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FUNDAMENTALS OF MODERN TELEVISION

ELEMENTS OF TELEVISION THEORY AND PRACTICE

INTRODUCTION: In our endeavor constantly to improve our technician course in television much serious consideration and study of theory is necessary. In a basic course of this kind it has been difficult to obtain material which can be studied without the use of complex formulae and involved mathematics. Therefore, it has been necessary for Television Training Institute to publish this text, making use of material which is clear and to the point. The following pages, we feel, will unravel television in an interesting and enlightening manner, on a plane which can be grasped by our entire student body.

SAMUEL SANDERS

TELEVISION TRAINING INSTITUTE.

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CHAPTER I - GENERAL FEATURES OF HIGH DEFINITION TELEVISION

INTRODUCTION

Purpose of Meetings

The purpose of these classes is to enable those individuals having a fundamental knowledge of broadcast receivers to gain a knowledge of television, including the INSTALLATION, OPERATION, and SERVICE of the receivers. It will be assumed that those in attendance have had no preliminary acquaintance with the theoretical fundamentals of television.

What Television Is

As a precise definition we may quote Standard M9-111 of the Radio Manufacturers Association, as follows: "Television is the electrical transmission and reception of transient visual images." This definition may be seen to rule out the use of powerful telescopes, which of course make possible vision at considerable distances; the definition however may be considered to include the use of a modulated light beam as a carrier of the television impulses, since electrical methods are used for production of the signals at the transmitter and for the reproduction at the receiver.

Although the foregoing definition of television properly makes no reference to sound transmission, as a matter of practical utility, a sound channel will always accompany television broadcasting. This is a natural course because of the important increase in the interest afforded by the accompanying sound, and also because of the relatively simple equipment required for the inclusion of the sound feature.

Comparison with Sound Broadcasting

As a first step toward the understanding of television, we may well compare a modern television system with the well-known sound broadcasting system. In

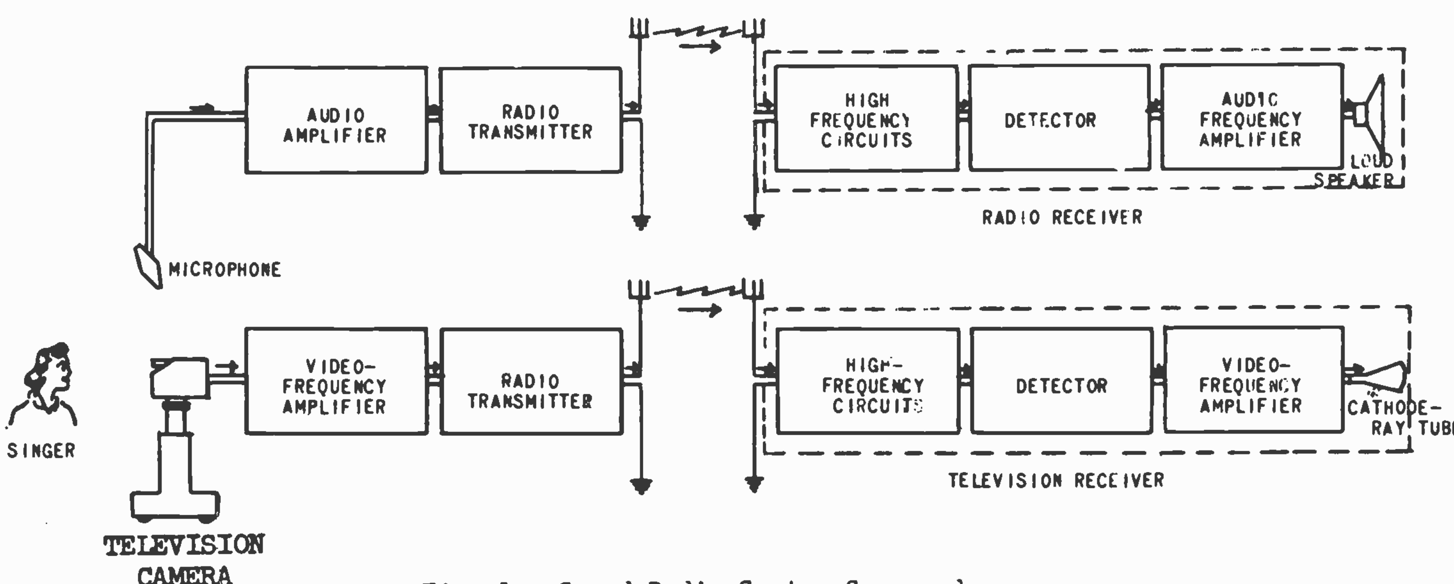


Fig. 1. Sound Radio System Compared With Television System.

Figure 1 we show at the top the essential parts of a sound broadcasting system, and immediately below this the corresponding portions of a television system. The microphone, audio amplifier, and radio transmitter of the sound system will be seen and it is unnecessary to describe the functions of these parts. Also at the sound receiver there are the high-frequency circuits, the detector, the audio amplifier, and the loudspeaker, which together constitute the radio receiver.

The pickup device at a television studio is called a "camera" in accordance with motion-picture practice, although generally the parts and operation are entirely different from those in a motion-picture camera. The television camera produces electrical signals, and these go into the "Video-Frequency Amplifier" which is seen as the next element in the television system. Here the picture signals, or "video" signals are strengthened; thence they go to the radio transmitter and modulate it. This description of the electrical operations in the television studio and transmitter is of course greatly simplified, particularly in the omission of the elaborate scanning and synchronizing arrangements which are essential; these matters will be considered in subsequent lectures.

At the television receiver there are high-frequency circuits corresponding to those in the radio receiver. These circuits may be merely radio-frequency amplifiers, in which case we have a tuned-radio-frequency television receiver. Or the high-frequency circuits may utilize the super-heterodyne principle with the same significance of frequency changing as in broadcast receivers. It is expected that in the United States most television receivers, if not all, will be of the superheterodyne type.

The detector in a television receiver operates in the same fundamental manner as in a broadcast receiver and the video signals which it produces are amplified in a video-frequency amplifier which corresponds to the audio-frequency amplifier of the sound receiver. In place of the loudspeaker, some device must be used which will convert the varying amplitude of the video signals into corresponding variations of light; this device reconstitutes the original scene and thus makes the picture which the user sees.

The most common reproducing device is the cathode-ray tube. This may be called a "picture tube" on account of the fact that the desired picture is seen on the end of the tube. The action of the cathode-ray tube in reproducing a picture consists in the electron spot moving back and forth and up and down so as to cover the entire area of the picture, while the intensity of the spot is determined by the control grid of the tube. In this way each spot of the screen is made to have the proper brightness to reproduce the picture. It will be seen that the control grid in the cathode-ray tube controls the number of electrons in the beam in the same way that the control grid of an amplifier tube controls the plate current. This control-grid action is an essential part of the television reproduction. We mention this point because in the oscilloscope found in service shops there is usually no application of signal to a grid.

CHIEF PARTS OF TELEVISION SYSTEM

Pickup Device

The essential function of the television camera is to convert the light intensities of successive elements or points of the picture into proportional electrical currents. At the present time electronic means, with special types of vacuum tubes, are used for this purpose. Such tubes may be called "camera tubes" on account of their use in the television camera.

The most widely used camera tube has a mosaic plate on which an optical image of the scene is focused. The elements of this plate have photoelectric and secondary-emission characteristics. There are a great many of these elements, each insulated from the others and all held on a sheet of mica. On the back of this sheet of mica is a conducting metal coating, which is called the "signal plate." In operation the mosaic plate is scanned by a beam of electrons from a suitable "electron gun." The effect of this scanning is to cause varying potentials to be created on the signal plate as the scanning proceeds. These potentials are a measure of the changing brightness of the successive spots, and constitute the video signals which must be transmitted thru the television system to the cathode-ray tube of the receiver. The signal level produced by the camera tube is about one millivolt across a load of 10,000 ohms.

The Video Amplifier

On account of the many points into which the scene must be divided for high-definition transmission, and also on account of the number of times each second with which a complete scene must be reproduced, the range of frequencies produced by the television camera and its associated circuits extends to a very high value, such as four or four and a half megacycles. The range also goes down to zero frequency at the lower end, since the direct-current component conveys the information as to the average brightness of the scene.

The amplification of this very wide band of frequencies constitutes a severe requirement on the video amplifier. It has been found that a modified form of resistance coupling will accommodate all of the necessary frequency range except the lowest frequency components; special arrangements are used for taking care of this very low-frequency portion of the range. With the latest types of tubes, gains of 15 or 20 decibels per stage are obtained.

The video amplifier at the transmitter consists of a number of stages, and the first ones of these are located in the camera itself. This amplification in the camera raises the energy level of the video signals so that they are less subject to interference in transmission thru the flexible cable which connects the movable camera to the fixed equipment.

There is also a video amplifier in the receiver, and this usually has only one stage. It delivers the control voltage to the reproducing picture tube.

Radio Transmitter

Fundamentally the radio transmitter in a television system performs the same function as in a sound broadcasting system. The essential purpose is to produce a powerful high-frequency radio wave having such variation in amplitude, that is, such modulation, as to convey the desired signals.

Two reasons have operated to cause the carrier frequencies used in television radio systems to be considerably higher than those previously common with sound broadcasting systems. One of these reasons is the wide band of video frequencies which have to be transmitted. A moment's reflection, or examination of appropriate data, will lead one to the conclusion that radio systems in the communication art usually operate with carrier frequencies several times as great as the highest component of the signals to be transmitted. This permits the use of tuned circuits as the frequency-selecting means rather than involved types of filters. The other reason for the choice of higher carrier frequencies was the fact that the lower frequencies were already occupied more or less by other radio services. The Federal Communications Commission has now adopted 6 megacycles as the standard width of a television band, and has set up a group of channels on this basis. For example, the lowest-frequency one of the new bands extends from 54 to 60 megacycles.

All these television carrier frequencies lie in what is generally called the "ultra-high-frequency" band which is characterized by, first, the absence of the sky wave, and second, the limitation of the service range to approximately the horizon as seen from the transmitting antenna. Unfortunately the interference range extends considerably beyond the horizon. It would of course be fortunate if television stations had coverage similar to that of sound broadcasting stations. However the technical necessity for using the ultra-high frequencies renders this impossible There is something of a compensation in the fact that cities several hundred miles apart can use the same carrier frequencies for television without objectionable interference.

An assignment of frequencies from 54 to 216 megacycles has been made by the Federal Communications Commission, providing for the needs of television, government services, and aviation. These assignments are as follows:

LOWER CHANNELS

Channel No.	Frequency Range
2	54-60 mc.
3	60-66 mc.
4	66-72 mc.
5	76-82 mc.
6	82-88 mc.
7	174-180 mc.

UPPER CHANNELS

Channel No.	Frequency Range
8	180-186 mc.
9	186-192 mc.
10	192-198 mc.
11	198-204 mc.
12	204-210 mc.
13	210-216 mc.

In addition to the foregoing assignments, the Commission has also made assignments for various services from 216 to 900 megacycles, including 32 television channels, each of 6 megacycle width. The practical value of these television assignments above 500 megacycles remains to be determined in the future.

Superheterodyne and Tuned-Radio-Frequency Receivers

Television receivers of the tuned-radio-frequency type require several stages of carrier-frequency amplification. It has been found impractical to make these with variable tuning; therefore these receivers are adapted for use only where a single television wavelength is to be received. Such is the case in England, where the London transmitter is the only station, and a number of such tuned-radio-frequency receivers have been sold. A service adjustment of the tuning for alignment upon the one channel is the only variation provided.

For the United States it is contemplated that more than one station will be available in many cities, so that tuning facilities must be provided for the choice of stations. Another consideration is that it is very desirable for a given model of receiver to be usable in or near any city having one or more stations. Therefore all American receivers at present accommodate 12 television channels below 216 mc. The use of the superheterodyne circuit makes this practicable. A majority of the English receivers to date have been superheterodynes, but have provided only vernier tuning for one station frequency.

It may be observed that the twelve television channels allocated by the Federal Communications Commission and previously listed, do not constitute a single continuous spectrum; there are gaps, which are assigned to amateur operations, aviation, and government services. The existence of these gaps, and the adoption of push-button tuning for broadcast receivers, make it likely that most manufacturers will design television receivers with a push button or switch position for each of the assigned channels.

The choice of stations, which it is expected will be provided in American receivers, also makes desirable the feature of automatic volume control, which has not been incorporated in English receivers. The need for this feature arises from the different field strengths of the various stations to be received. There is little fading at the ultra-high frequencies, such as encountered at lower frequencies, because of the absence of the sky wave. However, sometimes highways and airways are so located that traffic on them affects the received television field strength, and in these cases fading will occur according to the motion of traffic.

The ordinary sound receiver has automatic volume control which operates to produce an approximately constant level of the carrier component; change of the percentage modulation does not alter the gain of the receiver. In a television receiver the conditions are different in that some indication of the average background brightness must be transmitted, and it is general practice to use the amplitude of the carrier component for this purpose. One expedient is to have an ordinary automatic-volume-control system in the sound portion of the television receiver and use the control voltage from this to determine the gain in both the sound and vision carrier amplifiers. Another expedient, applicable to push-button television receivers in the absence of fading, is to have no automatic volume control, but provide a volume-adjusting screw for each push button; these screws are for the service man to adjust when installing the receiver. Other possibilities as to automatic volume control depend on the polarity of the video modulation, and will be discussed later.

Intermediate-Frequency Amplifier

The very wide band of video frequencies to be accommodated in a television receiver makes it essential to employ a much higher intermediate frequency than used with sound receivers. Values of intermediate frequency from about 12 megacycles to 40 megacycles have been used.

The band width which these intermediate-frequency amplifiers must transmit is relatively much greater than in the usual broadcast receiver despite the use of a much higher intermediate frequency. In the television receiver special steps must be taken to accommodate this band width. These measures generally take the form of damping resistors across the primary and secondary of the intermediate-frequency transformers. These of course lower the gain; on this account about three intermediate stages are required, with four transformers. The developments of tubes with high mutual conductance greatly assist in securing the necessary gain in the intermediate and also the video amplifiers of television systems.

Reproducing Device

The output of the last intermediate stage of the television receiver is applied to a detector, which is ordinarily of the diode type, from which the detected video signals go to the video amplifier of the receiver. After amplification, the video signals go to the reproducing device which converts them into optical form for viewing.

Most television receivers employ the cathode-ray tube as a reproducing device. Tubes of large size have been made, screen diameters of 12 inches being fairly common. The deep-green screen color which was formerly about the only color obtainable for picture tubes has given way to "black-and-white" tubes of attractive appearance. The black-and-white tubes actually have considerable blue and other colors, but give a picture which the layman would describe as "black and white."

SCANNING

Necessity for Scanning

A very simple picture could be transmitted by a group of multiple circuits, there being one circuit for each part of the picture. In Figure 2 we show such a system for the transmission of a picture having only four parts. At the moment indicated, two of the parts are dark and the other two are light. As time goes on, the four parts vary their brightness in any manner, and the system reproduces all these effects at the receiving end. It will be seen that a photo-sensitive cell is provided to be operated by the light from each of the four parts of the scene. An individual circuit for each of these cells connects with the corresponding lamp of the reproducing apparatus, so that the variations are reproduced properly. It will be realized of course that this is a schematic representation, and that various additional apparatus would be required for practical operation.

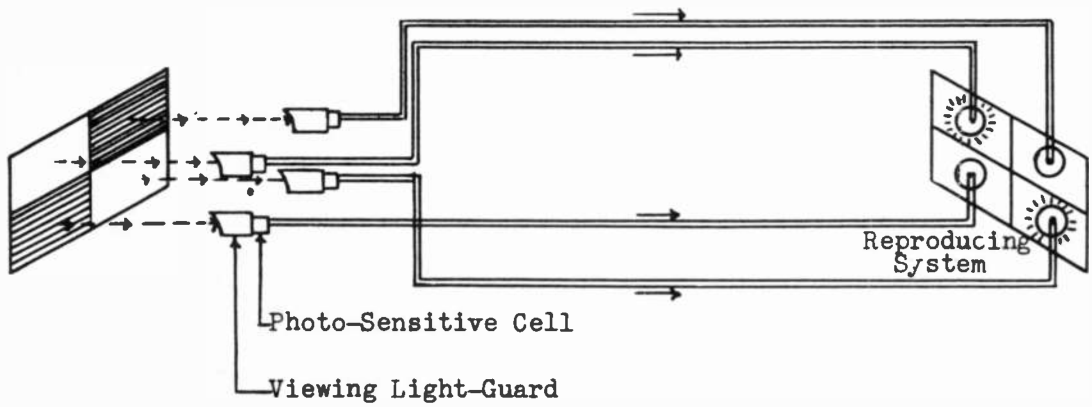


Fig. 2. Multi-Channel Transmission of Very Simple Changing Picture.

The multiple-circuit system for television, however, is in fact totally impracticable on account of the very great number of picture points required for good definition. Thousands of wires or radio channels would be required to transmit even a poor television picture by this means. Recourse is therefore had to a system whereby successive points of the scene can be transmitted in order over one circuit. In Figure 3 the same simple television scene of only four parts is shown being transmitted by the use of such a process. It will be seen that a commutator is provided so that the photo-cells are connected in turn to the line at the transmitter, and that the lamps are similarly connected in turn to the line at the receiver. It is necessary of course that the two commutators be maintained in synchronism, that is in step with each other, so that the proper lamp will always be in circuit for each photo-sensitive cell. By rotating the commutators at moderate speed and having lamps of appreciable thermal capacity, the intermittent nature of the reproducing process may be brought within the persistence-of-vision characteristic of the eye, and a steady re-created scene like the original will be observed.

The arrangement of Figure 3 may be considered as a crude scanning system. It is of course impracticable for present-day television use because of the large number of photo-sensitive cells which would be required.

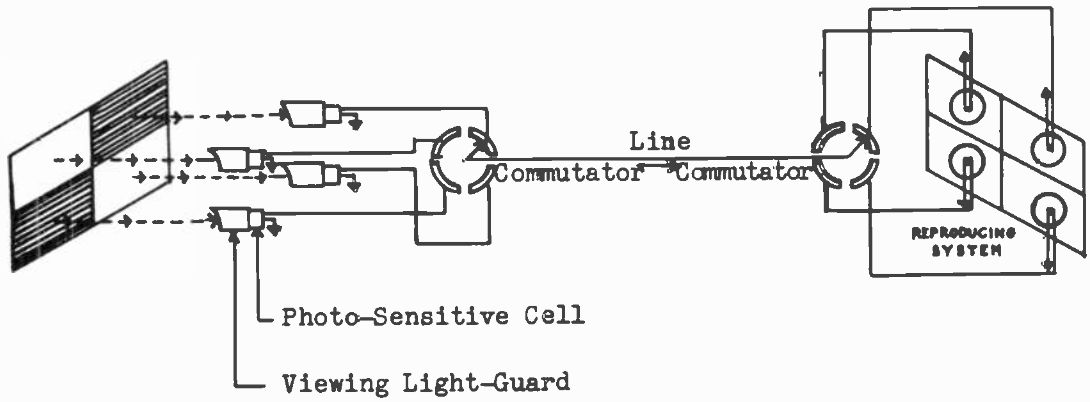


Fig. 3. Transmission of Very Simple Television Image By Time Division of One Circuit.

In modern television transmission an elaborate system of picture analysis and synthesis, that is point-by-point transmission, is used. The scene is scanned horizontally from left to right. That is, the entire television system is engaged at one moment in transmitting the intensity of the light at the upper left-hand corner of the scene. The scanning spot then proceeds horizontally to the right, and the television system transmits continuously the illumination corresponding to the various points along this line. At the end of this first line, a quick return to the left side is made, and a line slightly below the first one is scanned. In this way the process continues line by line until the entire scene has been traversed. It will be seen that the process is similar to reading print on a page, where the eye travels from left to right and reads one line after another until the page is finished. In Figure 4 is shown a simple scene scanned in five lines.

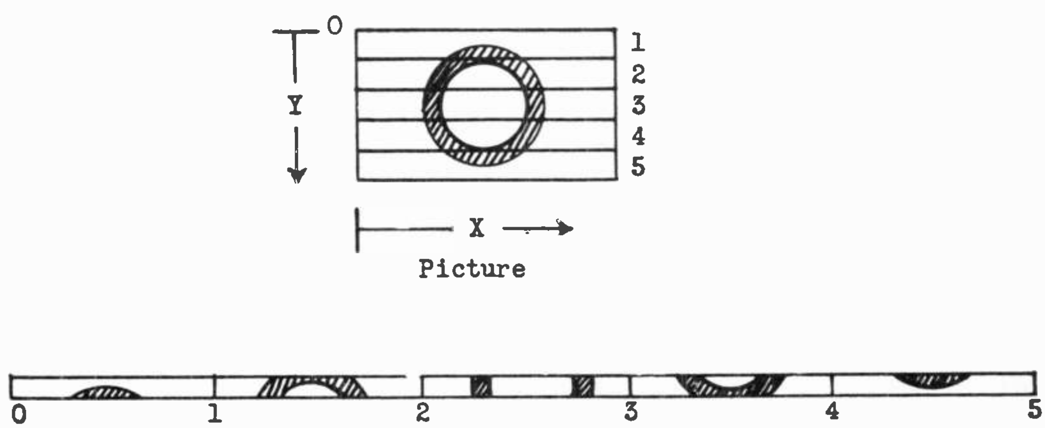


Fig. 4.

It is well to note that the scanning of each line is smooth, continuous process, not intermittent as it would be if the line consisted of definite individual points. We may say therefore that, strictly speaking, the scene is transmitted by being divided into horizontal lines, each of which is sent as a steady process. It is often advantageous to consider television transmission as a point-by-point process, but in this case it should be kept in mind that the points along one line are merely the portions of the line and that they are transmitted as a continuous, not an intermittent, process.

The following definitions from the standards of the Radio Manufacturers Association and of the Federal Communications Commission are of interest.

"A Frame is a single complete picture."

"Scanning is the process of analyzing successively, according to a predetermined method, the light values of picture elements constituting the total picture area."

"Frame Frequency is the number of times per second the picture area is completely scanned."

As a summary on the essential nature of scanning, it can be said that each small area of the scene being scanned at the transmitter, yields its brightness value in turn to a photo-sensitive device, while at the receiver the apparent brightness of each small area of the viewing screen is modified in turn to develop a picture. It should be noted that the process of scanning is quite distinct from any system having a separate transmission channel for conveying simultaneously the brightness-value of every small area of the viewing screen.

Interlaced Scanning

The description of scanning in a modern television system which is given in the preceding section is simplified by the omission of the feature of interlacing, which we will now describe.

The successive lines which were scanned in the description in the preceding section should be thought of as slightly separated, so that one line does not lie against the line immediately above it. The interlacing process consists in going back again for a second scanning, at which time the scanning spot takes these intervals between the lines which were scanned previously.

The principle of interlacing is easily understood if the reader considers a simple experiment with a coin, a piece of paper, and a pencil. If the paper is placed over the coin, and horizontal lines starting at the top are drawn, slightly separated, the features of the coin will be partly revealed. The pencil may then be carried again to the top of the coin, and an additional set of horizontal lines be drawn between those of the first set. In Figure 5 we show diagrammatically the result of such a process.

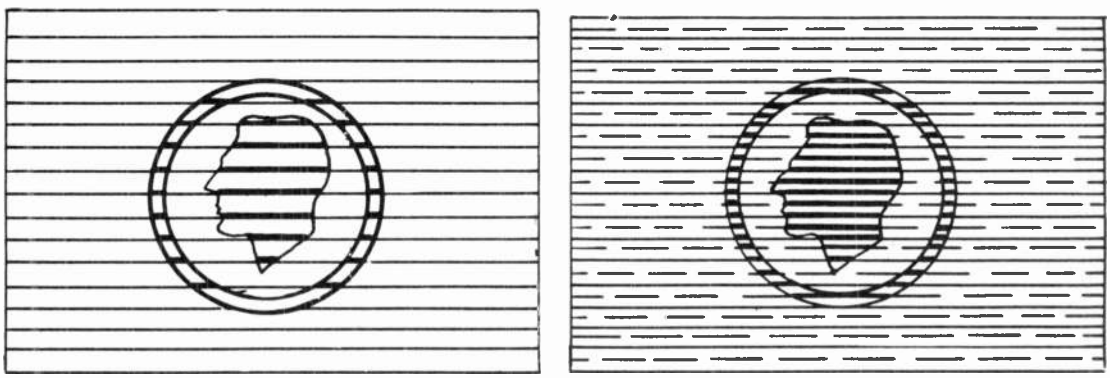


Fig. 5.
EXPLANATION OF INTERLACING WITH PAPER, COIN AND PENCIL.

The following standard definitions of the Radio Manufacturers Association and of the F.C.C. point out the difference between plain, or "progressive", scanning and interlaced scanning:

"A frame is a single complete picture."

"Frame Frequency is the number of times per second the picture area is completely scanned."

"Progressive Scanning is that in which scanning lines trace one dimension substantially parallel to a side of the frame and in which successively traced lines are adjacent."

"Interlaced Scanning is that in which successively scanned lines are spaced an integral number of line widths, and in which adjacent lines are scanned during successive cycles of the field frequency scanning."

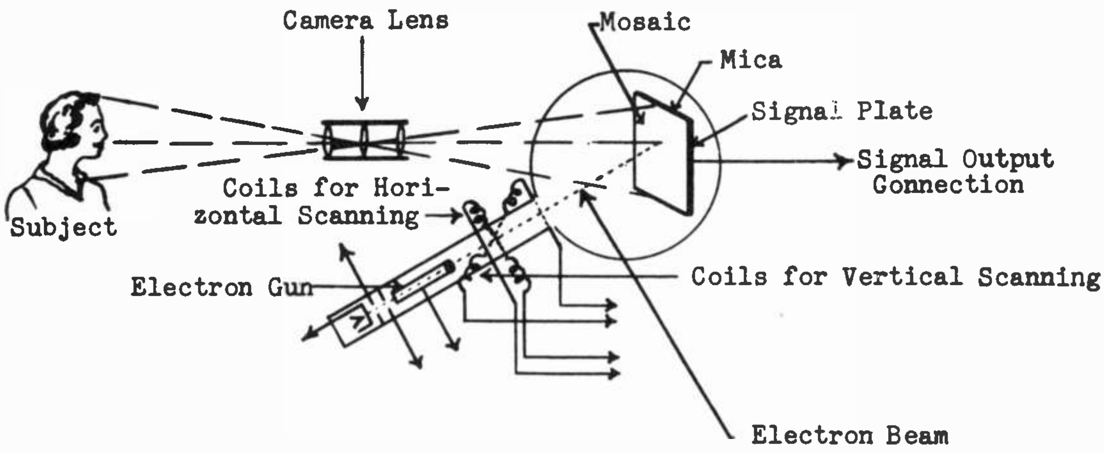
"Field Frequency is the number of times per second the frame area is fractionally scanned in interlaced scanning."

The purpose of the interlacing process is not to improve the definition of the picture; this could be accomplished by increasing the number of scanning lines with simple scanning. The reason that interlacing is employed is to reduce an objectionable effect called "flicker" which would otherwise be experienced. This effect will be described later.

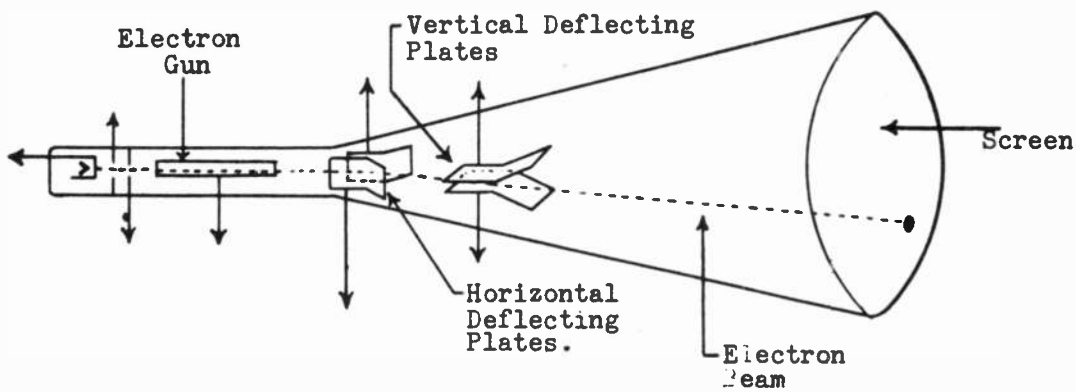
Scanning by Electronic Means

In Figure 6(a) we show the usual camera tube, which is scanned electronically. The scanning is accomplished by the electron beam sweeping over the mosaic plate under the control of the horizontal and vertical sets of scanning coils which are shown.

