum, the spot of light caused by the beam is darkest. When the beam is completely cutoff, the screen is black.

The beam current is dependent on the voltage difference between the cathode and control grid of the picture tube. Making the grid go positive or the cathode negative has the same effect on the current in the beam. Thus the video signal may be applied to either the grid or cathode of the picture tube as long as the polarity is such that the portions of the camera detail that are white cause the electron current to increase and the polarity of the blanking signals cause the tube to be cutoff.

Although the blanking and sync signals are also applied to the picture tube, they are not displayed on the tube face, because they occur during the time in which the picture tube is cutoff: e.g. the blacker-than-black or infra black region.

The video amplifier (fig. 2-9) is capable of amplifying signals from 0 to 4 mc. In order to obtain this large bandpass, special techniques must be used. The ability of the amplifier to pass 0 cycles or d-c results from the use of direct coupling between the video detector and video amplifier tube and also between the latter and the grid or cathode of the picture tube. The high frequency response of the amplifier is extended by using special peaking circuits that maintain the effective load resistance of the stage as the frequency increases. This compensates for the decrease in gain due to the shunting effect at these frequencies of the stray capacity in the circuits of the video amplifier.



NOTE
UNLESS OTHERWISE SPECIFIED
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF

2-10. Simplified Schematic of Audio Section

2-7. THE AUDIO SECTION

The audio section receives the 4.5 mc sound carrier output of the video detector. It amplifies, limits, and detects these signals to produce an audio signal which is applied to audio amplifiers that drive the loudspeaker.

In contrast to the video signal which is amplitude modulated, the sound carrier is frequency modulated.

Figure 2-10 is a simplified schematic of a typical television receiver audio section. The first stage, VI, is a conventional if amplifier of the same type used as picture if amplifiers except for the resonant frequency. For the sound if amplifier, the circuits are tuned to 4.5 mc, the sound carrier frequency. The tuned grid circuit consists of a series resonant circuit. Because a series resonant circuit is practically a short circuit at its resonant frequency, the 4.5 mc carrier is accepted and all other frequencies are attenuated. VI drives V2, the ratio detector. The ratio detector functions to convert the frequency-modulation of the carrier into an audio signal.

The ratio detector has become a most popular type of f-m discriminator because it provides its own limiting action. In other words, its output is relatively insensitive to changes in carrier amplitude. Because of this, spurious signals resulting from noise and imperfect separation of the video signals and sound carrier at the video detector are rejected.

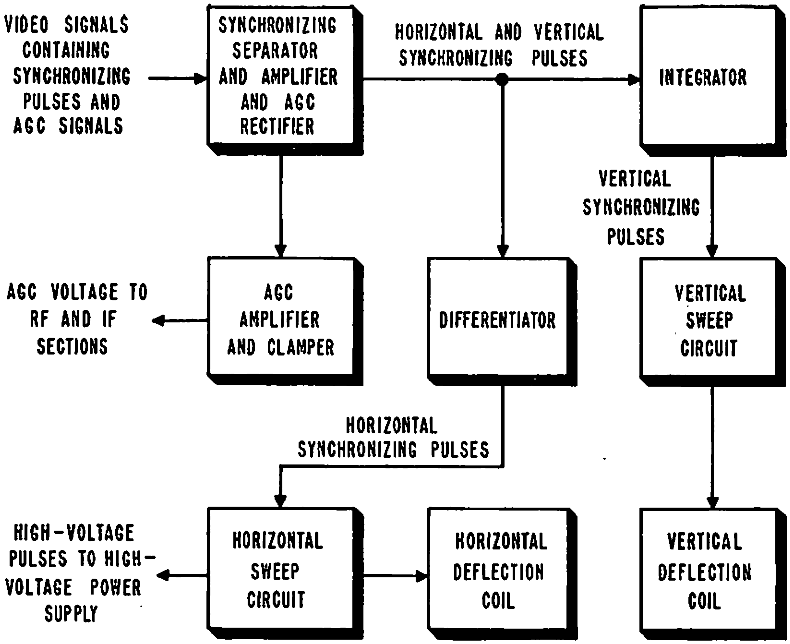
The audio output of the ratio detector is applied to a conventional audio amplifier. This stage amplifies the audio output of the ratio detector and applies it to the af output stage, which is a standard audio power output stage similar to the type found in every radio receiver.

It should be evident that the sound section of a television receiver is identical to the if and audio section of a conventional fm receiver.

2-8. SYNC AND SWEEP SECTION

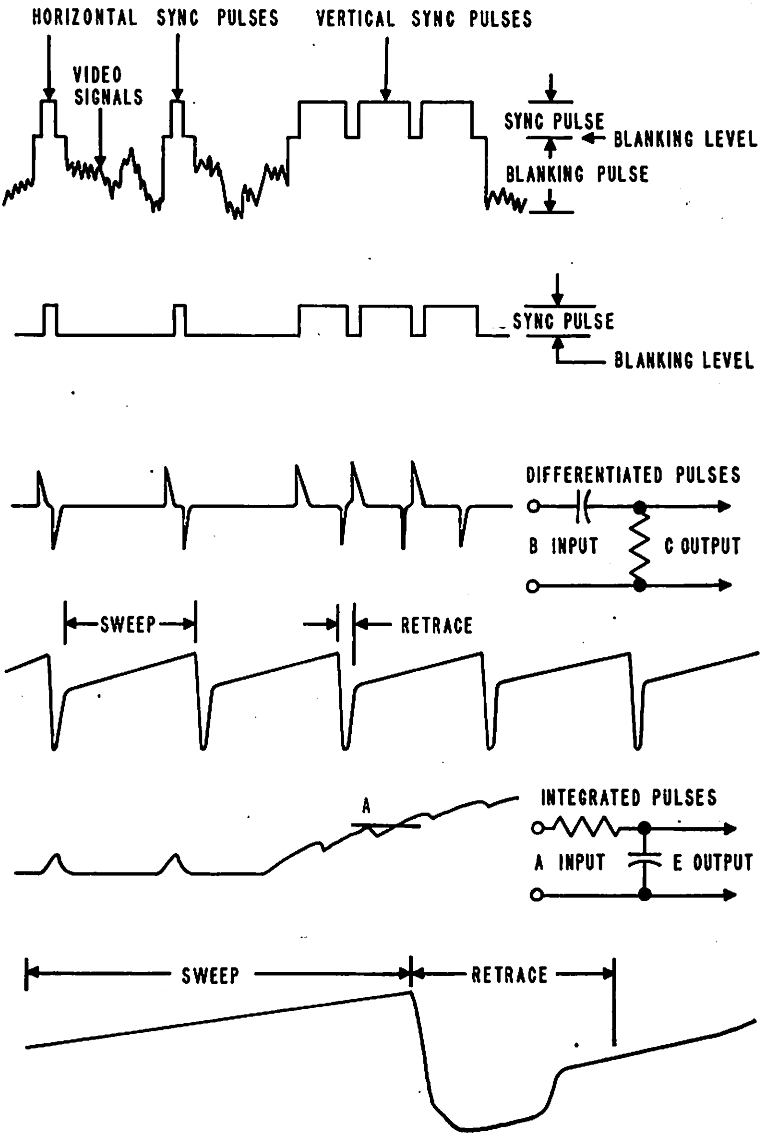
The sync and sweep circuits contain the components that reject or separate the video component from the composite signals. The signals that remain after rejecting the video components consist of: horizontal sync pulses, vertical sync pulses, and the blanking pulses. The sync pulses are used to trigger the sweep circuits in a manner such that the picture information displayed upon the raster line-by-line coincides with the picture information modulating the video carrier at the distant transmitter. Refer to the block diagram (fig. 2-11) of the sync and sweep circuits as the functional description of each block is given in the following paragraph.

The input to the sync separator, sync amplifier and AGC rectifier is shown in simplified form in figure 2-12a. The video component of the composite signal is lower than the blanking level while the sync pulse components are higher than the blanking level and mounted on the blanking pulse "pedestal". The sync separator functions like an electronic saw by cutting away the signals that occur below the blanking level (i.e. the video signals). The sync pulse output of the sync



2-11. Simplified Block Diagram of Sync and Sweep Section

separator (fig 2-12b) is fed to the sync amplifier, which increases the pulse amplitude it couples to the integrator and differentiator circuits. The rectifier circuit charges to the peak amplitude of the sync pulse and applies the resultant filtered dc voltage to the AGC amplifier and clamper which couple the AGC potentials to the grids of the rf and if amplifiers. Since the sync amplitude is constant as determined at the transmitter, it is a reliable indication of carrier strength and may be used for the AGC circuits. The video signals, however, vary in amplitude from scene to scene and may not be used to operate the AGC circuits. The integrator and differentiator circuits are resistor-capacitor (r-c) networks that are responsive to differences in sync pulse width. The integrator network consists of a resistor and capacitor across which the output of the sync amplifier is impressed. As shown in figure 2-12, the short duration horizontal sync pulses are unable to fully charge the capacitor while the long duration vertical sync pulses can. The resulting wave form comprises the input to the free-running blocking oscillator in the vertical sweep circuit. The free running or normal frequency of the vertical oscillator is designed to be approximately 60 cycles per second to correspond to the 60 fields per second used in present day black and white television receivers. The integrated sync pulse locks the oscillator in step with the vertical sweep circuits of the distant transmitter so that each time a new field is started at the transmitter a new field is started at the receiver. Somewhere after the



2-12. Waveforms of Sync and Sweep Section

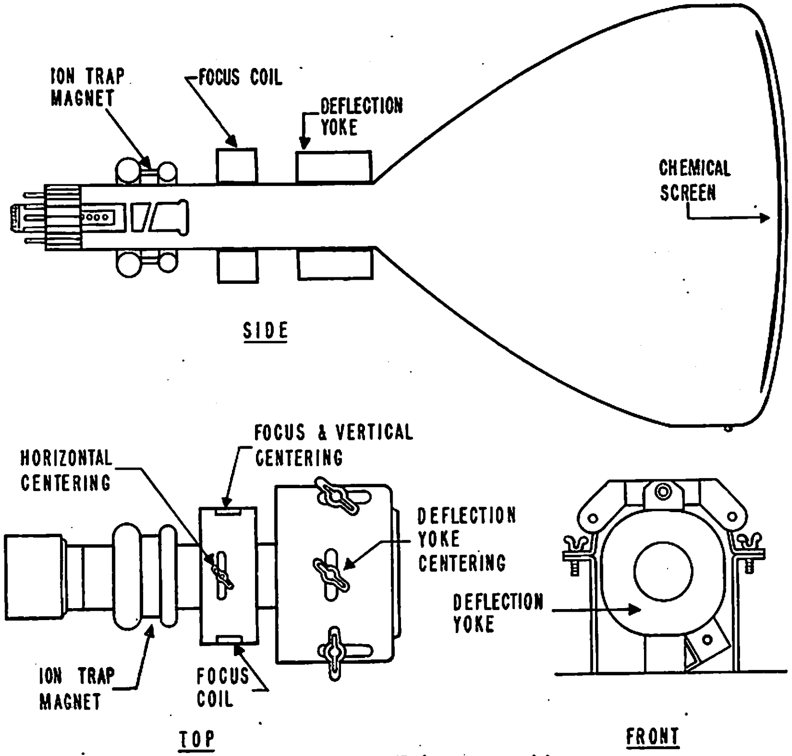
beginning of the vertical sync pulse, the charge at the output of the integrator network is sufficient in magnitude to trigger off the vertical oscillator to start the retrace of the electronic beam in the picture tube. The shaped and amplified output of the vertical sweep circuits is shown in figure 2-12f. This waveshape is applied to the vertical deflection coils, resulting in a sawtooth of current that increases linearly with time. The magnetic field resulting from the current through the deflection coil sweeps the electron beam very slowly from the top of the screen to the bottom. During the retrace period the screen is blanked out and the beam is rapidly returned to the top of the screen to start the next field. The differentiator circuit consists of a short time constant series r-c network across which the output of the sync amplifier is impressed. As shown in figure 2-12c, the differentiated horizontal and vertical sync pulses appear as similar wave shapes across the output resistor. The free running blocking oscillator in the horizontal sweep circuits is designed to be unaffected by negative going pulses from the differentiator circuit, and they can therefore be disergarded. The positive going portions are used to lock the horizontal sweep circuits in step with the horizontal sweep circuits at the distant transmitter, so that each time a new line is started at the transmitter a new line will be started at the receiver. Since the present state of the black and white television art specifies 15,750 lines each second, the frequency of the horizontal oscillator is adjusted to be 15,750 cycles per second. Referring to figure 2-12d it can be seen that each positive going differentiated horizontal sync pulse triggers off the retrace period of the horizontal sweep circuits so that the electron beam which has been slowly moving from left to right may be rapidly returned from right to left during the blanked out retrace period. The leading edge of every other differentiated vertical sync pulse serration also triggers off the retrace period for the horizontal sweep circuits. The output of the horizontal sweep circiut is applied to the horizontal deflection coils, whose action is similar to the action of the vertical coils on the output of the vertical deflection circuits. A portion of the horizontal waveshape is stepped up through the transformer and coupled to the high voltage power supply.

2-9. PICTURE TUBE ASSEMBLY

The picture tube assembly consists of the units that are mounted along the neck of the picture tube. These units serve to focus, deflect, and otherwise adjust the electron beam that scans the face of the picture tube. Figure 2-13 shows the top, front, and side views of a typical picture tube assembly, comprised of the following components:

(1) Ion trap magnet or "beam bender"
(2) Focus coil or focus magnet
(3) Deflection coils.

The electron gun of the television picture tube emits two types of electrically charged bodies. One body is the electron, a negatively charged body of extremely small mass travelling at a high velocity. The other body is the negatively charged ion, a body of much greater mass than the electron and traveling at comparatively slow velocities. When both particles travel through a magnetic field of constant strength, the lighter electron is deflected more than the heavier ion. This is to be expected, as a light body can be moved more easily than a heavy body. If the magnetic field just mentioned should be the magnetic field of the deflecting coils (to be discussed subsequently) the electrons would



2-13. Picture Tube Assembly

be displaced so as to cover or scan the entire face of the picture tube, while the ions would not be deflected and so would converge at one point in the center of the screen. The constant bombardment of the fluorescent surface by the heavy ions would soon damage the coating, leaving a distinctive brownish blotch called an ion burn. No picture information can be displayed by the burn area, as the brownish color is caused by the severe impairment of the fluorescent material. To avoid this condition, electron guns are constructed with guns which internally deflect the electrons and ions to one side. By placing a magnetic field (ion trap magnet or beam bender) near the point where the electrons and ions are aimed, the electron stream is brought back to the axis of the tube and continues through the rest of the gun structure toward the face of the tube. The heavier ions are relatively undeflected by the magnet and strike the neck of the tube. The magnets are usually labeled to designate the end that faces the picture tube. Reversing the polarity of some magnets with respect to the pole that faces the picture tube will result in a very dim or completely blank picture tube. The exact adjustment of the ion trap is important, as lack of brilliance or poor focus may result from misadjustment.

The focus coil consists of many turns of fine wire mounted in a suitable housing, supported by a mounting strip bolted to the receiver chassis. The focus coil in conjunction with the electron gun forms an "electromagnetic lens" that focusses the electron beam in a manner similar to that of an optical lens focusing a beam of light. Changing the magnitude of current flowing through the focus coil changes the intensity of its magnetic field and thus changes the focus point of the electron beam with respect to the screen of the picture tube. There is an optimum position for the focus coil relative to the end of the electron gun. The focus coil is set at this position during adjustment. The best focus is indicated by sharp line structure over the greatest area of raster. In some present day receivers the focus coil is replaced with a permanent magnet which reduces the drain on the low voltage power supply.

The deflection yoke houses the vertical and horizontal deflection coils. Each of the deflection coils is fed with the output of its respective sweep circuit; resulting in magnetic fields that sweep the electron beam across the face of the picture tube to produce the raster. Each of the deflection coils is discussed individually in the following subparagraphs:

(1) Vertical Deflection Coil. The vertical deflection coil is mounted in a horizontal plane so that the electron beam which is deflected at right angles to the magnetic field is swept in the vertical direction. The resistors paralleling each winding of the coil damp out the oscillations resulting from the strong magnetic field caused by the retrace currents. The coil is divided into two segments, one on each side of the tube, to provide a uniform magnetic field and thus a linear sweep.

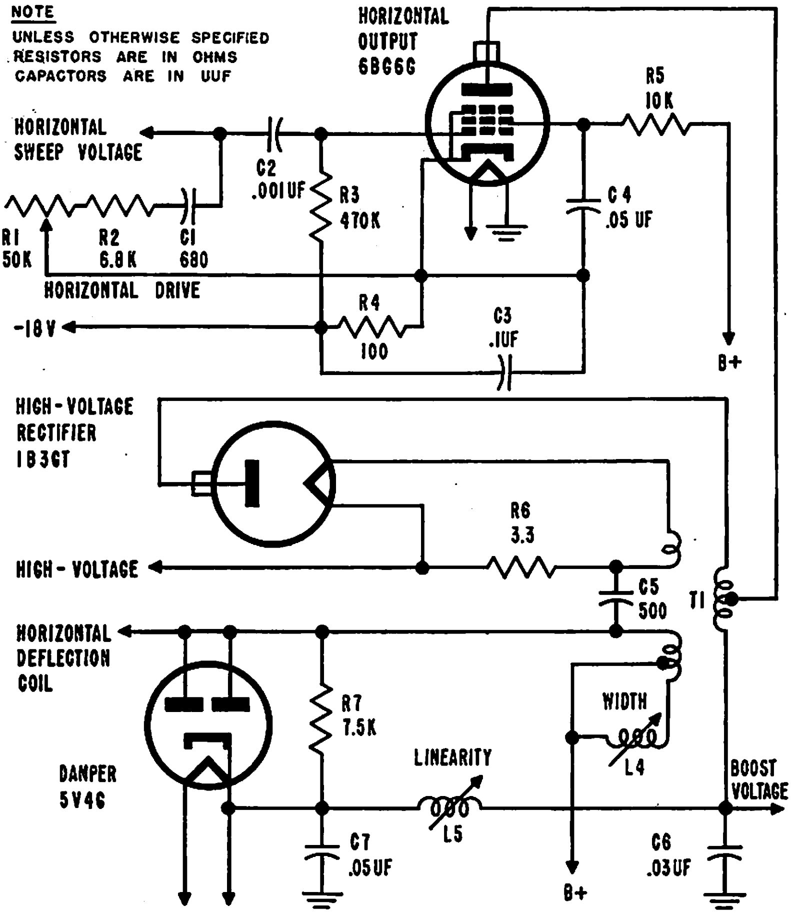
(2) Horizontal Deflection Coil. The horizontal deflection coil is similar to the vertical coil in that it is divided in two sections. These sections are mounted in a vertical plane on either side of the neck of the tube, thus providing a linear horizontal sweep.

A thumb screw is provided to allow for positioning the raster by rotating the deflection yoke around the neck of the tube. The correct positioning of the yoke is the point where all horizontal picture lines appear horizontal.

2-10. THE HIGH-VOLTAGE POWER SUPPLY

Three possible types of power supplies can be used to furnish the high voltage for the picture tube in the television receiver. These are:

1. The conventional 60 cycle supply. In this type of supply, circuits similar in design and operation to low voltage 60 cycle supplies are used. Because of the low current requirements of the picture tube, half-wave rectifiers are customarily used to keep the size, cost, and weight to a minimum. Two objections arise to the use of 60 cycle



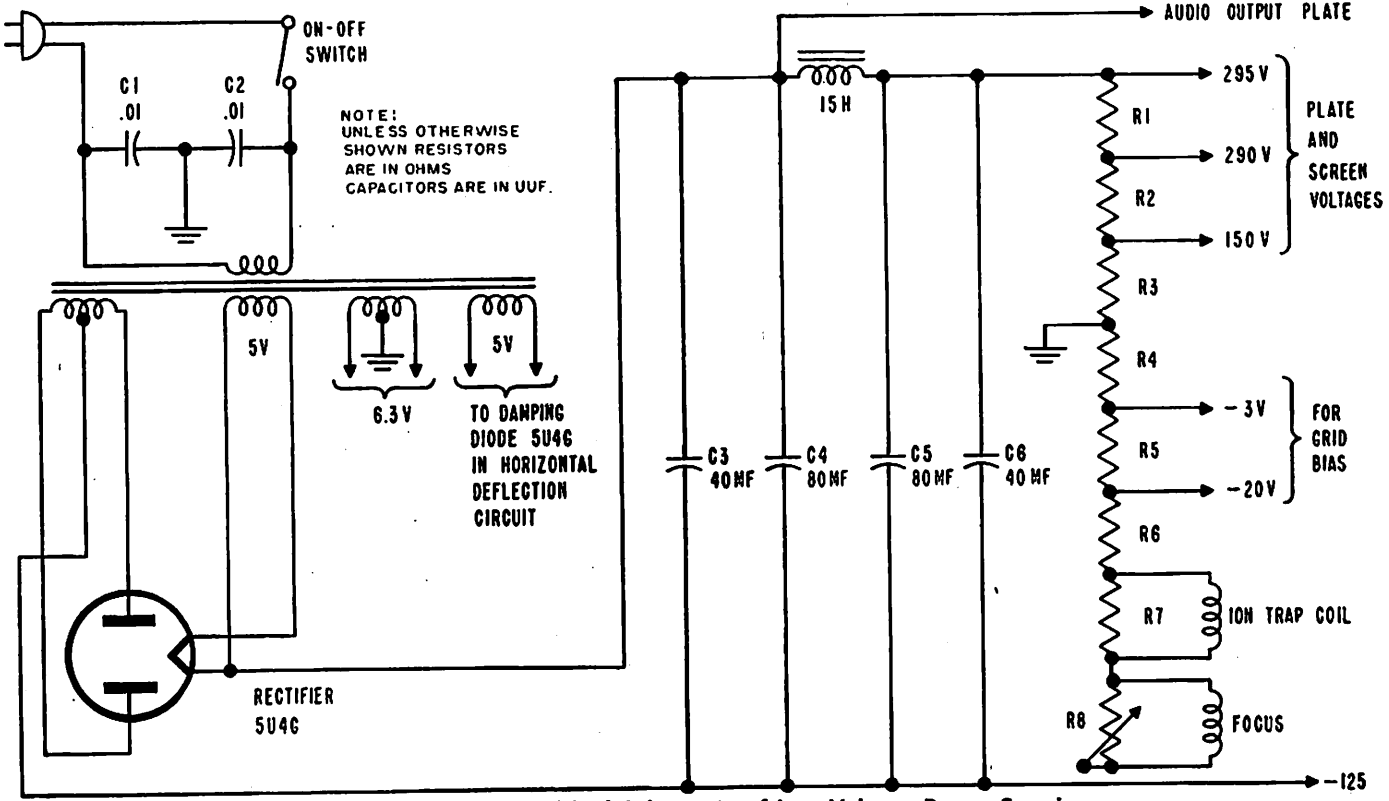
2-14 Simplified Schematic of Flyback Power Supply

supplies for the high voltage source. One is the considerable danger to life from charges on the filter capacitors of the supply. Due to the low frequency of the input power, the filter capacitors must be relatively large. As a result, the charge stored by these capacitors at the high output voltages can be lethal. The second objection is the cost and bulk of the components. The filter capacitors and transformers required for this type of supply are both large and expensive. For these reasons, high voltage 60 cycle supplies are seldom used in present day television receivers.

2. The radio frequency supply. The radio frequency supply attempts to remedy some of the faults of the 60 cycle supply by using a much higher frequency for the input to the half wave rectifier. Thus, a

source of 50 to 300 kc power is used insted of 60 cycles. The 50 to 300 kc input is derived from a power rf oscillator that is part of the complete power supply. In typical supplies of this kind, a tickler feedback oscillator using a 6L6 or 807 or similar type tube functions as an rf oscillator in the 50 to 300 kc range. The output of the oscillator is stepped up to several thousand volts by an air core transformer. The output of the transformer is then rectified and filtered in the same manner as in the 60 cycle supply. Because of the relatively high frequency of the input, the filter components are relatively small and inexpensive. A disadvantage of the rf power supply is the radiation emanating from the oscillator. Unless the supply is adequately shielded, radiation from the oscillator to other components of the receiver results in interference with the picture signals.