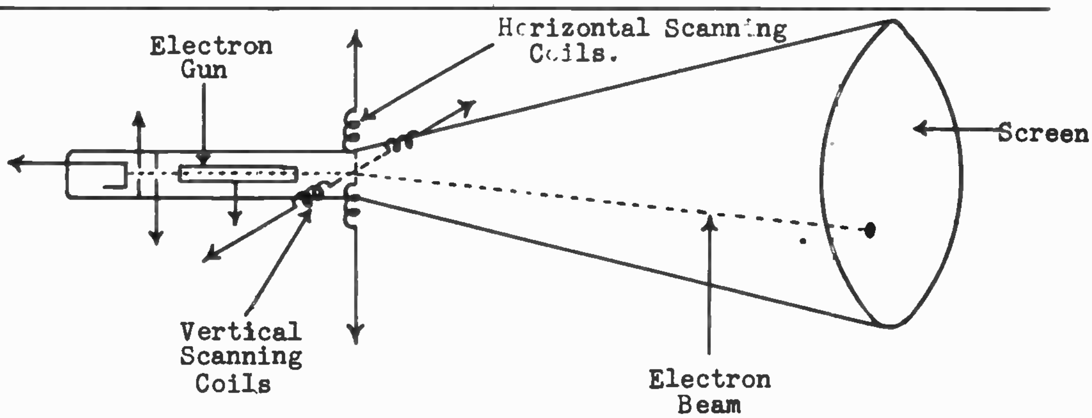
The deflection of a beam of electrons by means of a magnetic field may be explained by the well-known rule of motor theory where a wire carrying a current in a magnetic field experiences a force perpendicular to both the direction of the wire



(A) USUAL CAMERA TUBE.



(B) PICTURE TUBE WITH ELECTROSTATIC SCANNING.



(C) PICTURE TUBE WITH MAGNETIC SCANNING.

Fig. 6. Electronic Scanning Arrangements.

and the direction of the field. The beam of electrons in the present case is electrically similar to a corresponding flow of electrons along a wire and the beam experiences the deflecting force in the same way that an actual wire would.

For the horizontal scanning of the beam there are provided two windings, and from the discussion in the preceding paragraph it will be seen that these windings must be located above or below the neck of the tube. In practice one winding is above and the other below. Similarly for the vertical scanning, two coils are provided, one on each side of the neck of the tube. The instantaneous magnetic field is of course proportional to the instantaneous current. In this way the desired scanning action can be obtained by the passage of suitable current thru the scanning coils.

In Figure 6(B) we show a picture tube in which the scanning is accomplished by an electric field acting upon the electron beam. Pairs of deflecting plates are provided for scanning in the two component directions, in exactly the same manner as in the usual laboratory oscilloscope.

In Figure 6(C) we show a picture tube in which magnetic scanning for both the components is used. The action here is of course the same as in the camera tube of Figure 6(A). It is entirely possible with a picture tube to use magnetic scanning for one component and electrostatic scanning for the other.

Saw-Tooth Wave Form

With magnetic scanning it is necessary that the scanning current increase steadily so that the spot will travel uniformly from left to right. When the right edge is reached, the control grid of the cathode-ray tube receives a bias beyond cutoff, and the spot is extinguished. While the spot is extinguished the scanning current rapidly changes to a value corresponding to the beginning of a scanning line. The cutoff bias on the tube is then removed, the spot comes on again, and the scanning of the next line proceeds. Similarly with electrostatic deflection, the voltage must increase steadily as the point proceeds from left to right, and at the end of the line the voltage should quickly change to the value for the beginning of a scanning line. In this case also the spot is extinguished while the rapid change of voltage occurs.

This gradual change of value of scanning current or voltage, with a rapid return to the original condition, corresponds to a special wave form which is known as the "saw-tooth" wave form from its similarity to the teeth of a saw. In Figure 7 we show such a wave form. The essential characteristic of a saw-tooth wave form is that ideally the wave consists of only two straight lines. These differ in length, so that the two portions of the cycle, that is the increasing portion and the decreasing portion, are of unequal duration. In particular the saw tooth is usually plotted, as in Figure 7, so as to show the increasing portion of long duration and the decreasing portion of short duration. Special circuits are required to produce currents or voltages having this wave form. If amplifiers are used, they must have wide frequency characteristics in order not to impair this wave form. It is desired that the straight-line portion, which uses up most of the period of the cycle, be as straight as possible, that is have a high degree of linearity. As a matter of fact, however, there is a practical limit to the degree of linearity which can be obtained.

The return portion of the saw-tooth wave form is made as short as possible to reduce the amount of lost time. In practice this consumes about 15% of the line cycle for the line retrace, and about 7% of the vertical cycle for the vertical retrace.

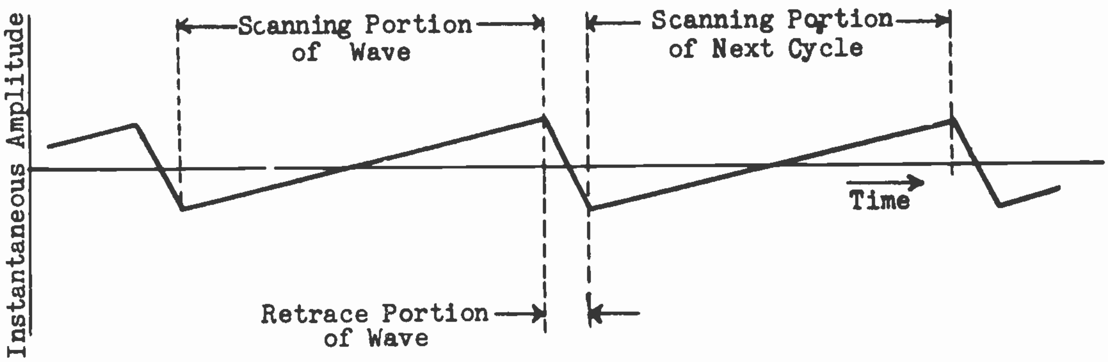


Fig. 7. Saw-Tooth Wave Form.

TRANSMISSION REQUIREMENTS

Range of Video Frequencies

A little reflection will quickly lead one to the conclusion that very high video frequencies are required in television transmission. For example if the picture is to be divided into 500 horizontal lines, and each line is considered to have 600 points, the entire picture consists of the product of these two numbers, or 300,000 points. It is necessary to reproduce the entire picture at a frequency comparable to motion-picture practice, and in fact in the United States, the use of 60-cycle power makes it certain that a frequency of 30 frames per second will be used. The 300,000 points and the 30 times per second that this image is reproduced, give a figure of 9,000,000 points per second. As a preliminary assumption, it may be said that one cycle will reproduce two points, giving a range of video frequencies extending to 4,500,000 cycles per second, or 4.5 megacycles.

It is desirable that a substantial fraction of the 4.5 megacycle range be transmitted by the circuits. The significance of this wide band may be missed at first; the idea is that the video amplifier must transmit all frequencies from zero up to this value as the upper limit. This includes all of the audio range, plus the usual range of long-wave signals, plus the usual broadcast range (ending at 1600 kilocycles), and in addition frequencies somewhat higher than this. Obviously such a requirement on the video channels, and the corresponding band-width requirement on radio-frequency and intermediate-frequency amplifiers, is very severe, and special designs must be used to obtain satisfactory results. We indicate these special features very briefly in the corresponding sections above, and will deal with them at length later.

Phase Requirements

The very wide frequency band is not the only requirement which is characteristic of a high-definition television system. An additional property which is necessary is a uniform time of transmission for the various frequency components. On account of the fact that this is a quantity which is of little interest in sound broadcasting, we give several paragraphs here discussing the subject.

It is well known that a fundamental frequency and a particular harmonic will give a certain wave form when the initial phases of the two frequencies are equal, but in general will give a different wave form for other initial relations of the phases of the two component frequencies. This is illustrated in Figure 8; it can be seen that in Figure 8(A) a fundamental and third harmonic, both going thru zero simultaneously and in the same direction, give an approach to a square-wave condition. In Figure 8(B) the two frequencies again pass thru zero simultaneously, but are now going in opposite directions; this is seen to give a high amplitude, and high voltages of this type may break down insulation in severe cases. It is seen therefore that the wave form of a wave consisting of certain frequency components depends on the phase relations among the components. For this reason, changes in phase relations in the video signal during transmission cause alterations in the succession of the various shades of light in the reproduced scanning lines, and thereby distort the picture.

The human ear has little or no appreciation of the phase relations of the components of a complex sound; change of phase only is generally not perceptible to a listener. The only qualification is in the case of very loud sounds, which may be exceptions. As an example of this general principle, the fundamental and third harmonic with various phases and wave forms, described in the preceding paragraph, sound alike to the ear at all low and medium amplitudes.

This independence of phase relations, which is a technical assistance in sound transmission, does not apply in the transmission of still pictures and television. The received wave form determines the shade along the reproduced lines, whence change of wave form affects the picture. Care is necessary in these optical transmissions to preserve the actual wave form.

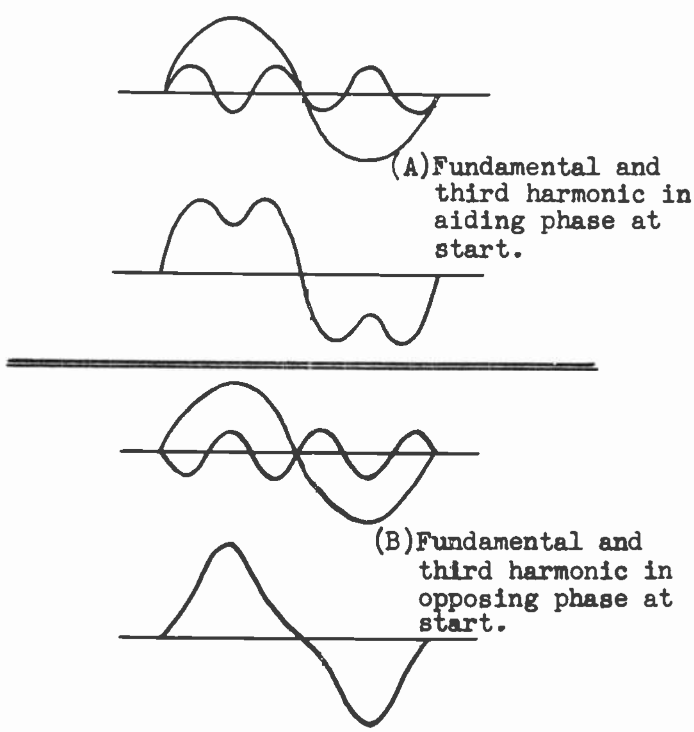


Fig. 8. Dependence of Wave Form on Phases of Components

A certain amount of time is of course required for the transmission of a signal of a given frequency thru various equipment and over wire and radio connections. An original complex wave form, made up of various frequencies, will be reproduced accurately if all frequency components require the same length of time for their passage thru the system. The requirement for ideal transmission in this regard may thus be stated as follows: The time of transmission thru the system shall be independent of frequency. Failure to meet this criterion is sometimes given the descriptive name of "velocity distortion," meaning that various frequencies have proceeded at different velocities thru the system. However, the usual term in television discussions is "phase distortion."

The picture faults observed with imperfect phase relations depend on whether the discrepancies are chiefly for the low video frequencies, or for the high video frequencies, or what other particular relations may exist. In general phase distortion will cause sharp edges in the original picture to be lost. Under some circumstances a light spot in the view may be accompanied by a succession of bright and dark shadows. A dark point in the view may have a similar train of shadows. Other errors in phase conditions may produce bas-relief effects.

CHARACTERISTICS RELATED TO HUMAN EYE

Illusion of Continuous Motion

Motion-picture experience dating from many years back, indicates that if successive pictures are projected on a screen, as in motion pictures, with a frequency of 16 per second, or even at lower frequencies than this, the observer will obtain the illusion of continuous motion. That is, the progress of moving persons and objects in the scene will appear to be smooth and continuous rather than jerky.

Special experiments made in England on this subject have shown that for slowly changing close-up views, a frequency of only 3 times per second is sufficient to give the impression of continuous motion; for rapidly moving subjects a rate of 10 per second was required. In these tests suitable steps were taken to prevent error due to flicker, which is another effect. The subject of flicker will be discussed later. At the present point it is desirable to consider the characteristic of the human eye known as "persistence of vision."

Persistence of Vision

If one looks steadily at an ordinary neon sign operating on a 60-cycle power supply, the red color appears to be continuously present; there is no suggestion of the actual intermittent character which the light possesses. As a matter of fact the light goes out and comes on many times each second. The apparently continuous appearance of such a neon sign is due to a characteristic of the human eye known as the "persistence of vision." Another example of persistence of vision is the continuous ring of light seen whenever an electric bulb is rotated rapidly in a circle.

The characteristic of persistence of vision makes possible the enjoyment of both motion pictures and television. Were it not for this characteristic, the observer in a motion-picture theater would be conscious of the many intervals during which the screen is totally black. In television the instantaneous appearance of the cathode-ray screen depends on the persistence, or phosphorescent, characteristic of the screen material. After a spot is illuminated by the cathode-ray beam, it glows with gradually decreasing intensity while many subsequent lines are being reproduced. If the observer had no persistence of vision he would be conscious of the fact that the line being scanned was bright, with the lines above, already scanned, decreasing gradually in intensity toward the top of the picture.

Flicker

If the frequency with which light issues from a lamp is not sufficient to give the impression of steady light, a rapid fluctuation in the intensity will be seen, and this phenomenon is known by the descriptive term of "flicker." Similarly if a surface is illuminated with an intermittent light, flicker may be observed. The possibility of flicker in motion pictures and television arises from the intermittent illumination which is generally characteristic of these arts.

In some large cities lights are operated on 25-cycle power, and these lights will be seen to flicker if observed out of the corner of the eye, that is if observed in such a way that the light is in the edge of the field of vision of the eye. Since an incandescent lamp operating on 25-cycle power produces 50 flashes of light per second, we can conclude that a 50-cycle flicker frequency is perceptible in the edge of the field of vision of the eye, but not in the center of the field of vision. The fact that an observer always looks directly at a motion-picture screen or a television receiver assists in meeting the requirement for absence of flicker, since the eye is less sensitive to flicker in the central portion of its field of view.

In addition to the frequency of the illumination, and the part of the retina used for the observation, one other factor determines the amount of flicker. This is the intensity of the light; flicker is more severe for the higher intensities of illumination.

Correction of Flicker in Motion Pictures

In accordance with the characteristics of flicker in the preceding section, it is possible to reduce the flicker by means of cutting off the light from the screen momentarily during the time when otherwise a given frame would be continuously shown. That is, after a new frame has come into place, it is shown for a short time, then the light is cut off, and then the same frame is shown again. At the end of this time the light is again cut off and a new frame brought into place. The shutter, which cuts off the light rotates once per frame, or 24 times per second, and it has one "working blade" and one "flicker blade." We show details of a typical projector and shutter in Figure 9.

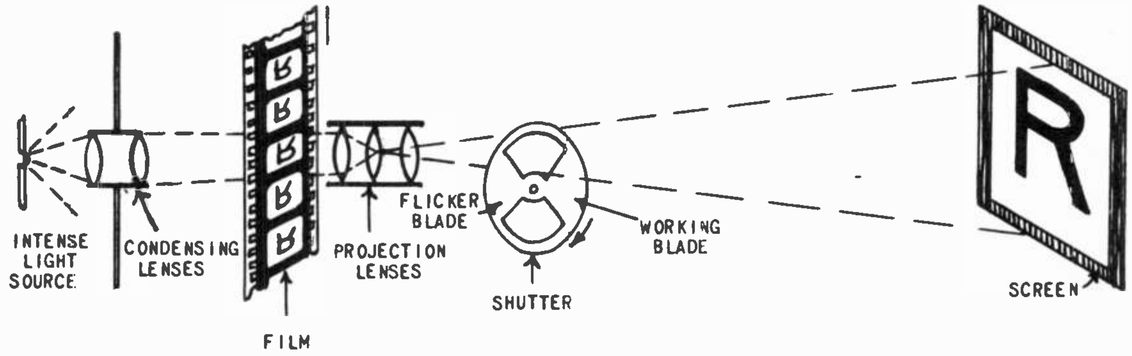


FIG. 9. ESSENTIALS OF MOTION-PICTURE PROJECTION.

The reduction of flicker by the use of a flicker blade on the shutter is accomplished primarily by the increase in the frequency of screen illumination. Some decrease of flicker also results from the decrease of illumination of the screen. However, this decrease of illumination is of itself not desirable, since tests have shown that in general at the present time, an increase of screen illumination would be welcomed by the audience; the difficulty about increasing the illumination is that suitable projectors are not available. Arcs taking up to 150 amperes are already used as light source to obtain as much light as possible.

Present motion-picture practice is characterized by projection at the rate of 24 frames per second; with each frame thrown on the screen twice by the two openings in the shutter, there is a total of 48 projections per second. This gives satisfactorily low flicker with as much illumination of the screen as is available.

Prior to the introduction of sound in movies, which began in 1926, motion pictures were projected at a nominal rate of 16 frames per second, but actually at rates often considerably higher. However it was sometimes desirable to project pictures at approximately the nominal rate of 16 per second, and under these circumstances the flicker obtained with a two-blade shutter was noticeable, there being only about 32 total projections of a picture on the screen per second. To alleviate this condition, three-blade shutters were being adopted during the last years of the silent-picture era. Such shutters of course gave a flicker frequency of 48 or more per second.

Correction of Flicker in Television

It is mentioned above on page 14 that an instantaneous view of the screen of a television receiver would show a horizontal band which is brightest at the bottom and is moving down the screen. This is a band rather than a single spot because of the phosphorescent character of the screen material, which causes it to glow for some time after the electron beam has passed on. The intensity of the band which would be seen at a given instant is greatest along the bottom edge of the band and declines upward, because the vertical scanning is from the top toward the bottom. We may say therefore that the reproduction of the television picture in interlaced American practice consists in such a band traveling from the top of the screen to the bottom each sixtieth of a second. This is sufficiently rapid to make flicker unobjectionable. If simple scanning were used, such a traveling band would traverse the picture only 30 times per second, and flicker would be noticeable. We may summarize this by stating that interlaced scanning is used to remove flicker without the increase of bandwidth which simple scanning at a higher frame frequency would entail. The phosphorescent character of the screen assists in the reduction of flicker, but is less important than the interlacing.

The use of 60-cycle power in the United States has an important influence on the choice of television standards, as is pointed out in the following section. This power frequency naturally leads to the choice of 60 partial scans, or fields, per second, and 30 complete scans, or frames. It is seen therefore that one frame consists of two fields; a field may be said to be half a frame. In British literature the half scanning is called a "frame" and the complete scanning is called the "entire picture" or some similar term.

INFLUENCE OF POWER-SUPPLY FREQUENCY

Relation of Frame Frequency to Power Frequency

All modern television systems have a frame frequency of half the power frequency in the particular country. In the United States where 60-cycle power is generally found, television receivers operate at 30 frames per second. Similarly in Europe where 50 cycles is the standard alternating-current frequency, television receivers operate at 25 frames per second. The use of a frame frequency equal to half the power frequency has important advantages, one of which is that the presence of hum in the video channel causes stationary rather than moving shadow bands in the picture. If another frequency were used, these bands would in general move up or down across the picture and appear prominent and objectionable.

The desirability of this relation between frame and power frequencies may be expressed in other terms if we consider the hum filtering in a television receiver; when the imperfections on the screen due to the hum are stationary, a larger amount of hum can be tolerated and a considerable saving in filter costs thus be realized.

The reader may desire an explanation of the production of interference by hum. The simplest type of interference to explain is the horizontal shadow-bands. For this explanation let us consider a scene in which the top, center, and bottom are black and the intervening portions gradually shading into white; along any horizontal line the shade is constant. The video output from this scene, being scanned at a field frequency of 60 per second, is a series of half sine waves, looking like the output of an unfiltered full-wave rectifier. Obviously if hum is introduced in the receiver, it will cause such a pattern to be seen, and if the field frequency of the scanning differs from the power-supply frequency, horizontal bands will move up or down across the scene.

The value of 30 frames and 60 fields per second for the United States is seen to satisfy the three requirements as follows: (1) frame frequency of 30 per second is ample to give satisfactory illusion of continuity of motion; (2) field frequency of 60 per second is sufficiently high to remove flicker;, and (3) frame frequency of 30 per second is equal to half the power frequency so as to give stationary rather than moving patterns resulting from hum.

CHAPTER 2 - THE TELEVISION SIGNAL

INTRODUCTION

In the first chapter was given a general description of a modern television system together with a discussion of scanning, persistence of vision and flicker. The various aspects of television will now be covered more fully. From the standpoint of general interest, it would undoubtedly be worthwhile to spend some time on the construction and operation of the various types of camera tubes, but because of the quantity of other material more essential in understanding the operation of television receivers, it will be necessary in this brief course to limit the discussion concerning camera tubes to that given in Chapter I.

The present chapter is devoted to the wave radiated by the transmitter which is used at the receiver for the purpose of reforming the original scene. Before discussing the wave in detail, we should consider additional television standards which have been adopted by the Radio Manufacturers Association.

STANDARDS

The general scheme of television was outlined in Chapter I, but a brief review will be given. At both the camera tube and the picture tube, the picture is scanned by an electronic spot (beam of electrons) in a series of adjacent horizontal lines. The fineness of the vertical detail which is reproducible is determined by the number of lines into which the picture is divided by the scanning process. After scanning the whole picture, the process must be repeated at a sufficiently rapid rate so that flicker will not be objectionable. This process is essentially the same, so far as the effect upon the eye is concerned, as that performed by the shutter on the familiar motion picture projector. The frequency at which the complete picture is scanned is the frame frequency.

In order to conserve the band width occupied by a television transmitter, it is desirable to keep the frame frequency as low as possible. Consequently, a trick, somewhat comparable to that used in a motion picture projector, serves to increase the apparent frequency of repetition. In using this device known as interlace, every other line of a picture is scanned, and after the whole picture has been scanned in this way, the lines in between are scanned. This affects the eye, insofar as flicker is concerned, as though the picture were scanned twice. This is true even though all details of the picture have been completely scanned only once. The apparent flicker frequency under these conditions is twice the frame frequency, and is called the field frequency. Now obviously, if anything other than a complete blur is to be obtained, it is necessary that the number of lines per frame, the order of scanning the lines and the number of frames per second be identical at the receiver and transmitter. These have accordingly been standardized.

Number of Lines Per Frame = 525

Approximately this number of lines is required to give a picture quality comparable to that of home movies. The exact figure of 525 lines is based on the fact that the type of interlacing used requires an odd number of lines, plus the fact that the figure chosen should have simple factors. The latter consideration is to simplify the generation of synchronizing frequencies at the transmitter.

Number of Frames Per Second = 30
Number of Fields Per Second = 60

The reasoning behind choosing the values of 30 frames and 60 fields per second was fully covered on page 17 of Chapter I.

Aspect Ratio 4:3

An aspect ratio of 4:3 has been standardized to conform with existing motion picture practice. (The aspect ratio is simply the width of the picture divided by its height.)

Polarity of Transmission Negative

In negative transmission, the passage of the camera scanning spot to a point of more light causes a decrease in the radiated power. The reasons for using negative transmission, as contrasted to positive as used in England, will be discussed in some detail in a later section.

Portion of Signal Amplitude Devoted to Synchronizing 20%

An axiom of television is that picture synchronism must be maintained even to the point where the picture signal is too weak to produce a usable image. Obviously a signal is useless, irrespective of its strength, if the synchronizing portion of the wave fails to keep the receiver in synchronism with the transmitter. Therefore, sufficient transmitter amplitude must be assigned to synchronizing, but more than this amount is not economical of power. Experience has indicated that 20% is a reasonable figure.

Transmission of Black Level

Because of considerations which will be made obvious later, black in a scanned picture is represented by a definite carrier level, independent of the light and shade in the picture.

RMA STANDARD TELEVISION SIGNAL

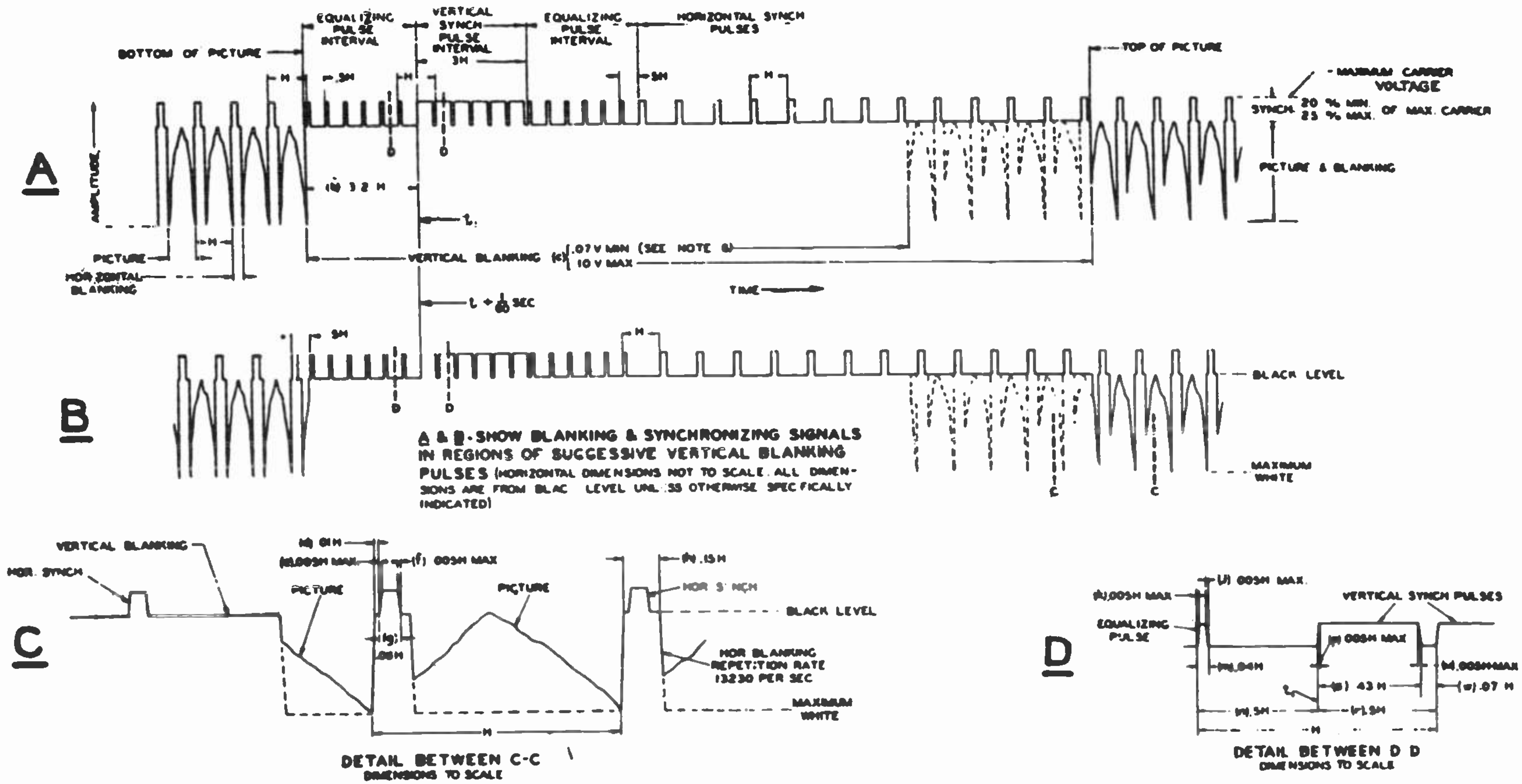
In Figure 10 is reproduced the RMA Standard Television Signal, a close inspection of which will reveal an immense amount of information. Diagrams A and B are portions of a single frame and show blanking and synchronizing signals in regions of successive vertical blanking pulses. It should be noted that the "black level" divides the television signal into two parts; voltages below this level represent the picture signal, and those above, the synchronizing. "Black level" is indicated on the right-hand side of Diagrams B and C. In Diagram C, the picture information is so labelled. (The particular view represented as being scanned in C starts as gray at the left edge, gradually increases to black near the center, and then gradually decreases to white at the right edge.)