3. The flyback power supply. The flyback supply is practically the only type of power supply used in today's television receivers, because of its simplicity and the little space its few components require. Figure 2-14 is a simplified schematic of a typical flyback power supply. As indicated in figure 2-2, the current applied to the horizontal deflection coil in the yoke consists of a straight rise which accomplishes deflection of the beam to the right on the screen and then a rapid fall, called the retrace, that brings the spot back to the left side of the screen ready to scan another line. The rapid drop in sweep current that occurs during retrace is used to generate the high voltage for the picture tube. In the circuit shown in figure 2-14, the horizontal output tube has a transformer for a plate load. This transformer is called a flyback transformer because of its special construction. It contains three windings; the primary, which includes an auxiliary high voltage winding, and two secondaries. One of the secondaries is used to couple the output of the horizontal output stage to the deflection yoke. The other secondary usually consists of a single turn of wire used to supply filament power to the rectifier tube. A special winding is provided on the transformer for this purpose to eliminate the necessity of having a special filament transformer with high voltage insulation. The sweep current supplied by the horizontal output tube is applied to the tapped section of the primary. During the interval of the retrace, the autotransformer action of the primary causes a large positive voltage to appear at the top of the primary. This voltage is rectified, filtered and applied to the picture tube. The damping tube acts as a one-way load on the flyback transformer. Because of the abrupt change in current during the retrace period, the tank circuit formed by the transformer and its distributed capacity would tend to oscillate for a few cycles. These oscillations



NOTE:
UNLESS OTHERWISE
SHOWN RESISTORS
ARE IN OHMS
CAPACITORS ARE IN UUF.

2-15. Simplified Schematic of Low Voltage Power Supply would exist after the end of the horizontal retrace or blanking period and cause erratic effects on the picture. The damper tube acts to short these oscillations to ground without interfering with the application of the sweep current to the deflection yoke or the generation of the high voltage, and in so doing develops extra d-c power across capacitor C6. This is called the boost voltage and acts to increase the efficiency of the horizontal output stage and the sweep generating circuits.

Due to the relatively high frequency of the supply, relatively little filtering is necessary. Generally only a simple resistor-capacitor combination of the nature shown in figure 2-14 is sufficient.

2-11. THE LOW VOLTAGE POWER SUPPLY

In general, the low voltage power supplies used in television receivers are standard full wave rectifiers with efficient filtering networks and good regulation. Many times, the power supply is connected so that both negative and positive voltages can be obtained. Figure 2-15 is a simplified schematic of a typical low voltage supply.

CHAPTER 3

TROUBLE-SHOOTING RECEIVERS

3-1. TROUBLE ANALYSIS

This chapter describes trouble-shooting techniques and methods that enable troubles in a television set to be rapidly located. The general approach to trouble location is presented first, followed by trouble-shooting techniques by picture analysis, and finally by trouble-shooting charts that enable the isolation of specific faults.

Fast, efficient and dependable trouble-shooting can most easily be achieved by the use of a systematic procedure. Haphazard testing wastes time and often causes the technician to overlook obscure circuit troubles.

Rapid location of troubles in a television receiver, on a systematic basis, is accomplished in the following three steps:

1. *Sectionalize* the trouble to a functional section of the receiver (such as the video section, power supply section, etc.).
2. *Isolate* the faulty stage within that section.
3. *Locate* the defective part in the faulty stage.

Sectionalization of the defective section can usually be accomplished by a careful examination of the trouble symptoms of the receiver with particular attention to the picture presentation (table 3-1).

Isolation of the defective stage is most easily performed by using either signal tracing or the signal substitution method described below.

Location of the defective components is based on observation, simple voltage and resistance measurements, as well as tube testing.

3-2. SECTIONALIZATION

Sectionalization of trouble is based on the simplified block diagram shown in figure 2-1. To find the defective section, turn on the receiver, attempt to tune in a station, then examine both sound and picture. Check the volume and tone quality of the sound; listen for excessive hum. Check for distortion of the picture, both in dimensions and shading. Tune to an unoccupied channel and examine the raster. Check for horizontal or vertical distortions. Compare the results of this check with the symptoms listed in table 3-1; the table gives the probable location of the defective section. For a more detailed method of checking each section of the receiver, refer to paragraph 3-7.

Table 3-1

TROUBLE LOCALIZATION

SYMPTOM			DEFECTIVE SECTION
SOUND	VIDEO	RASTER	
N.G.	N.G.	N.G.	Power supply
OK	——	N.G.	Sweep or high-voltage section
OK	N.G.	OK	RF and if sections
N.G.	N.G.	OK	Sound section
N.G.	OK	OK	Video section

3-3. ISOLATING THE DEFECTIVE STAGE

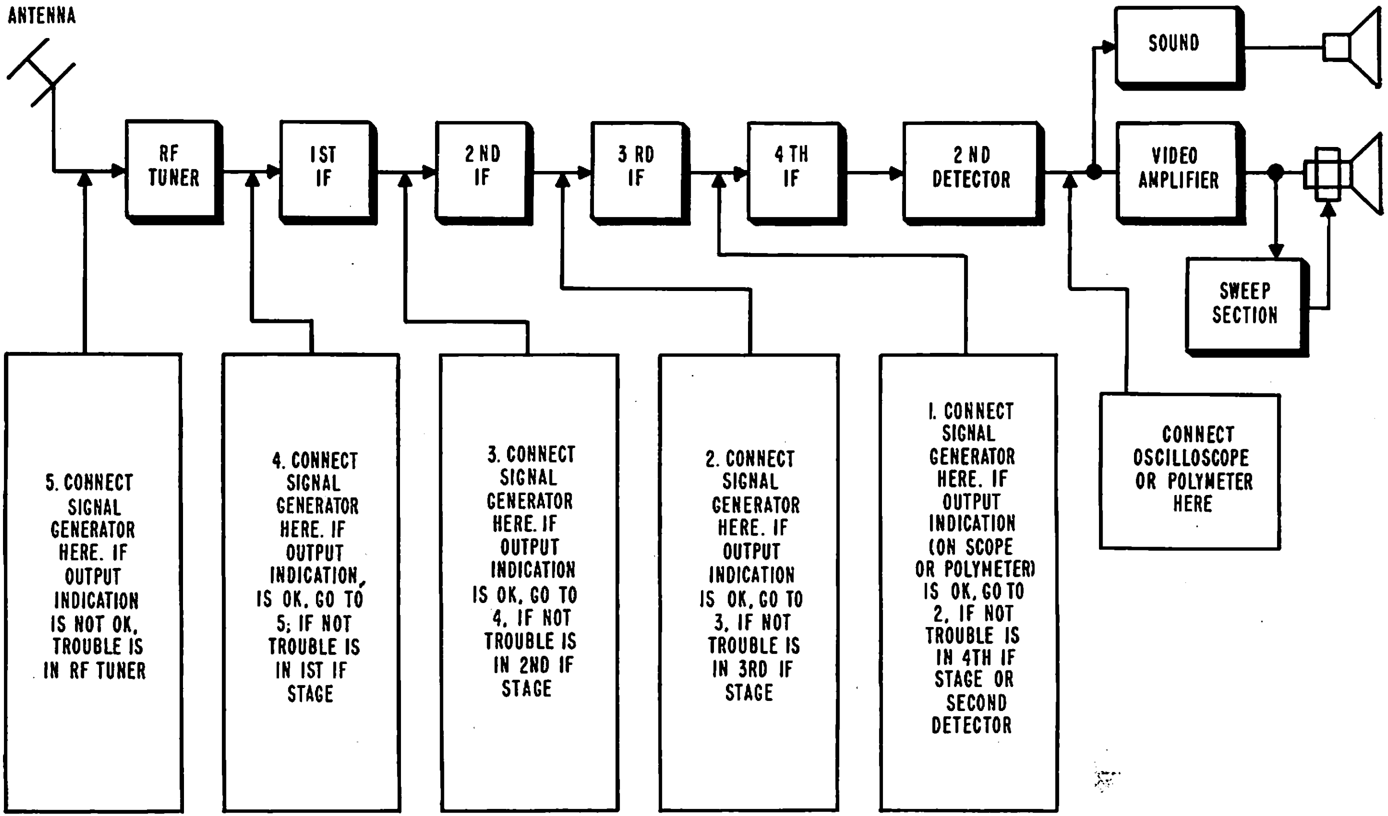
Signal substitution is the method used for isolating the defective stage after the faulty section has been found (figure 3-1).

In the signal substitution method, a detecting device is connected to the output of a section and a signal generator is connected to the input of the last stage of the defective section. If the detecting device shows the output signal to be abnormal, the last stage must be defective. If the signal is found to be normal, move the signal generator to the grid of the preceding stage, and repeat the process until the defective stage is isolated. Table 3-2 lists the test equipment and signal source used for each section.

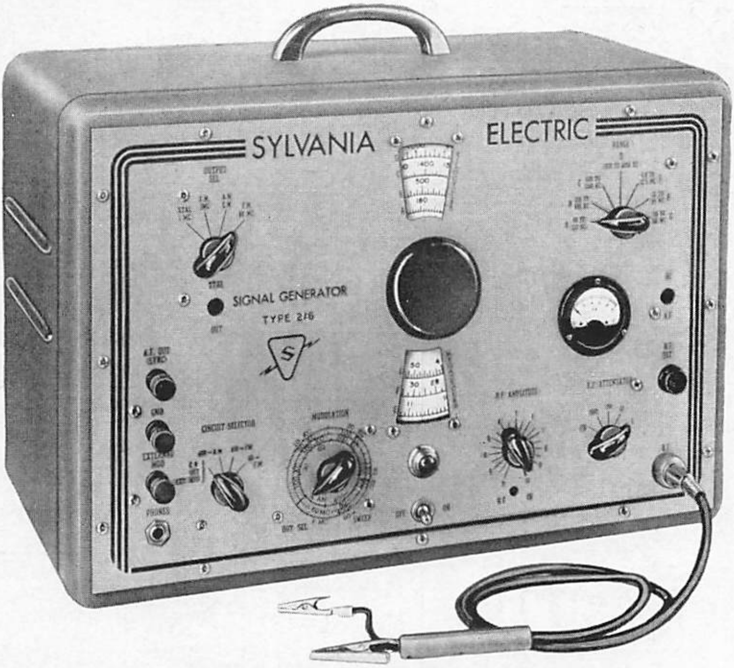
Table 3-2

TROUBLE ISOLATION METHODS

SECTION	SIGNAL SOURCE	DETECTING EQUIPMENT
Power supply	117-volt a-c line	
R-F and i-f	R-F signal generator	Polymeter with R-F probe or oscilloscope, connected to second detector output
Sound	A-F and R-F signal generators	Loudspeaker of receiver or Polymeter
Video	Output of R-F and i-f section, when tuned to R-F transmitter	Oscilloscope
	Signal Generator	CRT of receiver, or oscilloscope
Sync and sweep (Sync circuits)	Sync output of video system	Oscilloscope
Sync and sweep (Sweep circuits)	Output of sweep oscillators in receiver	Oscilloscope
High-voltage	Horizontal sweep pulse section of sweep output	Polymeter, with high-voltage probe



3-1. Signal Substitution



3-2. FM-AM Signal Generator

3-4. USEFUL TEST EQUIPMENT

The test equipment used for television receiver trouble shooting should be of the highest quality. Shortcomings of test equipment make it difficult to ascertain whether the incorrect response to a test is due to a fault in the receiver or in the test equipment. The time saved by using

3-3. TV Sweep Generator

proper equipment always compensates the technician for the cost of this equipment.

The following test equipment is required for rapid television receiver trouble-shooting and alignment:

1. FM-AM signal generator, such as Sylvania Type 216 (figure 3-2)
2. TV sweep generator, such as Sylvania Type 500 (figure 3-3)
3. TV marker generator, such as Sylvania Type 501 (figure 3-4)
4. TV oscilloscope, such as Sylvania Type 400 (figure 3-5)

3-4. TV Marker Generator

5. Oscilloscope voltage standard, such as Sylvania Oscilloscope Calibrating Standard Type 300 (figure 3-6)

6. Tube tester, such as Sylvania Type 220, including the Cathode-Ray-Tube Testing Adapter (figures 3-7 and 3-8)

7. Vacuum-Tube-Voltmeter, such as Sylvania Polymeter Type 221Z, including High-Voltage Probe Sync 223 or 225 (figures 3-9 and 3-10)

The FM-AM signal generator is used for trouble shooting and aligning the rf, if and sound sections. To cover all bands used, this unit must be capable of generating rf signals at frequencies from 4.5 to 60 megacycles (mc), and must have harmonics usable up to 216 mc. To insure accurate alignment, the frequency calibration must be reliable within

3-5. Oscilloscope

½ of 1 percent. Amplitude modulation (AM) for testing the rf and if section, and frequency modulation (FM) for testing the sound section must be available. The FM sweep must be at least 250 kilocycles (kc) wide. The output signal must be stable and free from hum. Radiation from the generator circuits must be small.

The TV-FM sweep generator is used for aligning the rf and if sections. It must have an rf output covering the frequency range from 20 mc to 216 mc, a linear sweep, and a stable output. The sweep width must exceed 6 mc, and the maximum output amplitude must exceed 0.1 volt.

The TV marker generator is used to mark rf and if response curves obtained during alignment with a sweep generator and oscilloscope, or to provide an accurate c-w signal for peaking tuned circuits, traps and stagger-tuned stages. It should have the same frequency coverage and output capabilities as the TV sweep generator.

The oscilloscope is used for checking waveforms in the sweep circuits and, in conjunction with the sweep generator, is used for alignment.

The screen should have a diameter of five inches or more, in order to enable the technician to observe details in the waveforms. The internal sweep frequency must be variable from 15 cycles per second (cps) to 16 kc, and the vertical amplifier must faithfully reproduce signals in the 10 cps to 2 mc range in order to make possible the viewing of lines, frames and sync pulses. A sensitivity of at least 0.05 volts rms per inch deflection is required. To prevent loading of the circuit under test, the oscilloscope must have high input impedance.

The oscilloscope voltage standard enables the voltage between any points within a complex wave displayed on an oscilloscope to be determined. Thus, direct comparison with waveforms in the receiver manufacturers' service data and those displayed on the serviceman's oscilloscope is possible.

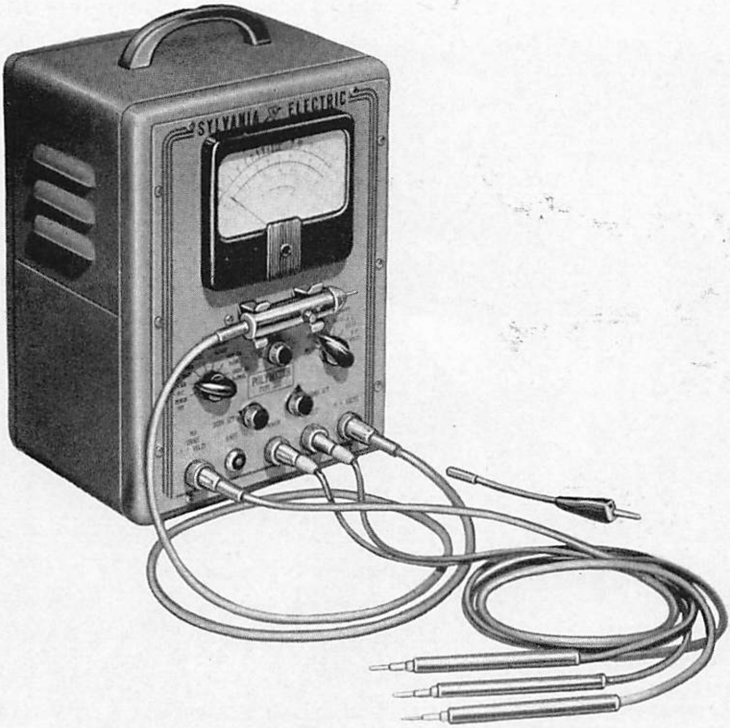
The tube-tester should test tubes under dynamic conditions. It must be capable of checking internal shorts and leakage, since such troubles are responsible for a large number of tube failures. The Sylvania Cathode-Ray-Tube Testing Adapter, when used with a Sylvania Tube Tester, allows testing of cathode-ray tubes for emission, shorts, and leakage without removing the tube from the cabinet.

The vacuum-tube voltmeter is the most important single item of the technician's test equipment. It is used to check rf, ac, and dc voltages, current, and resistance. To enable checking of all commonly encountered voltages, this meter must be capable of accurately measuring voltages ranging from 0.5 volts to 15,000 volts dc, and from 0.2 volts to 1,000 volts ac; ac and rf measurements must be flat from 20 cps to 216 mc. Resistances from 10 ohms to 100 megohms must be measured within an accuracy of 10 per cent or less. Sylvania Polymeter Type 221Z equipped with high-voltage probe, fulfills all these requirements.

3-6. Oscilloscope Calibrating Standard

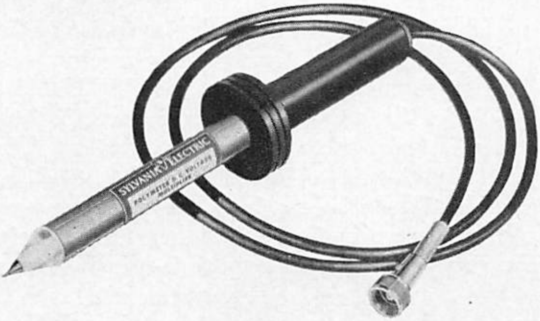
3-7. Tube Tester

3-8. CRT Testing Adapter

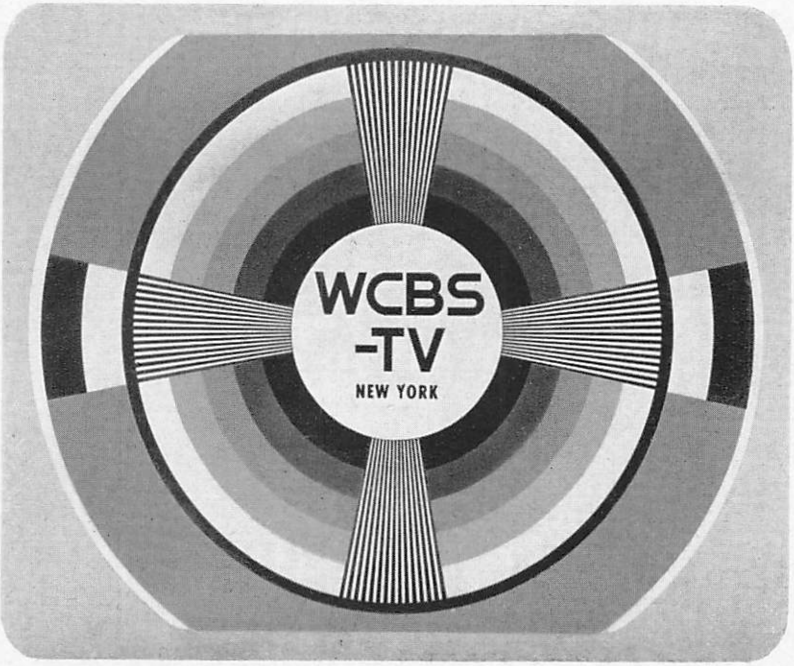


3-9. Polymeter

The arrangement of test equipment on the work bench, and the physical dimensions and layout of the bench, should be carefully chosen for maximum convenience and availability. A raised shelf at the rear of the bench keeps the test equipment handy, yet out of the way. The bench should be about 2½ feet deep, and at least 4 feet long. The entire bench should be brightly illuminated, preferably by a diffuse



3-10. High-Voltage Probe



3-11. Typical test pattern

light source. An additional adjustable light source, such as a gooseneck lamp, is also helpful. The top of the bench and the test equipment shelf should be covered completely with sheet metal, bonded with heavy cable or copper braid to a near-by ground, such as a cold-water pipe. This metal top helps to prevent detuning due to body capacity of receiver circuits during troubleshooting, and minimizes tendencies toward oscillation due to test-equipment cables.

3-5. THE TEST PATTERN

Many television stations transmit regularly a chart called the "test pattern." Each station has developed its own distinctive pattern, carrying its call letters and location. These test patterns provide a simple and rapid means for checking the operation, adjustment and alignment of all picture circuits of a television receiver.

Figure 3-11 shows the test pattern of the WCBS-TV transmitting station at New York City, as received on a properly adjusted receiver. The test patterns of most other stations are similar. The technician should acquaint himself with this pattern and that of local stations, so that he can identify deviations from the normal pattern.

The test pattern shown in figure 3-12 has the following features:

1. The light circle (11) should appear just inside the edges of the cabinet mask and the dark circle (2) should just touch the edges of the mask when the receiver horizontal and vertical SIZE controls and the centering magnet are correctly adjusted, and when the sweep circuit

is operating normally.

2. The dark circle (2) and the edges of the white disk (1) are perfectly round when the horizontal and vertical LINEARITY controls are correctly adjusted.

3. Wedges (3) and (8) are vertical, and wedges (10) and (4) horizontal, when the deflection yoke assembly is properly oriented with respect to the CRT and mask.

4. The lines in wedges (3, 4, 10) and (8) are sharp when the focus magnet and ion trap magnet are properly adjusted.

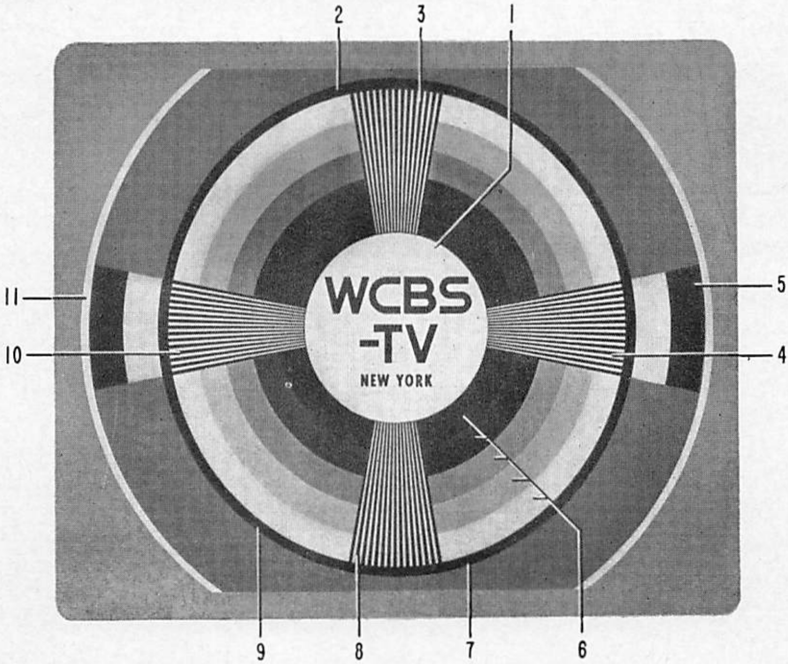
5. Concentric circles (6) are of different shades, from light gray to black, when the BRILLIANCE, CONTRAST and AGC controls are correctly adjusted.

6. Light or dark areas, blurs or smudges in the vertical wedges (3, 8) indicate improper bandwidth of the rf, if and video sections, or peaks and dips in the response curves of these sections.

7. Burring or curving of the lines in the horizontal wedges (4, 10) indicates improper adjustment of the VERTICAL SYNC control or improper operation of the integrator in the vertical sync circuit.

8. If the right-hand sides of the black segments (11) are lighter in shading than the left-hand sides, the low frequency response of the video amplifier section is probably poor.

9. If the entire pattern appears smudged, the video amplifier probably has defective high-frequency response.



3-12. Test pattern components

Figures 3-13 through 3-52 show the effects on the test pattern of improper adjustment and alignment, and of troubles in the receiver. The cause of the defect and the procedure for correcting the defect is given under each illustration.

3-6. LOCALIZING TROUBLES BY PICTURE ANALYSIS

Almost all troubles occurring in television receivers result, of course, in either abnormal pictures or abnormal loudspeaker output, or both. Careful examination of the picture and sound will usually localize the fault to a receiver section. The following pages contain symptoms of some troubles as evidenced by abnormal pictures. An analysis of each trouble, and reference to the appropriate trouble-shooting chart are also presented.

The abnormal pictures presented in the following pages are classified according to the characteristics of the picture. These are:

1. Brightness: the amount of light emitted by the CRT screen.
2. Contrast: the difference in tone between highlights and shadows.
3. Focus: the sharpness of detail in the picture.
4. Size of the picture relative to cabinet mask.
5. Position of the picture relative to cabinet mask, and absence of movement.
6. Distortion of straight lines due to defective or nonlinear sweeps.
7. Miscellaneous effects, such as presence of undesired lines, shading or ghosts in the picture.

The picture on the CRT is formed by the electron beam, the horizontal and vertical sweeps, and the video signals. The electron beam, generated by the CRT, is the moving spot that traces out the picture, the sweeps cause the motion of the electron beam, and the video signals control the brightness of the electron beam trace. When the technician examines an abnormal picture, he should ask himself: Is the fault due to trouble in the electron beam, the sweeps, or the video? The answer to this question determines which section he trouble-shoots.