In Diagram A, starting at the left-hand side is shown the video information developed in the last four scanning lines of the second field. Note that the video or picture information is interrupted for brief periods at the end of each line. During these periods, horizontal synchronizing pulses are transmitted which control the timing of the spot's return to the left side of the picture tube. While the spot is returning to the left side, that is, during the line retrace, the amplitude of the video signal is in the black or "blacker than black" level and hence the retrace is not visible.

At the completion of the last line in the second field which is marked "bottom of picture" in A, the signal is interrupted for a longer period during which the vertical synchronizing and the equalizing pulses are transmitted. It should be noted that also during this period, the amplitude is such as to always be in the black region, which of course again means that the spot of the picture tube is dark.

RMA STANDARD T-111 TELEVISION SIGNAL

525 LINES, 30 FRAMES PER SEC., 60 FIELDS PER SEC.; INTERLACED



1 DIAGRAM C SHOWS ENLARGED DETAIL VIEW OF SIGNAL IN VIEW B BETWEEN LINES C-C

2 DIAGRAM D SHOWS ENLARGED DETAIL VIEW OF SYNCH SIGNAL IN VIEW A BETWEEN LINES D D

3 H=TIME FROM START OF ONE LINE TO START OF NEXT LINE = 1/15,750 SEC.

4 V=TIME FROM START OF ONE FIELD TO START OF NEXT FIELD=1/60 SEC. = 262.5 H

5 LEADING AND TRAILING EDGES OF BOTH HOR. AND VERT. BLANKING PULSES HAVE SLOPES NOT INDICATED IN A&B WHICH SHOULD BE KEPT AS STEEP AS POSSIBLE

6 RECEIVER VERTICAL RETRACE SHALL BE COMPLETE AT END OF .07 V

FIG. 10

The first, or leading, set of equalizing pulses serve to make the conditions on successive fields the same at the start of the vertical synchronizing pulses. This is necessary for proper interlacing. They also serve to keep the horizontal oscillator operating during this period.

The group of six broad pulses are used to time the start of the retrace of the vertical saw-tooth oscillator which moves the spot from the bottom of the screen to the top. Six pulses are used instead of single broad one so that the horizontal synchronization may be maintained during this period.

Equalizing pulses follow the vertical synchronizing pulses for the same general reason that the leading set was provided.

Horizontal synchronizing pulses follow the second set of equalizing pulses so that the horizontal oscillator will be properly timed when the vertical blanking is removed.

The vertical blanking period is shown as occupying between .07 V and .10 V. (V is the time from the start of one field to the start of the next. Since there are 60 fields per second, V is 1/60 of a second). In actual practice, this figure is approximately .07 V when a camera tube is used in directly viewing a scene and in some cases may be .10 V when motion picture film is used. A receiver designed so that the vertical retrace is completed within .07 V will perform equally well when receiving a signal having either blanking period. The principal result of the longer blanking period is a picture having approximately 2.5% less height.

Since the complete picture is scanned by 525 lines 30 times each second, the electron beam moves across the screen 525 x 30 or 15,750 times each second. The frequency of the horizontal oscillator deflecting the beam may then be said to be 15,750 cycles per second, and the time for one cycle, H, becomes 1/15,750 of a second.

Because of the two-to-one interlace, the vertical synchronizing pulse groups occur twice per frame or 525 lines. Accordingly, the interval between the beginning of the vertical blanking on adjacent fields is 525/2 lines or 262.5 H. Figure 10 shows only the portion of the television signal near the vertical blanking regions and it should be kept in mind that there is a continuation of the wave represented in the right-hand side of Diagram A. This continues until 262.5 H has elapsed from the time the vertical blanking started in A. At the completion 262.5 H vertical blanking begins again as shown in B. After another 262.5 H the second field is completed and the second frame is started at the point where the first started in A.

Figure 11 shows the relation between the horizontal and vertical sweeps, as well as indicating the periods of blanking that occur during a complete frame. The shaded area at the right side of the diagram, labelled Field Blanking, corresponds to the vertical blanking period shown in A of Figure 11. At the completion of the vertical blanking in a period of 16.15 H, the first line at the top of the picture is scanned during a period of .85 H. Line blanking then takes place for .15 H, during which time the saw-tooth oscillator goes through its retrace to bring the spot back to the left side of the screen. The horizontal cycle just described is shown at the left edge of Figure 11, and has "1 H" marked above it. The horizontal cycle described continues for a total of 246.35 H before the field blanking again occurs. It should be noted that when the field blanking occurs, this time, that only .35 H of a horizontal cycle has been completed for the last line. Thus, the spot on this bottom line becomes invisible near the center of the screen. During the period of vertical blanking, the electron beam has gone through 16.15 horizontal cycles, and is again hear the center of the screen but, at the top, when the vertical blanking is removed.

Horizontal and Vertical Sweeps with Blanking

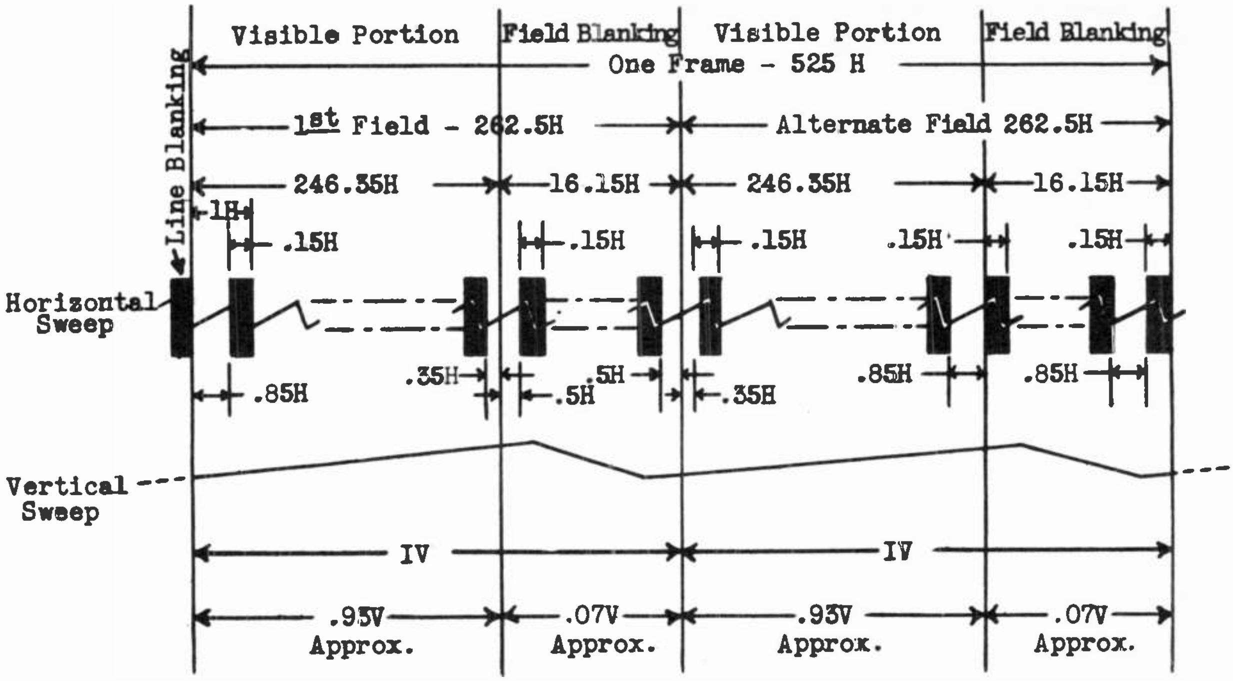


FIG. 11

Accordingly, the top line of the alternate field is only visible for the last .35 H. After an elapse of another 246.35 H field blanking again occurs, and one full frame has been completed.

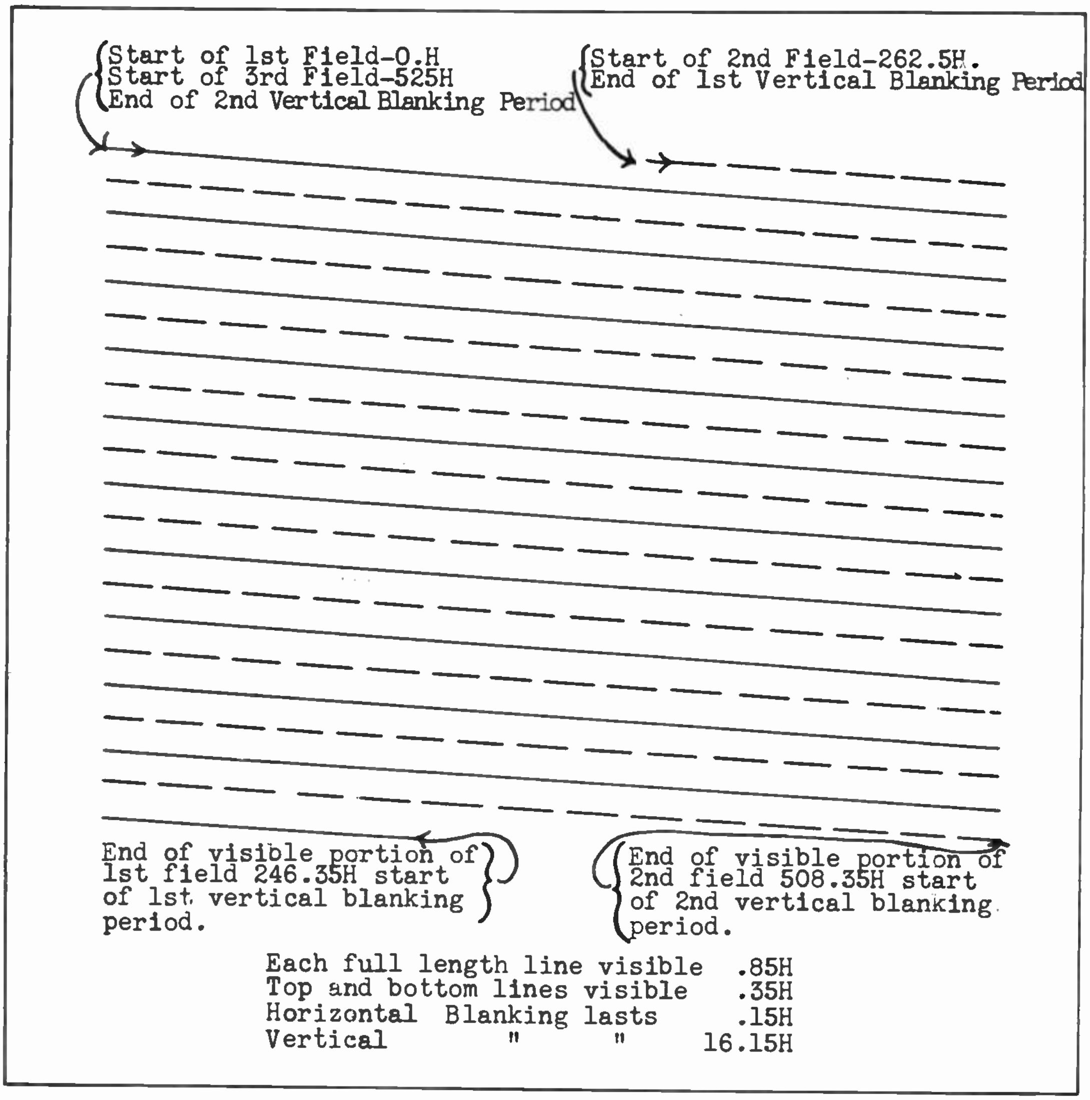


FIG. 12

Path of Electron Beam on Screen.

In Figure 12 is shown the path of the electron beam or spot on the screen of the picture tube. To simplify the diagram it has been drawn as though the scene were scanned in greatly less than 525 lines.

CHAPTER 3 - GENERAL REQUIREMENTS ON THE TELEVISION RECEIVER

INTRODUCTION

The two preceding chapters outline the general features of high definition television and the signal radiated by the transmitter. We proceed now to the use of this signal by the receiver. Since the course is intended for technicians who will be dealing exclusively with receivers, this material will be covered in considerably greater detail than that previously presented.

ASSIGNED TELEVISION CHANNELS

In Figure 13 is given the channels assigned for television use by the Federal Communications Commission. The channels will be seen to fall into two general groups, the first group consisting of six channels between 44 and 88 megacycles, and the second of seven channels between 174 and 216 megacycles. By an order of the FCC effective November 28, 1945, these 13 channels are reserved for television.

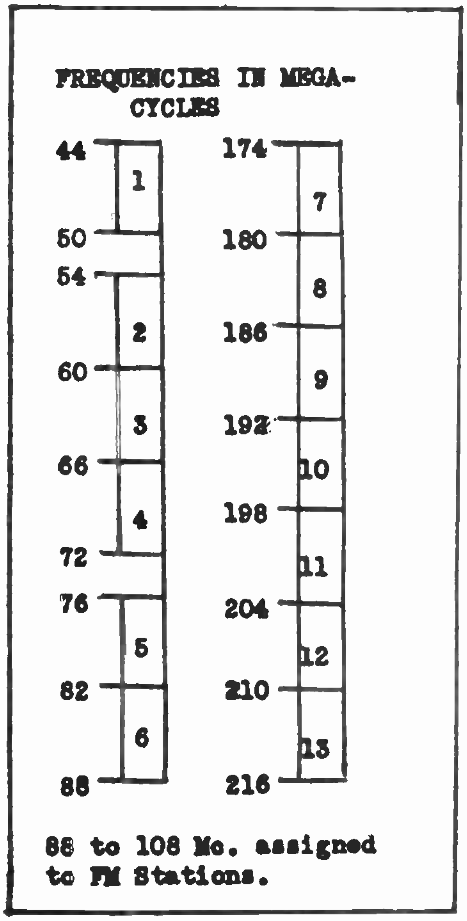


FIG. 13

TELEVISION CHANNELS ASSIGNED BY FCC

In Figure 14 is shown the details of location of the carriers and the guard band of each television channel. The most striking characteristic in this figure is that there is an interval of 4.5 megacycles between the sound and picture carriers in each channel, while there is only an interval of 1.25 megacycles from the picture carrier to the lower limit of the band. This arrangement is made in order to accommodate an upper sideband of picture frequencies occupying most of the region between the two carriers while the lower sideband is partially suppressed so as to be accommodated in the narrower region provided. The sound transmission operates, of course, with both sidebands present in equal amounts, and requires only a very small relative frequency band.

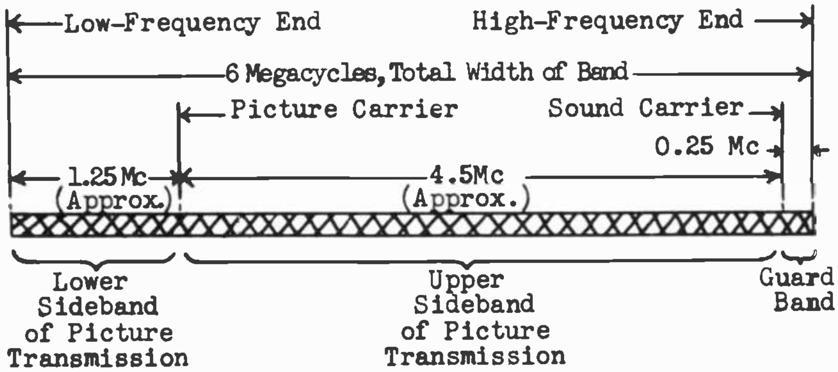


FIG. 14
ARRANGEMENT OF EACH TELEVISION CHANNEL

INTERVAL BETWEEN CARRIERS AND THE SESQUI-SIDEBAND METHOD

Single-Sideband and Sesqui-Sideband Methods

Probably all readers of the present chapter are acquainted with the conventional transmission of broadcast programs in which an unmodulated carrier component and upper and lower sidebands are radiated. It has probably also been observed that upon detuning a receiver, satisfactory reception is obtainable with the upper components of one sideband attenuated. This observation suggests that the essential information being transmitted does not require the double-frequency interval which is characteristic of the conventional method. This suggestion is really a fact which has been established by theoretical and practical work extending back for a number of years. As one case, the radiation of a single sideband without any unmodulated carrier component is used in transoceanic telephone practice to transmit the voice; a locally generated carrier is used at the receiver for detection. In this case the filtering operations, by which the single sideband is obtained, are possible because there is no necessity of accommodating lower audible and sub-audible frequencies.

For systems, such as television, in which modulation at very low frequencies must be transmitted, the use of a single sideband is impractical, but the sesqui-sideband method may be used. The meaning of sesqui-sideband is one and a half sidebands, and the significance is that one complete sideband is transmitted plus a fraction of the other sideband. Another name which has been used is "vestigial-sideband method." The carrier component is present in sesqui-sideband systems.

The lower modulation frequencies in a sesqui-sideband system are transmitted and reproduced by the conventional double-sideband method with the exception that the side frequencies on one side are less in amplitude than the corresponding frequencies on the other side. As higher modulation frequencies are considered, this condition becomes more pronounced, the weakened sideband contributing less and less and the normal sideband more and more to the detected signal. The point is reached in this way at which the contribution of the discriminated sideband is negligible, and all the detected signal delivered by the system is obtained from the normal sideband. In this way the system operates in the conventional double-sideband manner for very low modulation frequencies and gradually passes thru a transition to where it operates with carrier and single-sideband for the higher modulation frequencies.

A more detailed analysis of the sesqui-sideband method leads to the conclusion that for uniform reproduction of the various modulation frequencies, the transmission curve of the entire system must be down 6 decibels for the carrier and must have complementary characteristics on the two sides of the carrier for the lower modulation frequencies. For example, if the lower sideband is attenuated so that a given side frequency has a transmission thru the system of only 25 percent, the corresponding upper side frequency must have a transmission of 75 percent; similarly a higher modulation frequency may be represented by a transmission of only 10 percent in the lower sideband and a transmission of 90 percent in the upper sideband.

A limitation in regard to detection prevails in the case of single-sideband operation. For high modulation with a signal having several frequency components, either a linear or a square law detector introduces objectionable distortion. For this reason the usefulness of the single-sideband method is limited to cases where the percentage of modulation is low, or can be made low by the introduction of a large local carrier. With sesqui-sideband operation no difficulty is encountered if the modulation percentage is low for the higher signal components, which are transmitted single-sideband.

We see therefore that the sesqui-sideband method of transmission has two important characteristics: (1) it makes possible an important saving in the high-frequency band; and (2) the fidelity is satisfactory if the larger signal components occur in the lower-frequency region so as to give a low percentage of modulation for the upper frequency components.

Use of Sesqui-Sideband Method in Television

The characteristics of sesqui-sideband transmission, given in the preceding section, make it the natural choice for television. Here a very wide band of signal frequencies is to be transmitted, and the energy is located chiefly in the lower-frequency portion of this band. It is necessary to conserve frequency space, both to accommodate a number of stations on the air and to relieve the bandwidth requirements of transmitting and receiving apparatus. In Figure 15, we show the details of a single television channel, such as given in Figure 14, with the addition in a dashed line of the transmission characteristic necessary if the lower-frequency sideband were to be used to the same extent as the upper sideband. On the upper side of the picture carrier the transmission may extend to the sound carrier; there must be substantial attenuation at this point to prevent the sound carrier and its side frequencies from interfering with the picture transmission and being reproduced as an interference pattern in the picture. On the lower side of the picture carrier a frequency band with a width of 1.25 megacycles is provided for the attenuated lower sideband. Beyond this point any transmitted frequency components would lie in the next channel and constitute interference; as a practical matter an attenuation of 30 or 40 decibels should be provided at the transmitter against components thus falling in the next channel.

The predominance of the lower video frequencies, which permits the use of the sesqui-sideband methods, occurs because the usual scene consists of relatively large, fairly uniform, areas in comparison with the size of the scanning spot. It

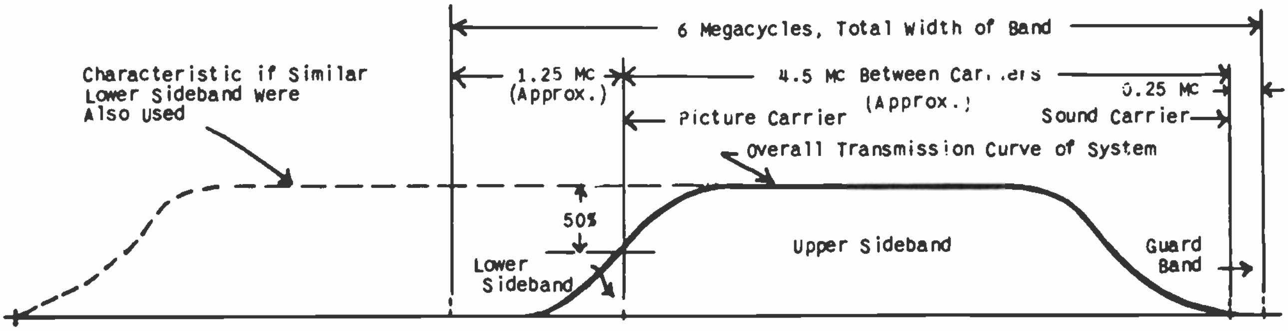


FIG. 15
SESQUI-SIDEBAND OPERATION OF TELEVISION CHANNEL

will be realized that it is unusual for a scene to have very fine and contrastly detail over most of its area.

We mentioned above on page 27 that the overall transmission curve must indicate an attenuation of 6 decibels at the carrier frequency, in comparison with the medium-high modulation frequencies, if discrimination between modulation frequencies is to be avoided. This attenuation may be provided at the transmitter, or at the receiver, or part at each place.

Effect of Carrier Interval on Receiver Design

The general arrangements of the high-frequency circuits of the television receiver have been worked out so as to give "single-dial" tuning accommodating the picture and sound of a given station at the same time. In particular, the radio-frequency circuits are provided with sufficient width to accept both the picture and sound carriers of the desired station, and the oscillator is set at such a frequency as to convert both carriers in one converter tube to the desired intermediate frequencies. For example, the station operating on TV channel #3 has a picture carrier of 61.25 megacycles and a sound carrier of 65.75 megacycles. If a particular receiver had an oscillator frequency, when tuned to this station, of 87 megacycles, and the intermediate frequency for the picture signal would be 25.75 megacycles, and the intermediate frequency for the sound would be 21.25 megacycles. With this arrangement it is seen that the oscillator frequency is located above both of the received carriers, with the result that the two intermediate frequencies have the same interval between them as the radio-frequency carriers, namely 4.5 megacycles. Also the picture intermediate frequency is higher than the sound intermediate frequency, which is a desirable relation.

TRANSMISSION OF DIRECT-CURRENT COMPONENT

Nature of Direct-Current Component
and Effect in Modulation

Servicemen are all familiar with alternating-current waves having direct-current components, for example the voltage across the load resistor of a resistance coupled amplifier. By using a coupling capacitor between the plate of the first tube and the grid of the next, the alternating-current component is transferred while the direct-current component is eliminated. In the upper diagram of Figure 16 is shown an alternating-current wave without a direct-current component.

When an alternating-current wave is used to modulate the carrier with the conventional type of modulation, the average carrier amplitude, averaged over the modulation cycle, remains the same. In other words the envelope of the modulated carrier on each side has as its alternating-current axis the peak value of the carrier before modulation. This is shown in the second diagram of Figure 16.

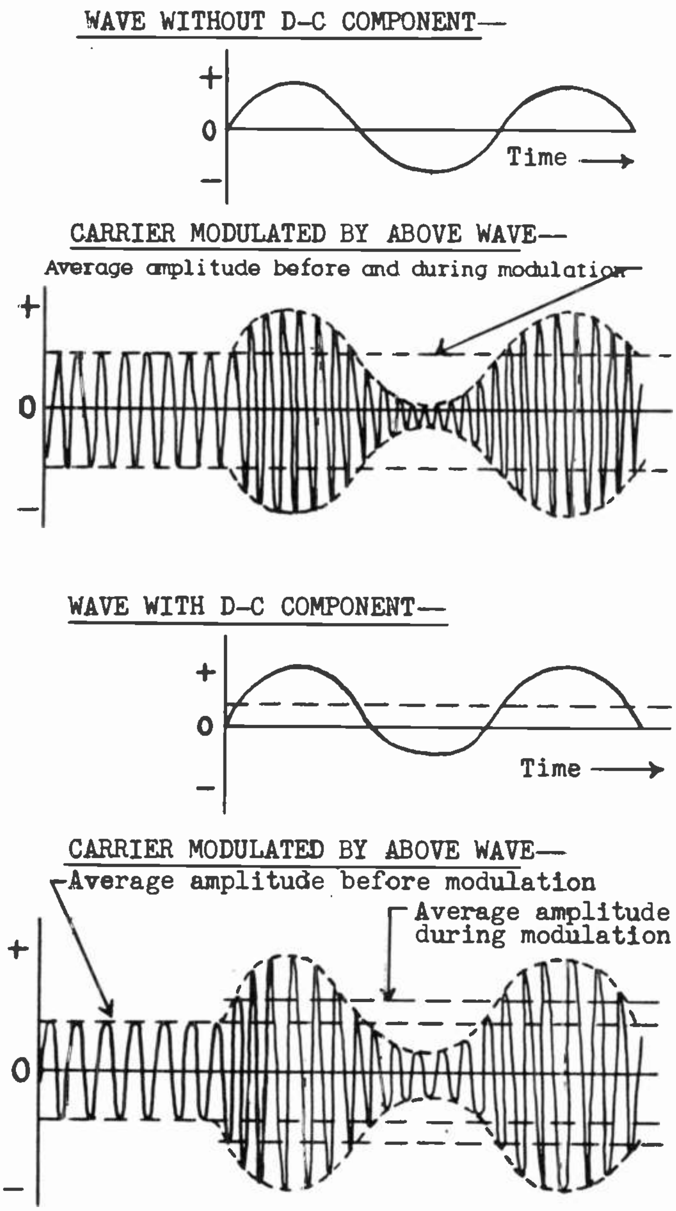


FIG. 16
EFFECT OF D.C. IN MODULATION

The presence of a direct-current component in the modulating wave is a condition not found in sound broadcasting. It causes a change in the average carrier amplitude when the modulation begins; this is indicated in the third and fourth diagrams of Figure 16. In the third diagram a waveform with a positive direct-current component is shown, and in the fourth diagram it may be seen that the application of this wave in modulation produces an increase in the average carrier amplitude. If the direct-current component of the modulating wave had been negative, there would have been a decrease in the average carrier amplitude.

In terms of antenna current we may note that in the absence of a direct-current component, the radio-frequency current peaks before modulation are 50 percent of the maximum current which the station can produce. The station is assumed to operate at maximum instantaneous power on the peaks of 100-percent modulation. Upon the application of an alternating-current wave as modulation, this 50-percent value is the mean line, or alternating-current axis, of the modulation envelope. Should a direct-current component be present, this value may be 40 percent, 60 percent, or any other proportion, of the maximum antenna current.

Stabilization of Video Levels

In Figure 10, page 21, of the preceding chapter there are given the details of the complete video wave, and it may be seen that there is a range of potentials devoted to picture shades from white, thru gray, to black, and also a further range of potentials devoted to synchronizing signals. Electrically the synchronizing signals are therefore in a region which is "blacker-than-black," or "infra-black." In the receiver it is necessary to perform two functions related to these characteristics; these are (1) the separation of the potentials in the synchronizing range from those in the picture range; and (2) the reproduction of each potential in the picture range with the proper brightness, including instances of sustained constant values, such as when the screen is dark for an appreciable length of time.

A receiver with direct-current couplings in its video amplifier will have an absolute brightness-voltage relationship throughout, and therefore can be designed to perform the two functions just listed. However, it is often desired to use alternating-current couplings in the receiving video amplifier, and then reinsert the direct-current component.

Direct-current reinsertion is a special case of an important process called "stabilization", which is an alteration of the axis of a wave in such a way that the peaks of the desired polarity are brought to a constant value. Stabilization may be used for various purposes, in carrier as well as video portions of a television system; the polarity and the time constant are chosen according to the nature of the particular case. We may say that stabilization lines up a wave by its peaks, or that stabilization brings the peaks into line, that is to a constant value. The type of stabilization of chief interest in receiver practice is direct-current reinsertion. This reestablishes the absolute relation between picture shade and the potentials at the particular point in the circuit.

A circuit called the "sync separator" or "clipper" in the receiver rejects the picture range of potentials and accepts the sync range of potentials. The input portion of this circuit, if it does not have a direct coupling, requires stabilization. The sync separator is designed to respond to all signals on one side of some critical potential level, and to have no response to signals on the other side of this level; the level should be somewhat blacker-than-black, to insure that no picture components pass thru into the synchronizing circuits under any conditions. If thru misadjustment this level should be at a dark gray, picture potentials would get into the synchronizing circuits and impair the scanning of the picture tube. Should the critical level be on the proper side of black, but be considerably removed from the black level, the amplitude of the sync pulses obtained from the complete signal might be insufficient - this condition is, however, seldom encountered.

Another point at which receivers may have an alternating-current coupling, and therefore require reinsertion of the direct-current component, that is, require stabilization of the signal, is in the grid circuit of the reproducing picture tube. An improper adjustment of the stabilization here will cause incorrect average brightness; also with one direction of the misadjustment, the scanning lines occurring during the field retrace will appear in the picture.

From the discussion already given it will probably be realized that the video wave delivered to the grid of the picture tube must contain a direct-current component and that this component conveys the information as to the average brightness of the picture. In order to make certain that this point is clear, let us consider two special scenes. In case the scene is black, or almost black, the average video voltage must be, for proper operation, at or near the cutoff voltage for the particular tube. In case the scene is white, or almost white, the average video voltage must, of course, be near zero tube bias. In order to transmit one of these scenes and hold it fixed for any substantial length of time, it is obviously necessary to transmit the direct-current component of the picture.

We may summarize the preceding paragraphs by stating that: (1) the voltage wave finally used to actuate the picture tube of the receiver should contain the direct-current component, which represents the average brightness; (2) the operation of separating the sync signals from the picture signals requires the presence of the direct-current component; (3) after loss of the direct-current component in an alternating-current video coupling it may be regained by a stabilization process, often using a diode; and (4) there is the obvious fact that the direct-current component is transmitted thru radio-frequency and intermediate-frequency circuits because the carrier frequency amplitude represents it.

In Figure 10 of the last chapter there is given the wave radiated by the transmitter. This wave has the two related characteristics that: (1) a direct-current component is present; and (2) the top of the blanking pulses represents black. If this wave is transmitted thru an alternating-current coupling, the direct-current component is of course removed; this operation has the effect on the height of the blanking pulses, measured from the axis of the resulting wave, of making them represent the average brightness of the picture. The direct component can be regained by the usual reinserting process, which lines up the sync peaks as they were in the original wave; however we can say in terms of the height of the blanking pulses, that the information which they contained as to average brightness of the scene is employed in the reinserting process to regain the lost direct component.

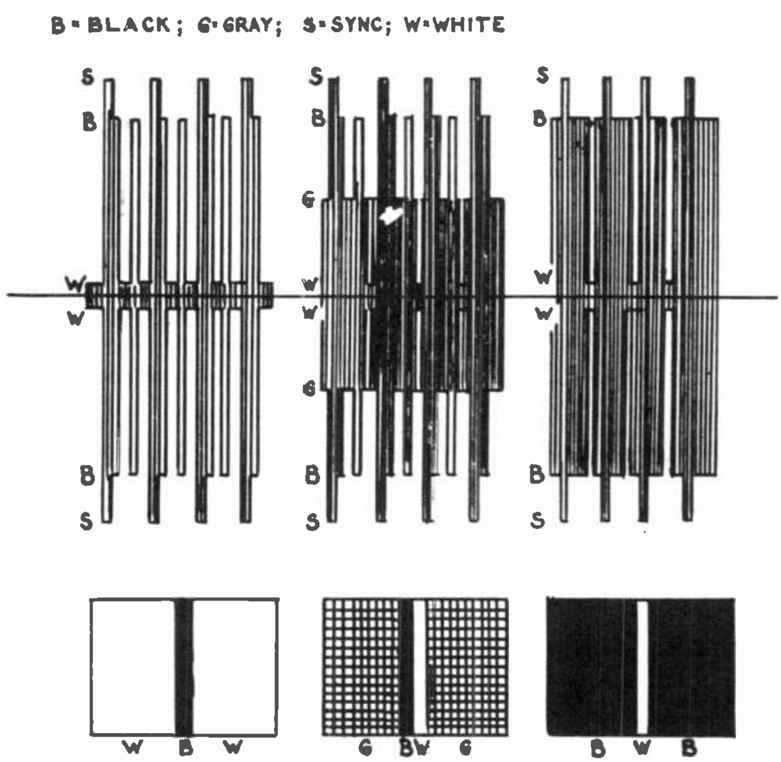


FIG. 17

CARRIER WAVE WITH DIRECT-CURRENT TRANSMISSION AND NEGATIVE POLARITY.

In order to better visualize the signal radiated by the transmitter with direct-current transmission, Figure 17 is shown. The figure illustrates a few lines from each of three pictures as follows: (1) a white background having a black vertical bar in the center, for which the wave-form is shown at the left; (2) a gray background having a black bar followed by a white bar, for which the wave-form is shown in the center; and (3) a black background having a white bar, for which the wave-form is shown at the right. The figure shows that direct-current transmission is employed, because the synchronizing pulses occur at a fixed level in the transmitted wave and likewise the various shades, while the carrier or the average radiated power varies. This power is small in the first case and large in the third case.

INTERLACING

Pairing of Interlaced lines

A certain type of fault in the field scanning will cause an interlaced "raster" to have pairing as shown in Figure 18. (The appearance of a picture screen when only the scanning lines are seen, that is, when no picture is being transmitted but conditions are otherwise normal, is called the "raster", a term of German origin). Close examination of this figure will show definitely the occurrence of the lines in pairs, rather than with uniform spacing. This fault impairs the detail, and in the limit halves the effective number of scanning lines; for example a 525-line picture becomes a 262.5-line picture upon total failure of the interlace, that is upon complete pairing. The cause of pairing is an incorrect relation on the screen between the sets of lines of the two fields. If one field is regarded as occurring first the pairing can be considered to be due to each line of the second field occurring with a slight vertical displacement from its proper position; each such second line lies too close to the adjacent line of the first field on one side, and too far from the adjacent line of the first field on the other side. This causes the complete interlaced pattern, or raster, to show the appearance of lines in pairs. In Figure 18 the lines of both fields are drawn solid in order to give an impression similar to that which might be observed in a service shop.

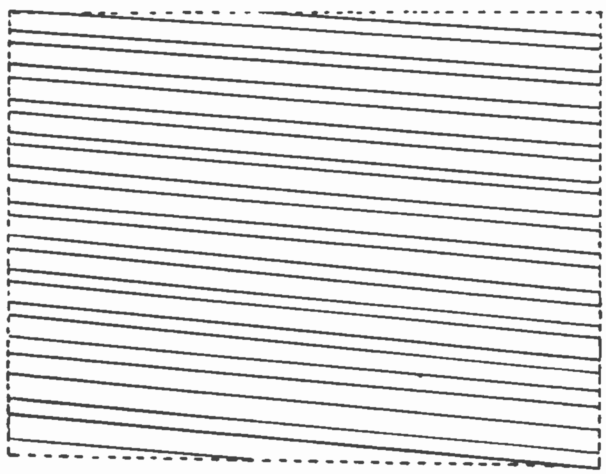


FIG. 18
ILLUSTRATION OF IMPERFECT INTERLACE, OR PAIRING.

REASONS FOR EQUAL AND RECTANGULAR SYNC PULSES

In Figure 10, page 21, which gives the complete video wave, it may be seen that the sync pulses for the line and field synchronizations have the same height, and also that both are practically rectangular in shape. These characteristics have been chosen with due consideration, and in the present section we give the reasons for the choice.

Equal Height of Line and Field Sync Pulses

Before the adoption of the wave of Figure 10, consideration was given to the use of sync pulses of different height for field and line synchronization, and particularly to the possibility of having the field sync pulses of greater height than the line sync pulses. Such an arrangement can be made to afford sharp field timing and also separation between the field and line sync pulses by amplitude discrimination. However, the arrangement has the characteristics of: (1) assigning a portion of the power range of the transmitter to the sole function of field synchronization; and (2) incurring the risk of loss of the amplitude difference in an overloaded receiver. Since it is possible to obtain satisfactory results without these features, the choice of equal height for the two types of pulses was made.

Rectangular Shape of Sync Pulses

In Figure 10 the specification is included that the leading and lagging edges of all sync signals shall occupy not more time than 0.005H, where H is the line period of 1/15,750 second. This specification is essentially a statement of the small permissible amount by which the sync pulses may depart from a perfectly rectangular shape. In Figure 10, the duration of line and equalizing pulses is shown at both base and tip in terms of the maximum transition time of 0.005H. For a shorter transition time, the duration at the base remains the same, and the duration at the tip is correspondingly greater. The duration of the broad field-sync pulses is discussed below under "Broad Pulses as Field Sync Signal."

The most important advantage of the rectangular shape of a synchronizing pulse is that the timing, which is represented by an edge of the pulse, is preserved despite great "abuse" in the way of distortion in transmission. As an example of this we show in Figure 19 the action of a negative-grid limiter which cuts off the applied pulses beyond a certain point. It will be seen in this figure that with the rectangular shape, variation of the input level, as shown in dashed lines, does not affect the timing to, established by the leading edge of the pulse. However, with a non-rectangular shape, this is not in general the case. To illustrate this there is shown in figure 19 the operation with a triangular wave, and it can be seen that erroneous times t_1 and t_2 characterize the base of the output pulse with change of input level.

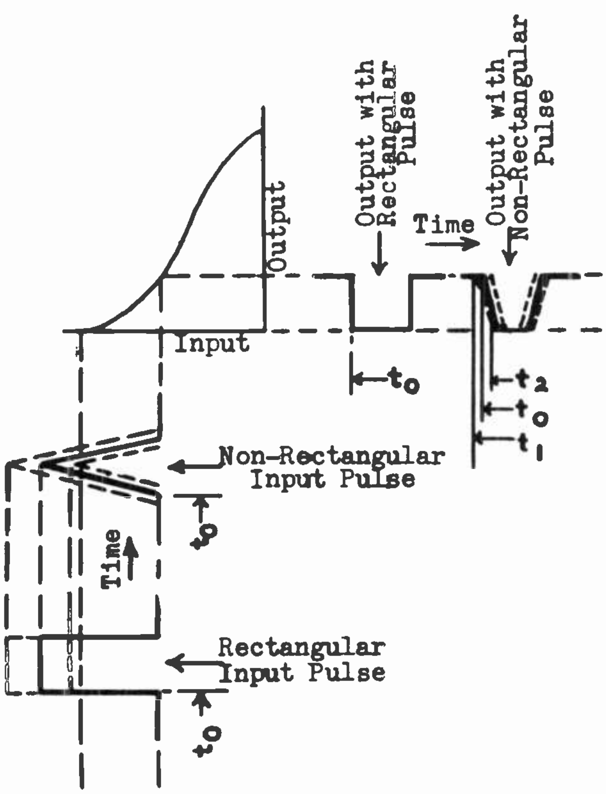


FIG. 19
PRESERVATION OF TIMING BY USE OF RECTANGULAR PULSES

The operation of cutting, or limiting, is characterized essentially by the complete removal of part of the amplitude range. In another type of distortion to which sync signals are exposed, namely crushing or compression, all parts of the amplitude range are retained in amount sufficient for restoration, but are altered in their relative proportions. After a compression rectangular pulses can be restored to their original height by either expansion or amplification; there is no need of matching the characteristic of the compressor with a complementary characteristic in an expander.

It is seen therefore that with the rectangular shape, amplitude distortion does not have to be corrected - it is only necessary to obtain the final required height of pulse. This fact makes it possible to use the non-linear portions of tube characteristics, both in the transmitter and the receiver, for handling the sync signals.

HORIZONTAL BLANKING AND SYNC

Duration of Line Blanking

The duration of the line blanking pulse must be sufficient to allow the line scanning system to return the spot to the left-hand side of the picture and also to permit resumption of the normal velocity of the spot in the trace direction. We have seen in Figure 8 that 0.15H is allotted for the line blanking pulse; this is 15 percent of approximately 70 microseconds, or about 11 microseconds. This length of time for the line blanking is about as short as can be used economically. It is of course desirable to have this interval short in order to use as much time as possible for actual picture transmission; for this reason it has been set at about as short a value as is usable under practical conditions.

Uniform Line Timing in the Field Blanking Interval

The scanning circuits of a television receiver are usually designed on the basis that the normal line scanning will be maintained during the field retrace. That is, the line scanning coils at the picture tube operate continuously, whether or not the electron beam is present. As a matter of fact, during both field and line retraces, the electron beam is cut off by the control grid under the influence of the blanking pulses. This does not however prevent the scanning currents and the resultant magnetic fields from being in operation.

To permit the maintenance of line scanning during the field retrace, there are provided, as shown in Figure 10, suitable pulses throughout the field blanking interval. Before considering these pulses in detail, let us note two relevant facts: (1) the excursion of the complete video wave from the black level to the sync level is the essential line timing operation - this synchronizes the line oscillator in the receiver; and (2) the line oscillator is insensitive to pulses occurring a substantial time in advance, for example pulses occurring in the middle of the scanning of a line.

We may now note that in Figure 10 there are represented at the upper left corner the last few lines of normal scanning which occur at the bottom of the picture being transmitted. Here the horizontal sync pulses may be seen, and note may be taken of the left side of each, which determines the timing of the line oscillator at the receiver. An interval of time designated as H, equal to the line period of 1/15,750 second, elapses between each of these synchronizing strokes. This timing is maintained during the insertion of the equalizing pulses because these include a pulse with a leading edge occurring at each interval of H; the equalizing pulses have been made narrower than the regular line pulses by advancing their lagging edges - the leading edges are unaltered in position. It will be seen that there are also equalizing pulses located just half-way between those we have been considering; the function of the equalizing pulses is described below in connection with the field sync signals. At the present point it is sufficient to note that these additional pulses do not introduce any difficulties in the line scanning.

At the end of the period of insertion of the equalizing pulses, the first broad pulse of the vertical sync signals occurs with its leading edge at one of these intervals of H or H/2. Each broad pulse terminates soon enough to accommodate, at the next H/2 instant of synchronization, an upward stroke of the curve, from the black level to the synchronizing level, as required for the line synchronizing operation.

At the termination of the vertical sync pulses in Figure 10, there is a second group of six equalizing pulses, spaced at intervals of H/2 which serve to time the horizontal oscillator in the same manner as the equalizing pulses occurring before the vertical sync signals.

We may conclude this treatment of the uniform line timing during the field blanking interval by stating the essential result that vertical strokes of the wave in the direction toward sync level occur regularly at double line frequency, permitting the maintenance of normal operation of the line oscillator.

For the other field of the frame, represented by the second curve in Figure 10, the same remarks apply as above in regard to line timing by the upward strokes. In this case also there is the additional set of upward strokes during the period of both sets of equalizing pulses and during the vertical sync pulses. We may note that for this field the line oscillator is tripped by the second, fourth, etc., equalizing pulses, in comparison with the first, third, etc., for the first field.

FIELD BLANKING AND SYNC

Broad Pulses as Field Sync Signal

The pulses inserted during the field blanking period for the field synchronization must of course be electrically distinguishable from the line sync pulses. Since it is desirable from other standpoints that the field sync pulses be of the same amplitude as the line sync pulses, and also that both be rectangular, as discussed above on page 32, this leaves only the duration and internal waveform of the field pulses available for modification. In practice it is both feasible and convenient for the field pulses to differ in duration alone. They are therefore specified in Figure 10 as rectangular and of maximum permissible duration consistent with the introduction of regular upstrokes at double line frequency for the maintenance of the line scanning. The field sync signal consists of six of these broad pulses.

The length of each broad pulse at the base, that is at the black level, is specified as 0.43H, leaving 0.07H as the duration of the following interval at the black level. It may be seen that this interval between the broad pulses can be regarded as an inverted line pulse, assuming use of the full 0.005H transition time which is the maximum allowed.

Accuracy of Field Synchronization

We have seen on page 32 that an incorrect relation on the screen between the two sets of fields of interlaced operation, produces an impairment of the interlacing in the picture, causing the raster to show pairing of the scanning lines. In Figure 18 we have shown such pairing.

In case pairing is observed a condition is likely to be encountered in which the line scanning is accurately interlaced during field retraces, but has the observed pairing during the field traces. This possibility arises from the method of synchronization of the scanning oscillators in the receiver, and in particular from the fact that their retrace is initiated by the received sync signals, while their trace is locally initiated. The beginning of the field trace may on this account be upset by interference from the line oscillator affecting the field oscillator. To make this clear we mention the following two facts: (1) the field scanning starts before the termination of the field blanking pulse (in fact it must have settled down to a constant velocity by the time the field blanking terminates), and the point of interest is the portion of its trace completed at the instant that the field blanking terminates and the reproduction of the picture begins; and (2) although line doubling pulses, or equalizing pulses, are received following the vertical sync signals, and although the field retrace terminates while these equalizing pulses are being received, the line oscillator itself is usually designed to remain at line frequency, and not assume the double line frequency during the field blanking. From these conditions, we see that a small amount of interference reaching the field oscillator from the line oscillator may cause the field oscillator to terminate its retrace at different times for the two sets of fields, thereby producing pairing of the interlace. This condition is frequently encountered, the pairing often amounting to about ten percent, which is the value shown in Figure 18. One remedy is to remove the coupling between the line and field oscillators by thorough shielding and isolation; by this means the interlace during trace, which is the effect of interest, can be made as good, or practically as good, as that obtained during retrace.

Leading Set of Equalizing Pulses

Equalizing pulses and double-frequency line strokes during the field sync signal are provided to satisfy the two requirements of (1) maintenance of line scanning during the field blanking, and (2) similarity of conditions in vicinity of the field sync signal for the two fields of each frame.

The equalizing pulses ahead of the field sync pulses can be seen in Figure 10 to be identical for the two fields of a frame. If these equalizing pulses were not provided, the field sync pulses would be preceded by different conditions for successive fields. Under these circumstances field sync circuits of the integrating type would act differently for successive fields and produce pairing of the interlace in the picture. The integrating type of field sync circuit is not the only one available, but it was considered desirable to provide these pulses to accommodate it. The integrating type sync circuit will be discussed later in the course.

Lagging Set of Equalizing Pulses

The lagging equalizing pulses are provided because they eliminate one source of interference with the constancy of the retrace duration of the field oscillator. In case there is imperfect inter-sync separation, some of the line syn signals may reach the field oscillator during its retrace and affect the timing of the initiation of its trace. If the lagging equalizing pulses were not provided, that is if there were only the normal line-frequency sync pulses during this period, the disturbing conditions would be different for the two fields of each frame; the timing of the start of the field trace might then be different for the two fields, resulting in pairing of the interlace.

These lagging pulses are terminated before the end of the field blanking period because in some receivers the line oscillator operates at double frequency while supplied with double-frequency sync pulses, and a recovery interval must be allowed in such a case to permit the re-establishment of normal operation at line frequency before the termination of the field blanking.

CHAPTER 4 - FREQUENCY CHARACTERISTICS OF THE RECEIVER

INTRODUCTION

In the preceding chapter there is given a statement of the general requirements on the receiver as established by the details of the transmitted video wave. In the present chapter the discussion of general receiver requirements is completed, taking up particularly the frequency characteristics of the scanning spots and of the electrical circuits which determine the picture detail.

The electrical transmission of low-frequency video components, including the direct-current component, is necessary in order to reproduce the picture with the proper average brightness, and with correct general shading over the reproduced scene.

The high-frequency characteristics of the circuit are closely related to the horizontal resolution since, in the rapid motion of the spot as it scans successive lines of the transmitted image, high-frequency components are developed by fine horizontal detail in the scene. This subject and the related matter of scanning-spot characteristics are discussed in one of the sections below.

THE MEASURE OF DETAIL

Detail in television practice is measured by the number of alternate black and white lines (the black lines having the same width as the white lines), which can be separately seen. In case the lines lie horizontally, the resulting observation obviously gives the resolution in the vertical direction; if the lines are vertical, the resulting observation gives the resolution in the horizontal direction.

Various charts have been designed on this principle for use as the subject for the television camera and so arranged that observations at the receiver can be conveniently made, giving the horizontal and vertical resolution of the system. In Figure 20 there is shown such a chart which we have used. This chart includes two horizontal wedges of approaching lines for observing vertical resolution. The point along such a wedge at which the separate lines partially disappear determines the resolution. The receiving picture tube is viewed at a fairly close distance for this purpose.

Reading the resolution chart requires some discretion and experience. Our recommendation is to locate a region along the wedge pattern as follows, and to take the reading in the middle of this region. This is the region of diminishing contrast between black and white lines. At one edge of this region, the lines just begin to lose their normal contrast; that is, the black lines begin to assume a grayish shade. At the other edge, the lines are just barely perceptible on the gray background. At the middle reading which is taken as the observed resolution, the lines are visible at reduced contrast.

If Figure 20 is held at a distance of about fifteen feet, such a reading for the eye alone may be made, and will illustrate the use of the chart.

The extremes of each wedge are designated 100 and 300; these figures indicate the total number of black and white lines resolvable in the entire height of the picture. Intermediate markers are provided at 150, 200, and 250 lines. The reasons why a maximum value of 300 lines is sufficient, and it is not necessary to go to 525 or beyond, are made clear in the later section entitled "Vertical Resolution." This method may be checked on a standard 525-line system operating under favorable conditions, where the vertical resolution should be about 394 lines.

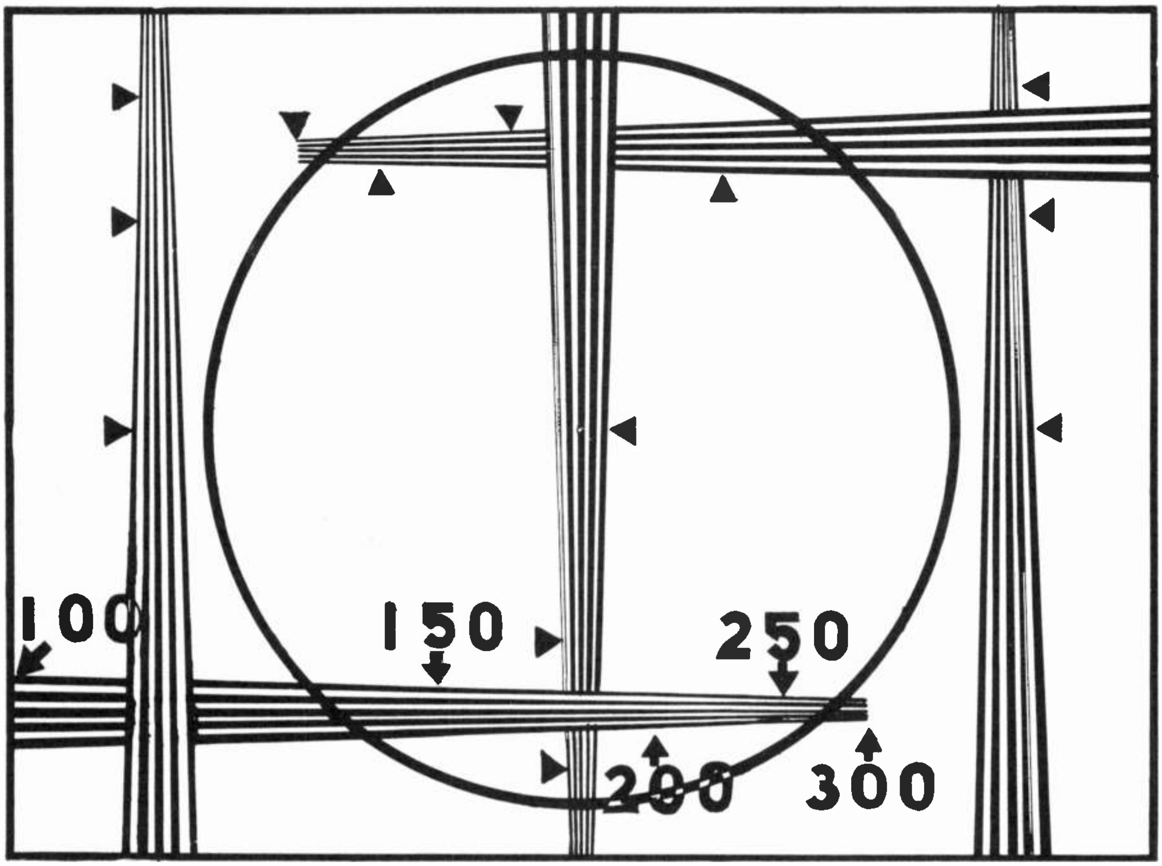


FIG. 20
RESOLUTION CHART

Figure 20 also includes three vertical wedges for observing the horizontal resolution. These are identical to the horizontal wedges just described. They therefore give the number of lines resolvable horizontally in a length equal to the height of the picture. The number of lines resolvable in the entire width of the picture is obtainable by multiplying by the aspect ratio, which is 4/3. However it is not desirable to use this quantity and in practice it is not done, because the important advantage of comparable figures for horizontal and vertical resolution would be lost. The horizontal resolution is therefore generally stated as the number of resolvable lines in a horizontal distance equal to the height of the picture.

THE SCANNING SPOT

In a mechanical television system, the shape of the scanning spot is determined by the shape of the aperture. In such a system the scanning operation is performed by the motion of this aperture. The intensity over the area of the aperture is constant.

In distinction to the mechanical aperture, a cathode-ray spot under practical conditions is circular in shape and non-uniform in intensity over this area. Such a spot may be visualized as a small mound with the highest point at the center. At the receiver the scanning spot is generally made small to give sharper detail, with the result that the line structure may be seen on inspection at close range.

However, at the usual viewing distance the line structure is nearly imperceptible, and therefore the apparent width of the scanning lines is equal to the line pitch.

A picture tube, under the conditions just described, may be said to have a "flat field," a term which indicates that the line structure cannot be seen. At the receiver this effect is ordinarily obtained by virtue of the viewing distance or, in other words, by virtue of the characteristics of the eye. However, in the mosaic tube at the transmitter it is desirable that a physically flat field be obtained. (This is accomplished by using a spot having an outside width of approximately twice the line pitch and an intensity distribution across the spot corresponding to a cosine-squared characteristic.)

VERTICAL RESOLUTION

As mentioned above, at the usual viewing distances a flat field is seen and therefore the apparent width of each scanning line is equal to the line pitch. The proper viewing distance is that which is barely sufficient to secure this effect. A horizontal narrow line in the scene will be reproduced by either one or two scanning lines depending on its position with respect to the scanning lines in the camera. If it is reproduced by one scanning line we may say that the relative resolution is unity, but if the reproduction requires two scanning lines we may say that the relative resolution is one-half. Figure 21 illustrates the two possible extremes in scanning a narrow horizontal line. In the second example it will be noted the line is reproduced with twice normal width and as gray instead of black.

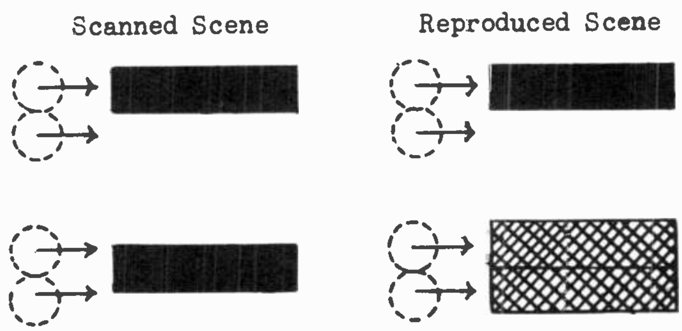


FIG. 21
LOSS OF DETAIL IN A NARROW HORIZONTAL LINE

A careful study has been made of the average width with which such a line is reproduced, considering all possible relations between it and the scanning lines. This was done by taking a slightly sloping line, almost horizontal in position. It was then necessary only to obtain the average width of reproduction along this line. The result arrived at in such an analysis is that a horizontal line is on the average reproduced with a width which is greater than the line pitch by the factor $\sqrt{2}$. Remembering that this is for average conditions in regard to the fortuitous relation between the narrow line and the scanning lines, it may be seen that a given number of scanning lines afford a vertical resolution which is only $1/\sqrt{2}$ times as great. The quantity $1/\sqrt{2}$ (or 70 percent) may be called the "vertical resolution factor." This is the chief factor explaining the need for only 300 lines as the maximum on the resolution chart.

In the case of the American television standards, when 441 lines per frame were provided. Of this number only 409 were used, and upon multiplying this number of useful lines by the vertical resolution factor, we obtain approximately 280 lines as representing the vertical resolution formerly afforded by the American standards.

HORIZONTAL RESOLUTION

The analysis of vertical resolution in the foregoing paragraphs is in terms of a line in a horizontal direction, or almost horizontal. For horizontal resolution, it is advantageous in an analogous manner to consider a very narrow vertical line, such as would be produced by a distant white flagpole against a dark background. The width with which such a narrow vertical line is reproduced at the receiver depends on (1) the size of the receiver spot, (2) the transmission characteristics of the electrical system, and (3) the size of the camera spot.