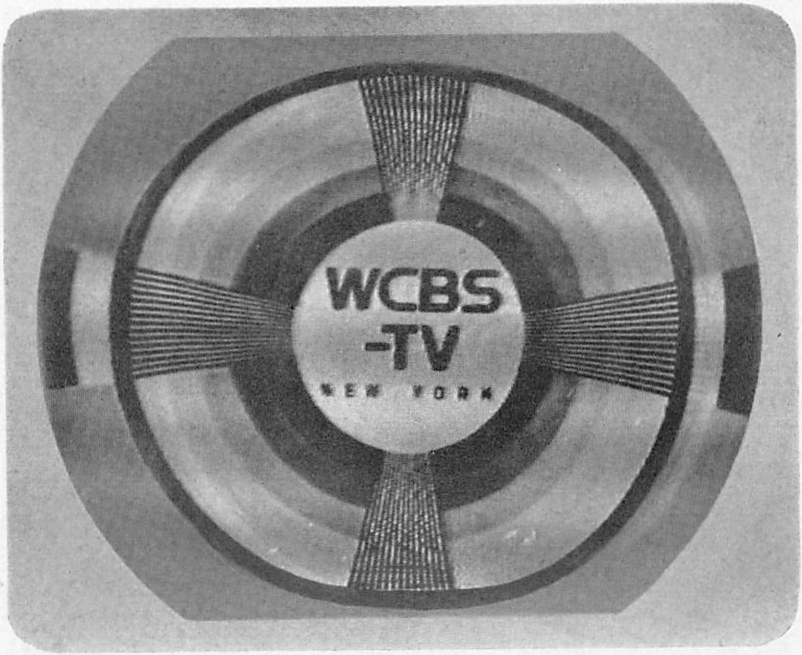


FIG. 3-13 BANDS ON PICTURE · SOUND NORMAL ·

SYMPTOM

Light and dark bands through picture varying with sound.

ANALYSIS

Trouble due to presence of sound in video signal applied to picture tube.

PROCEDURE

Check components and alignment in output of video detector. Check alignment of 4.5 mc take-off filter.

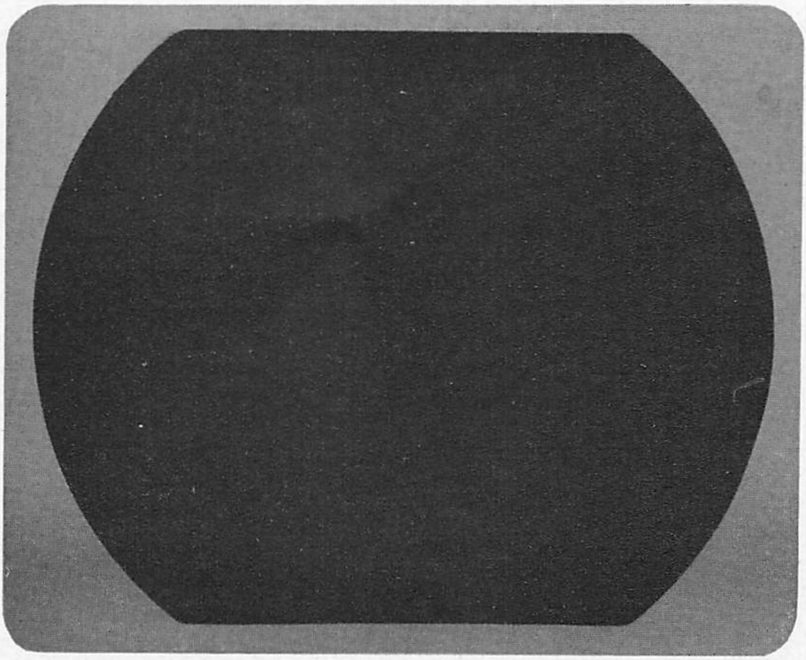


FIG. 3-14 NO RASTER · NO SOUND ·

SYMPTOM

No picture, no sound, no raster.

ANALYSIS

Trouble is in power supply section.

PROCEDURE

Check power line input to receiver and rectifier tubes; if normal see trouble-shooting chart A.

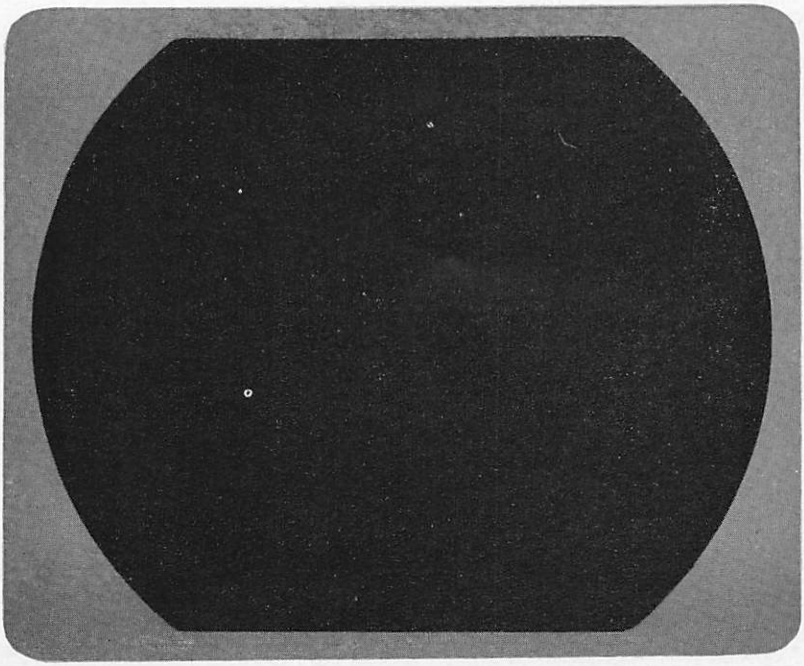


FIG. 3-15 NO RASTER • SOUND NORMAL •

SYMPTOM

No picture, no raster. Sound can be tuned in, and is of normal loudness and quality.

ANALYSIS

Trouble is due to fault in the generation of the electron beam, such as an absence of high voltage.

PROCEDURE

Measure the voltages applied to the picture tube and compare with those specified by manufacturer. If high voltage is excessively low, trouble is in sweep section or high voltage section, see trouble-shooting charts E and F.

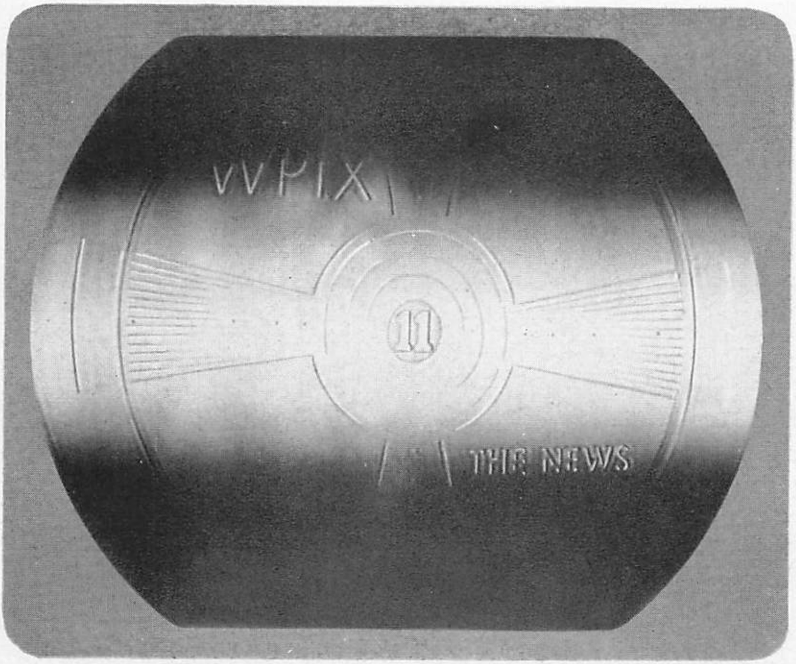


FIG. 3-16 PARTS OF PICTURE BLACKED OUT · LOUD HUM IN SPEAKER OUTPUT ·

SYMPTOM

Middle and top or bottom of picture black, remainder of picture curved and distorted. Loud hum in speaker.

ANALYSIS

Trouble is caused by 120 cps ac hum in rf, if or video sections, due to poor B+ filtering.

PROCEDURE

Check filter capacitors.

FIG. 3-17 SHADOW AROUND PICTURE • SOUND NORMAL •

SYMPTOM

Dark area around outer edge of picture; picture poorly focused; sound normal.

ANALYSIS

Trouble due to incorrect placement or adjustment of deflection coil, focus magnet, or ion trap.

PROCEDURE

Adjust deflection coil, focus magnet and ion trap according to manufacturer's instructions (also see chapter 4).

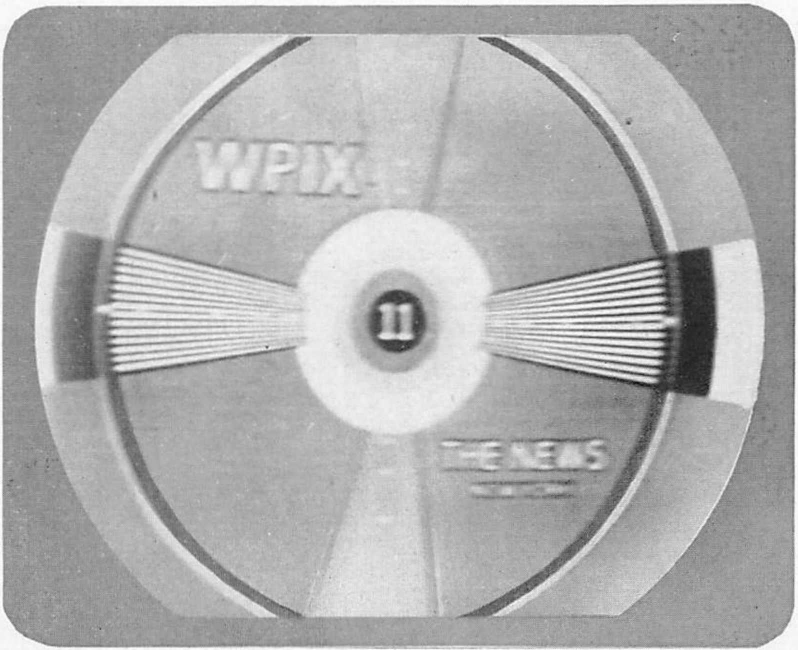


FIG. 3-18 HAZY PICTURE • SOUND NORMAL •

SYMPTOM

Loss of fine details in vertical wedge. Smeary appearance of picture detail.

ANALYSIS

Trouble due to a defect or serious misalignment in rf or if section or defective coils in the video amplifier.

PROCEDURE

Check video amplifier coil resistances. Then check alignment of picture if amplifier, then alignment of tuner.

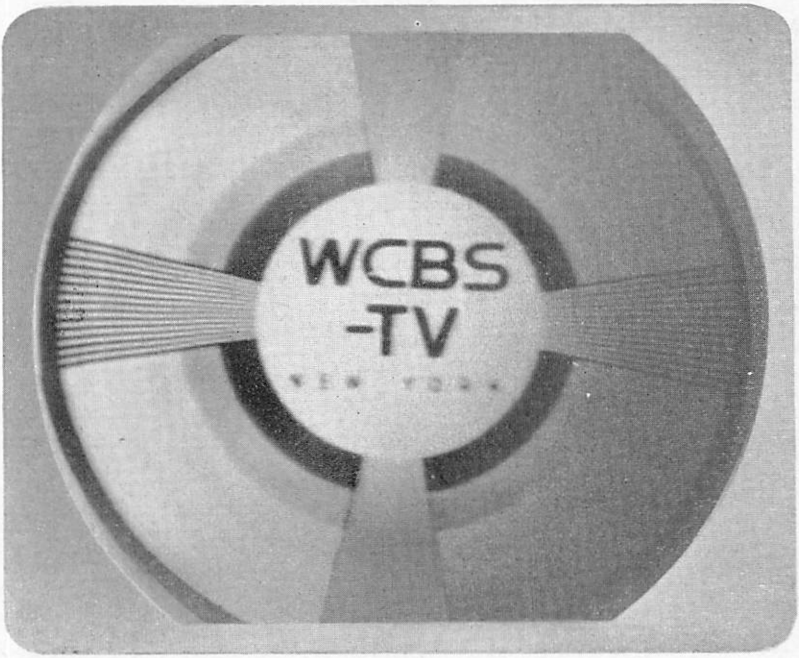


FIG. 3-19 DARK PICTURE · SOUND NORMAL ·

SYMPTOM

Part of picture dark.

ANALYSIS

Trouble is due to dirty tube face or safety glass.

PROCEDURE

Clean tube face and safety glass.

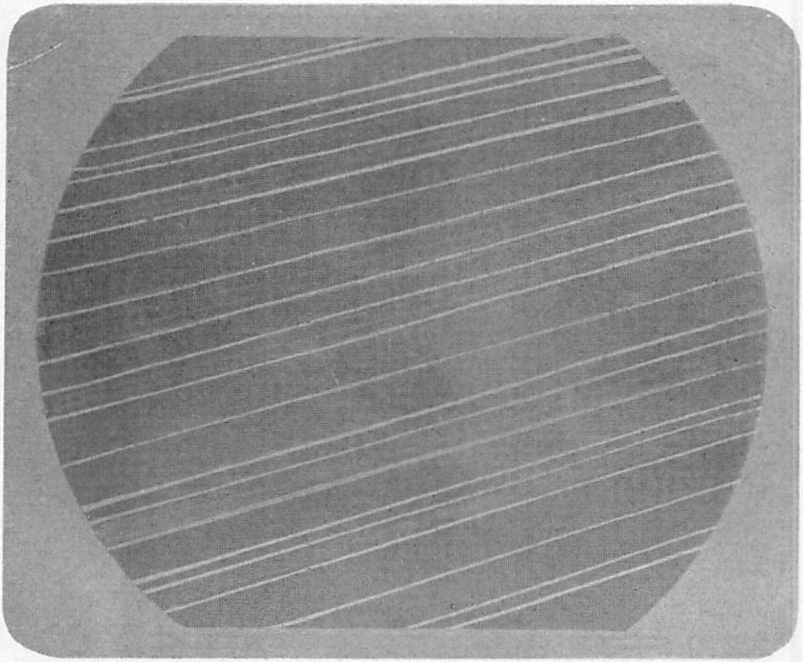


FIG. 3-20 NO PICTURE • RASTER PRESENT •

SYMPTOM

Raster present, but no video signals. Sound may be normal, or weak and distorted, or absent. Loss of synchronization as evidenced by white retrace running up and down.

ANALYSIS

If sound is absent, weak or distorted, trouble is in antenna or lead-in, or in rf or if sections. If sound is normal, trouble is in video section.

PROCEDURE

If sound is absent, weak or distorted, check antenna and lead-in; if normal, see trouble-shooting chart B for rf and if sections. If sound is normal, see trouble-shooting chart C.

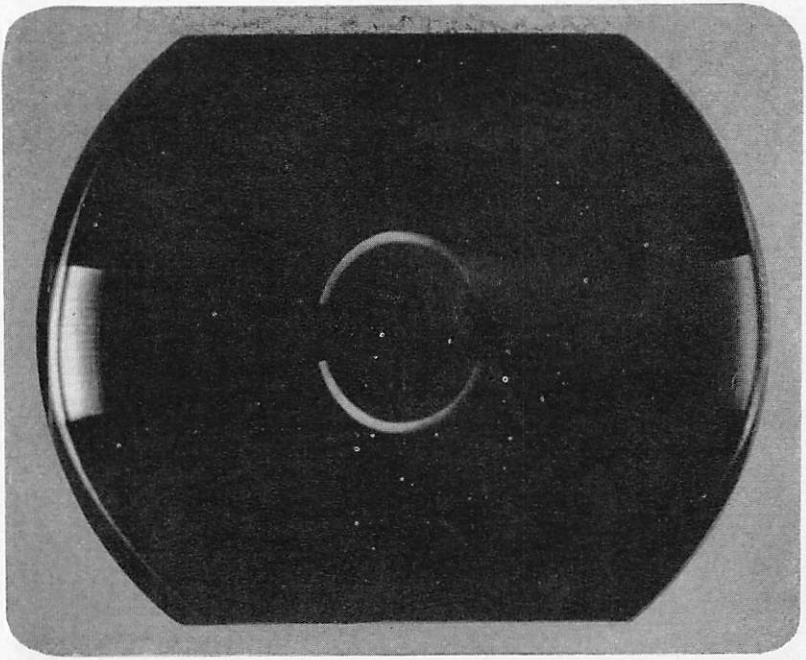


FIG. 3-21 VERY DARK PICTURE • LOUD BUZZ IN SOUND •

SYMPTOM

Picture dark, may almost be blacked out; loud buzz or distortion in sound.

ANALYSIS

Trouble due to excessive gain in rf and if sections, caused by absence of agc voltage.

PROCEDURE

See trouble-shooting chart E, steps 10 to 12.

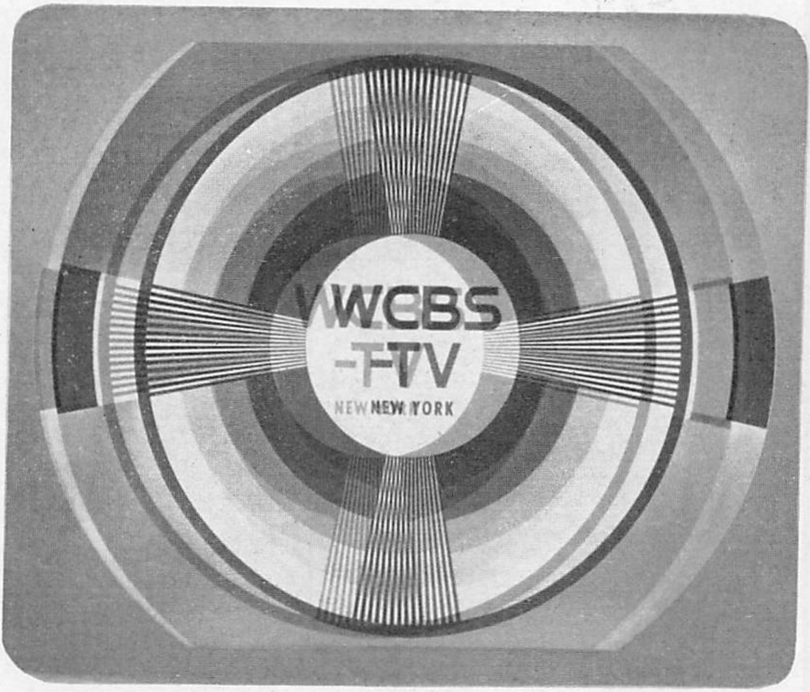


FIG. 3-22 GHOST IN PICTURE · SOUND NORMAL ·

SYMPTOM

Ghosts or shadows in picture; details not distinguishable. Sound normal.

ANALYSIS

Trouble due to reception of signals by way of multiple paths, or if long lead-in is used, to mismatch in lead-in at the receiver end.

PROCEDURE

Check antenna location and orientation, check lead-in.

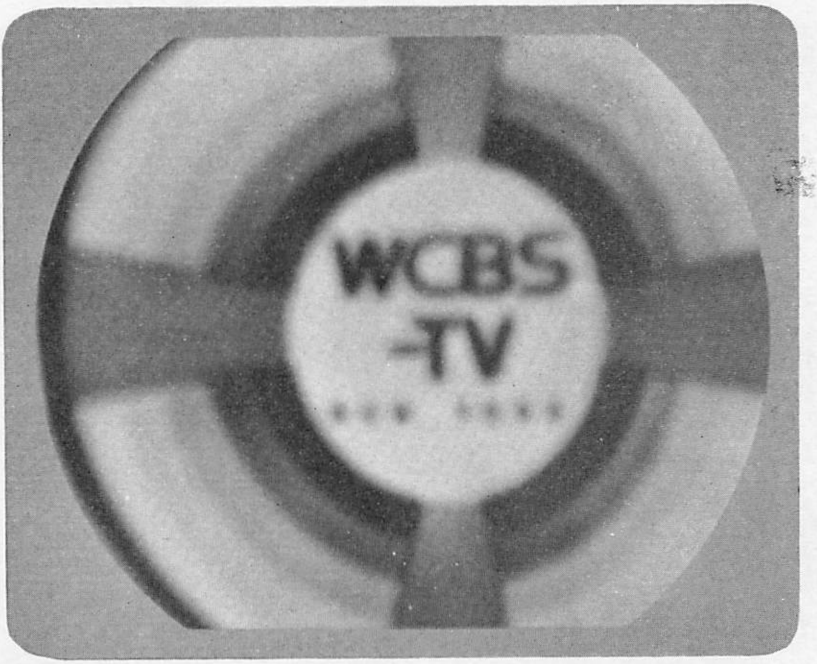


FIG. 3-23 PICTURE BLOOMING AND INDISTINCT • SOUND NORMAL •

SYMPTOM

Picture very large, not focused, appears indistinct; sound normal.

ANALYSIS

Trouble is due to improper voltages applied to cathode-ray tube or to defective high voltage supply.

PROCEDURE

Measure high voltage. If abnormal, check high voltage rectifier; if normal, see trouble-shooting chart F.

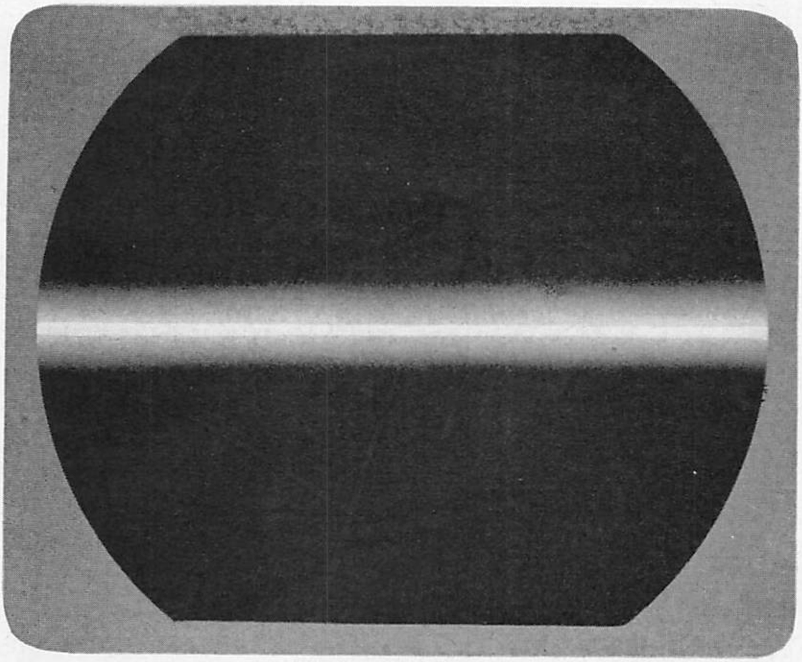


FIG. 3-24 HORIZONTAL LINE IN CENTER OF SCREEN · SOUND NORMAL

SYMPTOM

Screen blank except for very bright horizontal line; sound normal.

ANALYSIS

Trouble is due to absence of vertical sweep.

PROCEDURE

See trouble-shooting chart E.

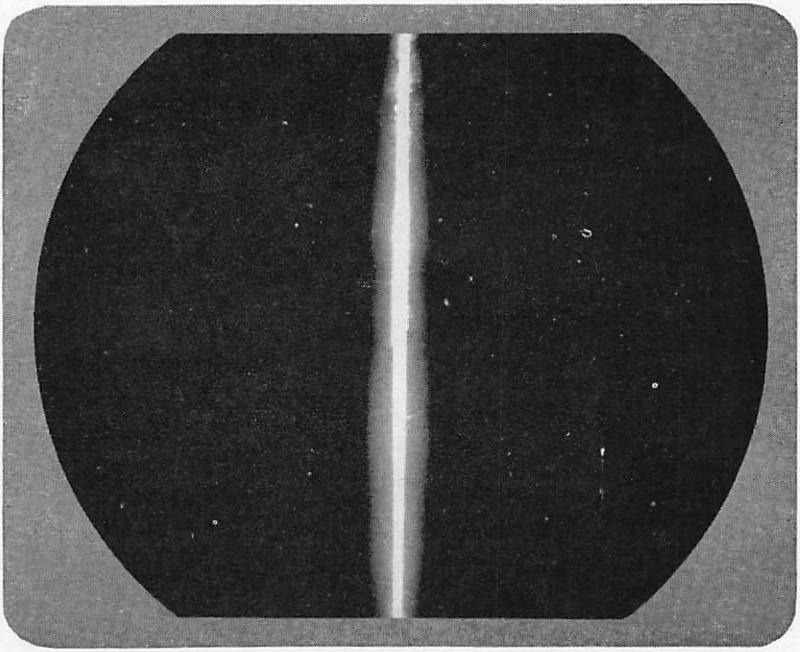


FIG. 3-25 VERTICAL LINE ON SCREEN • SOUND NORMAL •

SYMPTOM

Screen completely dark except for very bright vertical line in center; sound normal.

ANALYSIS

Trouble is due to absence of horizontal sweep. Sweep section apparently normal up to horizontal output transformer; otherwise there would be no high voltage and no brightness.

PROCEDURE

Check horizontal output transformer, deflection coils and associated components.

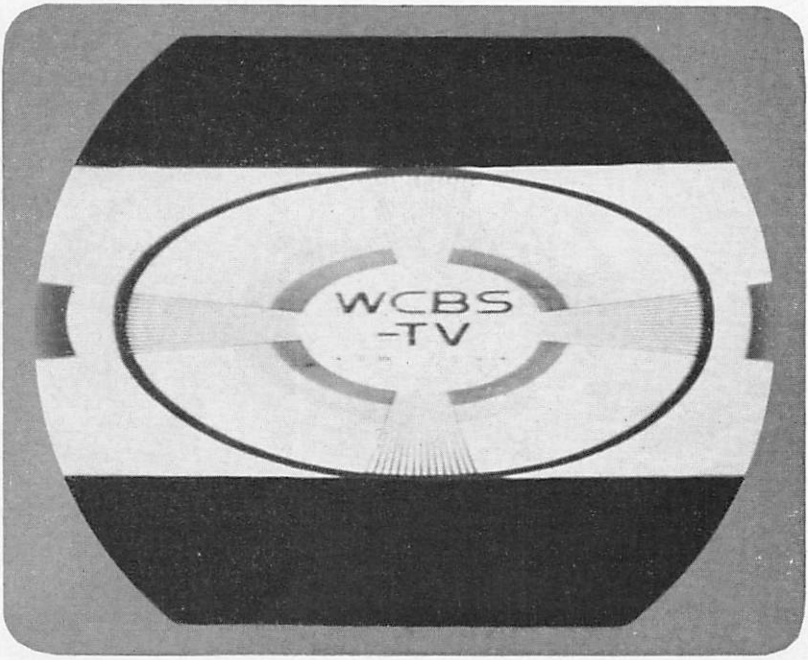


FIG. 3-26 PICTURE TOO TALL OR TOO SHORT • SOUND NORMAL •

SYMPTOM

Picture height incorrect; width, focus and sound normal.

ANALYSIS

Trouble is due to incorrect adjustment of the VERT. SIZE, vertical linearity control, or to defective vertical sweep.

PROCEDURE

Adjust VERT. SIZE and vertical linearity controls; if trouble persists, see trouble-shooting chart E.

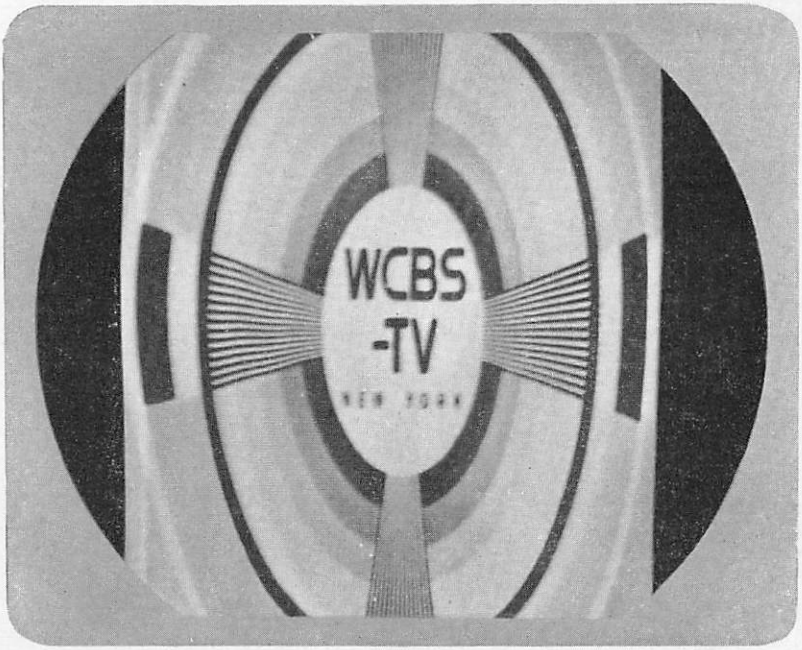


FIG. 3-27 PICTURE TOO NARROW • SOUND NORMAL •

SYMPTOM

Picture very narrow.

ANALYSIS

Trouble is due to defective horizontal sweep; high-voltage section apparently normal.

PROCEDURE

Adjust the slug of the HORIZONTAL SIZE coil; if fault persists, see trouble-shooting chart E for horizontal sweep circuits.

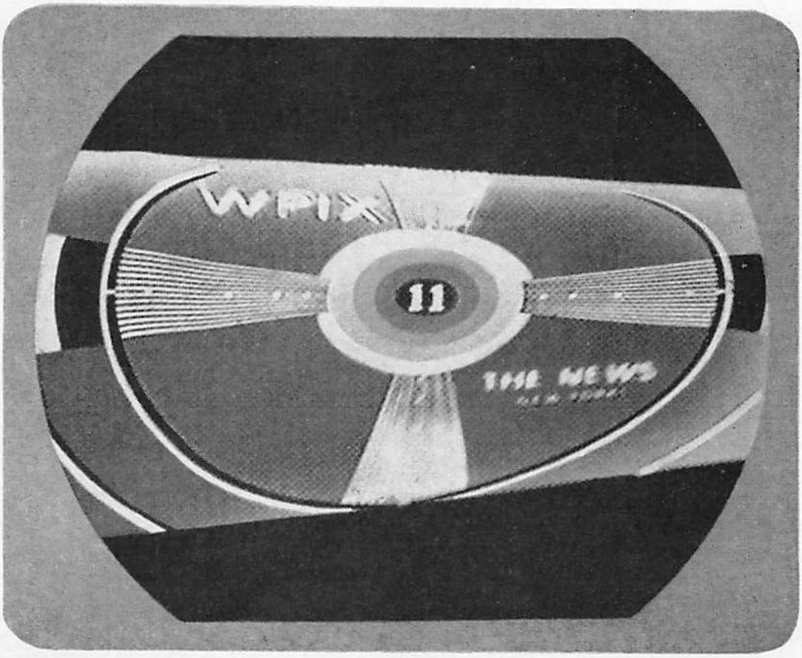


FIG. 3-28 PICTURE KEYSTONED VERTICALLY · SOUND NORMAL ·

SYMPTOM

Right-hand side of picture taller or shorter than left-hand side; sound normal.

ANALYSIS

Trouble is caused by defect in vertical deflection coils.

PROCEDURE

Check components in vertical deflection coil for short circuits or open circuits.

FIG. 3-29 PICTURE KEYSTONED HORIZONTALLY · SOUND NORMAL ·

SYMPTOM

Picture wider on top than on bottom; entire picture too narrow and unfocused; sound normal.

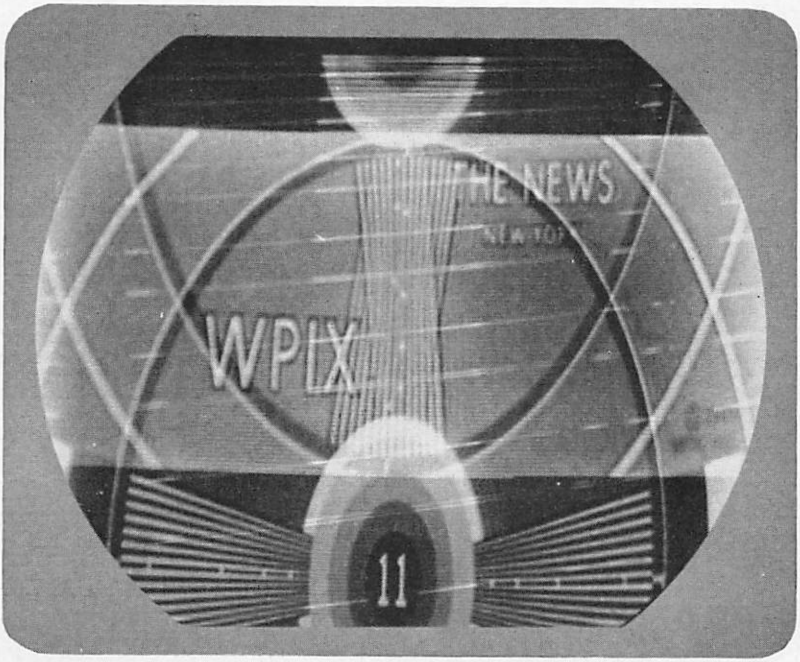
ANALYSIS

Trouble due to defect in horizontal deflection yoke.

PROCEDURE

Check components in horizontal deflection yoke.

Position Abnormal



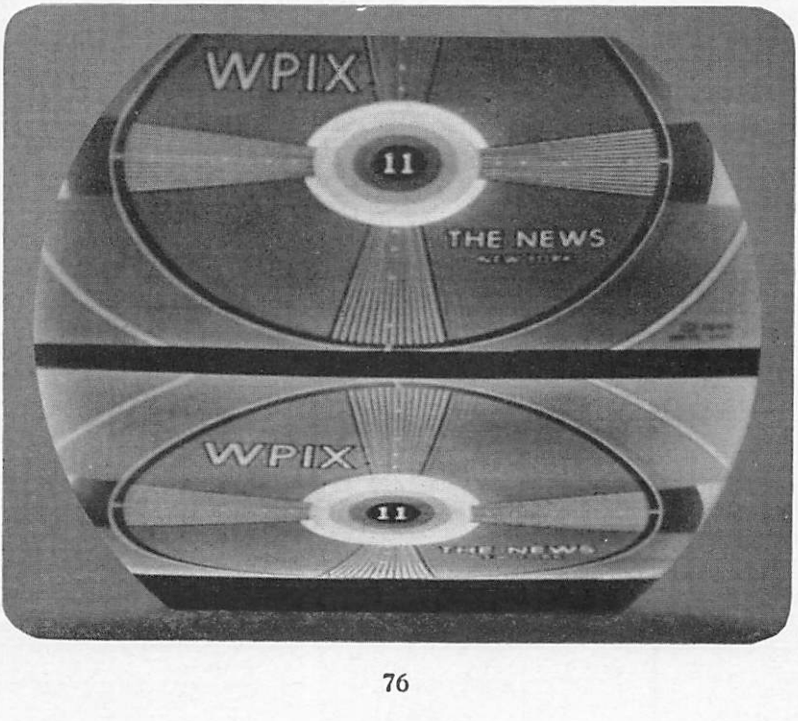


FIG. 3-30 PICTURE SPLIT VERTICALLY • SOUND NORMAL •

SYMPTOM

Parts of two pictures, or two separate pictures, displayed simultaneously. Pictures may be stationary, or may move slowly up or down. Sound normal.

ANALYSIS

Trouble is due to incorrect setting of VERT. SYNC control, or to defective vertical sweep.

PROCEDURE

Adjust VERT. SYNC control; if trouble persists, see trouble-shooting chart E.

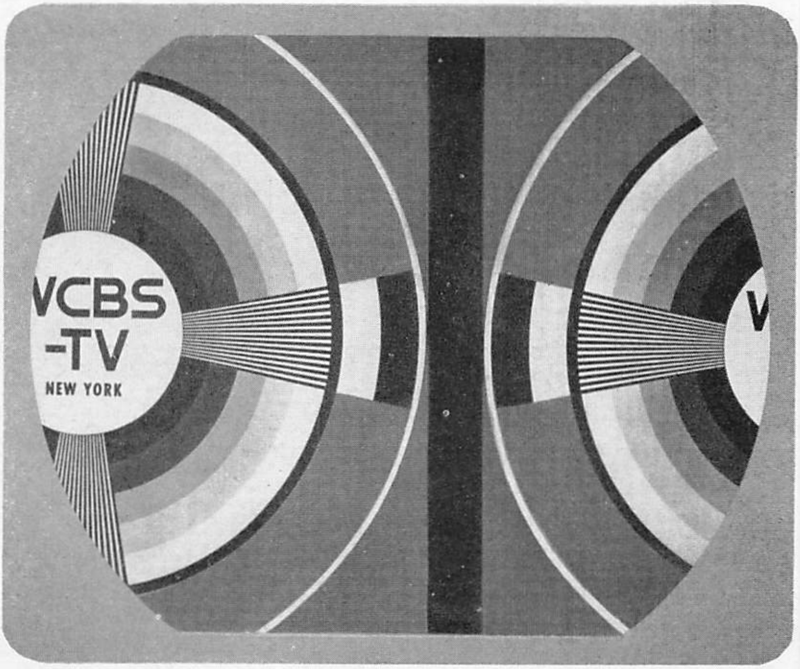


FIG. 3-31 PICTURE SPLIT HORIZONTALLY • SOUND NORMAL •

SYMPTOM

Black bar in center of picture, with half of picture displayed on each side of bar. Sound normal.

ANALYSIS

Trouble is due to incorrect adjustment of horizontal oscillator or transformer.

PROCEDURE

Readjust horizontal oscillator transformer slug according to manufacturer's instructions.

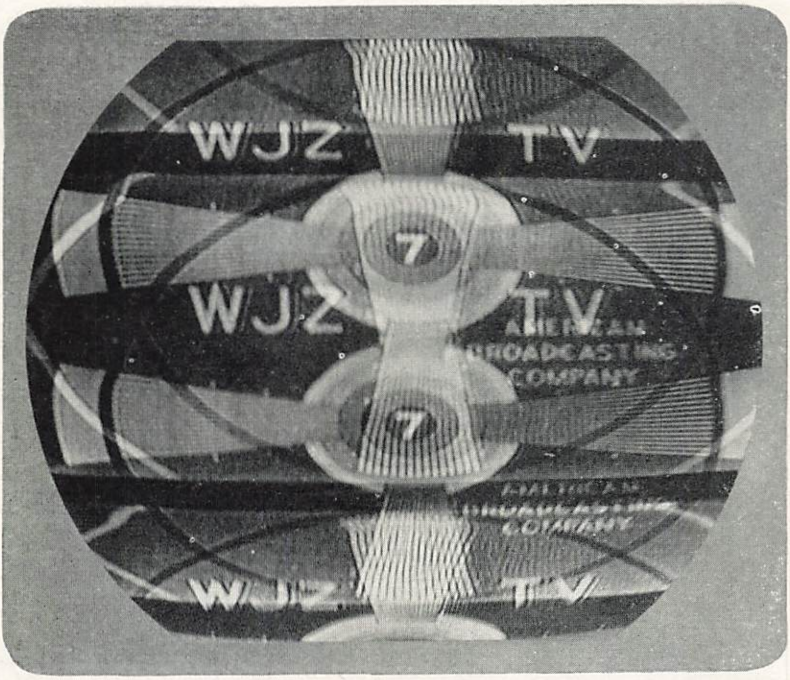


FIG. 3-32 PICTURE ROLLS UP OR DOWN • SOUND NORMAL •

SYMPTOM

Several pictures, superimposed one above the other. Entire display may continuously move up or down.

ANALYSIS

Trouble is due to improper VERT. SYNC control setting, or to a defect in the vertical sync and sweep circuits.

PROCEDURE

Adjust VERT. SYNC control; if trouble persists, see trouble-shooting chart E.

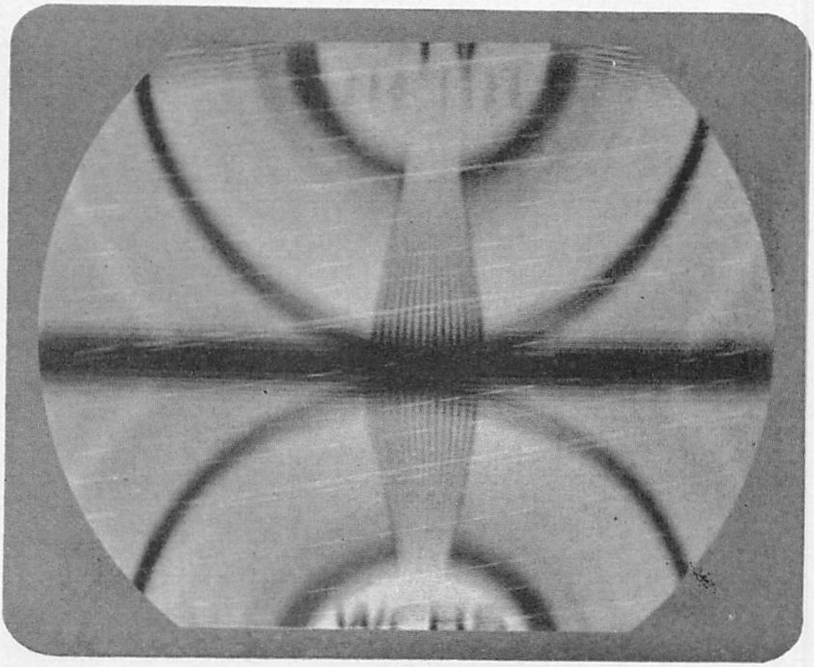


FIG. 3-33 PICTURE JUMPS UP AND DOWN • SOUND NORMAL •

SYMPTOM

Picture unsteady, jumps or vibrates up and down, occasionally rolls up or down.

ANALYSIS

Trouble is due either to poor vertical sync or trouble in vertical sweep circuit.

PROCEDURE

See trouble-shooting chart E.

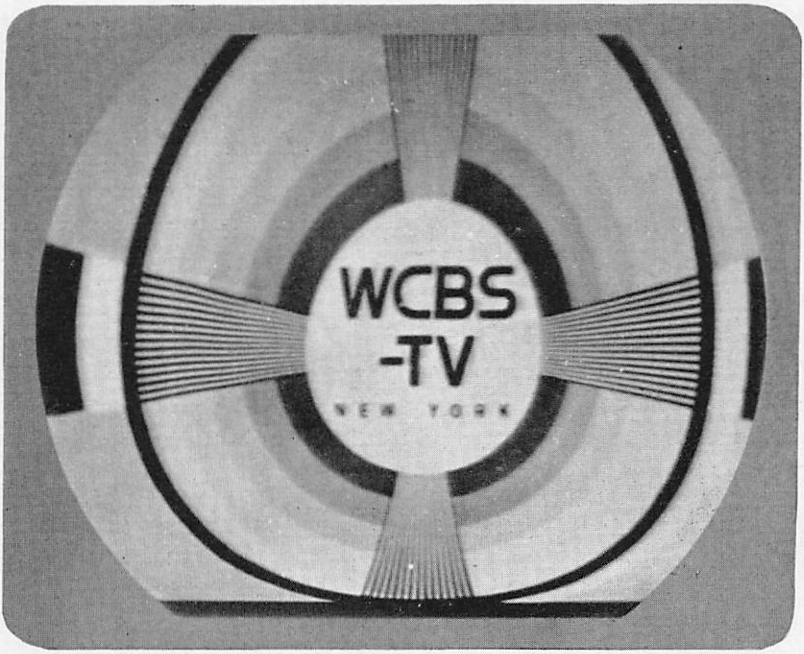


FIG. 3-34 VERTICAL NON-LINEARITY · SOUND NORMAL ·

SYMPTOM

Top and bottom of picture out of proportion with each other. Sound normal.

ANALYSIS

Trouble is due to incorrect adjustment of VERT. LINEARITY or VERT. SIZE controls, or to defective vertical sweep.

PROCEDURE

Adjust VERT. LINEARITY or VERT. SIZE control or both. If trouble persists, see trouble-shooting chart E.

FIG. 3-35 HORIZONTAL NON-LINEARITY · SOUND NORMAL ·

SYMPTOM

Right-hand and left-hand sides of picture out of proportion with each other. Sound normal.

ANALYSIS

Trouble is due to incorrect adjustment of HOR. LINEARITY or HOR. DRIVE controls, or to defective horizontal sweep.

PROCEDURE

Adjust HOR. LINEARITY and HOR. DRIVE controls in accordance with manufacturer's instructions. If trouble persists, see trouble-shooting chart E.

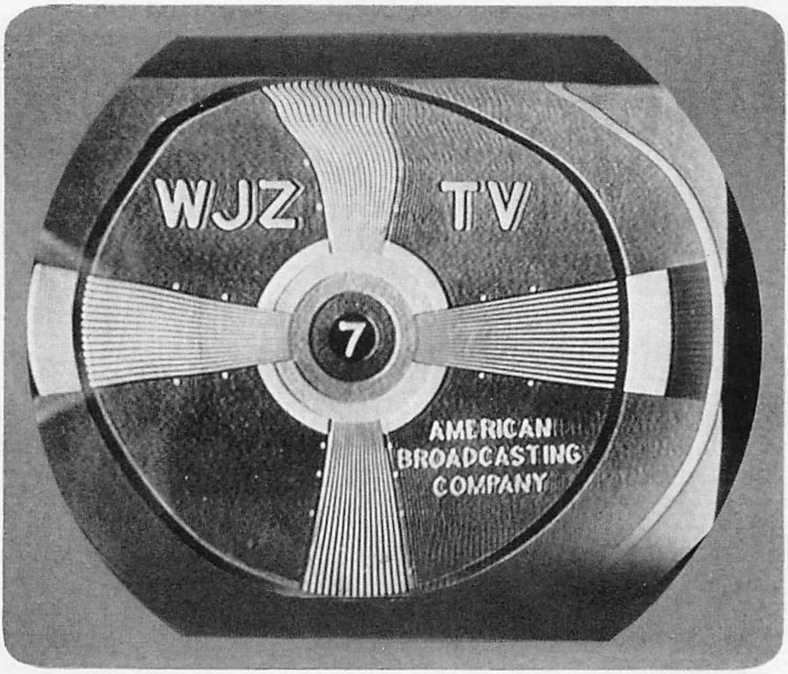


FIG. 3-36 TOP OF PICTURE WAVY • SOUND NORMAL •

SYMPTOM

Top of picture wavy. Sound normal.

ANALYSIS

Trouble due to misadjustment of horizontal hold control, horizontal oscillator transformer slug, defect in sync circuit, or overloading of video circuit.

PROCEDURE

Readjust horizontal oscillator transformer slug. If trouble persists, see trouble-shooting chart E.

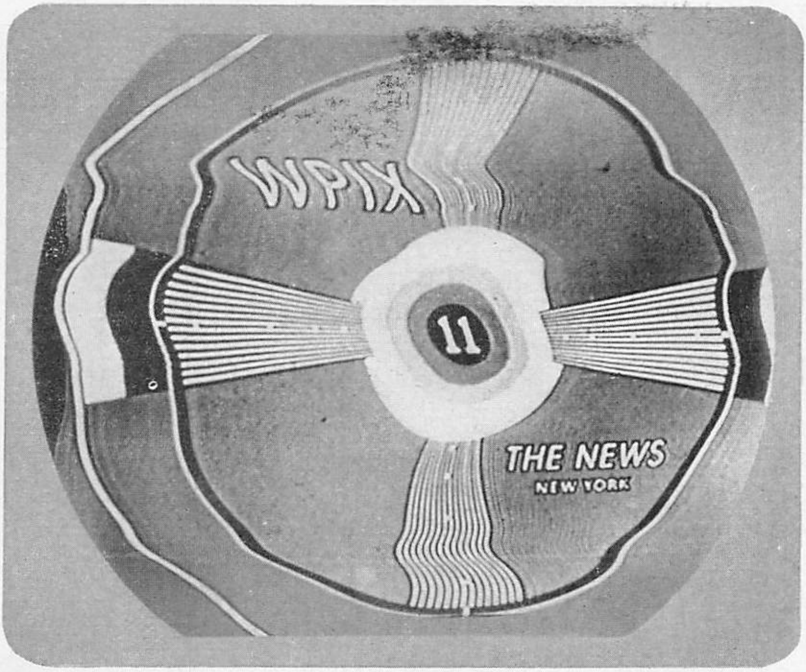


FIG. 3-37 PICTURE WAVY · SOUND NORMAL ·

SYMPTOM

Vertical lines in picture are wavy. Sound normal.

ANALYSIS

Trouble is due to 60 or 120 cycle hum in the horizontal sync circuit.

PROCEDURE

Check tubes in sync and sweep section for heater-cathode leakage. If normal, check sync circuit for 60 or 120 cycle pick-up.