Considering only the size of the receiver spot, the narrowest vertical line in the picture is a vertical succession of spots as shown in Figure 22. Each spot producing this line is the result of a very short electrical impulse acting on the control grid of the picture tube. To produce such a pulse it is necessary that the camera spot be much smaller than the receiver spot and that the electrical system have perfect transmission characteristics. It is seen in Figure 22 that, under these circumstances, the vertical line has the same width as a horizontal line produced by the motion of the spot. Therefore the effective width of the vertical line is likewise equal to the line pitch.

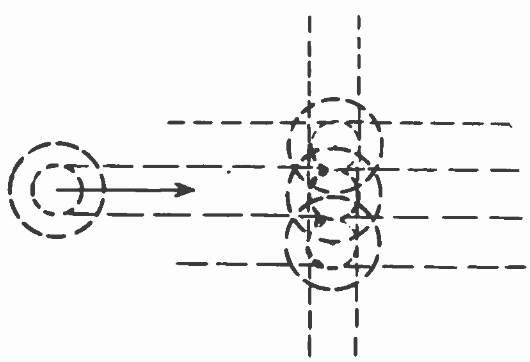


FIG. 22
DEMONSTRATION THAT THE MINIMUM WIDTH OF REPRODUCTION OF A VERTICAL LINE IS EQUAL TO THE PITCH OF THE SCANNING LINES.

Adding the effect of a camera spot of substantial width to that of the receiver spot causes, as would be expected, a greater blurring or soft-focus effect in the reproduction. There is therefore a greater width of reproduction of a narrow vertical line in the scene. This is caused by the width of the camera spot giving substantial duration to the electrical pulse. If the camera spot has the same relative size as the receiver spot, it is found that it increases the effective width of the vertical line by a factor of 4/3. The effective width is then 4/3 times the line pitch.

In addition to the camera and receiver spots, the third factor which determines the width of the reproduced narrow vertical line is the electrical characteristics of the connecting circuits. Irregularities in the transmission over the video-frequency range, in the nature of amplitude and phase distortion, may seriously widen and otherwise distort the received electrical signal pulses, and thereby increase the width of reproduction.

A scanning spot of a given size will handle the larger details of the field effectively. However, it will fail to handle very fine details, smaller than the spot size. Figure 23 shows an enlarged view of closely spaced vertical bars constituting very fine horizontal detail, too fine for the spot to handle. It may be seen that, with the spot shown, the action with successively finer detail is steadily poorer. This applies to either the camera spot or the receiver spot. The

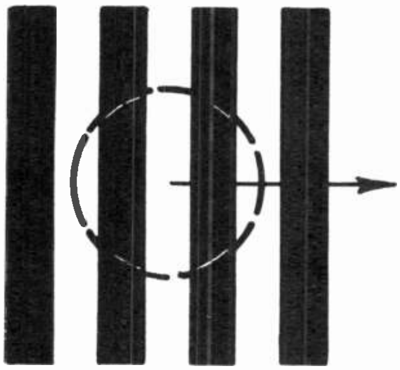


FIG. 23
THE FAILURE OF THE SCANNING SPOT
TO HANDLE VERY FINE
HORIZONTAL DETAIL

signal frequency associated with such detail rises as the detail becomes finer; in fact, it is equal to the frequency with which the spot passes alternate lines in the fine detail. On this account the spot may be said to attenuate the higher-frequency picture components to an increasing degree, and therefore to have low-pass filter characteristics.

The electrical portion of a television system has to pass only the components handled by the spots, and especially the major components. The more intense components appear to be at the harmonics of 30 and 60 cycles up to one or two kilocycles and at the harmonics of the line frequency of 15,750 cycles up to about one-half megacycle. Higher-frequency components are essential for horizontal picture detail but the amplitude of each is usually small.

EQUAL VERTICAL AND HORIZONTAL RESOLUTION

An optical system, such as a telescope or microscope, usually has a circle of confusion giving non-directional resolution characteristics; that is, the vertical resolution is equal to the horizontal. The presence of unequal resolution in the two directions gives an effect analogous to astigmatism in the eye, making small symmetrical objects appear unsymmetrical. In setting up the standards of a television system, it is natural to provide for equal vertical and horizontal resolution. It may be noted that this provision is consistent with the future possibility that, after standards are established and the vertical resolution is fixed, it may be beneficial in the receiver to have the horizontal resolution as great as possible, even if this is greater than the vertical. This subject is considered further in the section below entitled "Requirements at the Higher Video Frequencies."

The criterion of equal vertical and horizontal resolutions means that the widths of reproduction of the very narrow vertical and horizontal lines, which are considered above, are equal.

It has been shown above that the vertical resolution afforded by the RMA standards is 394 lines. For equal resolution in the two directions, the horizontal resolution must also have this value. An involved theoretical investigation has shown that where $(f_c)_{Mc}$ is the upper frequency limit of the system, and N_h is the horizontal resolution, the following equation, to a very close approximation, applies.

$$(f_c)_{Mc} = \frac{N_h}{100}$$

Substituting 394 for N_h in the equation shows the required cutoff to be 3.9 megacycles. In other words, horizontal resolution equal to the vertical resolution requires for the system a frequency range extending to 3.9 megacycles.

The American television standards, as well as the standards adopted in other countries for high-definition transmission, give a good picture in the sense that non-technical persons viewing the received programs consider them to have adequate entertainment value. Certain technical data which account for this fact may be mentioned. In comparison with motion picture practice the aspect ratio of 4/3 is the same. As another point, the receiving-tube screen gives satisfactory results when viewed at the optimum distance of 5 or 6 times the picture height. At this distance, the width of reproduction of the narrow line is about two minutes of arc, which is not much greater than the limit of resolution of the eye for light conditions on a picture tube.

REQUIREMENTS AT THE HIGHER VIDEO FREQUENCIES

The characteristics of a television system at the higher video frequencies, including both carrier-frequency and video-frequency operations, affect the sharpness of fine horizontal detail. If these higher-frequency characteristics are not satisfactory, spurious details may appear in the picture in the form of fine shadows and multiple images at vertical lines or edges. In this section the transmission requirements at the higher video frequencies are considered.

As indicated in the previous section the transmission characteristic of the receiver should extend to the value of f_c, which is 3.9 megacycles, and preferably somewhat above, in a gradual cutoff. If the receiver has a higher cutoff than this, the horizontal resolution will slightly exceed the vertical, in case the station transmits these components. Such improvement in picture detail must be weighed against the increased cost of the extended receiver transmission characteristic. If the receiver cutoff is below 3.9 megacycles, there will be a proportional reduction of the horizontal resolution. In receivers using a small picture tube the vertical resolution may be somewhat less than 394 and accordingly the band-width of the receiver may logically be reduced a corresponding amount to give a horizontal resolution comparable to the vertical.

Sesqui-Sideband Requirement

The sesqui-sideband method of operation introduces a transmission requirement which is superimposed on the other requirements described, and which can be considered as relating to the higher video frequencies. This is the requirement that the system have an attenuation of 6 decibels for the carrier relative to the transmission for the upper video frequencies of modulation of the full side-band. In other words, these upper video components must be accentuated by 6 decibels in comparison with the carrier.

In Figure 24, the upper diagram shows three transmission characteristics for the receiver, on the basis respectively of zero, 3 decibels, and 6 decibels as the receiver's share of the attenuation of the carrier. (The desired 6 decibel attenuation curve is the lowest shown). The ordinates and abscissas in Figure 24 are plotted on linear scales. At the left of the upper diagram an additional guard band of 0.25 megacycle is shown as an added protection against interference from the sound carrier of the next lower channel. In the case of more than one television station in a given city, there will probably be receiving locations where such an undesired adjacent-channel sound carrier is considerably stronger than the picture carrier of the desired station. At the right of this diagram, the curve is shown sloping down to a very small value of transmission for the sound carrier of the desired station. In the lower diagram of Figure 24, a representative transmission characteristic for only the video portion of the receiver is given.

Effects of Amplitude and Phase Distortion

The analysis of amplitude and phase distortion by necessity requires mathematical treatment which is somewhat too involved for use in this elementary course. Accordingly, this section will be limited to describing an example of such distortion.

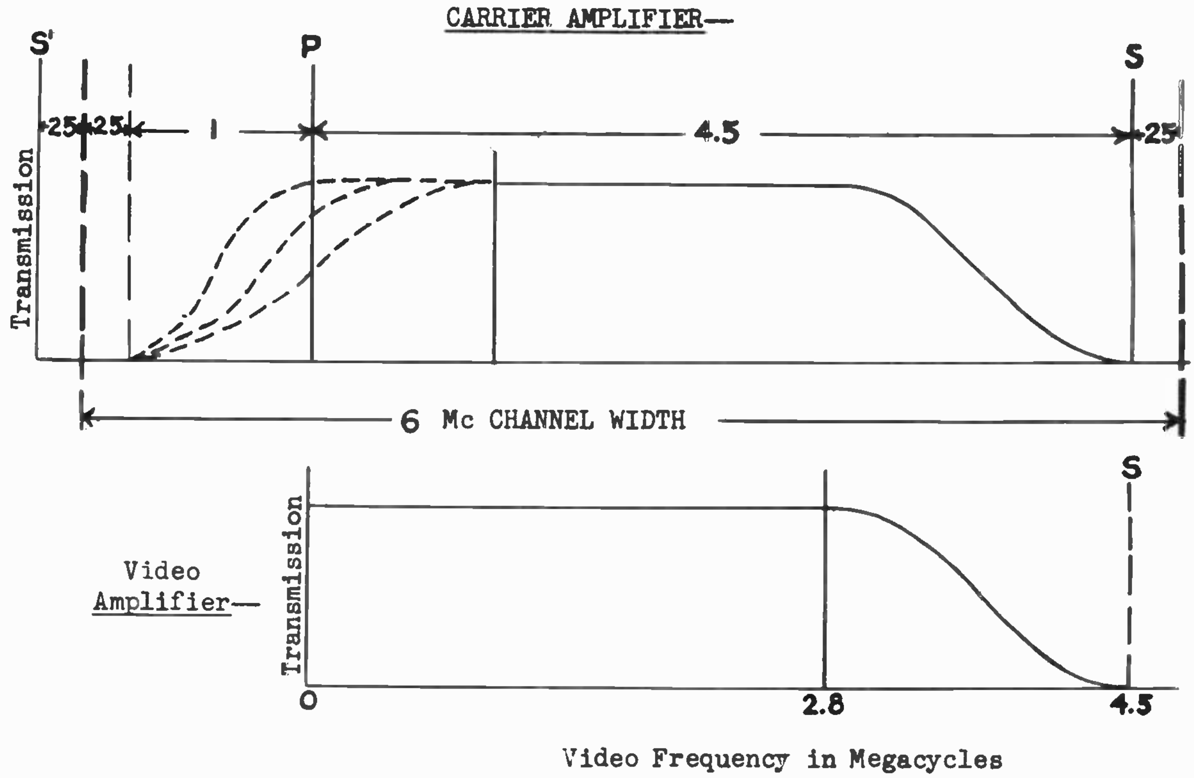


FIG. 24

AMPLITUDE CHARACTERISTICS OF THE CARRIER-FREQUENCY AND VIDEO-FREQUENCY AMPLIFIERS OF THE RECEIVER.

In Figure 25 is shown the effect on a fairly narrow pulse of a system having both a limited frequency range and phase distortion. The dashed line may be considered to represent a vertical object in the picture, with the object repeating with a period of ten times its width. The solid line shows the output of the amplifier if components above the twentieth harmonic were cut-off. That is, the highest-frequency component passed by the amplifier has a period one-half the width of the pulse. The phase distortion is assumed to be leading at the lower frequencies and lagging at the higher frequencies in an amount that may occur in a receiver. The combined effect of sharp cut-off and the phase distortion gives little distortion of the leading edge but a severe transient oscillation on the trailing edge. Multiple images of light and dark in the picture are the result of the transient oscillation. In understanding the above concerning frequency distortion it should be recalled that a rectangular pulse with sharp corners is composed of an infinite number of components of generally decreasing amplitude at higher frequencies. (An analysis of such a rectangular wave may be made by the Fourier Series method.)

Application of These Principles to the Sections of the Receiver

The foregoing discussion of high-frequency transmission characteristics is in terms of the video frequency, including the effect of carrier-frequency circuits on the video modulation. From a practical standpoint, the various portions of the receiver must be considered and this is done briefly in the following paragraphs.

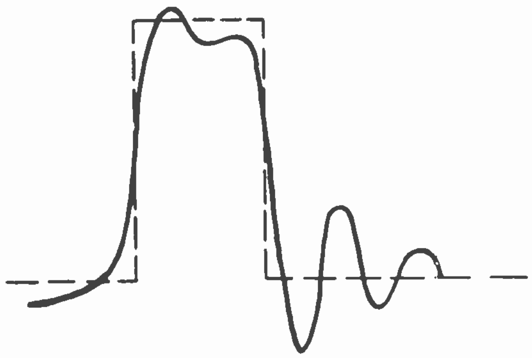


FIG. 25
THE EFFECT OF BOTH SHARP CUTOFF AND PHASE DISTORTION ON A FAIRLY NARROW PULSE.

The antenna and its transmission line, taken with the wave pattern in the transmission medium, may introduce serious amplitude and phase distortion. Such effects are produced by nearby reflections of the waves and by reflections due to mismatching or departure from critical damping in the antenna system. From a design standpoint, the solution lies in the matching of impedances at the various points, or in the provision of critical damping. Attenuation in the transmission line reduces some of these effects.

As for the antenna design, it should be free from frequency selectivity over its operating range. This property is obtained in highly damped small antennas, but only in certain types of large antennas (large as compared with the operating wavelengths). Also this requirement must be considered in the use of reflectors or other devices for securing directive characteristics.

In the installation of a television receiver a certain amount of experimentation may be essential even with a well designed antenna kit. It is necessary to locate the antenna at a point where sufficient signal from one or more stations is received without objectionable echoes and without objectionable noise. There is a possibility of serious interference from automobile ignition systems.

The radio-frequency amplification of the receiver should not be too selective, although it may be called on for the reduction of image response and the prevention of cross-modulation. Its selectivity in the desired channel is considered as modifying the band-pass characteristics of the intermediate-frequency amplifier.

The intermediate-frequency amplifier of the receiver is the main source of selectivity. It is desirable that it have level amplification and relatively linear phase characteristics. However, since some of the carrier attenuation necessary in the sesqui-sideband method of operation is to be furnished in the receiver, some or all of the receiver's share may be located in the intermediate-frequency amplifier. In this case it will be sufficient for the phase to be linear over only the fully used sideband. There should be enough selectivity in the intermediate-frequency amplifier against the sound carrier of the same station to avoid sound detection in the picture detector, which would produce interference in the picture by the audio frequencies appearing as low video-frequency components. It is considered that 15 to 25 decibels attenuation relative to the picture carrier is sufficient.

In connection with the video amplifier, the above discussion of transmission characteristics is directly applicable. Since carrier attenuation in connection with the sesqui-sideband method is to be provided in the receiver, some of this may be located in the video amplifier in the form of reinforcement of the higher video frequencies. Should the provision of phase-correcting networks be made, it is better to locate them in the video amplifier, where such correction is obtained more easily than in the carrier amplifiers. Some selectivity against the sound carrier of the same station should be provided in the video amplifier to prevent the formation of a very fine line by the sound carrier acting as a high-frequency picture component. For such a high video frequency, namely 4.5 megacycles corresponding to the beat note with the sound carrier. there is appreciable attenuation in the receiver spot; adding this to the electrical attenuation should give a total overall figure of the order of 40 decibels. About 15 to 20 decibels at 4.5 megacycles is desirable in the video-frequency amplifier.

REQUIREMENTS AT THE LOWER VIDEO FREQUENCIES

The lower video frequencies correspond in carrier amplifiers to side frequencies located so close to the carrier frequency that there is little likelihood of impairment of the transmission. The problem of securing satisfactory transmission characteristics at the lower video frequencies therefore exists chiefly in video-frequency couplings.

Low-frequency video components, including the direct-current component, may be transmitted thru a video amplifier by the use of direct coupling, or may be lost and recovered by the use of the principle of reinsertion which will be covered later. The preservation of the low video frequencies in addition to the direct-current component by means of re-insertion is possible because the reinserted direct-current component can vary with time in the manner necessary to reinsert these low frequencies.

A T. T. I. TELEVISION RECEIVER
WITH 16 INCH ROUND TUBE
INSTALLATION

CHAPTER 5 - CHIEF FEATURES OF THE TELEVISION RECEIVER.

INTRODUCTION

The two preceding chapters describe the requirements which the television receiver must satisfy as determined by the characteristics of the transmitted wave and by the desired fineness of picture detail. The present chapter gives a general description of the parts of the receiver and a discussion of the operations by which these requirements are met.

GENERAL ARRANGEMENT OF RECEIVER

Figure 26 shows the general circuit arrangement of a typical television receiver in block form. There are a great many operable circuit combinations, the larger number of functions giving a greater variety than is possible in a broadcast receiver. The one chosen for illustration might be used in a rather high-priced television receiver. In the less expensive receivers a few of the parts might be omitted and other parts might be combined to simplify the construction.

The small curves in Figure 26 show the transmission characteristics of various portions of the circuit. In addition the wave-forms of the signals involved are indicated. The significance of these will be apparent in the following account of the operation.

In its general plan the receiver of Figure 26 is a superheterodyne. There is a radio frequency amplifier preceding the first detector. This is followed with audio and video intermediate-frequency amplifiers, audio and video second detectors, and audio and video frequency amplifiers. As far as the block diagram shows, the function of the parts in the picture channel are the same as in the sound channel. The principal differences between the video portion of Figure 26 and a conventional sound receiver are in the auxiliary channels which select portions of the incoming signals for special purposes. The radio-frequency circuit and modulator handle both picture and sound carriers, converting them to intermediate frequencies which are amplified in separate circuits. At the video second detector the circuit splits three ways, providing information for the video amplifier, video AVC circuit and synchronizing circuits.

The transmission curve for the radio-frequency stage, is wide enough to accommodate both the picture and sound carriers, which have a separation of 4.5 megacycles. The oscillator of the receiver operates at a higher frequency than either incoming carrier, and therefore produces a picture intermediate frequency which is higher than the sound intermediate frequency. Both carriers are moved down in frequency by the action of the modulator.

Since the video band extends to about 4 megacycles, the chosen intermediate band must all lie above this value; otherwise the intermediate-frequency band cannot be separated from the video frequencies. It is desirable to keep the intermediate frequency below 40 megacycles because about here the input conductance of the available vacuum tubes begins to become an important factor. Difficulties from stray capacity coupling and from lead inductances are also troublesome at higher frequencies. The selection of a particular intermediate-frequency band between these limits of say 20 to 40 megacycles depends on the location of strong stations which might produce interference. The most serious danger of interference at intermediate frequency is from foreign short wave transmitters operating in the neighborhood of 7 and 14 megacycles.

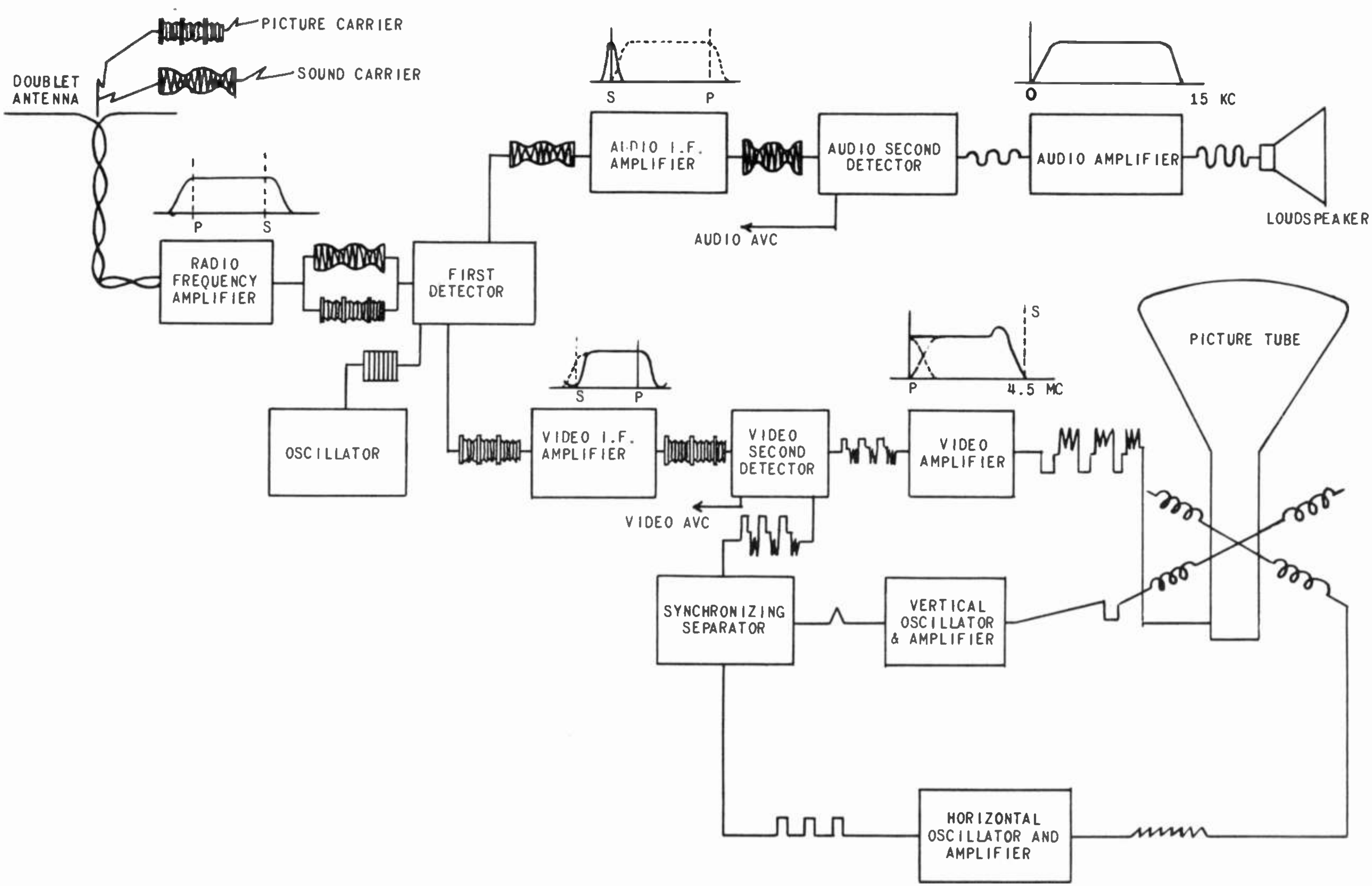


FIG. 26
ARRANGEMENT AND TRANSMISSION CHARACTERISTICS OF TYPICAL TELEVISION RECEIVER

The F. M. sound channel, from a transmission standpoint, needs only pass the frequency band required for a high-fidelity reproduction of the sound portion of the program. Frequency modulation would have the additional important advantage of being less vulnerable to automobile-ignition interference. However, the provision of an intermediate sound stage with a conventional FM bandpass of 150 kc would impose a severe stability requirement on the frequency of the oscillator. Consequently an I. F. capable of passing a total width of the order of 300 kilocycles is generally provided. The occurrence of interference in the sound channel due to video components in the neighborhood of 4.5 megacycles can be prevented only by suppression of these frequencies at the transmitter.

The transmission curves shown in Figure 26 for the intermediate stages which carry the picture signals show some attenuation at the picture carrier. This attenuation is sufficient to add up to an overall of 6 decibels from the antenna to the video detector.

The video amplifier may connect to the picture tube either directly or by means of an alternating-current coupling and a reinserter. In the latter case the reinserter may be thought of as contributing a transmission characteristic declining with increasing frequency, as shown by the dotted line in the sketch, while the alternating-current coupling contributes the opposite characteristic shown by the dashed curve; the overall result is flat down to zero frequency as shown by the solid curve.

The synchronizing separator eliminates by amplitude discrimination the picture portion of the signal leaving only the horizontal and vertical synchronizing pulses. These are separated and used to control the timing of the horizontal and vertical oscillators. The output of each oscillator is reenforced by one stage of suitable amplification, and the resulting saw-tooth current is passed thru the corresponding winding of the scanning yoke for the deflection of the scanning spot

RECEIVER CONTROLS

The number of controls which can be provided in a television receiver is imposing when it is realized that, from the user's standpoint, it is desirable to require as few adjustments as possible. For a further consideration of the matter, the following controls are of interest:

General:

(1) On-Off Switch

(2) Television-broadcast switch (to turn off the television portion of the receiver when receiving ordinary broadcast signals);

(3) Channel selector (switch positions or push buttons, one for each TV

(4) Vernier tuning control;

Sound Channel:

(5) Volume control;

(6) Tone control (one or two);

Picture Channel:

(7) Contrast control;

(8) Brightness control;

(9) Focus control;

Line Scanning:

(10) Horizontal hold control;

(11) Horizontal centering control;

(12) Horizontal size control;

(13) Horizontal linearity control;

Field Scanning:

(14) Vertical hold control;

(15) Vertical centering control;

(16) Vertical size control;

(17) Vertical linearity;

A few of these controls need further explanation. The main tuning control (#3) tunes the set to the desired frequency. To compensate for oscillator drift a vernier tuning control (#4) is required. A slight oscillator drift may tune the set off the sound channel. This is very apt to happen, for instance, if the highest frequency band (210 to 216 megacycles) is being received with the oscillator operating at about 237 megacycles. If the sound channel is only 300 kilocycles wide, an oscillator frequency drift of one part in 4600 will move the sound channel from the center of the pass-band to one edge. The problem is less severe of course at the lower frequencies and with intercarrier sound channels. Another difficulty caused by slight oscillator mistuning is that the picture carrier moves away from the point on the receiver response curve which gives the required 6 decibels attenuation. With all of the attenuation located in the receiver and with the sharp-sided selectivity curve furnished by a highly selective receiver, this problem becomes serious.

The contrast control (#7) adjusts the gain to give the desired voltage swing on the picture-tube grid. If the receiver has automatic volume control, the contrast control may be located beyond the last stage having automatic control, and also beyond the point at which the synchronizing signal is taken off. If the set does not have automatic volume control, the contrast control varies the bias on the radio-frequency and intermediate-frequency tubes.

The brightness control (#8) is used to adjust the bias of the picture tube and should be set so that the black level in the picture signal coincides with the cutoff of the picture tube.

The focus control (#9) adjusts the size of the spot. It differs from most of the controls in the picture channel in that the ordinary customer has no difficulty in understanding its purpose or in adjusting it.

The controls listed for the scanning system should be located in some place where they will not be touched by the customer, at least until he has spent considerable time adjusting the other controls. The two "Hold" controls are intended to set the oscillator constants within the range over which the synchronizing signal maintains synchronism. The centering control is used to correct for variations between tubes. It ordinarily requires no adjustment except when a new picture tube is installed. The size controls are needed to adjust the lengths of the scanning paths according to the mask used to frame the picture. They are adjusted only when there is a drift in the values of circuit components or a change in tube characteristics. The linearity controls are for the maintenance of linearity in the trace portion of the saw-tooth scanning wave. Adjustment of these is also required only to compensate for changes in tube characteristics or drift in resistors.

THE ANTENNA

Television receiving antennas will be of more standardized designs than those which are generally used for broadcast reception. A short piece of wire, such as the usual indoor antenna, will frequently pick up sufficient signal strength to operate the television receiver. The pickup of such an antenna is, however, generally too variable over the frequency range of a single television channel, so that some of the video frequencies will be far too strong or too weak. For this reason television antennas almost always have the form of a doublet, which can be made to pass uniformly a broad band of frequencies.

A common difficulty encountered with television antennas is the reception of one or more reflected waves along with the direct wave. Such reflected waves have necessarily traveled longer distances than the direct wave, and therefore arrive later and produce on the screen repetitions of the picture displaced to the right. This causes the appearance of ghosts or echo effects. Such a condition can be prevented by the use of directivity, so as to discriminate against the undesired waves. In some cases interfering noise is more serious than multiple paths, and the directivity of the antenna can be best used to discriminate against the direction of the noise. The multiple-path effects are more common close to the transmitter, at least where the transmitter is located in a city having many tall buildings. In a few locations close to a transmitter, where more than one station is to be received, it may be necessary to use a different antenna system for each station, each system having the proper directional characteristics.

In locations sufficiently far from the transmitter so that there is insufficient signal strength to override the receiver noise (thermal agitation and tube noise), directional antennas may be used to increase the signal pickup.

The great majority of television antennas will therefore be simple horizontal doublets. The rest of the antennas will be more directional types, usually consisting of two doublets of which one is the antenna proper and the other a reflector. Considerably more complicated arrangements, such as wave antennas, can be used for further improvement.

In case the transmission line from the antenna is improperly terminated at the antenna and receiver ends, the received wave may traverse the antenna system more than once; that is, it may be reflected at the receiver, return to the antenna, be reflected again, return to the receiver, and there cause a faint multiple image. Such images give the same type of distortion as that caused by multiple-path transmission.

RADIO-FREQUENCY CIRCUITS

With the usual balanced transmission line, the antenna coupling system must perform the following functions: (1) provide a suitable impedance termination for the transmission line; (2) convert from balanced operation at the input side to unbalanced operation at the output side; (3) provide voltage gain; and (4 provide selectivity.

INTERMEDIATE-FREQUENCY CIRCUITS

Several types of intermediate-frequency transformers are available. The simplest type, a two-circuit transformer, is suitable for use in some positions. In addition there must be intermediate-frequency transformers in the picture channel having trap circuits for the sound channel of the desired station and others having trap circuits for the sound channel of the next lower station. The trap circuit which is tuned against the sound signal of the desired station must of course be in such a stage that the sound intermediate-frequency voltage can be tapped off ahead for the sound channel of the receiver.

THE DETECTOR

After amplification at an intermediate-frequency, the signal must be detected before it can be used to control the grid of the picture tube. The problem of separating the video frequency signal from the intermediate-frequency output involves special consideration in order that the full range of video frequencies will be present in the output of the detector.

SEPARATION OF SYNC SIGNALS

The sync signals are separated from the complete video wave by some form of a limiting circuit which will pass only the portion of the signal containing the sync pulses. Such circuits will be discussed in a later section. The sync pulses are then separated by any of a number of methods and used to control the timing of the horizontal and vertical saw-tooth oscillators. These circuits also will be discussed in a later section.

THE PICTURE TUBE

The picture tube is fundamentally similar to the tubes used in oscilloscopes. Three points of difference, however, may be mentioned: (1) the sizes of picture tubes are usually large; (2) the colors are generally an approach to white; and (3) the electron gun must include provisions for modulation, that is for controlling the intensity of the beam in accordance with the received video signals.

The present performance of picture tubes is the result of much improvement in the efficiency and color characteristics of fluorescent screens, and also in the design of electron guns.

The fundamental requirement is for the electron beam to produce a luminous spot of high intensity. Using the efficiency factor of the screen, this luminous effect corresponds to a given number of watts energy in the beam. This power may be obtained by means of various combinations of current and voltage. Two considerations lead to the choice of high voltage and low current as the preferred operating condition: (1) higher voltage makes the initial random velocities of the electrons a smaller percentage of their final velocity, and thus facilitates focusing; and (2) high current is difficult to obtain with practicable designs of the cathode and the small apertures of the electron gun.

CHAPTER 6 - DIRECT-CURRENT INSERTION

INTRODUCTION

In chapter 3, a section outlines the nature of the direct-current component which may be present in alternating-current waves, and discusses the uses of the direct-current component in a television receiver. In the section referred to it was pointed out that: (1) the voltage wave finally used to actuate the picture tube of the receiver should contain the direct-current component, which represents the average brightness; and (2) the operation of separating the sync signals from the picture signals requires the presence of the direct-current component. The present chapter deals with the theory of DC reinsertion and the methods by which it is accomplished.

DC REINSERTION USING A DIODE

It is an obvious fact that the direct-current component as represented by the carrier amplitude of the radiated signal is impressed on the video second detector, since the radio-frequency and intermediate-frequency portions of the receiver do not materially alter the form of this signal. The video detector may be either a plate circuit rectifier or a diode rectifier, but because of its simplicity the latter is usually used. In the upper diagram of Figure 26A is represented the variations in carrier amplitude during the transmission of two successive horizontal lines of a scene having a white field with a narrow vertical bar. Figure 26B represents

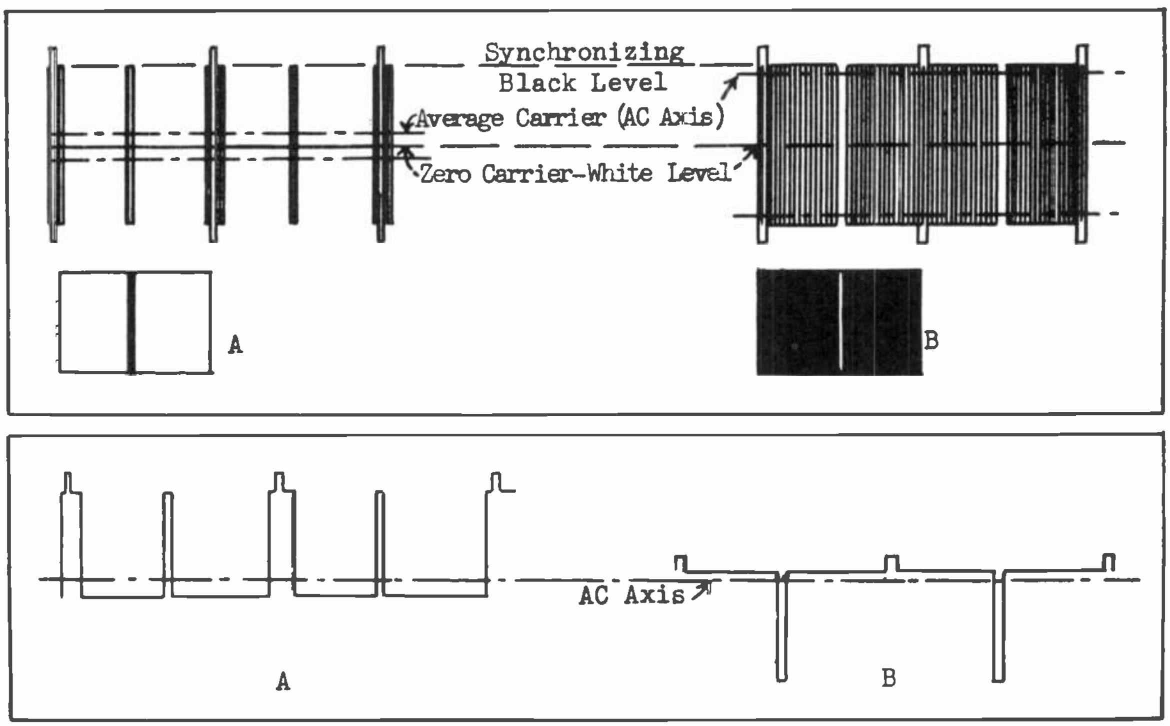


FIG. 26

CARRIER ENVELOPE FOR TWO CONDITIONS OF BLACK AND WHITE
IN TRANSMITTED PICTURE, AND VIDEO SIGNAL SHOWING AC AXIS

the variations during the transmission of a picture having a black field with a single narrow vertical white line. When the intermediate-frequency signal of Figure 26 is applied to the diode the signal appearing across the diode load resistor will be essentially the same as one-half of the input wave. The direct-current component of the signal present in the modulated wave will also be present in the signal across the diode load. Accordingly, white in the picture is represented by minimum voltage across the load, black by 80% of maximum voltage, and the synchronizing information by the upper 20% of the voltage range.

If the output of the video detector were sufficiently great it would be possible to couple the grid of the picture tube directly to the load resistor. However, in practice one or more video amplifier stages will usually be utilized. Since a direct coupled amplifier is difficult to handle because of instability at low frequencies, the direct-current and low video frequencies are removed by using capacitance and resistance coupling between the stages. The direct-current and low frequency components are then reinserted at the grid of the last amplifier tube.

Without the direct-current restoration the signal applied to the grid of the picture tube would vary about its alternating-current axis as shown in the lower portions of Figure 26. As can be seen, the height of the top of the synchronizing pulses above the AC axis is not constant, but varies in proportion to the average amount of white in the picture being scanned. An inspection of the video signal shown in Figure 26A reveals that the signal extends above the AC axis approximately four units and below the axis one, while in 26B the signal extends above the axis slightly more than one unit and below almost four units. In each case the sync peaks are one unit greater in amplitude than the blanking pedestal but in A the blanking pedestal extends three units above the axis while in B the blanking pedestal is but a fraction of a unit above the axis. Obviously if the blanking pedestal in the first example were of proper amplitude to cause the picture tube spot to be extinguished, such would not be the result in the second case. Normally the video amplifier tube or picture tube is operated so that the grid is negative with respect to the cathode. In order to accomplish this, if it is assumed that the pulses above the axis are positive, a negative bias must be placed on the grid which is equal to the amplitude of the wave above the axis. If five units of negative bias were applied to the grid, then the sync peaks when scanning a white scene would just equal the negative bias, thus putting the grid at zero instantaneous potential with respect to the cathode. With this bias, while the grid would never be positive with respect to the cathode, the blanking pedestal which should always represent such a potential such as to extinguish the spot, would only do so for one particular value of average brilliancy transmitted.

In order that the blanking pedestals may always place the grid at such a potential as to extinguish the spot, it is necessary that the pedestals be "lined up" to the same height or potential when applied to grid. Since the sync peaks are always the same amount greater in amplitude than the blanking pedestals irrespective of the AC axis position it would of course suffice to line up the sync peaks. This can readily be accomplished by using a peak detector, or rectifier, which will develop a bias just equal to the amplitude of the sync peaks above the AC axis. Such a circuit using a diode is shown in Figure 27.

An explanation of the circuits operation is easily understood by reference to the diagrams in the lower portion of Figure 27. Initially, when the set is first turned on or when no signal is being received the potential across C, the coupling capacitor is zero, neglecting the B plus potential. However, as soon as a video signal appears across the load resistor of the preceding stage, it is applied to the diode by C. It is of course varying about the AC axis as no DC is present. When the

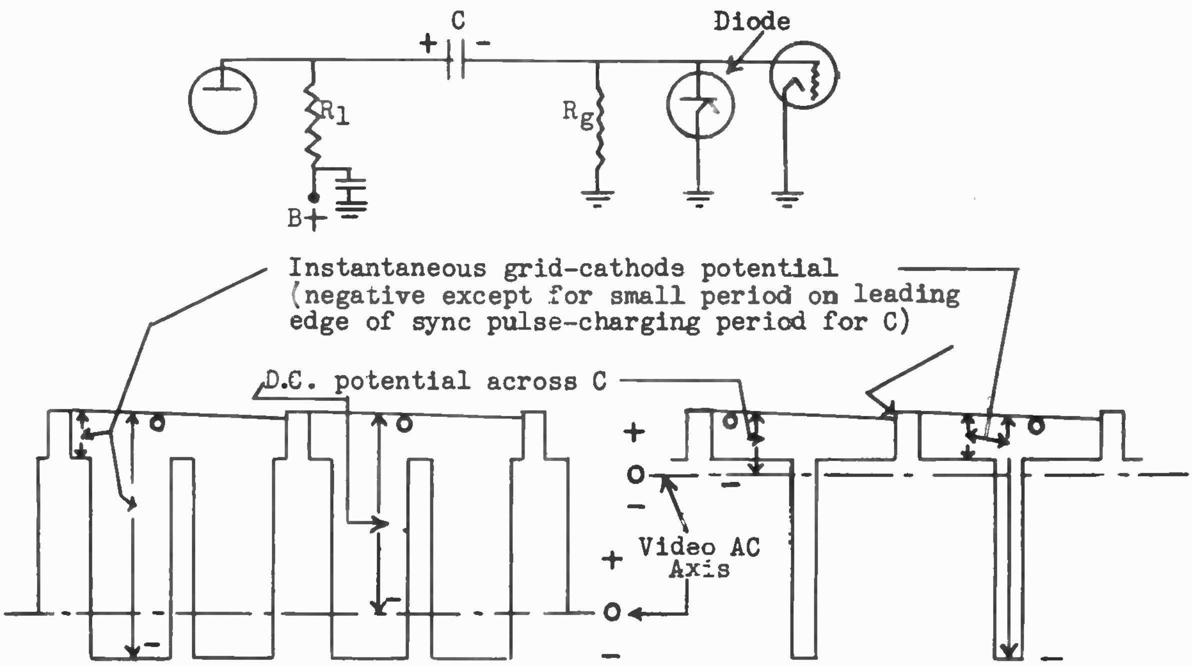


FIG. 27
CIRCUIT USING A DIODE FOR RESTORING THE DC COMPONENT TO THE VIDEO SIGNAL

diode plate becomes positive with respect to the cathode it conducts, and can be considered a short to ground. With a positive video potential on the side of the capacitor away from the diode and ground potential on the diode side, there exists a potential difference across the capacitor and it becomes charged after several horizontal cycles to a value just equal to the difference between the sync peak potential and the AC axis. When a sync pulse has passed, C discharges relatively slowly through R_g which is much higher in resistance than the diode is when conducting. The DC potential built up across C can be considered to be a negative bias just equal to the difference between the sync peaks and the AC axis of the video signal. The time constant of the grid resistance and coupling capacitor should be sufficiently long to maintain the bias substantially constant during the picture intervals between line sync pulses, but sufficiently short to follow the variations introduced by the time constant of the video frequency circuits preceding this point. It will be noted from the diagram that the diode current flows during the peaks of the sync pulses, thus maintaining them at approximately the zero bias point regardless of the position of the AC axis, and that the blanking pedestal or black level therefore occurs again always at the same voltage level, as it did in the video detector circuit before the DC component was lost. It must be born in mind that the video AC axis which has been repeatedly referred to is the AC axis when many horizontal cycles are considered and is not the axis or average value of the video information contained in a single line. The number of lines which must be considered in determining the video AC axis is dependent upon the RC time constant, that is, the product of R_g and C in the circuit diagram of Figure 27. In practice the time constant is usually made to have a value of the order of .01 to .05 seconds.

As indicated in the previous paragraph it should be noted that not only the DC component is lost and then restored, but some of the extremely low video frequencies are likewise lost and restored.

DC REINSERTION USING GRID OF VIDEO AMPLIFIER AS RECTIFIER IN PLACE OF DIODE

Since the grid of an amplifier tube draws current when it is positive with respect to the cathode, it is possible in many cases to eliminate the diode in the DC reinsertion circuit shown in Figure 27. The grid then acts as a rectifier to charge capacitor C to a potential equal to the excursions of the sync peaks above the video AC axis. The impedance of a diode when it is conducting is usually somewhat lower than the grid-cathode impedance under the same conditions but this is usually not a particularly important factor insofar as the DC restoration circuit is concerned.

The method just outlined for obtaining the variable bias necessary for DC reinsertion operates in the same general manner as grid leak bias used in oscillators and amplifiers.

CHAPTER 7 - SYNCHRONIZATION

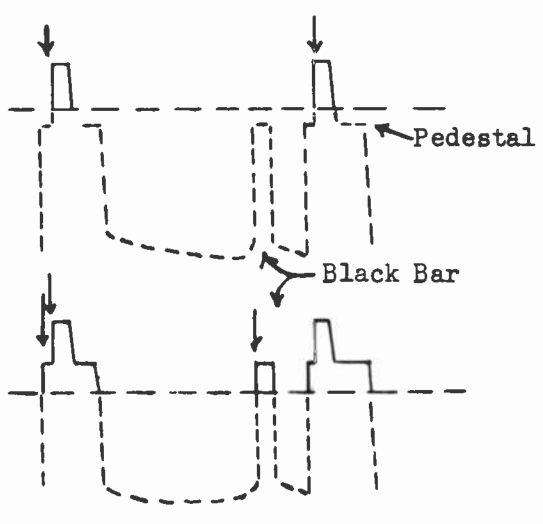
INTRODUCTION

In order to reproduce a true image on the screen of the picture tube, the scanning spot at the receiver must accurately trace the same pattern as the spot in the camera tube. As outlined in previous chapters, the synchronization of the scanning at the receiver with that at the transmitter is accomplished by transmitting characteristic pulses at the end of each line and at the end of each field. These synchronizing pulses as shown in Figure 10, page 21, occupy a region of signal voltages greater than that representative of black, or more precisely the region of carrier amplitude from 80-100 percent of the maximum carrier.

The present chapter outlines various methods used to separate the synchronizing signals from the picture signals, and also methods of separating the horizontal synchronizing pulses from the vertical synchronizing pulses.

SYNCHRONIZING SIGNAL SEPARATION

In order to prevent the picture information from interfering with the synchronizing circuits it is necessary to separate the synchronizing pulses from the remainder of the transmitted signal. This would ideally be done just at the blanking level, but practically it is advisable to do it at a slightly higher level in order to avoid any possibility of interference from the picture signal. It is obvious that if the picture signals were allowed to affect the synchronization, a black portion would trigger the line oscillator ahead of time, since this oscillator is always timed by a leading edge. Proper and improper separation of sync signals are shown in Figure 28. In the lower diagram it can be seen that a black bar in the picture information might by improper separation have the same affect as a horizontal sync pulse in timing the horizontal oscillator.



PROPER SEPARATION

IMPROPER SEPARATION

FIG. 28
CORRECT AND INCORRECT SEPARATION OF SYNC SIGNALS FROM PICTURE INFORMATION

There are three well-known methods of separating the sync signals from the picture information. The biased diode method shown in Figure 29 is probably the simplest. In this circuit the diode draws enough current on sync peaks to establish a

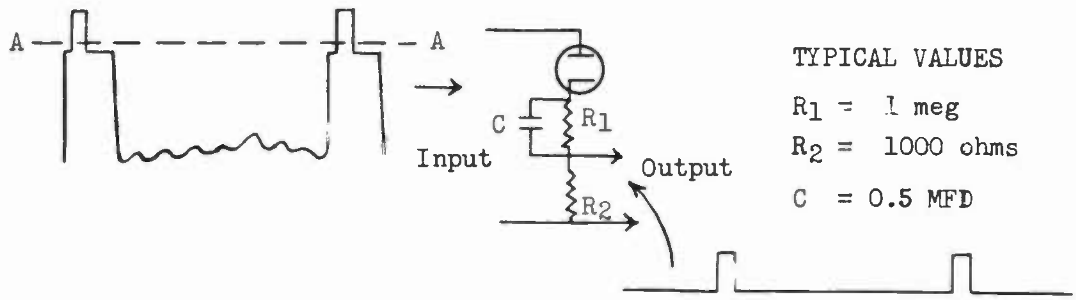


FIG. 29
BIASED DIODE SEPARATOR

bias across C which is sufficient to keep the diode from conducting except when the input voltage exceeds the potential A-A. However, when the potential rises above A-A, that is, on sync pulses, the diode conducts and a voltage appears across R_2 proportional to the sync pulses. This system is satisfactory except that the output is relatively small, and some video signal is coupled to the output circuit by the diode's plate-cathode capacitance.

A second type of separator circuit using grid current limiting is shown in Figure 30. In this circuit a relatively large resistor, R_1, is applied between the coupling capacitor and the grid. When the signal is positive the grid draws current and is a low impedance path to ground. R_1 and the grid-cathode impedance act as a voltage divider and since the grid-cathode impedance is low when the grid is positive, most of the signal will appear as a voltage drop across R_1, with a very small amount between grid and cathode. However, when the grid is negative, as on sync pulses, the grid cathode impedance will be high and most of the signal will appear between the grid and cathode. Accordingly the output will occur mainly when the signal is in the negative region or on the sync pulses.

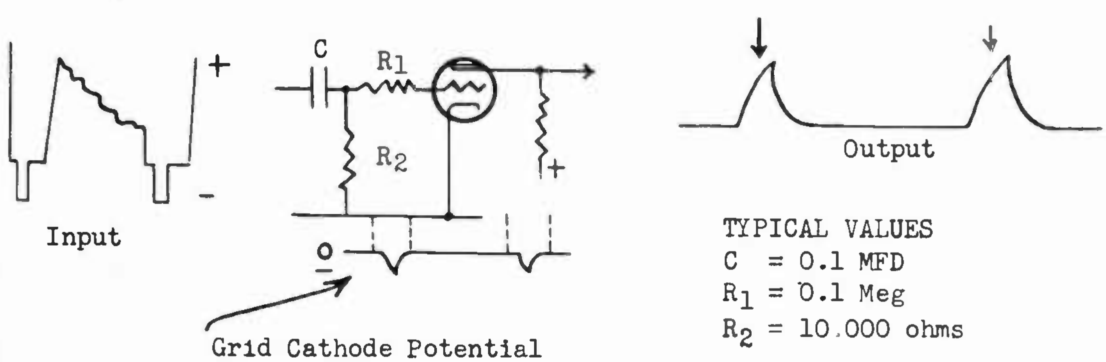


FIG. 30
GRID CURRENT LIMITING SEPARATOR

There are two objections to the grid limiting circuit, although it has been used in a number of early television receivers. First, R_1 and the input capacitance of the tube forms a low-pass filter which rounds off the sharp corners of the pulses and delays the triggering. Second, no matter what tube is used, the impedance of the grid-cathode path is enough so that the video causes some change in grid-cathode potential, and hence in plate current during the interval between sync pulses. This may result in a different AC axis for signals containing varying picture information. The difficulty results from the fact the sync pulses have a finite slope, and since the saw-tooth oscillators trip at a given level, any shift in the AC sync pulse axis advances or retards the point at which the sync wave crosses the triggering level. The low pass filter effect, mentioned above as rounding off the sharp corners of the pulses, makes this condition even worse.

The third type of separator or "clipper" is used in General Electric television receiver. In Figure 31 is shown the circuit using a triode operating at low plate voltage. The sync peaks are "lined up" by DC reinsertion which is accomplished by the grid current charging the grid capacitor to a potential where only tips of the pulses draw grid current and all the video lies beyond cut-off. Thus, the video information cannot influence the plate voltage at all except thru the small grid-plate capacitance, and since there is considerable gain in the tube, this effect is usually small.

This circuit can be improved in the presence of random noise by using a small series grid resistor so that there is some grid-current limiting and the output is more free from all small disturbances. This is shown in Figure 32.

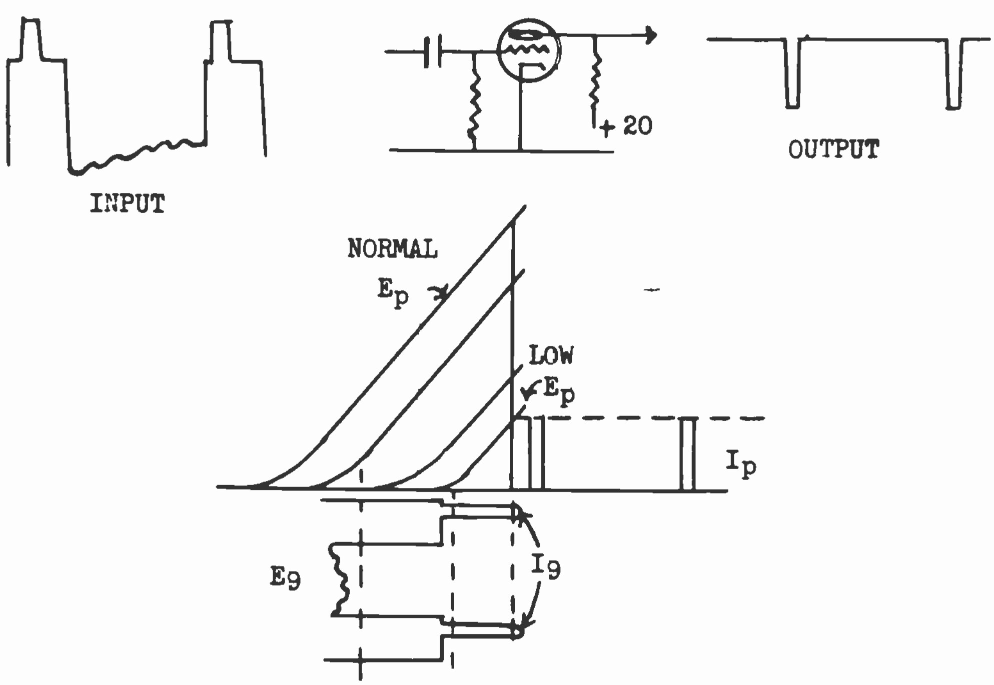


FIG. 31
TRIODE CLIPPER USING DC REINSERTION

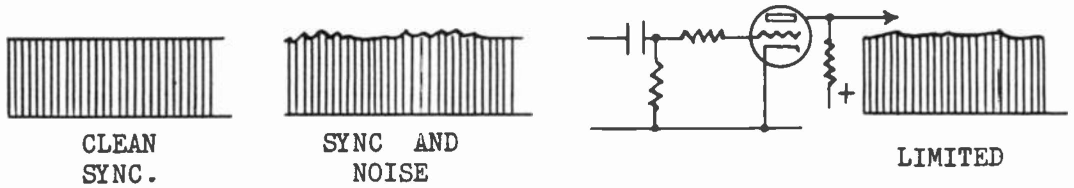


FIG. 32
TRIODE CLIPPER USING DC REINSERTION AND SMALL AMOUNT OF GRID-CURRENT LIMITING

In case additional gain is desired in the clipper circuit a pentode may be substituted for the triode. A further advantage of a pentode is its lower grid-plate capacitance.

INTER-SYNC SEPARATION

After the portion of the signal lying in the sync region has been separated from the picture information, the horizontal and vertical sync pulses must be separated and fed to their respective oscillators. The simplest method is that used in most British receivers and many American. The wave after coming from the clipper is fed two ways: one way thru an R-C low-pass filter to the vertical oscillator; and the other thru a high-pass R-C filter to the horizontal oscillator.

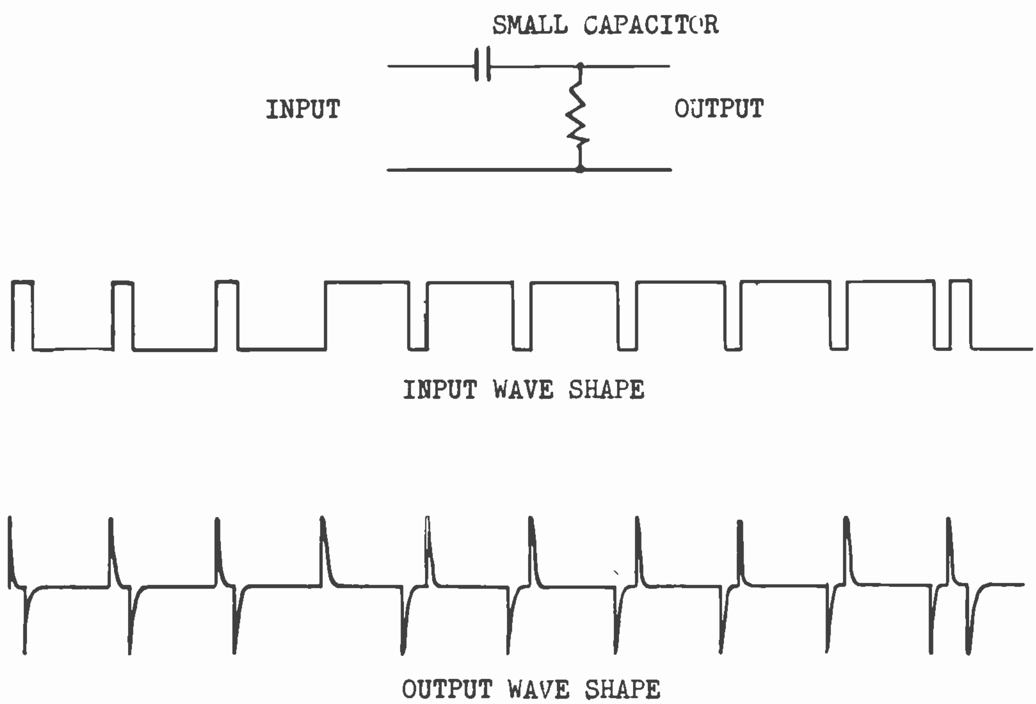


FIG. 33
HIGH-PASS R-C FILTER FOR OBTAINING HORIZONTAL SYNC PULSES (DIFFERENTIATION)

The input of the high pass filter shown in Figure 33 is coupled to the output of the clipper. The diagram illustrates how the broad vertical pulses are eliminated from the signal, but at the same time horizontal pulses are obtained from the leading edges of the vertical pulses to maintain horizontal synchronization during the vertical blanking period. The horizontal, equalizing, and vertical sync pulses, so far as the output is concerned, all cause upward excursions which are identical except for the 1/2 H spacing of the latter two groups. However, as mentioned in an earlier chapter, the horizontal oscillator is not susceptible to synchronizing pulses during the mid-range of the trace and thus, the oscillator synchronizes only on the proper alternate pulses occurring at the 2H frequency.