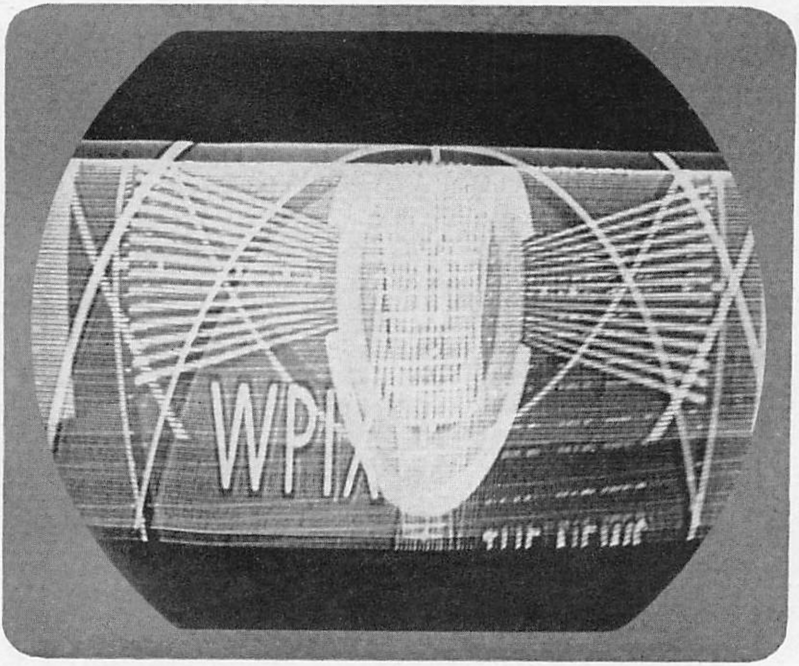


FIG. 3-38 VERTICAL FOLDOVER · SOUND NORMAL ·

SYMPTOM

Picture folded back on itself vertically, i.e., upper portion of picture super-imposed over lower portion.

ANALYSIS

Trouble is in vertical sweep circuits.

PROCEDURE

Check vertical sweep circuits; see trouble-shooting chart E.

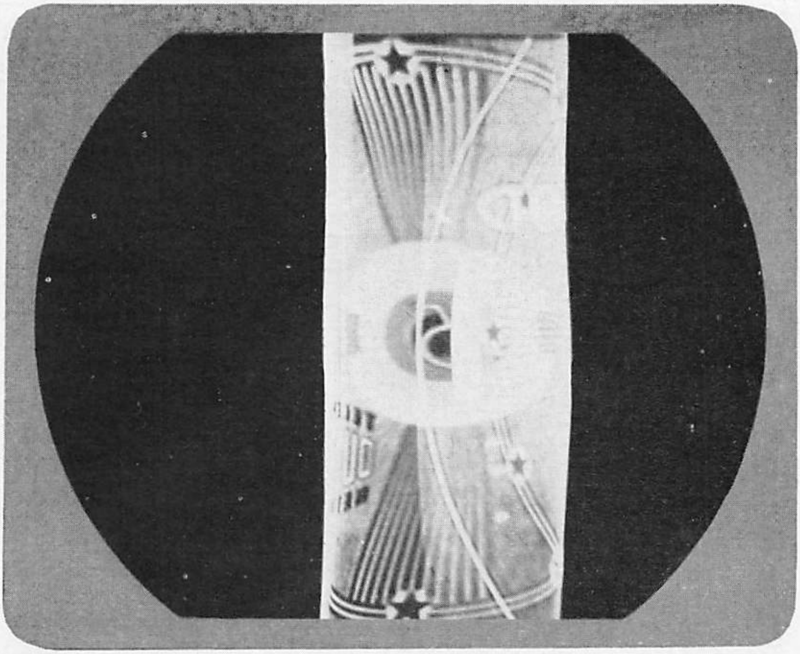


FIG. 3-39 PICTURE OVERLAPS HORIZONTALLY ("Horizontal Foldover") • SOUND NORMAL •

SYMPTOM

Picture folded back on itself. Sound normal.

ANALYSIS

Trouble due to defective horizontal sweep waveform.

PROCEDURE

See trouble-shooting chart E.

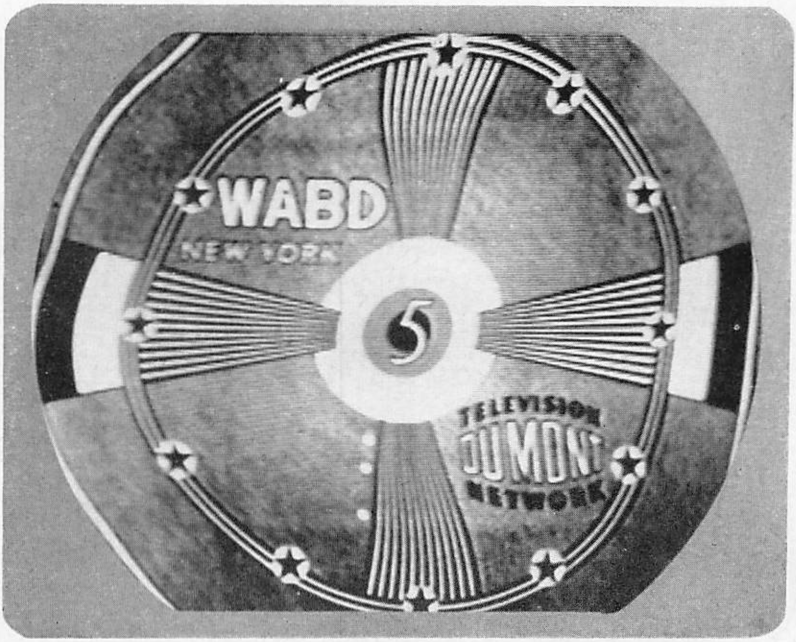


FIG. 3-40 SIDES OF PICTURE CURVED & DISTORTED · HUM IN SPEAKER OUTPUT ·

SYMPTOM

Picture distorted in the horizontal direction. Loud hum in speaker.

ANALYSIS

Trouble is caused by 120-cps ac hum in sweep section, due to defective B+ filtering.

PROCEDURE

Check filter capacitors and filter chokes.

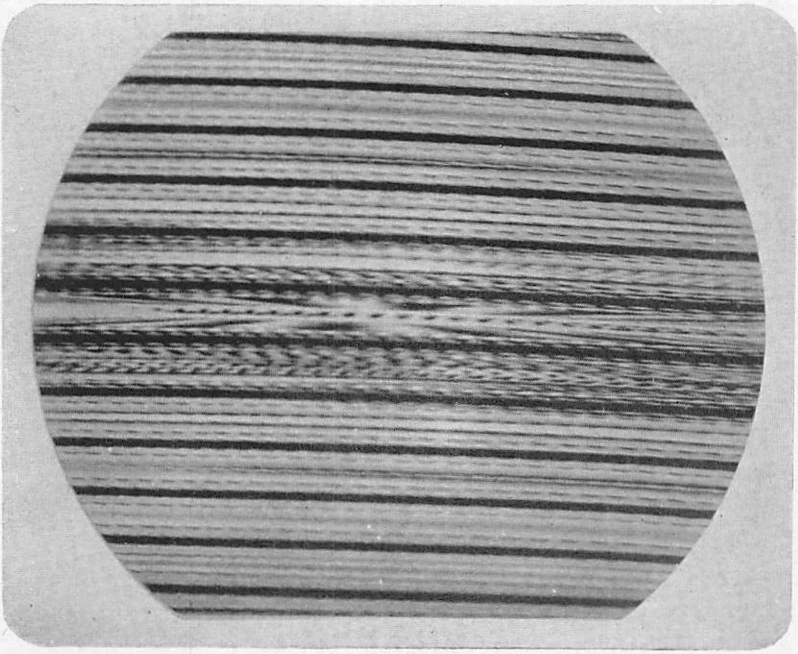


FIG. 3-41 HORIZONTAL BARS ACROSS SCREEN · SOUND NORMAL ·

SYMPTOM

Horizontal oscillator circuit "off" frequency. Sound normal.

ANALYSIS

Trouble is in horizontal sync or sweep circuits.

PROCEDURE

See trouble-shooting chart E.

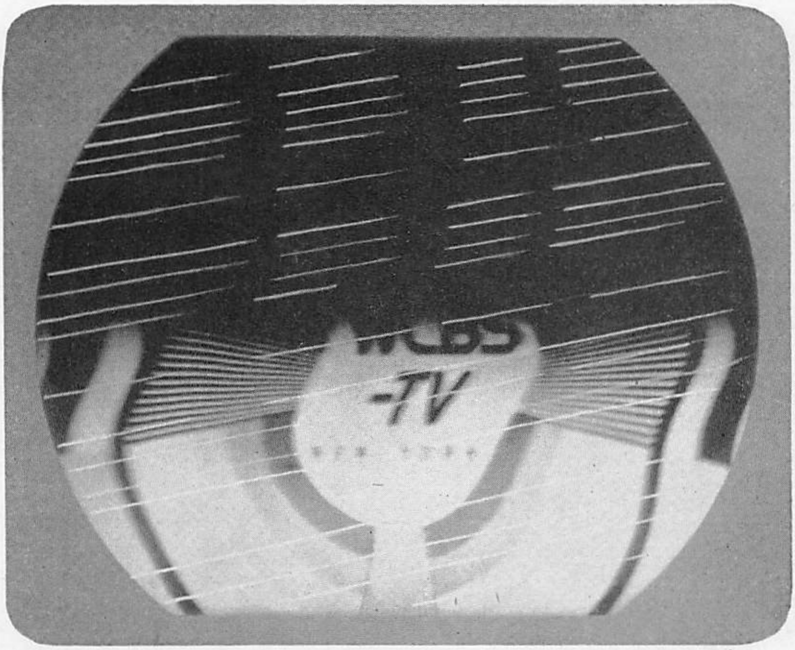


FIG. 3-42 PART OF PICTURE BLACKED OUT AND SIDES OF PICTURE CURVED • LOUD HUM IN SPEAKER OUTPUT •

SYMPTOM

Top or bottom of picture blocked out, with slanted white bars across blocked-out part of picture. Picture simulates rolling waves. Poor or no horizontal hold. Sides of picture curved and distorted. Loud hum in loudspeaker output.

ANALYSIS

Trouble is due to 60-cps hum in rf, if, video and sweep circuits. The hum is probably caused by heater-cathode leakage in one of the tubes of the rf, if, video sections.

PROCEDURE

Check tubes with tube-tester for heater-cathode leakage, check B+ filter circuits.

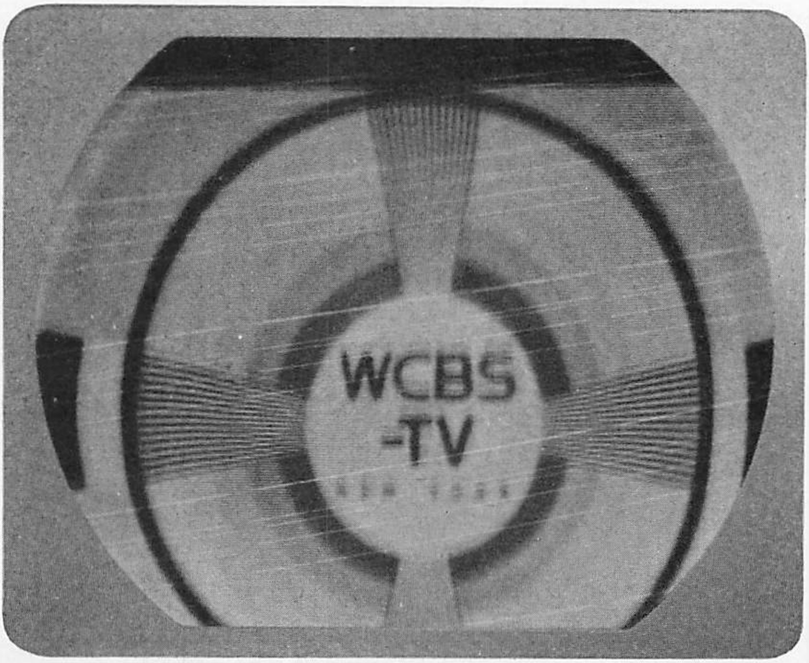


FIG. 3-43 JUMPING PICTURE · STATIC IN SOUND ·

SYMPTOM

Picture jumps up and down erratically, with thin white lines passing through picture; bursts of static in loudspeaker output.

ANALYSIS

Trouble due to pick-up of external electric noise, or to intermittent shorts or loose connections in antenna and lead-in or receiver.

PROCEDURE

Check antenna and lead-in and receiver connections for shorts, grounds and loose connections. Tap components to locate intermittent or noisy component.

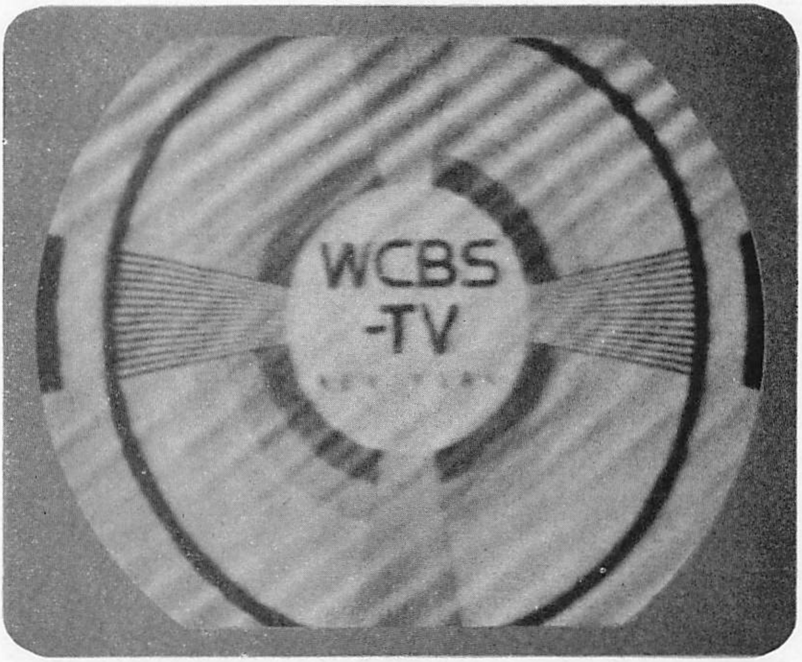


FIG. 3-44 DIAGONAL LINES THROUGH PICTURE • SOUND NORMAL •

SYMPTOM

Alternate light and dark diagonal lines through picture. Lines may be stationary, or may appear erratically.

ANALYSIS

Trouble due to rf interference.

PROCEDURE

Attempt to locate the source of interference, and to remove the interfering radiation at the source. If this cannot be done, relocate antenna for minimum interference pick-up, or install wave-traps in lead-in.

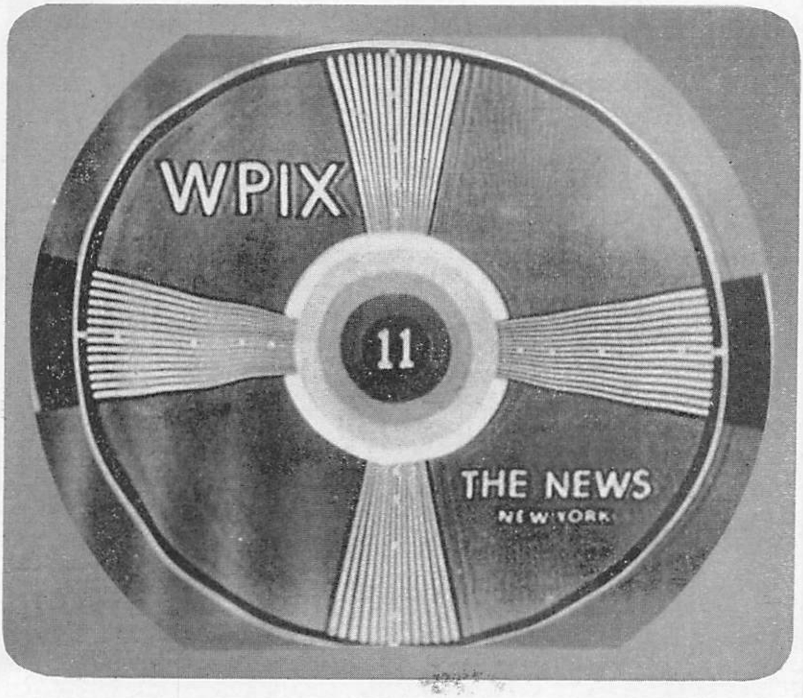


FIG. 3-45 PICTURE HAS "WRINKLED" APPEARANCE • SOUND NORMAL •

SYMPTOM

Alternate light and dark vertical bars at left side of picture. Sound normal.

ANALYSIS

Trouble is due to oscillations in horizontal deflection coils, or weak damper tube.

PROCEDURE

Check capacitors and resistors in horizontal deflection coil circuit, check damper.

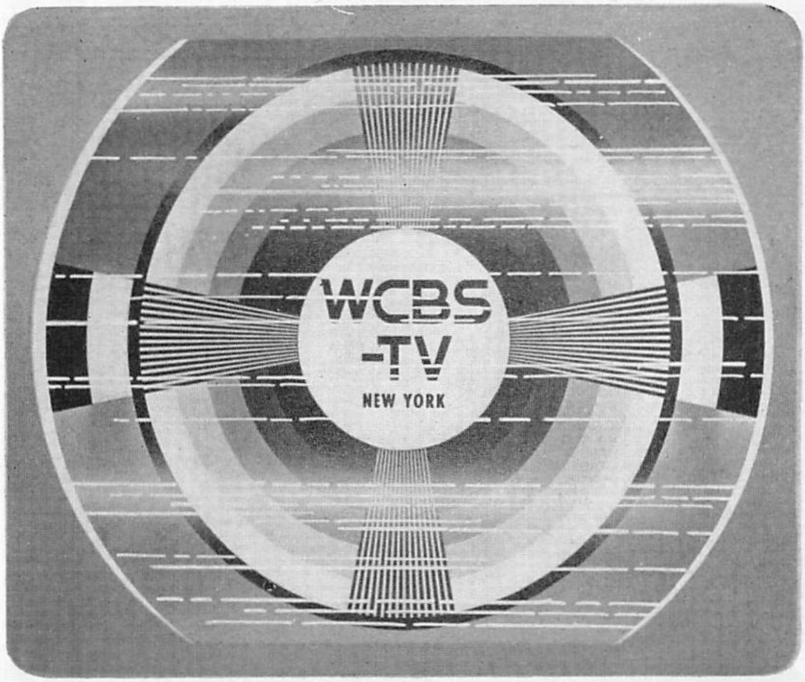


FIG. 3-46 ERRATIC LINES THROUGH PICTURE •

SYMPTOM

Horizontal or slanted lines, or spots or streaks appear erratically in the picture. Sound may contain hum or static, or may be normal.

ANALYSIS

Trouble due to interference radiation from near-by automobiles, or other electrical equipment.

PROCEDURE

Attempt to locate the radiation source and to remedy it by using filters or shielding the source. If this cannot be done, use shielded transmission line or relocate antenna for minimum interference pick-up.

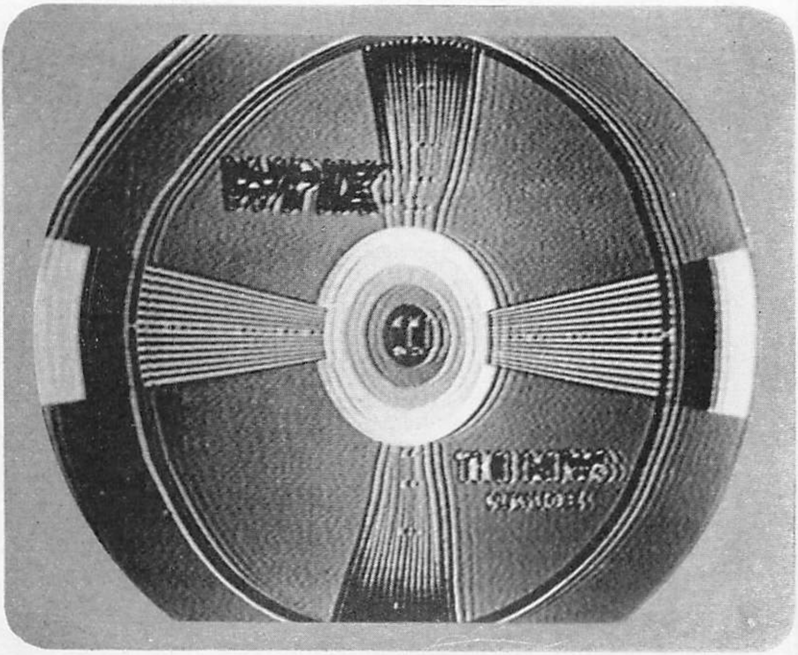


FIG. 3-47 PICTURE SMEARED · SOUND NORMAL ·

SYMPTOM

Sound normal.

Picture distorted and wavy, has "smeared" appearance.

ANALYSIS

Trouble due to incorrect bandpass in rf, if, or video section.

PROCEDURE

Check video load resistors for change in value and decoupling capacitors.

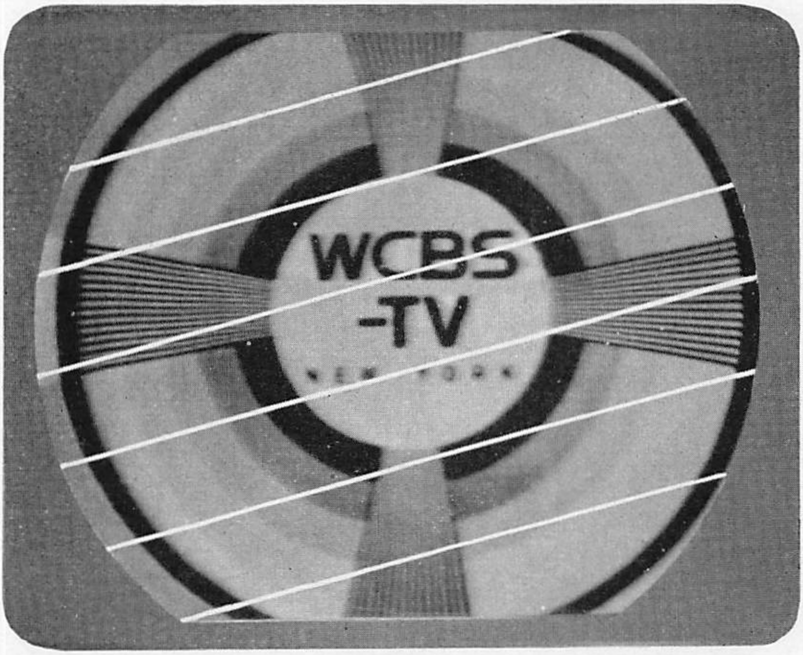


FIG. 3-48 WHITE LINES THROUGH PICTURE · SOUND NORMAL ·

SYMPTOM

Picture normal execpt for diagonal white lines. Brightness control has no effect. Sound normal.

ANALYSIS

Trouble due to gassy picture tube, defective brightness control, or to incorrect voltages applied to picture tube.

PROCEDURE

Check picture tube, using cathode-ray tube testing adapter and tube tester, or using substitution method. If tube is good, check brightness control and voltages at CRT socket to locate defective component.

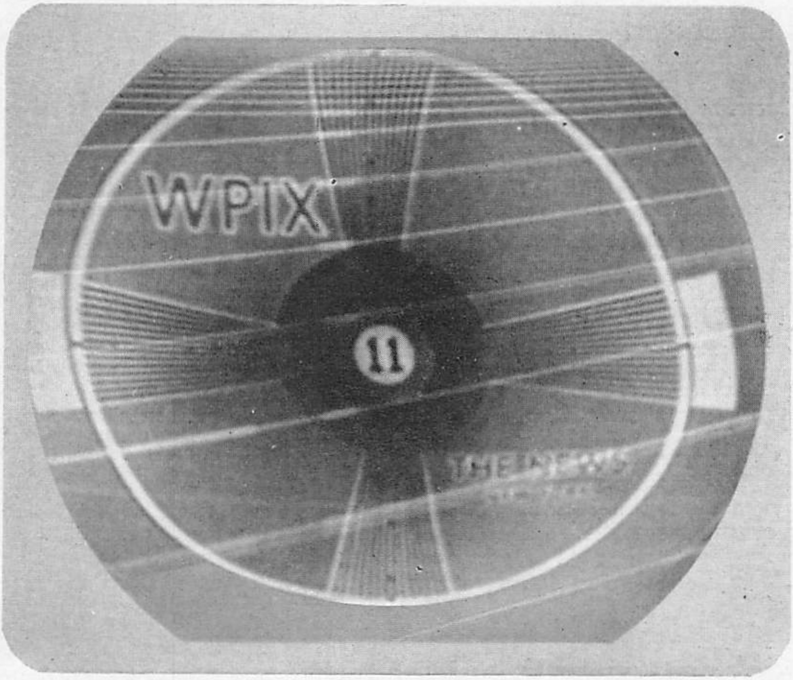


FIG. 3-49 PICTURE TURNS NEGATIVE • SOUND NORMAL •

SYMPTOM

Picture is normal when CONTRAST control is turned counter-clockwise, but dark areas turn silvery-white as control is advanced clockwise. Sound normal.

ANALYSIS

Short in agc line, or low emission of picture tube.

PROCEDURE

Readjust CONTRAST control. If trouble persists, or satisfactory picture contrast cannot be attained, check picture tube, check capacitors and resistors in agc circuit (see steps 10 through 12, trouble-shooting chart E).

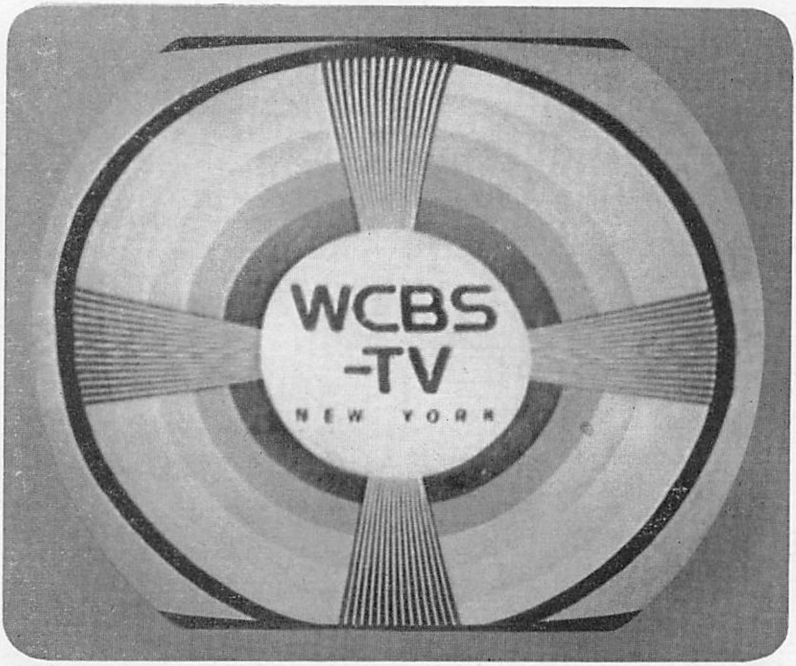


FIG. 3-50 WAVY LINES ACROSS PART OF PICTURE • SOUND NORMAL •

SYMPTOM

Wavy horizontal portion, either too light or too dark. Sound normal.

ANALYSIS

Trouble due to rf interference, caused by nearby diathermy, rf induction heating or other equipment.

PROCEDURE

Attempt to locate interfering equipment and to eliminate interference by shielding and filtering of this equipment. If this cannot be done, relocate antenna and lead-in, or install filters or wave-traps in lead-in.

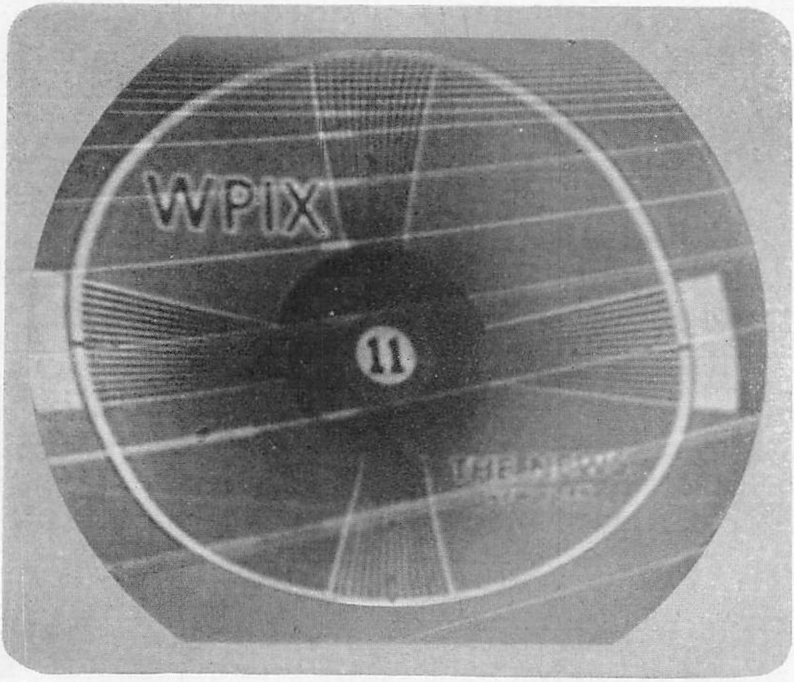


FIG. 3-51 PICTURE TURNS NEGATIVE • SOUND NORMAL •

SYMPTOM

Light subjects are dark, while dark subjects are light in the picture. Diagonal white lines run through picture. Sound normal.

ANALYSIS

Trouble due to rf radiation pick-up from nearby transmitter or receiver causing overloading of receiver.

PROCEDURE

Attempt to locate the source of the radiation and to eliminate trouble by shielding this source, or installing filters and wave-traps. If this cannot be done, re-locate receiver antenna and lead-in for minimum pick-up, and install filters or wave-traps in lead-in.

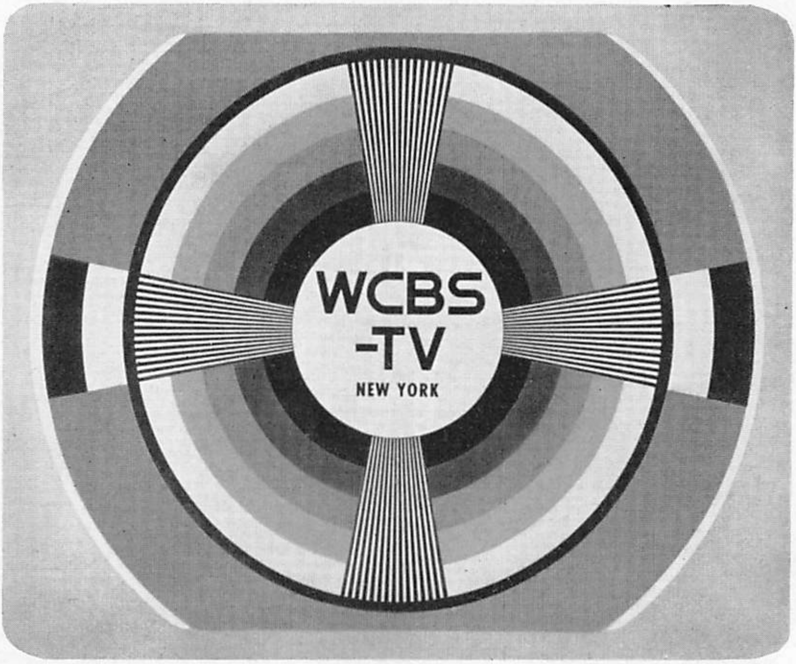


FIG. 3-52 NORMAL PICTURE, BUT SOUND ABNORMAL •

SYMPTOM

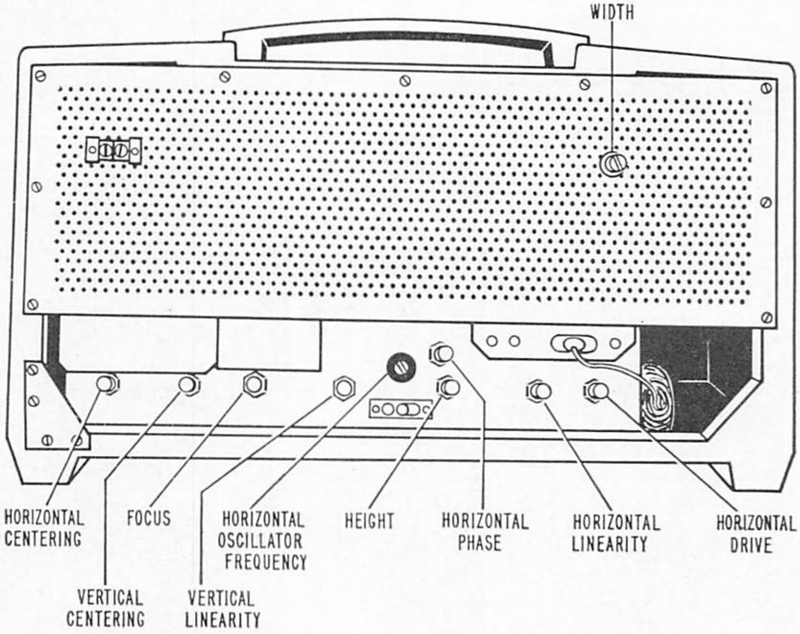
Sound absent, weak or distorted. Picture normal.

ANALYSIS

Trouble is in sound section. Power supplies and antenna apparently normal.

PROCEDURE

See trouble-shooting chart D.



3-53. Rear panel controls of typical chassis

3-7. TROUBLE-SHOOTING CHARTS

The trouble-shooting charts presented in the following pages, if followed carefully, enable the technician to isolate the defective stages in a television receiver. A separate chart is furnished for each of the five sections of the receiver. If the technician is not certain in which section the fault lies, he should either use the information contained in the preceding paragraphs of this chapter, or perform the following tests described in the trouble-shooting charts:

Trouble-shooting chart	*Steps to be performed*	*If "expected result" listed in chart is not obtained, trouble is in*
A	2 and 3	Power supply section
B	1, 6, 7, 8, 9	
C	1, 2, 3	Video section
D	5	Sound section
E	3, 7, 9, 10, 11, 12	Sync and sweep section
F	1	High-voltage section

Specific values and waveforms given in the following charts pertain to the Sylvania 1-366 chassis. These specific values and waveforms have been given to implement the instructions and are comparable to most of the sets on the commercial market.

TROUBLE-SHOOTING CHART A
LOW VOLTAGE POWER SUPPLY

Instruments required:

1. Polymeter
2. Tube tester

Notes:

1. All voltage readings should be within ±15% of the values given.
2. If a component is overheating, disconnect one side of the component before proceeding.

STEP	PROCEDURE	EXPECTED RESULT	IF OBTAINED	IF NOT OBTAINED
1	With Polymeter, measure a-c filament voltage.	6.3 volts	Go to step 2.	Check line-cord, power line fuse interlock, on-off switch (on volume control), and power transformer.
2	With Polymeter, check positive d-c voltage output (fuse to chassis).	Proper B+ voltage	Go to step 3.	No voltage: Check rectifier tubes and filter choke. Low voltage: Check filter capacitors and bleeder resistors. High voltage: Check bleeder resistor.
3	With Polymeter, check negative d-c voltage output.	Proper B— voltage	Power supply section normal	Check filter capacitor and bleeder resistors.

TROUBLE-SHOOTING CHART B
RF & IF SECTIONS

Instruments required:
1. Polymeter
2. Oscilloscope
3. Signal generator
4. Sweep generator
5. Tube tester.
6. Substitute Tube Shield, made by insulating tube shield on mixer tube from ground

Notes:
1. Check all tubes before trouble-shooting.
2. Remove antenna connections and set tuning control to unused channel.
3. Remove agc amplifier tube from its socket.
4. All voltage readings should be within ±30% of the values given.

STEP	PROCEDURE	EXPECTED RESULT	IF OBTAINED	IF NOT OBTAINED
1	Connect Polymeter across second detector output	Less than 0.5 volts dc	Go to step 2.	Oscillations in rf & if sections. Check decoupling capacitors and alignment.
2	Same as Step 1, but connect signal generator tuned to 25 mc to grid of 4th if stage. Turn modulation off. Set rf attenuator to 1, amplitude control to 10.	More than 5 volts dc	Go to step 3.	Trouble in 4th if stage or second detector; check voltages and resistances in these stages to locate defective component.
3	Same as step 2, but connect signal generator to grid of 3rd if stage, and set attenuator to 10.	More than 5 volts dc	Go to step 4.	Trouble in 3rd if stage; check voltages and resistances in this stage to locate defective component.

4	Same as step 2, but connect signal generator to grid of 2nd if stage and set attenuator to 100.	More than 5 volts dc	Go to step 5.	Trouble in 2nd if stage; check voltages and resistances in this stage to locate defective component. Check components in AGC lines.
5	Same as step 2, but connect signal generator to grid of first if stage and set attenuator to 1000.	More than 5 volts dc	Go to step 6.	Trouble in first if stage; check voltages and resistances in this stage to locate defective component.
6	Connect signal generator tuned to 55.25 mc, to antenna terminals. Turn modulation off. Set attenuator to 10k. Set receiver tuning control to channel 2, then vary slightly for maximum Polymeter reading.	More than 5 volts dc	Go to step 7.	Trouble in rf tuner, in connections, or in input to first if stage. Check tubes in rf tuner, connections, input voltages (+125 volts dc, and 6.1 volts ac), and picture if output cable; if normal, replace rf tuner.
7	Same as step 6, but tune signal generator to 211.25 mc; set receiver tuning control to channel 13, then vary slightly for maximum Polymeter reading.	More than 5 volts dc	Go to step 8.	Trouble in rf tuner.

8	Same as step 6, but disconnect Polymeter; connect oscilloscope to output of second detector. Adjust oscilloscope for maximum gain.	No signal. Straight line on oscilloscope screen	Go to step 9.	If a 60-cycle signal is displayed on oscilloscope, trouble is due to heater-cathode leakage; check all tubes with tube tester or by substitution. If a 120-cycle signal is displayed on oscilloscope, trouble is due to insufficient plate supply filtering; check filter capacitors.
9	Disconnect signal generator. Place substitute tube shield on mixer tube and connect sweep generator to it. Connect signal generator to insulated tube shield. Adjust sweep generator and signal generator to obtain over-all if bandpass response shown. Keep oscilloscope gain high.	See Figure 4-3.	RF & IF sections normal	Realign if section, using procedure given in chapter 4.
10	Replace agc amplifier tube.			

TROUBLE-SHOOTING CHART C
VIDEO SECTION

Instruments required:
1. Polymeter
2. Signal generator

Notes:
1. Check all tubes before trouble-shooting.

STEP	PROCEDURE	EXPECTED RESULT	IF OBTAINED	IF NOT OBTAINED
1	Connect signal generator, tuned to 55.25 mc, to antenna terminals. Turn on amplitude modulation. Connect Polymeter to measure ac video detector output (between pin 7 of V7 and chassis). Set receiver tuning control to channel 2. Adjust rf attenuator on signal generator for a 2-volt reading on Polymeter; then connect Polymeter to measure video amplifier output. Set CONTRAST control fully clockwise.	Polymeter indicates between 30 and 50 volts ac.	Go to step 2.	Trouble in video amplifier. Make voltage and resistance checks in this stage to locate defective component.
2	Disconnect signal generator Connect Polymeter to measure dc cathode voltage of CRT. Set CONTRAST control to center of its range.	—20 to —40 volts.	Go to step 3.	Trouble in CRT cathode circuit or CRT. Make resistance checks to locate defective component.

3	Connect Polymeter to measure dc grid voltage of CRT. Set BRIGHTNESS control to center of its range.	—60 to —100 volts.	Video Section normal	Trouble in CRT grid circuit or CRT. Make resistance checks to locate faulty component.

TROUBLE-SHOOTING CHART D
SOUND SECTION

Instruments required:

1. Polymeter
2. FM signal generator
3. Sweep generator
4. Oscilloscope

Notes:

1. Check all tubes before trouble-shooting.
2. Remove the video detector tube from its socket.

STEP	PROCEDURE	EXPECTED RESULT	IF OBTAINED	IF NOT OBTAINED
1	Connect af output of signal generator (400 cps) to control grid of af output tube.	Tone in loudspeaker output.	Go to step 2.	Trouble in af output tube or loudspeaker. Make voltage and resistance checks to locate defective component.
2	Turn volume control to center of its range and connect af output signal generator across VOLUME control.	Tone in loudspeaker output.	Go to step 3.	Trouble in first af amplifier. Make voltage and resistance checks to locate faulty component.

3	Connect signal generator rf output, tuned to 4.50 mc, to limiter control grid. Set modulation control to 75-kc sweep width, and attenuator for maximum output. Vary VOLUME control over its limits.	Tone in loudspeaker output.	Go to step 4.	Trouble in limiter or ratio detector. Make voltage and resistance checks to locate defective component.
4	Same as step 3, but connect signal generator output to video detector output.	Tone in loudspeaker output.	Go to step 5.	Trouble in sound if amplifier. Make voltage and resistance checks to locate defective component.
5	Replace V7 in its socket, then tune in a local station. Listen to sound quality and volume.	Good sound quality and loudness.	Sound section normal	If buzz is present, or output volume is low, realign sound section. If high frequencies predominate in the output ("tinny" sound), check tone compensating and de-emphasis components and loudspeaker.

TROUBLE-SHOOTING CHART E
SYNC AND SWEEP SECTION

Instruments required:

1. Polymeter
2. Oscilloscope

Notes:

prevent accidental contact.
2. Check all tubes before trouble-shooting.
1. High voltages exist in this section. Exercise due caution to

STEP	PROCEDURE	EXPECTED RESULT	IF OBTAINED	IF NOT OBTAINED
1	Remove horizontal and vertical oscillator tubes. Connect oscilloscope to cathode of horizontal sync separator. Set sweep frequency at 30 cps, then at 7,875 cps.	See Figure 3-54, parts g and h.	Go to step 2.	Trouble in horizontal sync separator; make voltage and resistance checks to locate defective component; check video section.
2	Same as step 1, but connect oscilloscope to plate of sync amplifier and clipper.	See Figure 3-54, parts m and o.	Go to step 3.	Trouble in sync separator or sync amplifier and clipper; make voltage and resistance checks to locate defective component.
3	Connect oscilloscope to grid of vertical oscillator. Set sweep frequency to 30 cps.	See Figure 3-54, part e.	Go to step 4.	Trouble in integrator. Check resistor and capacitors in this circuit to locate defective component.

4	Replace horizontal oscillator tube. Connect oscilloscope to plate of horizontal oscillator. Set sweep frequency at 7,875 cps.	See Figure 3-54, part u.	Go to step 5.	Trouble in horizontal discriminator, control tube or oscillator. Check tube or oscillator. Check voltages and resistances in these stages to locate defective component.
5	Connect oscilloscope to plate of horizontal discharge stage. Set sweep frequency at 7,875 cps.	See Figure 3-54, part v.	Go to step 6.	Trouble in horizontal discharge stage. Check voltages and resistances in this stage to locate defective component.
6	Connect oscilloscope to screen of horizontal output stage. Set sweep frequency at 7,875 cps.	See Figure 3-54, part y.	Go to step 7.	Trouble in horizontal output or damper stages. Check fuse, then check voltages and resistances in these stages to locate defective component.
7	Connect oscilloscope across horizontal deflection coils Set sweep frequency at 7,875 cps.	See Figure 3-54, part p.	Go to step 8.	Trouble in horizontal output transformer or deflection coils. Check resistances and capacitors to locate defective component.

8	Replace vertical oscillator tube. Connect oscilloscope to grid of vertical output stage. Set sweep frequency at 30 cps.	See Figure 3-54, part p.	Go to step 9.	Trouble in vertical oscillator. Check voltages and resistances in this stage to locate defective component.
9	Connect oscilloscope to vertical deflection coil. Set sweep at 30 cps.	See Figure 3-54, part w.	Go to step 10.	Trouble in vertical output stage or deflection coils. Check voltages and resistances to locate defective component.
10	Connect Polymeter to measure dc voltage at plate of agc line clamper. Remove agc amplifier tube.	—0.2 volts	Go to step 11.	Trouble in agc line clamper. Check resistances in this stage to locate faulty component.
11	Replace agc amplifier tube. Connect Polymeter to measure dc voltage at agc amplifier plate. Tune receiver to unoccupied channel.	0 to —0.4 volts	Go to step 12.	Trouble in agc amplifier. Check resistances in this stage to locate faulty component.
12	Same as step 11, but tune receiver to strongest local station. Set agc control fully clockwise.	—3.0 to —6.0 volts	Sync and sweep section normal	Trouble in agc amplifier. Check resistances in this stage to locate faulty component.

INSTRUCTIONS

Note 1: The terms "Vertical" and "Horizontal" refer to the sweep speed of the oscilloscope employed. For "Vertical," the sweep speed was 30 cps, for horizontal, it was approximately 8 kc (7875 cps).

Note 2: All waveforms are taken with the oscilloscope horizontal sweep direction from left to right and with upward deflection corresponding to positive polarity.

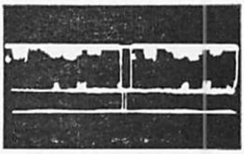
Note 3: In some instances the waveforms obtained will not be identical with those shown, due to the electrical characteristics of the oscilloscope used.

Note 4: All waveforms are measured with respect to chassis unless otherwise indicated.

Note 5: Contrast maximum unless otherwise indicated.

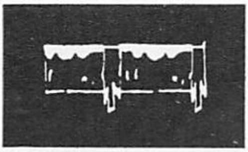
*The peak to peak (P/P) voltages of these waveforms are dependent on the depth of modulation of the transmitted signal; voltages shown are obtained when modulation is approximately 90 percent.

A



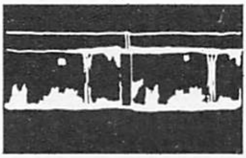
*6BF5 (V8) Video Amplifier Control Grid (Pins 1 and 7) 3.5 Volts P/P Vertical

B



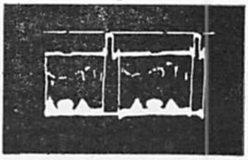
*6BF5 (V8) Video Amplifier Control Grid (Pins 1 and 7) 3.5 Volts P/P Horizontal

C



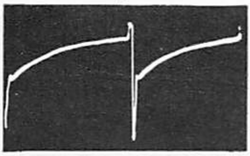
*6BF5 (V8) Video Amplifier Plate (Pin 5) 55 Volts P/P Vertical

D



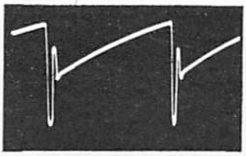
*6BF5 (V8) Video Amplifier Plate (Pin 5) 55 Volts P/P Horizontal

E



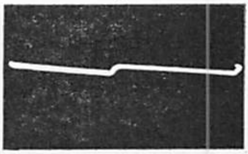
6BL7GT (V15) Vertical Oscillator Control Grid (Pin 1) 600 Volts P/P Vertical

F



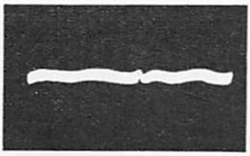
6BL7GT (V15) Vertical Oscillator Plate (Pin 2) 235 Volts P/P Vertical

G



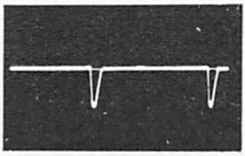
12AX7 (V14) Hor. Sync. Sep. and AGC Rectifier Cathode (Pin 8) 2. 6 Volts P/P Horizontal

H



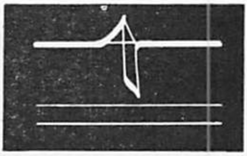
12AX7 (V14) Hor. Sync. Sep. and AGC Rectifier Cathode (Pin 8) 2. 6 Volts P/P Vertical

I



12AX7 (V14) Hor. Sync. Sep. Plate (Pin 6) 37 Volts P/P Horizontal

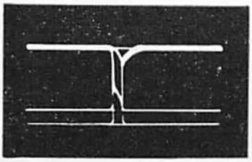
J



12AX7 (V14) Hor. Sync. Sep. Plate (Pin 6) 37 Volts (P/P Vertical

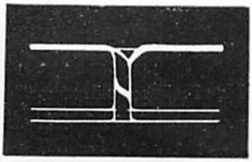
3-54. Waveforms of Sylvania I-366 chassis

K



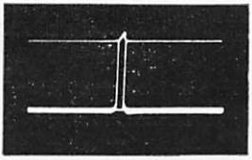
12AX7 (V14) Sync Separator Plate (Pin 1) 25 Volts P/P Vertical

L



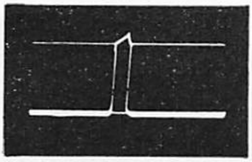
12AX7 (V14) Sync Separator Plate (Pin 1) 25 Volts P/P 60 cps sine wave

M



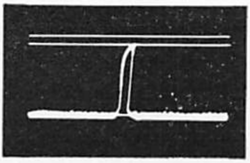
12AU7 (V13) Sync Amp. and Clipper Plate (Pin 1) 110 Volts P/P Vertical

N



12AU7 (V13) Sync Amp. and Clipper Plate (Pin 1) 110 Volts P/P 60 cps sine wave

O

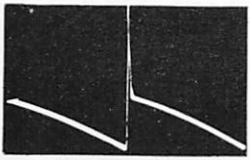


12AU7 (V13) Sync Amp. and Clipper Plate (Pin 1) 100 Volts P/P Horizontal

P

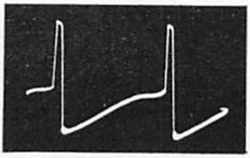
6BL7GT (V15) Vertical Output Control Grid (Pin 4) 95 Volts P/P Vertical

Q



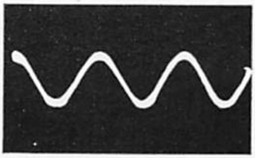
6BL7GT (V15) Vertical Output Plate (Pin 5) 830 Volts P/P Vertical

R



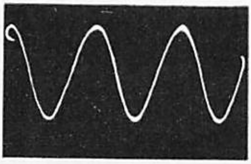
6AL5 (V16) Hor. Discriminator Plate (Pin 7) 70 Volts P/P Horizontal

S



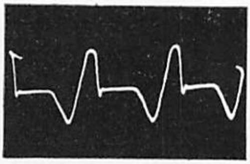
6AL5 (V16) Hor. Discriminator Plate to Plate (Pin 7 to Pin 2) Scope ground to pin 7 - 23 Volts P/P Horizontal

T



6AU6 (V17) Hor. Control Plate (Pin 5) 68 Volts P/P Horizontal

U

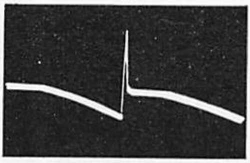


12AU7 (V18) Hor. Oscillator Plate (Pin 6) 95 Volts P/P Horizontal

V

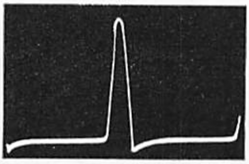
12AU7 (V18) Hor. Discharge Plate (Pin 1) 105 Volts P/P Horizontal

W



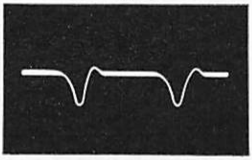
Vertical Yoke Coils (Test Point 1) 55 Volts P/P Vertical

X



6W4GT Damper Cathode (Pin 3) 2000 Volts P/P Horizontal

Y



6BQ6GT Hor. Output Screen (Pin 4) 45 Volts P/P Horizontal

3-54. Waveforms of Sylvania 1-366 chassis (continued)

TROUBLE-SHOOTING CHART F
HIGH-VOLTAGE SECTION

Instruments required:

1. Polymeter
2. High-Voltage Multiplier Probe

Notes:

1. THE HIGH VOLTAGE IN THIS SECTION CAN BE DANGEROUS. Exercise due caution to prevent accidental contact. Refer to chapter 5 for the correct method of measuring high voltage.
2. Check high-voltage rectifiers, horizontal output tube and damper tube before beginning trouble-shooting.
3. Perform steps 6 and 7 of trouble-shooting chart E. If expected results are not obtained, follow the procedure given in these steps before trouble-shooting the high-voltage section.