It should be noted that the output voltage of the high-pass filter is proportional to the current through the resistance leg of the filter. The current flowing through the resistance is of course the charging current of the capacitor, and since the capacitor is relatively small the charging current very closely follows the rate of change in the potential applied to the input. For this reason this type of circuit is often called a differentiation circuit because of the close analogy to differentiation in calculus.

The output of the clipper is also fed to a low pass filter for obtaining the vertical oscillator's timing pulses. Such a circuit shown in Figure 34 has a very slight response to the horizontal pulses, and with horizontal pulses applied to the input gives an output voltage of saw-tooth wave shape having an amplitude of a few percent of the input wave. However, with the broader vertical sync pulses applied to the input, the filter output voltage builds up rapidly as shown in the diagram. It should be noted that the resistance in series with the capacitor is sufficiently large to prevent the capacitor from charging up to the full input potential on any one cycle of the input. The output which is taken off across the capacitor is, of course, proportional to the charge on the capacitor. This continues to rise so long as the input wave on its upward excursions puts more charge into the capacitor than is drawn out on the downward excursions, and since the vertical sync pulses are wide compared to the interval between pulses the output will rise during the period the six vertical pulses are applied to the input.

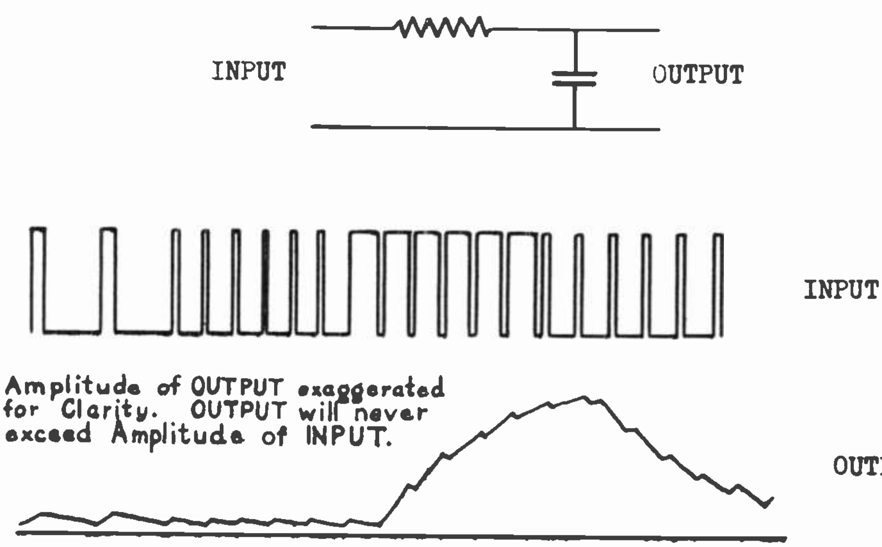


FIG. 34
LOW-PASS R-C FILTER FOR OBTAINING VERTICAL SYNC PULSES (INTEGRATION)

After the vertical sync pulses have passed, the output potential decreases as shown. The output potential in the diagram has been drawn with excess amplitude for clarity; actually the output will never exceed the amplitude of the input signal.

The output wave of the low pass filter can be seen to approximate the area under the input wave. Integration, as used in mathematics means to "sum up", and for this reason the term is often used to describe the low-pass filter circuit shown in Figure 34.

The principal objection to using the low-pass filter is that the sloping vertical pulse may not result in sufficiently accurate triggering of the vertical oscillator for good interlace.

Much more precise timing or triggering is obtained by a system known as the "differentiated vertical." As the name implies, a high-pass R-C filter is used to exaggerate the trailing edges of the vertical pulses. It is possible to use a trailing edge since it is comparatively easy to complete the retrace of the vertical oscillator during the time allowed. In Figure 35 is shown such a circuit together with the input and output wave. The circuit of 33 is the same as that in Figure 35

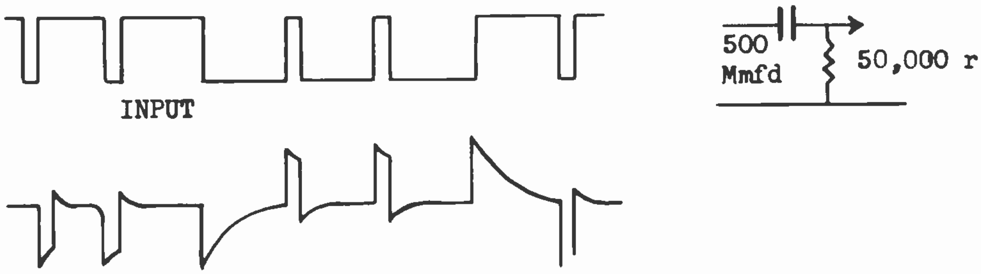


FIG. 35
DIFFERENTIATED VERTICAL INTERSYNC SEPARATOR

except for the considerably longer time-constant in the latter, and the use of opposite halves of the output waves for controlling the oscillator timing. In Figure 33 the time constant is usually something less than one microsecond, while in Figure 35 it is of the order of 25 microseconds. This system of Figure 35 has been found to be more sensitive to noise than the low-pass circuit shown in Figure 34, because it exaggerates high-frequency peaks instead of tending to average them out.

A system which has the advantages of the two circuits just described and none of the disadvantages is incorporated in the largest General Electric receivers. The circuit, shown in Figure 36, works on the trailing edge of the pulse, and is responsive only to the duration of the pulse and not to the amplitude. In order to more readily understand the operation, the wave shapes of the signal at a number of points in the circuit are plotted. The first tube in the circuit which has zero bias on it except when a pulse is being received, draws considerable plate current through R_1, with a resultant voltage drop across the resistor. When a negative sync pulse is received the tube's plate current is reduced and the potential at point B rises slowly as C_1 is charged. The time constant of R_1C_1 is sufficiently great so that the potential at B charges but a small amount during any sync pulse except the broad vertical sync pulses. Thus, any noise impulse except one having a duration comparable to that of a vertical sync pulse, or one occurring right on a vertical pulse, cannot effect the potential at B or the timing of the vertical oscillator. As soon as the sync pulse is over, the tube draws high plate current to discharge C_1 in a very short time.

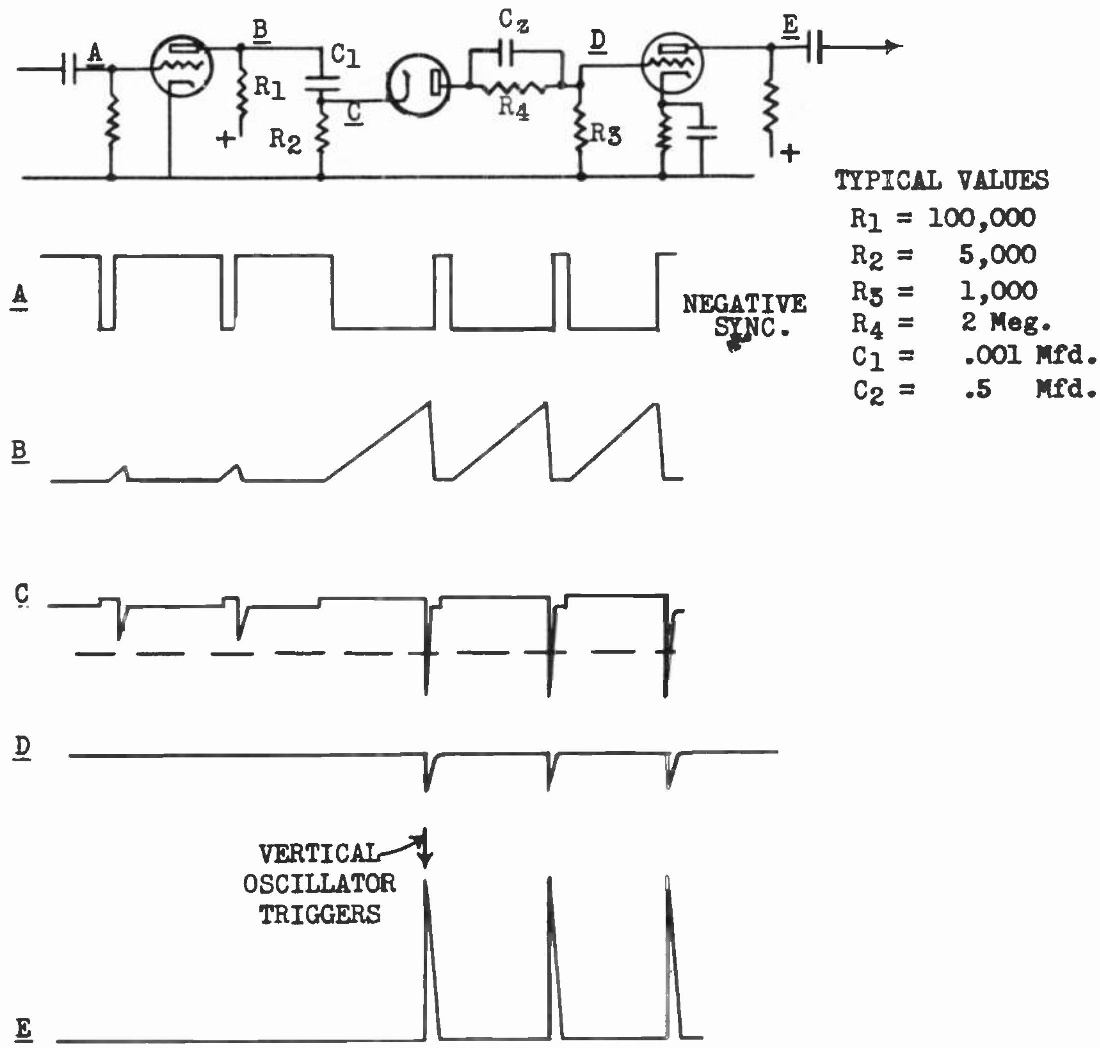


FIG. 36
VERTICAL INTERSYNC SEPARATOR USED IN LARGER GENERAL ELECTRIC RECEIVERS

Since R_2 is in series with the capacitor the charging and discharging current must flow through it. However, during the verticals the charging lasts for a longer period, C_1 receives a greater charge and the discharge current is correspondingly greater. This, in turn, flowing through R_2 produces the sharp pulse shown in C.

The wave shown in C, consisting of small horizontals and large verticals is sent through a diode separator similar to the one in Figure 29, to leave only the verticals as shown in D. These are then applied to the grid of the last tube in Figure 36 where they are amplified and reversed in polarity as shown in E.

There are many variations in the circuits used for separating the horizontal pulses from the vertical but since the only difference between the various sync pulses is the duration, or width of the pulse, the circuits can be quite easily analyzed by considering the time-constants involved. It should be born in mind, that the vertical pulses each occupy .43H or approximately 33 microseconds, the horizontal pulses .08H or 6 microseconds, and the equalizing pulses .04H or 3 microseconds.

CHAPTER 8 - SAW-TOOTH OSCILLATORS AND DEFLECTION CIRCUITS

INTRODUCTION

In order to reproduce the original scene televised at the transmitter, it is essential that the electron spot on the picture tube accurately follow the same path as the spot used in scanning the camera mosaic. As pointed out in chapters 1 and 2, the motion of the camera spot is the resultant of two saw-tooth waves acting simultaneously on the electron beam, one moving it across the scene at a uniform speed 15,750 times per second and the other moving it downward at a uniform speed 60 times per second. In the receiver it is necessary that the waves have exactly the same timing and uniform speed during the portion of the trace in which the spot is visible. Since the motion of the spot is dependent not only upon the saw-tooth waves generated but also upon the deflection circuits, these two closely related topics will be discussed in this chapter.

The matter of accurate synchronization of both the horizontal and vertical saw-tooth oscillators has been discussed in previous sections at sufficient length to make it unnecessary to emphasize its importance. It is quite possible, however, for the horizontal and vertical oscillators to be accurately synchronized so far as timing is concerned, but still produce such a motion of the spot as to result in considerable distortion of the image. For example, if the trace portion of the receiver's horizontal oscillator is not a straight line; that is, the spot fails to move across the picture tube at a uniform speed, but instead has an exponential curve with the spot moving faster at the left side of the screen than at the right, the reproduced scene will be expanded or stretched out at the left and crowded at the right. With the conditions just cited, a circle would appear egg-shaped and point to the right. Similarly, if the vertical oscillator produced an exponential wave, the circle would appear as egg-shaped with the broad base towards the top and the point towards the bottom of the screen.

SAW-TOOTH OSCILLATORS

Most saw-tooth oscillators depend fundamentally upon the charge and discharge of a capacitor to produce the wave, although there are innumerable circuit variations for charging and discharging the capacitor. When a capacitor and a resistor are connected in series to a source of potential, the voltage across the capacitor varies with time as shown in Fig. 37. It will be noted that the lower part of the curve is practically a straight line and is suitable for use as a portion of a saw-tooth wave. A saw-tooth oscillator is simply a circuit which allows the capacitor to charge for a short time over the linear portion of the curve and then abruptly discharges it. This cycle is repeated over and over again to give a continuous saw-tooth wave.

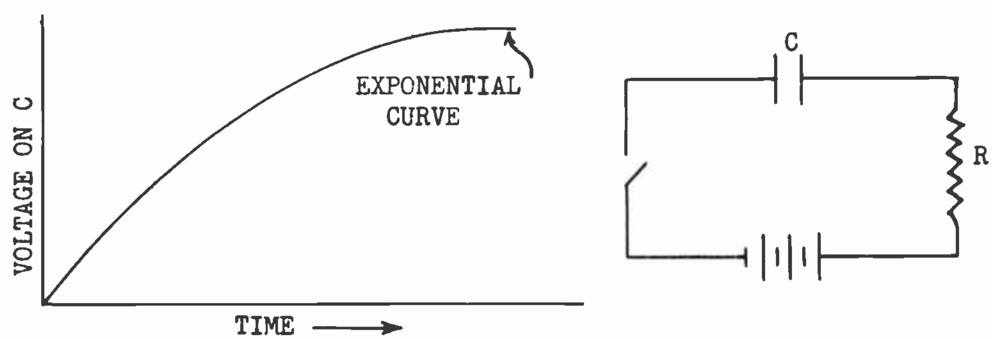


FIG. 37
CAPACITOR CHARGING CURVE

One of the simplest methods of discharging the capacitor is by means of a gas filled triode such as the 884 or 885. Tubes of this type have a very low internal voltage drop when the gas is ionized and a very high one when not ionized. Ionization is caused by electrons in the region between the grid and plate striking the gas molecules with sufficient energy to transform some of the gas molecules into positive ions. When this occurs, the voltage drop in the tube is of the order of 15 volts irrespective of the plate current, so long as the ratings of the tube are not exceeded. Whether the electrons have sufficient velocity to ionize the gas is, of course, a function of both the grid and plate voltages. In Fig. 38 are shown typical control characteristics, circuit and output wave of a gas-filled triode saw-tooth oscillator. An inspection of A shows that if the potential of the grid is -6, the tube will not ionize until the potential on the plate is 50 volts. With this bias on the grid in circuit B, the potential on capacitor C when plate voltage is first applied will slowly increase to 50 volts at which time the tube will ionize and discharge the capacitor down to 15 volts when ionization will cease and cycle will be repeated as shown in C. The output wave is then a 35 volt peak-to-peak saw-tooth wave, providing R, C and the plate supply voltage are large enough so that only the straight or nearly straight portion of the capacitor's charging curve is used. The dashed curve in C is the capacitor charging curve if the triode has sufficient bias to prevent ionization at the full plate supply potential.

The frequency of the saw-tooth oscillator of Fig. 38 is determined by the size of R, C and the plate supply voltage, since these all affect the time required for C to charge from 15 to 50 volts. The size and also the frequency are affected by the bias, inasmuch as the greater the bias, the greater will be the plate potential before ionization and also the greater the time before this potential is reached.

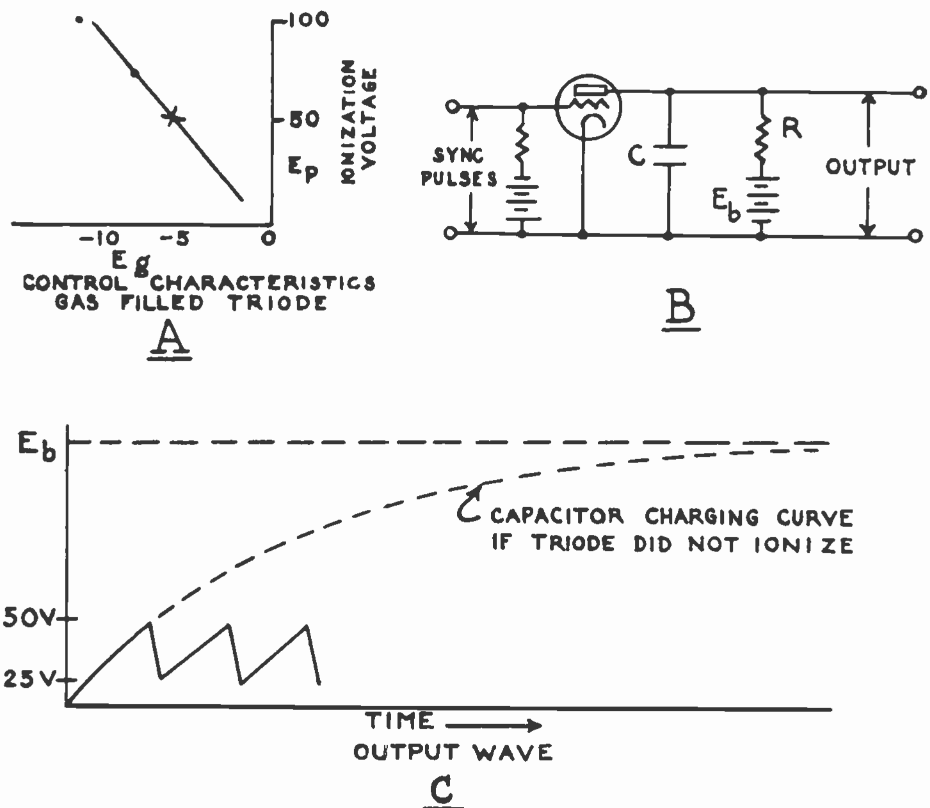


FIG. 38
GAS FILLED TRIODE SAW-TOOTH OSCILLATOR

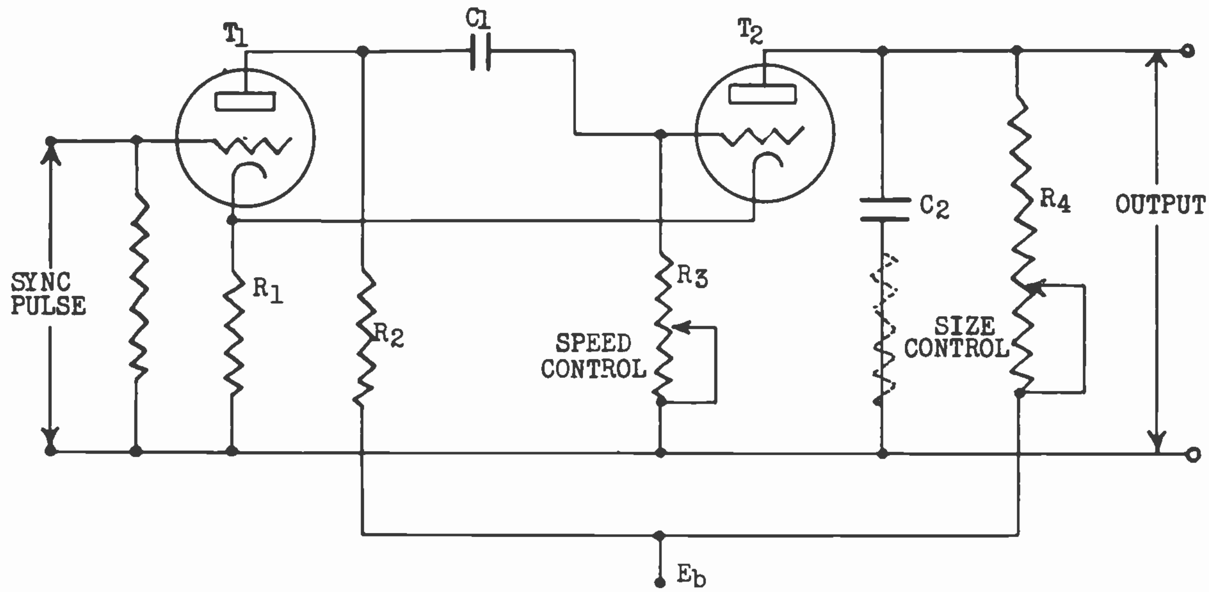
Synchronization may be accomplished by impressing a positive sync pulse on the grid circuit, which will cause the tube to ionize before it otherwise would with the fixed bias. It is apparent that if the tube has already ionized when the sync pulse is applied, the sync pulse will be ineffective. For this reason, it is essential that the "free running" period of the oscillator be somewhat lower than the desired frequency of the synchronized saw-tooth output. The lower the free running period of the oscillator, the greater is the required amplitude of the synchronizing signal to be effective. In noisy locations, it is sometimes possible to take advantage of this fact by lowering the free running frequency of the oscillator so that extraneous pulses, such as noise signals present in the synchronizing signal, will have little effect on the synchronization unless they exceed the amplitude of the synchronizing pulses.

It should be mentioned here that not all gas filled tubes de-ionize rapidly enough to be used in horizontal oscillator circuits where the discharge must be completed in less than .08H or less than 11 microseconds.

It is possible to use a high-vacuum type tube to perform the operation of discharging the capacitor and since this type tube has no limitations with regard to ionization time, it is most often in this country used for the horizontal oscillator and in many cases for the vertical oscillator as well. As just described, a gas-filled tube utilizes a very simple circuit, inasmuch as it is only necessary to once start the ionization of the gas for it to remain ionized until the capacitor is discharged to the 15 volt level. Contrasted to this, the high-vacuum tube must have a continuous application of a suitable potential to its grid to cause high plate current throughout the discharging period. For this reason, the circuits using vacuum tubes are somewhat less simple.

One common type of saw-tooth oscillators using high-vacuum tubes is the multivibrator or relaxation oscillator. There are many variations of this circuit which fundamentally is a two-stage resistance-coupled amplifier having common coupling or feedback between the two stages. Such an arrangement will oscillate because the 180° phase shift between the grid and plate of a vacuum tube causes the output of the second tube to supply to the first tube an input voltage that has the right phase to sustain oscillations. The usefulness of the multivibrator arises from the fact that the output wave shape may be made quite linear, and from the fact that the frequency of oscillations is readily controlled by an injection of a voltage pulse.

The horizontal oscillator in General Electric receivers is a special form of the multivibrator as shown in Fig. 39. R_1, the common cathode resistor serves as coupling between the two tubes. An exact analysis of the circuit's operation is somewhat involved but the general method of operation is easily understood. The tubes, T_1 and T_2 may be of the same type and in practice are often twin triodes in one envelope, such as the 6F8G. To understand the method by which the circuit oscillates, it may be assumed that the plate supply, E_b, has just been applied. Initially, T_1 will draw most of the plate current because of its lower plate resistor. In fact, T_1 will draw enough plate current to cause the common cathode bias developed across R_1 to be sufficient to cut off the plate current of T_2 since the plate potential of T_2 will be relatively low because of capacitor C_2 charging up through the one megohm resistor, R_4. However, in a short time the potential of C_2 and the plate of T_2 will be great enough to cause T_2 to begin drawing plate current. This plate current flowing through R_1 will produce a greater bias on T_1 which will cause a decrease in T_1's plate current and an increase in the plate potential of this tube. This positive potential coupled through C_1 to the grid of T_2 will further increase T_2's plate current causing in turn a further increase in the positive signal applied to the grid of T_2. The high plate



TYPICAL VALUES

R_1 = 1,000 Ohms
R_2 = 100,000
R_3 = 50,000
R_4 - 1,000,000
C_1 = 200 Mmfd
C_2 = 1,000 Mmfd

FIG. 39
MULTIVIBRATOR OR RELAXATION TYPE SAW-TOOTH OSCILLATOR

current of T_2 will, in a very short time, discharge C_2 to a level whereby the cathode bias across R_1 will cause the plate current of T_2 to cease. T_1 will then draw more current making the grid of T_2 more negative as the result of the negative signal coupled through C_1 and also because of the cathode bias. Again, after a short time, C_2 will have charged to a sufficient potential to allow T_2 to begin drawing plate current and the cycle will be repeated. The potential across C_2 will be a saw-tooth wave, the retrace portion corresponding to the period in which C_2 is being discharged by the plate current of T_2.

The circuit may be synchronized by applying a negative pulse, such as the output of the low pass filter discussed in Chapter 7, to the grid of T_1. This negative pulse on the grid of T_1 will cause a large positive pulse to appear in the plate circuit of T_1, and this in turn coupled through C_1 will cause T_2 to begin drawing plate current and start the discharge cycles described above. The same considerations previously discussed regarding the free-running frequency of the oscillator being lower than the synchronized frequency apply to this circuit.

It should be added in connection with the operation of the oscillator that the grid of T_2 actually goes positive with respect to the cathode during the initial period when the positive signal is applied to its grid. When this occurs, a negative potential is built up across C_1 which must discharge through R_3, the grid leak. By varying the value of R_3, the period before T_2 resumes drawing plate-current may be changed. R_3 may accordingly be used as a frequency control. The value of R_4 through which C_2 receives its charge will determine the potential upon C_2 when a synchronizing pulse occurs. This control thus functions to determine the amplitude of the saw-tooth wave, and may be used to change the size of the picture.

The resistor shown in dashed lines in series with C_2 is used to change the shape of the output wave when magnetic deflection is utilized. It will be discussed in some detail in a later section dealing with deflecting circuits.

Still another type of saw-tooth oscillator, probably the simplest high-vacuum circuit using one tube, is the blocking oscillator, which is used in General Electric receivers for vertical deflection. The circuit together with wave forms is shown in Fig. 40. The transformer serves as a coupling between the plate and grid circuits and is so wound that an increase in plate current causes an increase in grid potential which further increases the plate current until finally the plate current can no longer increase because of limited cathode emission. This causes the flux in the plate coil to start to collapse which reverses the grid polarity to still further reduce the plate current until it is cut off. In the description so far, it is apparent the circuit performs quite similar to a conventional oscillator having coupling between the plate and grid coils. One difference should be noted, however, and that is the large value of the two megohm grid leak, R_1. In the first part of the cycle

TYPICAL VALUES
FOR VERTICAL OSCILLATOR
R_1 = 2,000,000
R_2 = 2,000,000
C_1 = .02 MFD.
C_2 = .25 MFD.

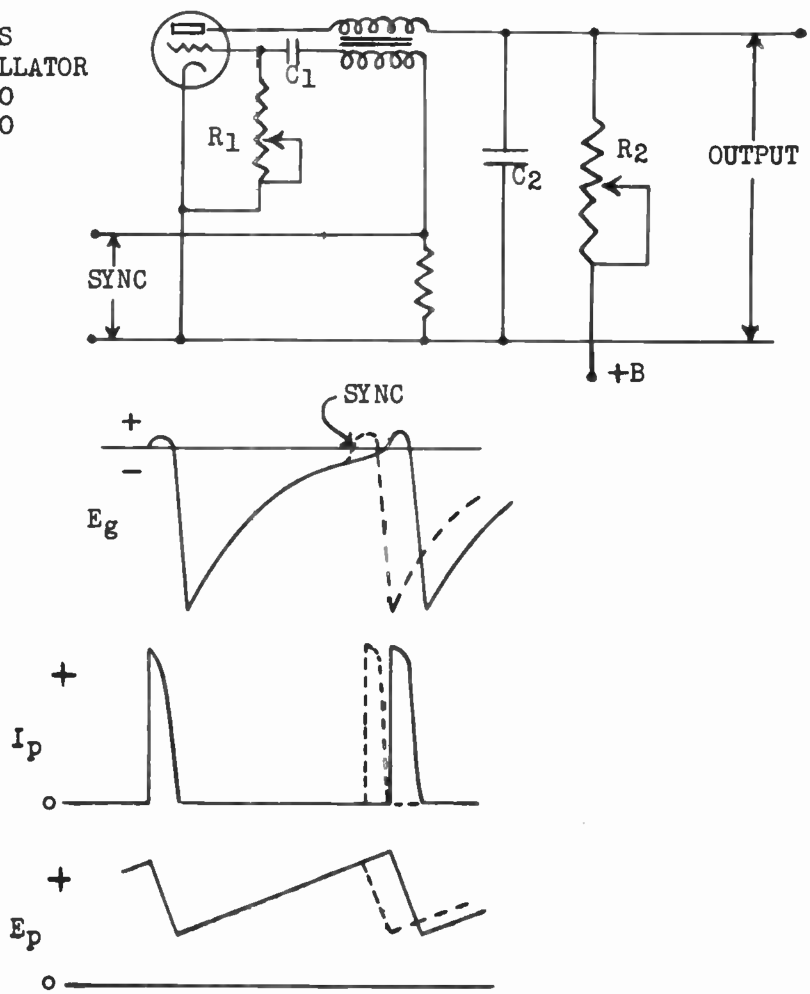


FIG. 40
BLOCKING OSCILLATOR TYPE SAW-TOOTH GENERATOR

just outlined, the grid is driven positive causing grid current to place a negative charge on C_1 which must leak off thru R_1 to almost zero potential before the cycle can be repeated. By lowering the value of R_1, C_1 is discharged more rapidly and the charging cycle repeats in a shorter interval. In this manner, R_1 acts as a speed control for varying the free running speed of the oscillator. The pulse of plate current occurs for a very short period of time, and the 60 cycle oscillator would actually oscillate at about 2,000 cycles were it not for the fact that by the time 1/2 cycle is completed, the plate voltage is very low and the grid voltage quite negative thus stopping the oscillation until the negative charge on C_1 has leaked off and the potential on C_2 increased.