STEP	PROCEDURE	EXPECTED RESULT	IF OBTAINED	IF NOT OBTAINED
1	Measure high-voltage at CRT high-voltage connector, using Polymeter and high-voltage multiplier probe.	Approximately 9000 volts for 10 inch tube to 16000 volts for 20 inch tube	High-voltage section normal	Trouble in high-voltage section. Check resistances and capacitances in this section to locate defective component.

CHAPTER 4
ALIGNMENT AND ADJUSTMENT

4-1. INTRODUCTION

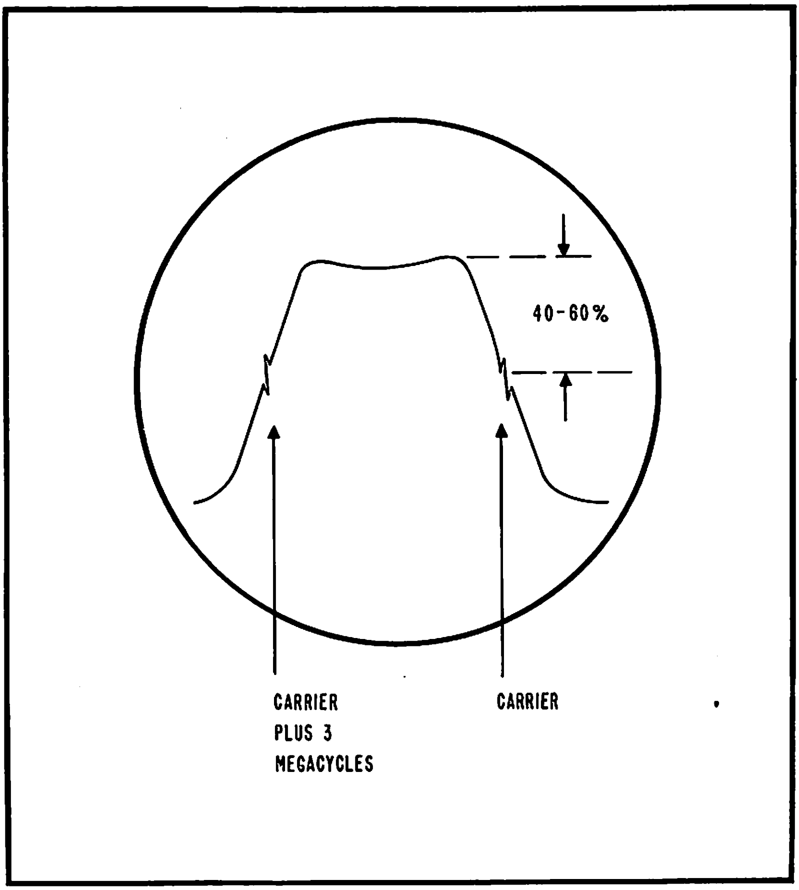
This chapter describes the methods for alignment and adjustment of television receivers. Specific procedures for a typical receiver are also included. These procedures are similar, but not identical, to those used in most sets. In order to insure optimum results, closely adhere to the manufacturer's instruction on the set to be aligned.

4-2. PRE-ALIGNMENT CONSIDERATION

The alignment of a television receiver is very similar to the alignment of a broadcast receiver. In both cases a signal source and an output indicating device are connected to the receiver. The .coils and capacitors of the receiver are then adjusted until the output indicating device shows that proper operation is obtained. However, while broadcast receivers are usually aligned for maximum gain only, television receivers are aligned for both proper bandpass and maximum gain. The reason for this is that narrow bandpass in broadcast receivers (about 10 kc) is sufficient, while wide bandpass (3.5 mc or more) is required for optimum television reception.

Television receivers are aligned during manufacture, hence re-alignment during installation is usually not required. Rough handling or jarring of the receiver during transportation or installation may, however, disturb the tuned circuits sufficiently to necessitate re-alignment. For this reason it is advisable to check the receiver bandpass during installation, using either the test pattern transmitted by a local station, or a frequency-modulated signal generator and oscilloscope. Alignment should also be checked after replacement of any component in the rf, if, and sound sections.

Before beginning the adjustment of tuned circuits, it is advisable to check the receiver bandpass in order to ascertain whether abnormal receiver operation is caused by incorrect alignment, or by other troubles such as defective components, rf interference pick-up, or poor antenna and lead-in. The alignment check is made as follows: Connect a sweep generator to the antenna terminals, and an oscilloscope to the control grid of the first video amplifier stage. Synchronize the oscilloscope horizontal sweep with the sweep generator sync output. Connect a signal generator to the antenna terminals through a small capacitor (about 5 mmf); its output is used to furnish markers. Connect the negative lead of a —3 volt battery to the AGC line, positive lead to ground. Tune the receiver to Channel 2, and adjust the sweep generator to cover the 54 to 60 mc band. Use the minimum signal generator output necessary to produce the desired waveform. This avoids distortion due to overloading. Set the marker frequency at 55.5 mc, then at 58.5 mc. The response at both these frequencies should



4-1. RF and IF Section Bandpass

be more than 70% of the maximum response, and the response curve should have the outline shown in figure 4-1. Repeat, tuning the receiver to Channel 13, adjusting the sweep generator to the 210 to 216 mc band, and setting the markers at 211.5 and 214.5 mc. To check the sound section, tune the receiver to a local station, and listen to the sound; if the sound quality and volume are satisfactory, and there is no hum or buzz, the sound section is correctly aligned.

The if section is aligned by using a sweep generator and oscilloscope, but stagger-tuned circuits can also be aligned by using only a signal generator and a polymeter. The sound section can also be aligned by using a signal generator and polymeter, but discriminator or ratio detector alignment is usually more accurate if a frequency-modulated sweep generator and an oscilloscope are used.

In aligning a stagger-tuned if circuit, the output of an amplitude-modulated signal generator is connected to the mixer, and a polymeter is attached to the receiver video output. The generator is tuned to the resonant frequencies and the individual tuned circuits are adjusted for a maximum or minimum polymeter output as required by the manufacturer's instructions. After completing the alignment, it is usually advisable to check the receiver response curve by using a sweep generator and oscilloscope. Deviations from the desired response can then be compensated for by a "touching up" of the tuned circuits.

In aligning a bandpass transformer coupled if circuit, a sweep generator is connected to the grid of the last if stage, and an oscilloscope to the video detector output. The resonant frequencies of the if transformer primary and secondary are then adjusted until the response curve displayed on the oscilloscope conforms with that furnished by the manufacturer. Markers are used to judge the response at various frequencies in the passband. The sweep generator is then connected to the grid of the preceding stage and the process is repeated until the mixer input is reached and the entire if section has the desired response. The waveform obtained in each step must conform closely with that shown in the manufacturer's instructions.

The amplitude of the signal generator or sweep generator output must be kept as small as possible, in order to prevent changing of receiver response characteristics due to overloading. The amplitude of the signal generator output used for providing markers must also be kept small in order to prevent distortion of the waveform displayed on the oscilloscope.

The connection of test equipment to a television receiver sometimes results in spurious oscillations in the receiver, caused by the inductive and capacitative effects of the connecting cables. These oscillations cause a steady Polymeter reading or a jittery oscilloscope display, independent of signal generator setting. These effects can be minimized by placing a grounded metal sheet on top of the work bench and connecting the ground terminals of the receiver and test equipment to this sheet. The connection of a 50-ohm non-inductive resistor across the signal or sweep generator rf output lead is also helpful, as is careful placement of test instrument leads.

Oscillations may also be caused by incorrect tuning of one of the if circuits in a stagger-tuned if section. When this condition occurs during the tuning of one if stage, detune the stage *preceding* this stage until the oscillations stop, then proceed with the alignment, and finally retune the detuned circuit. If oscillations persist, they may be caused either by regeneration due to test leads as described above, or by a defective decoupling capacitor or loading resistor. Ohmmeter and capacitance-meter checks, or capacitor substitution, serve to locate the faulty component.

At times it seems impossible to achieve the frequency response specified by the manufacturer. If this occurs, carefully repeat the alignment procedure several times, making certain that the manufacturer's instructions have not been misinterpreted. If the difficulty persists, proceed as follows:

1. If the manufacturer furnishes the response curve of each stage, check these response curves separately, using the instruments and connections specified by the manufacturer. When the stage with the incorrect response curve has been located, check all resistors, capacitors and coils in this stage. If all components appear to be in good condition, replace the if coils or transformers, then re-align that stage.

2. If the response curve of each individual stage is not known, check the resistors, coils and capacitors in the grid and plate circuit of each stage. If all components appear to be in good condition, replace the suspected if coils one at a time until the defective coil is located.

When it is desired to re-align all sections of a television receiver, the if circuits should be aligned first, followed by the sound circuits.

The following instruments are required for complete alignment of a television receiver:

1. Polymeter (Sylvania type 221Z)
2. Signal Generator (Sylvania type 216)
3. TV Sweep generator (Sylvania type 500)
4. TV Marker Generator (Sylvania type 501)
5. Oscilloscope (Sylvania type 400)

The characteristics of these instruments are discussed in chapter 3. In additon, Sylvania Focalizer Adjustment Tool 898-0001, Core Slub Alignment Tool 898-0002 and Special Video Alignment Tool 890-0003 are useful for maximum speed and convenience in adjusting the focalizer and the tuned-circuit slugs.

4-3. IF CIRCUIT ALIGNMENT

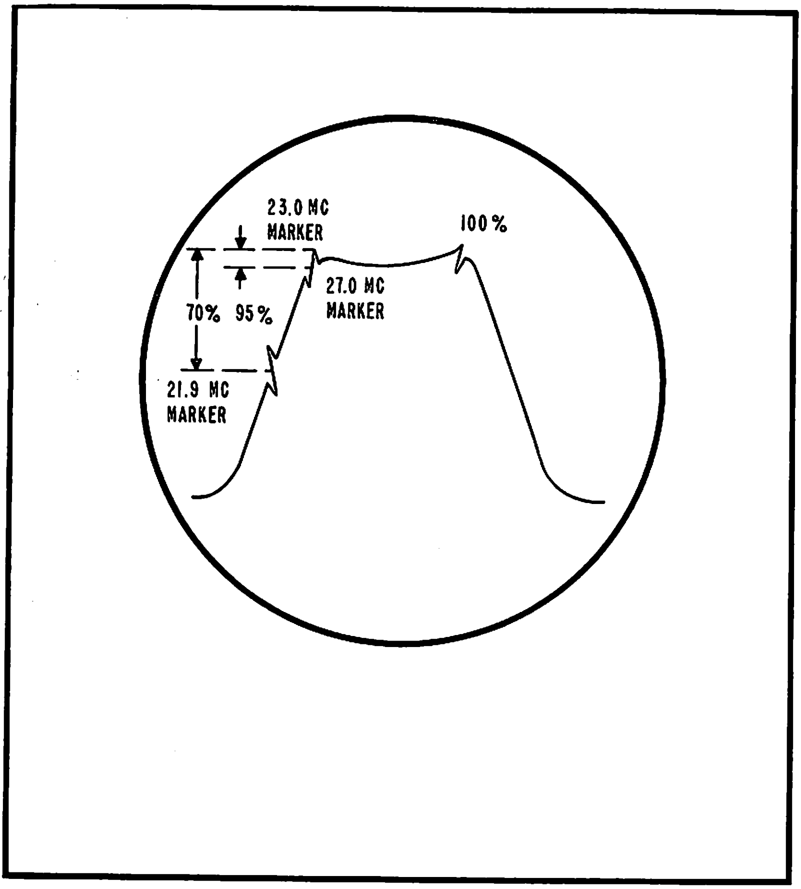
A. Preliminary Procedure.

First remove the chassis from the cabinet by performing the following steps:

1. Remove all front panel knobs.
2. Remove the screws securing the chassis to the cabinet. In table models, these screws are accessible from the bottom of the cabinet; in console models, from the rear of the cabinet.
3. If the receiver is equipped with a built-in antenna, disconnect this antenna, remove the interlock cover screws, then remove interlock cover.
4. Remove speaker plug if used.
5. Slide chassis out the back of the cabinet.
6. Lay chassis on right side to gain access to under-chassis adjustments.

Next prepare the receiver for if alignment by proceeding as follows:

1. Make up a temporary tube shield by removing a portion of a spare shield so that it will not be grounded when placed on the converter tube.
2. Remove the video amplifier tube (V-8). Connect negative lead of 3-volt battery to AGC lines; positive lead to ground. Remove Polymeter.
3. After completing the if alignment, be sure to remove the



4-2. Last IF Transformer Bandpass

temporary tube shield; replace it with the original shield. Remove battery connections.

B. Alignment of a Typical Stagger-Tuned IF System.

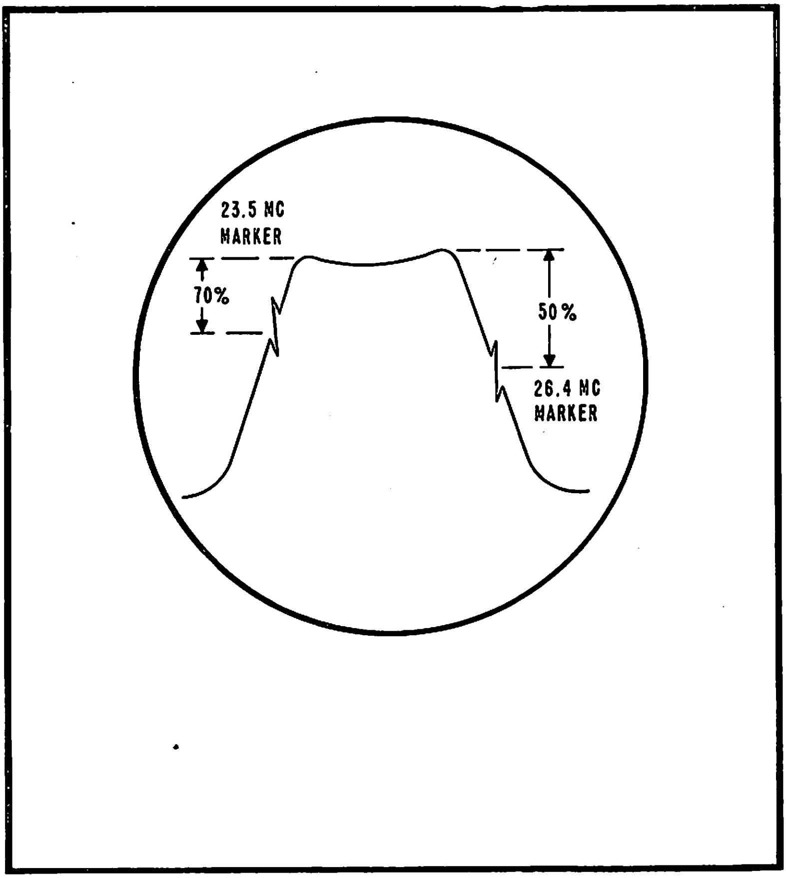
Note: Items in parentheses apply to Sylvania 1-366 receiver.

1. Connect Polymeter to measure dc voltage across second detector load resistor.

2. Connect AM signal generator to a temporary shield on the converter tube.

3. Tune signal generator to trap frequency and adjust trap coil slug for minimum output. Adjust attenuator on signal generator for Polymeter reading of less than 2 volts.

4. Follow the procedure in the following table. Adjust attenuator on signal generator to keep Polymeter reading between 1 and 2 volts.



4-3. Overall IF Transformer Bandpass

Step	*Tune signal generator to frequency of*	*Adjust core of*	*To obtain*
A	Third if transformer (T57, 25.9 mc) (See manufacturer's instructions for correct frequency for other receivers.)	Third if transformer (T57)	Maximum Polymeter reading
B	Second if transformer (T56, 23.6 mc)	Second if transformer (T56)	Maximum Polymeter reading
C	First if transformer (T55, 25.5 mc)	First if transformer (T55)	Maximum Polymeter reading
D	Converter coil (L8, 24.5 mc)	Converter coil (L8)	Maximum Polymeter reading

Step	*Tune signal generator to frequency of*	*Adjust core of*	*To obtain*
E	Trap coil (L55, 27.9 mc)	Trap coil (L55)	Minimum Polymeter reading

5. Disconnect Polymeter.

6. Connect sweep generator through a 0.005-mf capacitor to control grid of 4th video if amplifier. Connect oscilloscope across video detector load resistor. Set sweep generator to 24.5 mc, 10 mc sweep to obtain response curve similar to that in figure 4-2.

7. Using TV marker generator to furnish markers (loosely coupled to signal generator lead), adjust the two cores on the fourth if transformer to obtain the response curve shown in figure 4-2.

8. Disconnect sweep generator and TV marker generator. Connect sweep generator to the temporary shield. Wrap three turns of insulated wire around the temporary shield, then connect TV marker generator. Turn the oscilloscope gain to maximum and use the sweep generator attenuator to control display amplitude. The oscilloscope display should now resemble that shown in figure 4-3.

9. Touch-up the adjustments of all if transformers to obtain the response curve shown in figure 4-3. This completes the if alignment procedure.

C. Alignment of a Typical Bandpass-Coupled IF System.

1. Connect oscilloscope across video detector load resistor; set oscilloscope gain to maximum. Connect signal generator to cathode of mixer.

2. Connect sweep generator to grid of third if amplifier.

3. Adjust fourth if amplifier tuning slugs to obtain peak at 28.2 mc, then adjust trimmer capacitor for peak at 24.35 mc. The oscilloscope display should now be identical with that shown in part A of figure 4-4.

4. Disconnect sweep generator. Tune signal generator to adjacent channel sound if frequency (29.2 mc) and turn on amplitude modulation. Adjust adjacent channel sound trap for minimum amplitude on the oscilloscope.

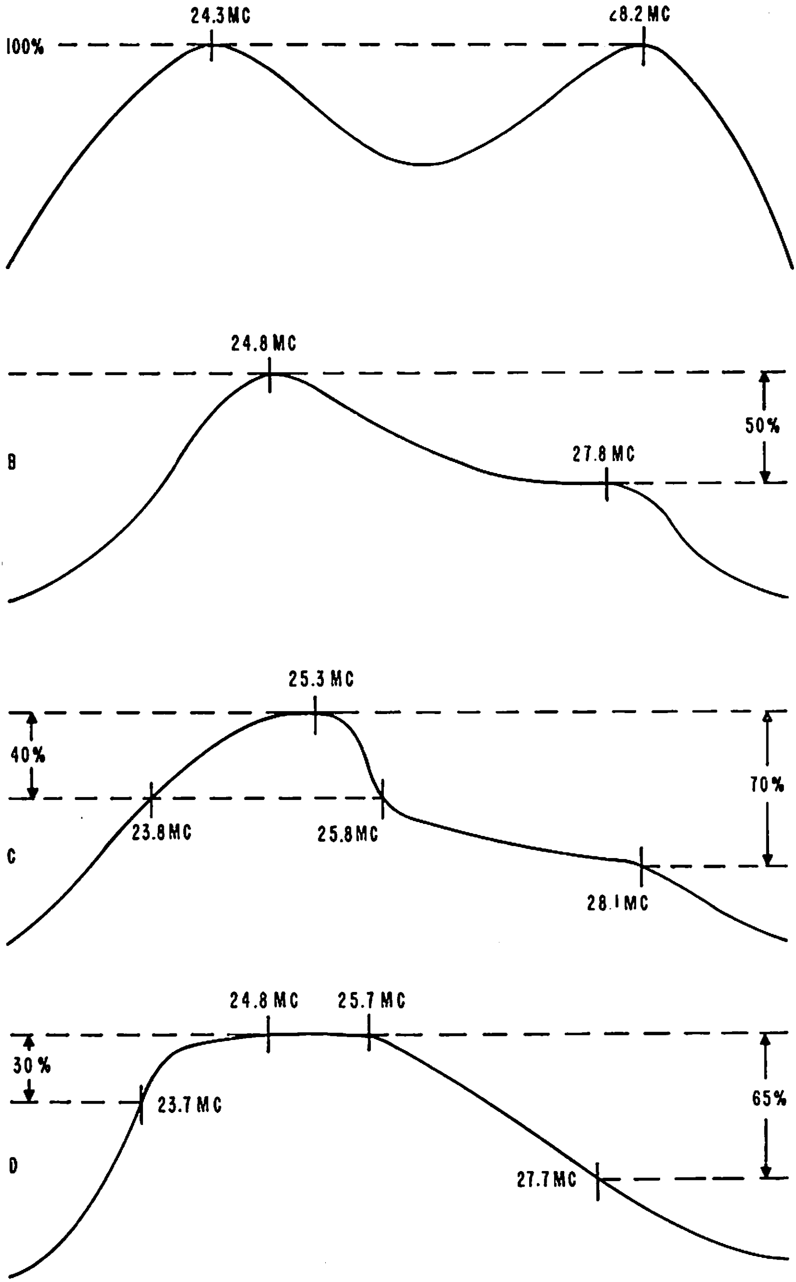
5. Tune signal generator to sound if frequency (23.2 mc). Adjust sound trap for minimum amplitude on the oscilloscope.

6. Connect sweep generator to grid of second amplifier. Adjust third if transformer slugs to obtain oscilloscope display shown in part B of figure 4-5.

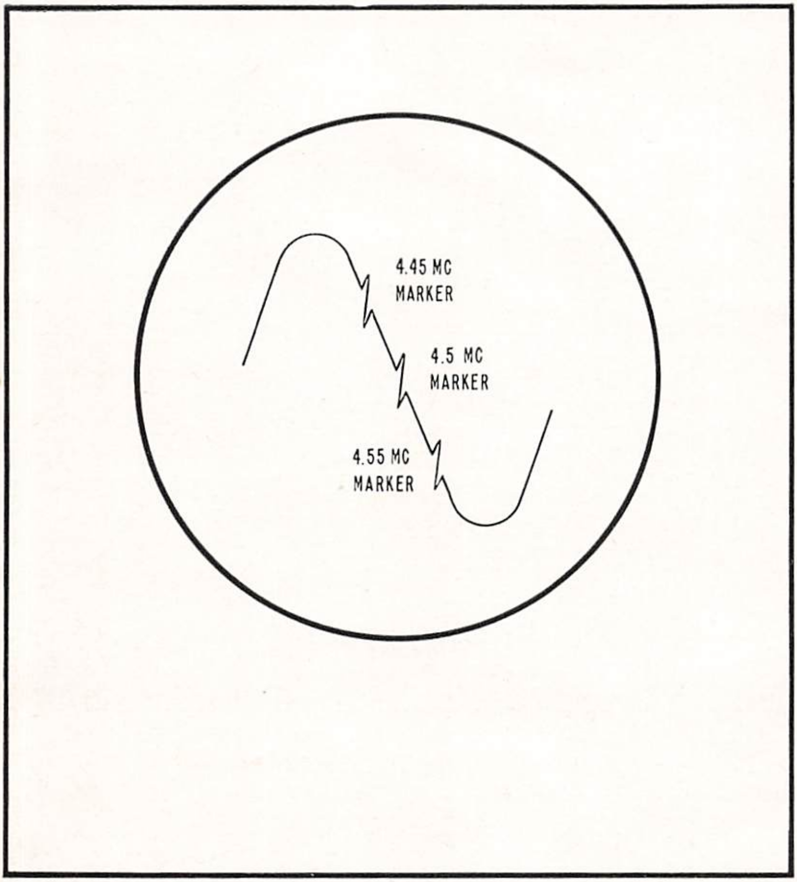
7. Connect sweep generator to first if amplifier control grid. Adjust second if transformer slugs to obtain oscilloscope display shown in part C of figure 4-4.

8. Connect sweep generator to mixer jig shield. Adjust first if transformer slugs and trimmer capacitor to obtain oscilloscope display shown in part D of figure 4-4.

9. The if alignment has now been completed.



4-4. Typical Bandpass Receiver Bandpass



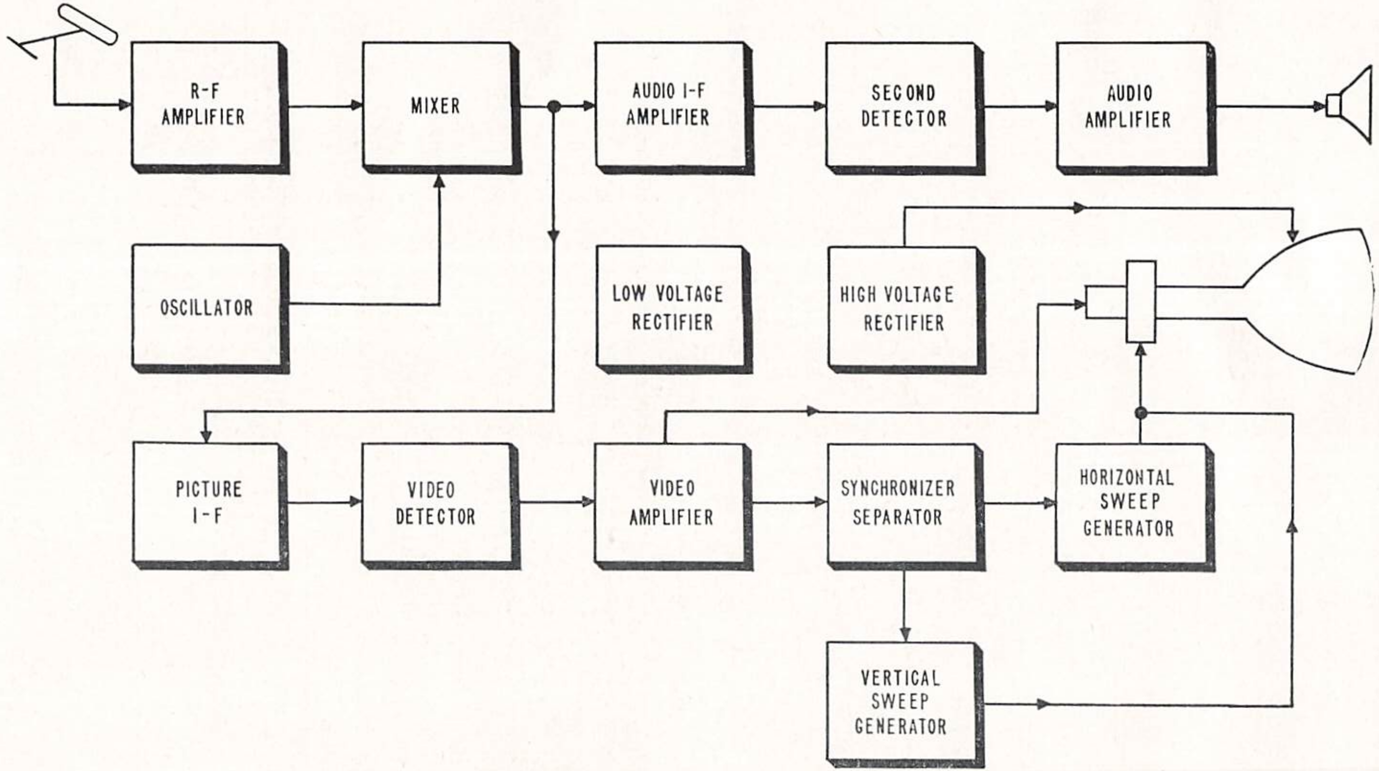
4-5. Intercarrier Ratio Detector Band

4-4. SOUND CIRCUIT ALIGNMENT

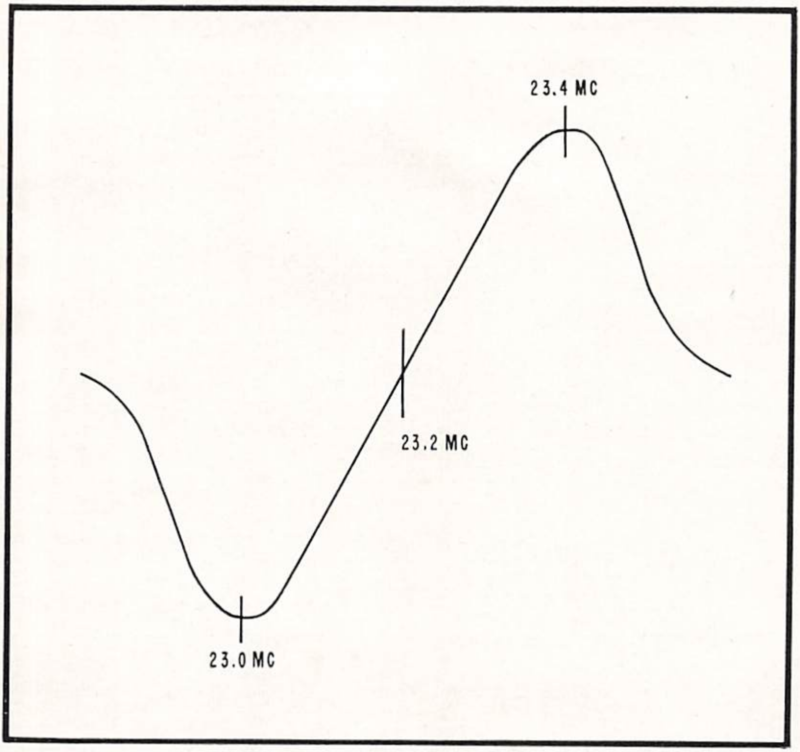
The circuit differences between intercarrier-type and separate if type sound systems were explained in detail in chapter 2. These differences consist essentially of the frequency used (4.50 mc for intercarrier, 21 to 23 mc for separate if), and the circuit section at which the sound is separated from the video signal (video section for intercarrier, picture if section for separate if). Methods for sound section alignment of two typical receivers using intercarrier and separate if sound systems respectively, are outlined in this paragraph.

A. Intercarrier Sound Section Alignment.

1. Connect a sweep generator, tuned to 4.5 mc, through a 0.005-mf capacitor to the second detector output. Adjust the sweep width to about 250 kc. Connect oscilloscope through a 270k isolating resistor across the limiter grid resistor.



4-6. Typical Dual Channel IF Receiver Block Diagram



4-7. Typical Dual Channel IF Receiver Ratio Detector Bandpass

2. Adjust 4.5-mc trap coil core until marker is centered at peak of response curve. Disconnect oscilloscope.

3. Connect oscilloscope across volume control. Adjust the three cores of the discriminator transformer until the oscilloscope display resembles that of figure 4-5. Make certain that the 4.50-mc marker is exactly in the center of the curve, that the curve is a straight line between the 4.45- and 4.55-mc markers, and that the peak-to-peak amplitude is as large as possible.

B. Separate IF Sound Circuit Alignment.

1. Connect signal generator, tuned to sound if frequency, to grid of first video if amplifier. Connect Polymeter to measure dc voltage across ratio detector balance resistor. (See figure 4-6).

2. Adjust the slugs of the sound if transformers for maximum Polymeter indication. Use rf attenuator on signal generator to keep Polymeter indication between 2 and 3 volts during this adjustment. Adjust primary of ratio detector transformer for maximum Polymeter reading.

3. Turn balance capacitor in ratio detector for minimum capacitance (fully counterclockwise). Connect oscilloscope through 270k isolating resistor across volume control. Connect sweep generator, tuned to

sound if frequency and adjusted for a 250-kc sweep width, to grid of first audio if amplifier. Use AM signal generator to furnish markers.

4. Tune signal generator to audio if frequency and adjust ratio detector transformer secondary until the marker is displayed at the center of the response curve (fig. 4-7). Adjust ratio detector primary and secondary for symmetrical response; then touch up all ratio detector adjustments to obtain the response curve shown in figure 4-7.

4-5. RF TUNER ALIGNMENT

The following types of rf tuners are used most often in present-day television receivers:

A. Continuous tuning
    1. Variable capacitor (Sylvania 1-366)
    2. Variable inductor (Mallory Inductuner)
B. Channel switching
    1. Tapped line (RCA)
    2. Tuned circuit (Philco)

The alignment procedures used differ amongst the various types and the various manufacturers; hence the manufacturer's instructions must be carefully followed.

RF tuner alignment is usually a tedious time-consuming task, demanding instruments that meet the high standards required, as well as a thorough knowledge of high-frequency circuit theory. For this reason it is often advisable to replace a misaligned tuner rather than to attempt alignment, unless complete manufacturing instructions and high-grade test equipment is available.

4-6. ION TRAP, FOCUS MAGNET AND DEFLECTION COIL ADJUSTMENT

A. General.

The adjustments of the ion trap, focus magnet and deflection coils are interdependent, hence all three adjustments must be checked simultaneously.

Most ion traps are marked with an arrow to indicate the direction in which they should be placed with respect to the cathode-ray tube. The arrow, if used, should point toward the CRT screen. When the magnets are mounted on one side of the ion trap, the trap should be placed so that the magnets are on the side of the CRT neck that is *opposite* the high-voltage connector.

Most cathode-ray tubes used today have two small flanges welded on the electron gun structure. These flanges, known as "flags," form magnetic pole pieces when the ion trap is placed over the CRT neck. The ion trap is usually positioned so that the poles of the magnet (those of the *smaller* magnet, when the ion trap contains two magnets) are placed over the flags. The distance between ion trap and focus magnet should be about one inch.

Check that the deflection yoke is placed as far forward as possible on the CRT neck. If the yoke is not touching the flared front of the CRT, loosen the screws securing the yoke, slide the yoke forward, then tighten the screws again.

Check that the focus magnet is held against the yoke; if a gap appears between magnet and yoke, loosen the adjusting screws, push magnet forward until it touches the yoke, then tighten adjusting screws.

B. Ion Trap Adjustment.

1. Before turning on the receiver, position the ion trap as prescribed by the manufacturer or according to the instructions given in the preceding paragraph. Turn contrast control fully counterclockwise and set brightness control at 2/3 of maximum. Turn receiver on, allowing about 30 seconds for the tubes to warm up.

2. Slowly twist ion trap about CRT neck and slide it forward and backward along CRT neck to obtain maximum picture or raster brightness.

3. If part of the picture or raster is cut off or missing, do not readjust the ion trap; adjust the focus coil and deflection yoke to remedy this fault.

4. Tighten the ion trap fastening screw securely.

C. Focus Magnet and Deflection Coil Adjustment.

1. Connect the receiver to an antenna and tune in a local transmitting station. If a test pattern is being transmited, use this pattern for making the following adjustments.

2. Using the Sylvania Focalizer Adjustment Tool or a nonmetallic screw-driver, turn the focus magnet adjusting screw for maximum sharpness in both *horizontal and vertical* details. Best over-all focus is not necessarily obtained when focusing for either vertical or horizontal details, hence the final setting may be a compromise between optimum vertical and horizontal focus.

3. Adjust the horizontal and vertical SIZE and LINEARITY controls until the picture is slightly smaller than the cabinet mask, and is linear in both directions. If the picture edges are not parallel to the cabinet mask edges, loosen the deflection yoke screws and rotate the deflection yoke.

4. Move the centering adjustment shaft on the focus magnet to the right or left, and up or down, until the picture is centered in the cabinet mask. Readjust the horizontal and vertical SIZE controls so that the picture fills the entire mask.

5. Readjust the focus as described in step 2 above.

6. Finally, loosen the ion trap fastening screws, then twist and slide the ion trap for maximum picture brightness.

7. Carefully tighten all screws loosened during adjustment.

CHAPTER 5

SAFETY PRECAUTIONS

5-1. HOW TO HANDLE HIGH VOLTAGES

Voltages present in the interior of every television receiver can cause serious injury or even death. For this reason, the serviceman must adhere to certain rules when working on the chassis of an operating receiver. These rules are designed to reduce the hazards without reducing the efficiency of the serviceman. A tabulation of the rules follows:

1. When making voltage measurements, turn the receiver off and connect the probes of the meter to the point to be measured. Turn the receiver on and read the meter. Turn the set off before removing the meter probes.
2. Do not use metal rods, screwdrivers, etc., to probe the interior of the chassis.
3. Never attempt to make replacements or repairs on a set to which power is applied.
4. When making checks on the high-voltage section of the receiver, use only one hand.

5-2. PRECAUTIONS FOR HANDLING CATHODE RAY TUBES

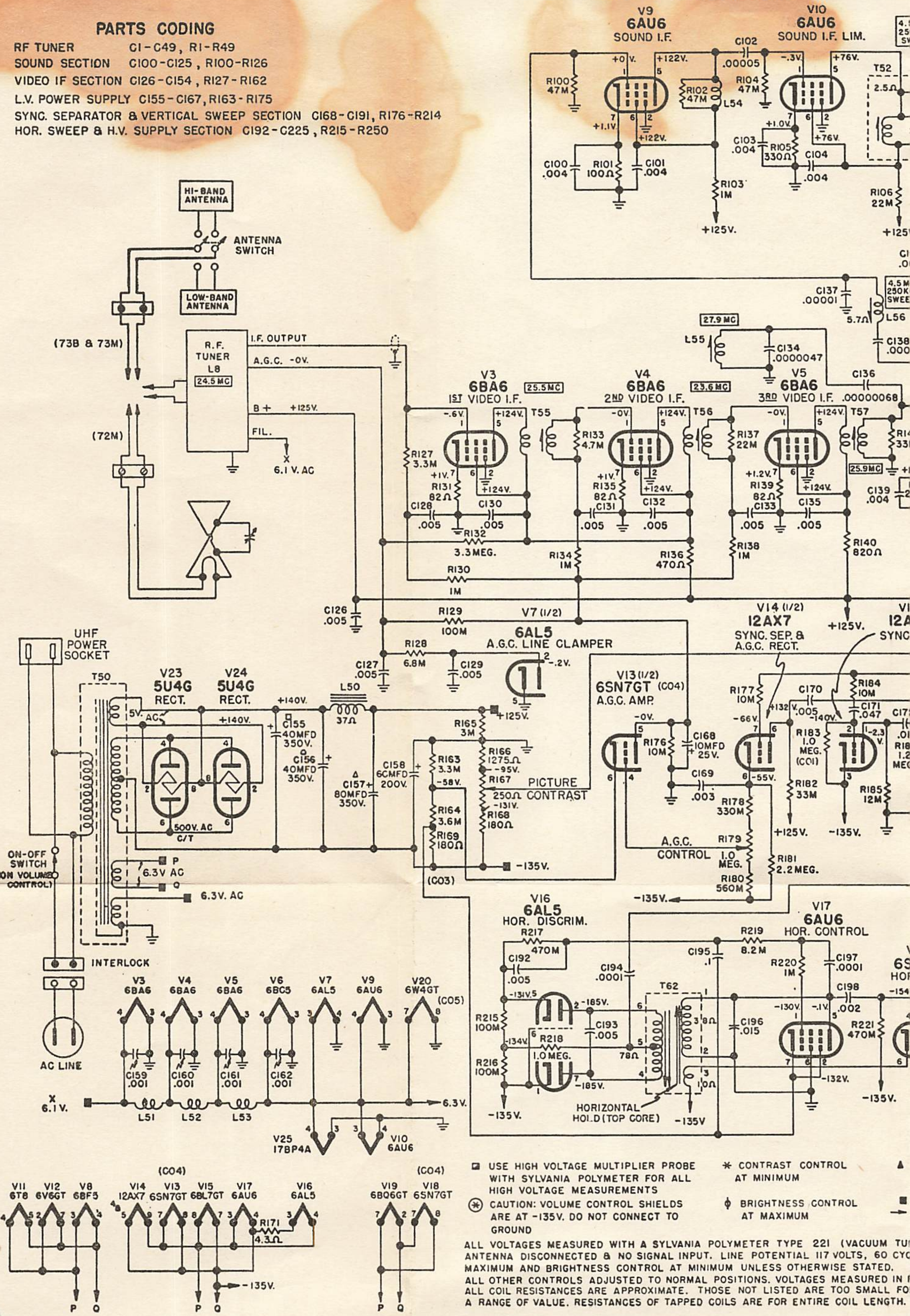
During the manufacture of the cathode ray tube, all the air is evacuated from the interior. As a consequence, the pressure exerted by the atmosphere on the surface of the bulb is enormous. Although the bulb is inherently very strong, a slight scratch can result in a violent implosion. An implosion is analogous to an explosion except that the direction of force is towards the bulb instead of away.

When repairing a receiver, avoid striking the cathode ray tube with sharp or hard objects. Before disposing of a defective cathode ray tube, it must be rendered harmless. To do this, wrap the tube with cloth and place in the cardboard shipping container with the socket uppermost. Using pliers, twist the key from the bottom of the socket. Then, using a small file inserted in the hole left when the key is removed, break the glass exhaust tip. This permits air to enter the bulb and renders it safe for disposal. During this operation, wear safety glasses and gloves.

SCHEMATIC DIAGRAM FOR I-366 TV CHA

PARTS CODING

RF TUNER	C1-C49,	R1-R49
SOUND SECTION	C100-C125,	R100-R126
VIDEO IF SECTION	C126-C154,	R127-R162
L.V. POWER SUPPLY	C155-C167,	R163-R175
SYNC. SEPARATOR & VERTICAL SWEEP SECTION	C168-C191,	R176-R214
HOR. SWEEP & H.V. SUPPLY SECTION	C192-C225,	R215-R250



■ USE HIGH VOLTAGE MULTIPLIER PROBE WITH SYLVANIA POLYMETER FOR ALL HIGH VOLTAGE MEASUREMENTS

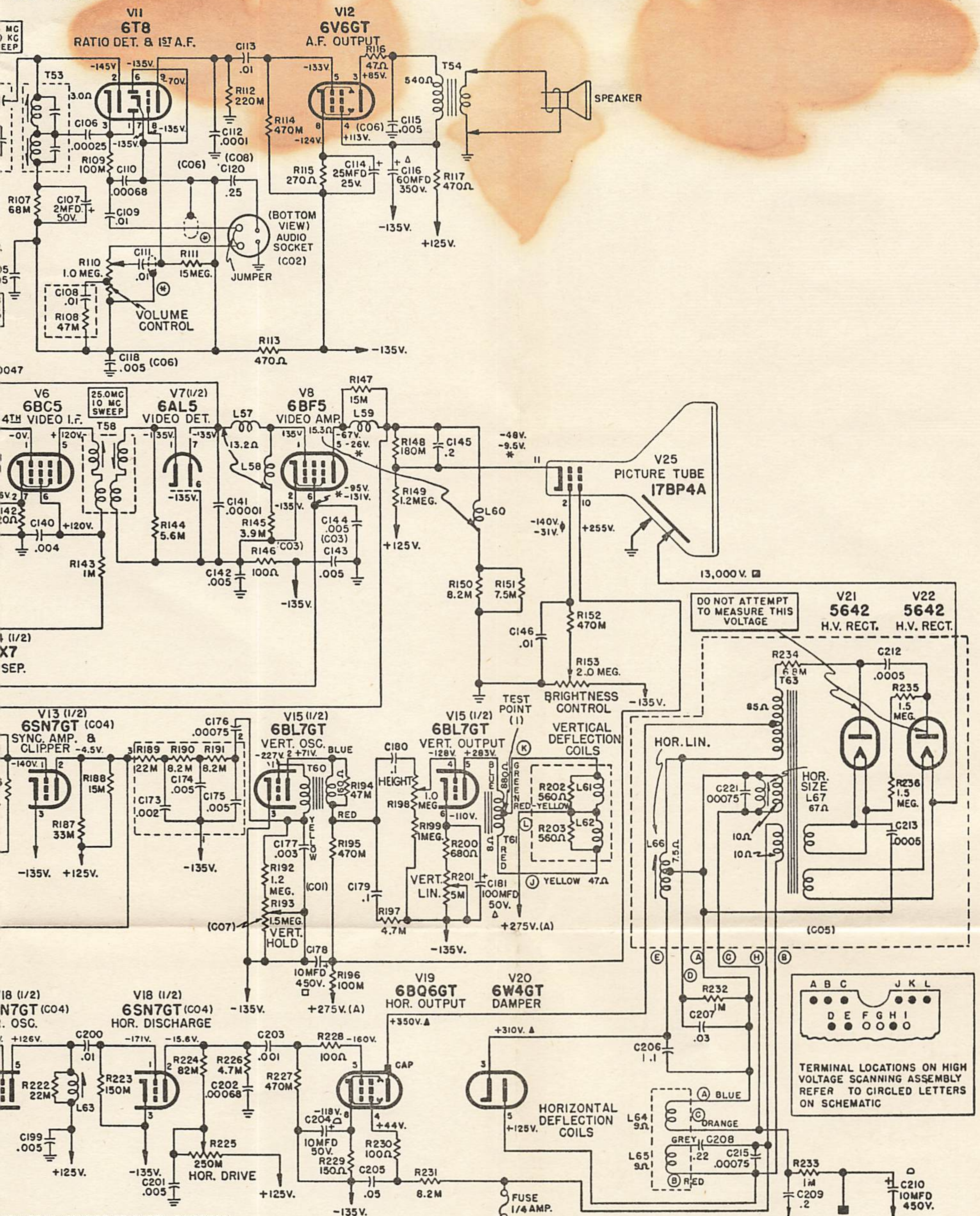
⊛ CAUTION: VOLUME CONTROL SHIELDS ARE AT -135V. DO NOT CONNECT TO GROUND

* CONTRAST CONTROL AT MINIMUM

ϕ BRIGHTNESS CONTROL AT MAXIMUM

ALL VOLTAGES MEASURED WITH A SYLVANIA POLYMETER TYPE 221 (VACUUM TU
ANTENNA DISCONNECTED & NO SIGNAL INPUT. LINE POTENTIAL 117 VOLTS, 60 CYC
MAXIMUM AND BRIGHTNESS CONTROL AT MINIMUM UNLESS OTHERWISE STATED.
ALL OTHER CONTROLS ADJUSTED TO NORMAL POSITIONS. VOLTAGES MEASURED IN
ALL COIL RESISTANCES ARE APPROXIMATE. THOSE NOT LISTED ARE TOO SMALL FO
A RANGE OF VALUE. RESISTANCES OF TAPPED COILS ARE FOR ENTIRE COIL LENGTH.

SSIS (C08)



HIGH PEAK VOLTAGE OF SHORT DURATION
(APPROX. 2,000V.) MAY DAMAGE METER
USED FOR THIS MEASUREMENT
VOLTAGE SOURCE
CONNECTED TO INDICATED VOLTAGE SOURCE

E VOLTMETER) UNLESS OTHERWISE STATED.
LES AC SUPPLY. CONTRAST CONTROL AT

ESPECT TO GROUND UNLESS OTHERWISE STATED.
R PRACTICAL MEASUREMENT OR OF TOO WIDE


S