Synchronization may be accomplished by injecting a positive synchronizing pulse on the grid circuit as shown in the diagram. If these synchronizing pulses are of sufficient amplitude to drive the grid up to cut-off, they will start plate current and initiate a new cycle. This is indicated by the dashed curve shown as being initiated by a sync pulse. Here again, the free running period should be somewhat longer than the period between synchronizing pulses.

DEFLECTION CIRCUITS

The deflecting circuit in a television receiver performs the operation of supplying a force which acts on the electron beam of the picture tube so as to move the spot in the same manner and in synchronism with the movement of the electron beam in the camera tube. As we have seen, the force producing the motion of the electron beam is of saw-tooth wave shape with a slow, linear rise and a rapid fall. It is, of course, essential that the forces producing the horizontal and vertical deflection be arranged so that they produce beam deflections at right angles to each other.

The force producing the deflection may be an electrostatic field or a magnetic field. In television receivers, the deflection may be electrostatic for both horizontal and vertical, magnetic for both, or a combination of electrostatic for deflection in one direction and magnetic for the deflection at right angles.

Electrostatic deflection is used in most service shop oscillographs and is familiar to the majority of service men. In this type of deflection a saw tooth wave of voltage is impressed on each pair of deflecting plates which are located just beyond the beam-focussing or generating gun. The beam is deflected or bent an amount proportional to the instantaneous voltage applied to the plates.

In order to more accurately maintain the focus of the electron beam, it is usually advisable to use push-pull deflection circuits. That is, instead of one plate of a pair being maintained at a steady positive potential and the potential of the other plate varied, both plates are made to vary in potential about a fixed positive potential as an operating point. This method of operation is easily accomplished by feeding the output of the saw-tooth generator into a phase inverter push-pull amplifier coupled to the deflecting plates. Since large voltages are necessary to sweep the larger tubes, choke coupling is sometimes necessary to maintain a high plate voltage on the output tube, which would ordinarily be lost in the large load resistor of a resistance coupled amplifier.

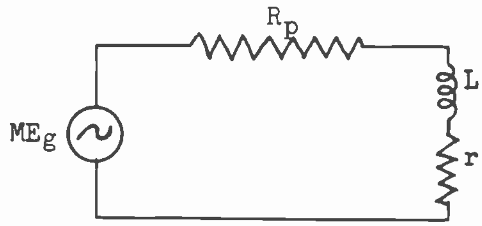
Since the deflecting plates must operate at a high positive potential considerably in excess of that applied to the saw-tooth amplifier, coupling capacitors must be used to isolate the DC. These capacitors are somewhat of a problem since they must withstand the anode voltage which may be 2,000 volts or higher, and in the case of the vertical deflection plates, transmit 60 cycles without distortion. Any appreciable leakage of the capacitor would change the fixed potential about which the saw-tooth wave varies, thus changing the centering of the picture. Since large, high-voltage capacitors are both bulky and expensive, it has been found advisable to allow some distortion of the saw-tooth wave in the coupling capacitor and compensate for it by predistorting the amplifier input wave. By using circuits involving only resistance and capacitance, the saw-tooth wave appearing on the deflection plates can be made linear in spite of relatively small coupling capacitors.

When magnetic deflection is employed for scanning, it is necessary to have a saw-tooth wave of current rather than a saw-tooth wave of voltage. The saw-tooth wave of current when passed through coils arranged around the neck of the tube produces a saw-tooth wave of magnetic flux through the neck of the tube. The electron beam is deflected in proportion to the flux density. Considerable care must be taken in designing the deflection coils in order to insure uniform distribution of the flux across the neck of the tube, as otherwise there will be beam defocusing or deflection wave shape distortion.

In the usual arrangement, there are two sets of coils for each deflecting circuit, making a total of four coils for the entire deflecting assembly. The two coils of one set are placed on opposite sides of the picture tube neck so that the resulting flux is at right angles to the neck. The other set of deflecting coils are similarly placed on opposite sides of the neck but so that their flux is at right angles not only to the neck but also to the first set. To increase the inductance of the coils and also provide shielding a laminated core is placed around the outside of the four-coil assembly.

It is desirable that the cross coupling between the horizontal and vertical windings be small to prevent reactions between them. This can be accomplished by inserting an electrostatic shield between the two sets or by making one or both sets of windings low impedance so that large voltages are not present across the windings. It is customary to use the latter procedure and utilize step-down transformers for driving the low impedance deflecting circuits.

As previously indicated, in magnetic deflection, the current through the coils must be saw-tooth in shape rather than the voltage applied to the coils. The wave shape of the voltage required on the grid of the output tube depends upon the tube impedance and the coil inductance and resistance. The equivalent circuit in its simplest form, shown at the top of Fig. 41, is actually correct only if the output tube is operating over the linear portion of its characteristics, but it is an accurate enough approximation to be useful in considering the wave shapes required at the grid to give saw-tooth current waves in the deflecting coils. If the circuit were predominantly resistive, the required voltage wave would have the same shape as the desired current wave, and so would be saw-tooth as shown in the top figure. On the other hand, if the output circuit were pure inductance and the plate resistance, R_p, would be ignored, the input signal would be a simple pulse having a duration equal to the return time, as shown in the second curve of Fig. 41. It may not be readily apparent at first that such a rectangular voltage wave applied to an inductance will produce a saw-tooth wave, but, it should be recalled that whenever a varying current flows through an inductance, a back voltage, the result of the changing flux cutting the turns of the coil, is built up. This bucking voltage is proportional to the rate at which the curren is changing in amplitude and is always of such a polarity as to buck the voltage causing the current change. Since a cycle of a saw-tooth current wave has a period in which the current is increasing at a constant rate, and another period in which the current is decreasing at a different but constant rate, it is apparent the bucking voltage during these two periods will be a constant but a different value for each period. Since the bucking voltage is constant during each period, it is only necessary to apply a rectangular voltage wave to the inductance as shown in

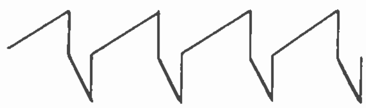


EQUIVALENT CIRCUIT FOR TUBE AND MAGNETIC DEFLECTION COIL

SHAPE OF VOLTAGE WAVES (E_g) REQUIRED TO PRODUCE SAW TOOTH CURRENT WAVE

FOR RESISTANCE

FOR INDUCTANCE



FOR INDUCTANCE AND RESISTANCE

FIG. 41
INPUT VOLTAGE WAVE SHAPES REQUIRED FOR SAW-TOOTH CURRENT WAVES

order to obtain a saw-tooth current wave. Mathematically, the required input voltage would be $E_g = L\frac{di}{dt}$, which simply states that the input voltage is equal to the product of the inductance and the rate at which the current changes.

In the actual case, where both inductance and resistance are present, it is necessary to combine the wave shapes of resistance and inductance in the proper proportion, such as shown in the bottom curve of Fig. 41, in order to get a saw-tooth wave of current. Such a voltage wave can be obtained by utilizing the resistor shown by the dashed lines of Fig. 39 as being in series with capacitor C_2. The voltage across C_2 in this arrangement is a conventional saw-tooth wave-suitable for overcoming the resistance drop of the deflection circuit. The voltage across the resistor in series with C_2, however, is in the form of a pulse as shown in the lower part of the wave of Fig. 41. This is because when C_2 discharges there is a sudden rush of current thru the dashed resistor of Fig. 39, while during the charging period, the current through the resistance is small and substantially constant. The value of this resistor should be much smaller than the resistor through which C_2 and the tube receives its potential.

In the horizontal deflecting circuits pentode output tubes are usually used because of their high input voltage sensitivity and power handling ability. The plate impedance of these tubes is so high that the circuit inductance becomes practically negligible compared to the plate impedance, and the grid voltage is essentially a simple saw-tooth. However, because of the high impedance of the output tube, it offers little damping to the inductance of the circuit, so that when the current suddenly changes, a transient oscillation is set up which should be damped out if proper linearity at the initiation of the trace portion of the wave is to be had. In Figure 42 is shown such a transient, together with proper damping and too great damping. If the path of the electron beam is not linear as horizontal blanking is removed, it is obvious that the picture will be distorted at the left edge. Several methods of damping have been used including RC circuits similar to those often placed across the output circuit of pentode audio amplifier tubes. Another method which has been employed is the use of a diode in series with an RC load circuit, the diode acting as a switch so that damping only occurs during the negative peak. Another method which is quite simple but performs exceptionally well, is the use regeneration or negative feedback to lower the impedance of the output tube. Such a circuit used in certain General Electric receivers consists simply of an RC network between the plate and grid of the output tube.

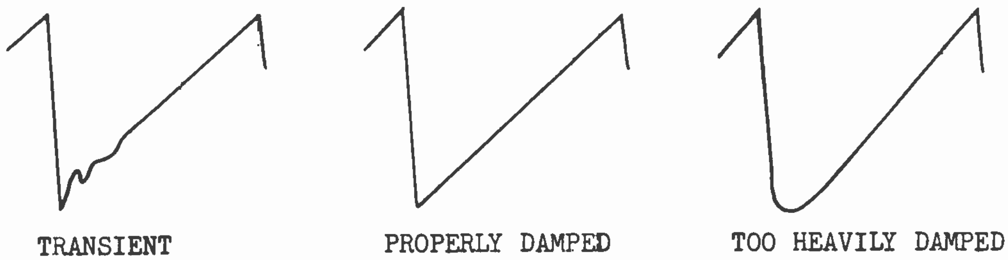


FIG. 42
TRANSIENT OSCILLATIONS IN HORIZONTAL DEFLECTION CIRCUIT

Since a saw-tooth wave is composed of many harmonics plus the fundamental, it is necessary that the step-down transformer between the horizontal output tube and the deflecting coils have good frequency and phase characteristics if the wave is to be passed without distortion. The fundamental frequency of the horizontal oscillator is 15,750 cycles per second, and for good transmission of the wave, it is advisable to pass at least up to the tenth harmonic. Thus, the range over which this transformer must operate is seen to be from approximately 15 to 150 K.C.

The vertical deflection circuits are much simpler than the horizontal because of the lower frequencies involved. For this reason, a smaller vertical deflecting output tube may be used and there is usually a lack of transients to be damped out.

CHAPTER 9 - TELEVISION ANTENNAS AND RECEIVER INSTALLATIONS

INTRODUCTION

The previous chapters have covered the general principles of modern high definition television and the important circuit details found in television receivers. Regardless of how well designed a receiver may be or the excellence of the television transmitter, it is essential that the receiver be properly installed if the full capabilities of the system are to be approached. Because of the high sensitivity of modern broadcast receivers the chief installation problem is an antenna which will give a reasonably good signal-to-noise ratio. In direct contrast, the television installation involves not only this problem but several other equally or even more important ones including that of an antenna system which is uniformly responsive within fairly close limits, over a 6 mc. range for each television channel, and one which does not result in ghost or spurious images on the screen. In addition are the problems of properly locating the receiver in the home, the degree of darkness in the room, the proper viewing distance for maximum enjoyment, and the quite important item of educating the customer in the proper operation of the receiver controls.

ANTENNAS

For all practical purposes the frequencies assigned to television, 50 mc. and above, are too high to be refracted back to the earth by the ionosphere, as is the case for frequencies somewhat lower. The critical frequency above which refraction in the ionosphere fails to return signals back to the earth depends upon the electron density of this ionized region which has daily, seasonal, and yearly variations, dependent upon the sun's radiation. While for very brief periods, signals as high in frequency as 60 mc. have been refracted by the ionosphere back to the earth, the usual critical frequency is below 40 mc. For this reason television must depend upon waves passing directly from transmitter to receiver through the space above the ground. However, because of the curvature of the earth the range of the signals is limited to moderate distances even when the transmitting and receiving antennas are placed at the highest possible elevation.

It may be assumed at first thought that if the wave is not refracted by the ionosphere a straight line path must exist but such is not the case, as it is still possible for energy to reach the receiver either as a result of refraction by the earth's atmosphere or by diffraction of energy around the curved earth.

The refraction of ultra-high frequencies by the earth's atmosphere comes about because the variation of atmospheric temperature, pressure, and moisture content with height cause the refractive index of the atmosphere to decrease with elevation and this tends to bend the waves back toward the earth. The amount of curvature that results varies with atmospheric conditions but on the average it is equivalent to assuming that the earth's diameter is increased by 25 to 35 per cent. In Figure 43 is shown a diagram to illustrate the path of a wave as the result of atmospheric refraction.

The range of a station considering only the straight-line path depends upon the heights H_t and H_r of the transmitting and receiving antennas, respectively according to the formulae

$$\text{Maximum distance for straight-line path} = 1.23\ (H_t + H_r)$$

where the antenna heights are in feet, and the distance is in miles. In considering atmospheric refraction the distance is increased by a factor of 1.25 to 1.35 depending

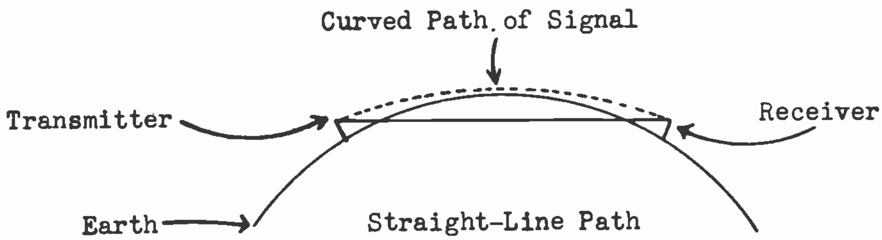


FIG. 43
DIAGRAM ILLUSTRATING HOW ATMOSPHERIC REFRACTION PERMITS ULTRA-HIGH FREQUENCY RECEPTION BEYOND STRAIGHT-LINE PATH

upon the atmosphere's refractive index. In Figure 44 are several curves showing the effect of antenna heights and atmospheric refractions upon the direct-ray transmission ranges. With the exception of the first curve which is for the straight line path, all curves are calculated on the basis of the effective range being increased by a factor of 1.3 because of refraction in the earth's atmosphere. On the right side of the figure is a chart giving the range for several transmitting antenna heights in excess of 1000 feet.

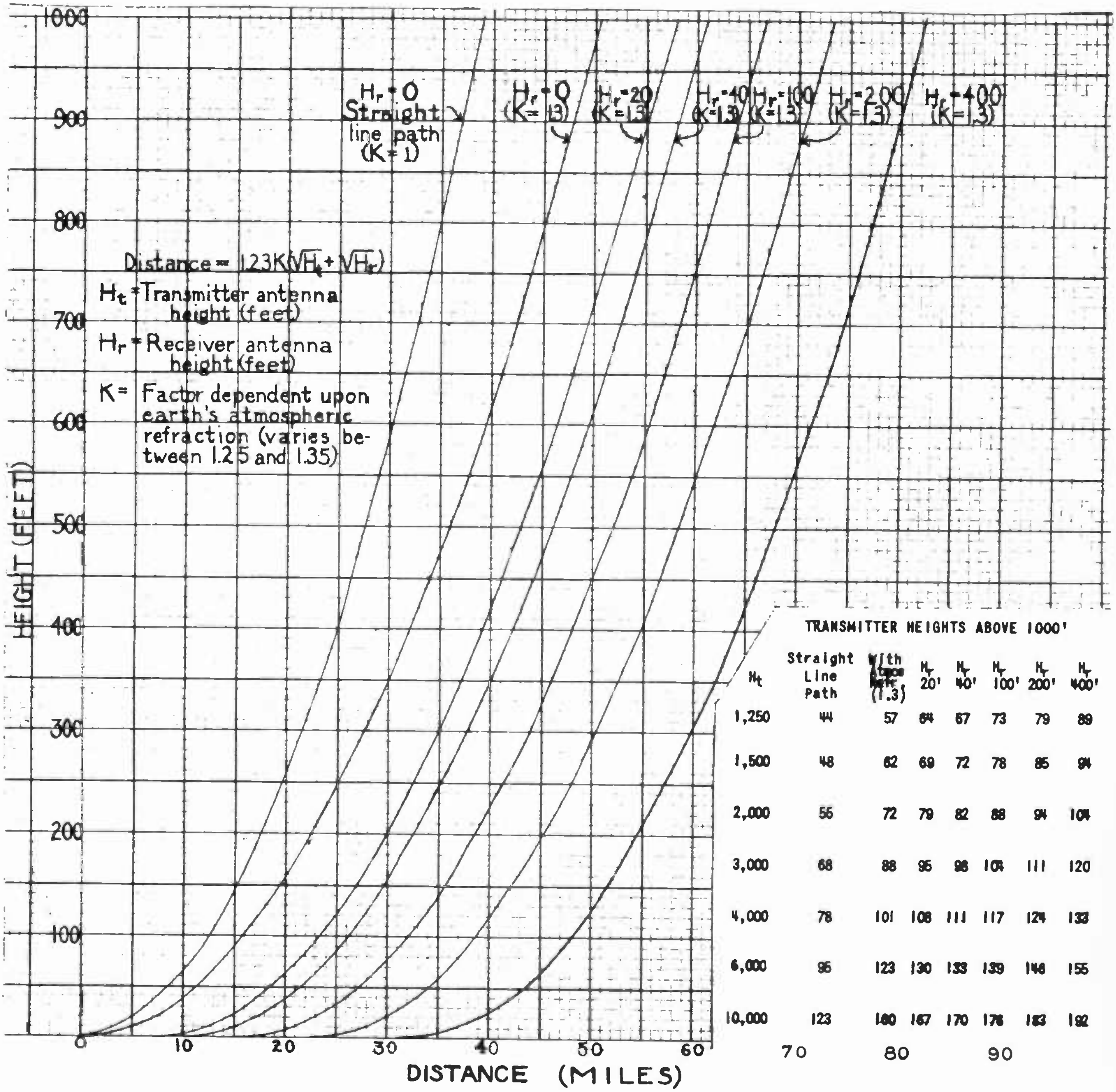
It is of interest to note that light rays are refracted in the same manner as the radio waves and that Figure 44 accordingly also gives the maximum possible optical range.

When one antenna is high and the other relatively low, a given number of feet increase in either antenna height is much more effective in increasing the range if it is applied to the lower antenna. For example, increasing an antenna 10 feet high to 100 feet increases the range of the direct-ray by the same distance, approximately 11 miles, as does increasing a higher antenna from 1000 feet to 1500 feet. Since receiving antennas are relatively low and transmitter antennas relatively high it is apparent that increasing the receiver height is much more effective than increasing the transmitter height by the same amount.

In addition to the refracted path or direct path it is quite possible for the signal to be reflected by objects but this is normally of negligible importance in considering the maximum range of the station. However, reflected signals play an important part in television antenna installations because of spurious images which may appear on the screen.

A vertical transmitting antenna radiates waves which are vertically polarized, while a horizontal antenna radiate horizontally polarized waves. Normally the receiving antenna should lie in the same plane as the polarization of the incoming wave. When a radio wave has passed through an ionized region the refracted wave received will have both vertically and horizontally polarized components irrespective of the polarization of the waves radiated from the transmitter. The ultra-high-frequency waves used for television are not refracted back to the earth by the ionosphere, and consequently the waves reaching the receiving antenna do not have their polarization changed by the ionosphere. Reflections from the earth, buildings and other objects may alter the polarization but it is usually of minor importance.

The choice between the use of vertically and horizontally polarized waves is one involving many considerations. Tests have shown that in metropolitan areas having tall buildings more serious reflections occur when the waves are vertically polarized. Since signals reflected from buildings and other large objects introduce distortion in the picture because of their relative time delay and phase relations



TRANSMITTER HEIGHTS ABOVE 1000'

H_t	Straight Line Path	With Atmos. Refr. (1.3)	H_r 20'	H_r 40'	H_r 100'	H_r 200'	H_r 400'
1,250	44	57	64	67	73	79	89
1,500	48	62	69	72	78	85	94
2,000	56	72	79	82	88	94	104
3,000	68	88	95	98	104	111	120
4,000	78	101	108	111	117	124	133
6,000	95	123	130	133	139	146	155
10,000	123	160	167	170	176	183	192

FIG. 44

EFFECT OF ANTENNA HEIGHTS AND EARTH'S ATMOSPHERIC REFRACTION UPON MAXIMUM DIRECT-RAY TRANSMISSION to the direct path signal, horizontally polarized waves are more desirable in such locations. It has also been found that a horizontally polarized receiving antenna is somewhat less susceptible to ignition noise and other electrical interference. For these reasons horizontally polarized waves are used in this country, while in Europe where there are fewer tall buildings and less ignition interference vertical polarization is favored. Accordingly, in this country receiving antennas of the doublet type are placed with their length horizontally.

When a television signal reaches the receiver over two paths having different lengths from the transmitter, there will be reproduced two images separated by an amount dependent upon the difference in the time of arrival of the two signals. Since the electron spot is moving across the screen at a very high speed the time difference between the arrival of the two signals does not have to be very great in order to be seen. In fact, since the spot moves across the screen 15,750 times per second and 15% of this time is used in returning the spot to the left side of the screen, the actual visible motion of the spot from the left side of the screen to the right must take place in approximately 64 microseconds. Radio waves travel 186,000 miles in one second or slightly less than 12 miles in the time required for the spot to move from the left to the right side of the screen. By measuring the horizontal displacement of the multiple images the difference between signal paths is readily determined. This in many cases is of aid in locating the object causing the reflection and in installing an antenna which is unresponsive in the direction of the reflection. In Figure 45 is a diagram for determining in miles the difference between two paths when the horizontal multiple-image displacement is measured on the screen of the picture tube. Curves are shown for 5, 9 and 12 inch picture tubes and are calculated on the basis of the picture width being 4-1/4, 7-3/4 and 10 inches respectively.

There are many types of antenna that may be used for television, the simplest being the dipole or doublet type. However, the design of such an antenna is complicated by the fact that it should have a fairly flat response over a 6 mc. band. The usual half wave doublet made of number 12 or 14 wire is highly selective with regard to frequency and isn't too well suited for reception on a single signal television channel, and is very unsuitable if several television channels are to be received by the one antenna. By increasing the diameter of the conductor to 1/4" or 1/2" the response becomes much more flat over a broad band of frequencies.

The usual method of transferring the signal from the antenna to the receiver is by means of a low impedance twisted pair transmission line. At the resonant frequency a half-wave dipole has an impedance at its center of 68-72 ohms, but in television, because of the broad bands to be covered the impedance varies over fairly wide ranges. For this reason the transmission line is usually designed to have an impedance that is more nearly the average value encountered over the operating range of the antenna. Using large diameter rods as antenna elements the transmission line may well have an impedance in the vicinity of 100 ohms.

The solid curve of Figure 46 illustrates the horizontal directivity of a horizontal dipole antenna. An inspection of this figure shows that in the direction the antenna points the pickup is very low, while a few degrees on either side of the antenna's axis the pickup is relatively high. The directional characteristics of such an antenna should be kept in mind when making installations as it is often possible to materially increase the signal-to-noise or signal-to-image pickup by rotating the antenna so that its axis points towards the noise or along the path of the reflected signal. Such an orientation may decrease the signal pickup somewhat but it may be beneficial because of the very great reduction in noise or reflected signal pickup. In Figure 47 a doublet antenna in a typical installation is shown.

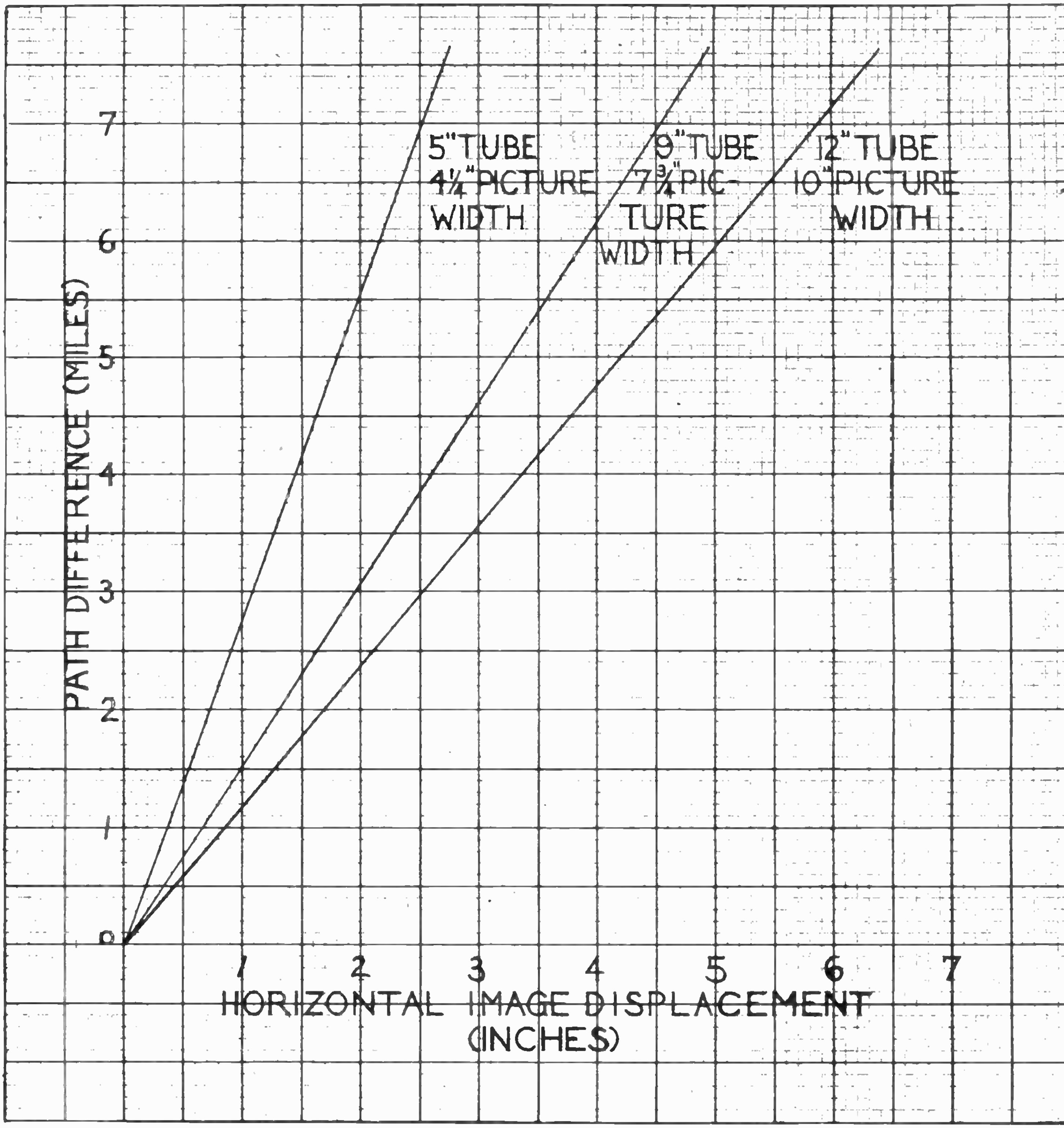


FIG. 45

DIAGRAM FOR DETERMINING PATH DIFFERENCE FROM OBSERVED DISPLACEMENT OF MULTIPLE IMAGE ON 5, 9, AND 12 INCH PICTURE TUBES

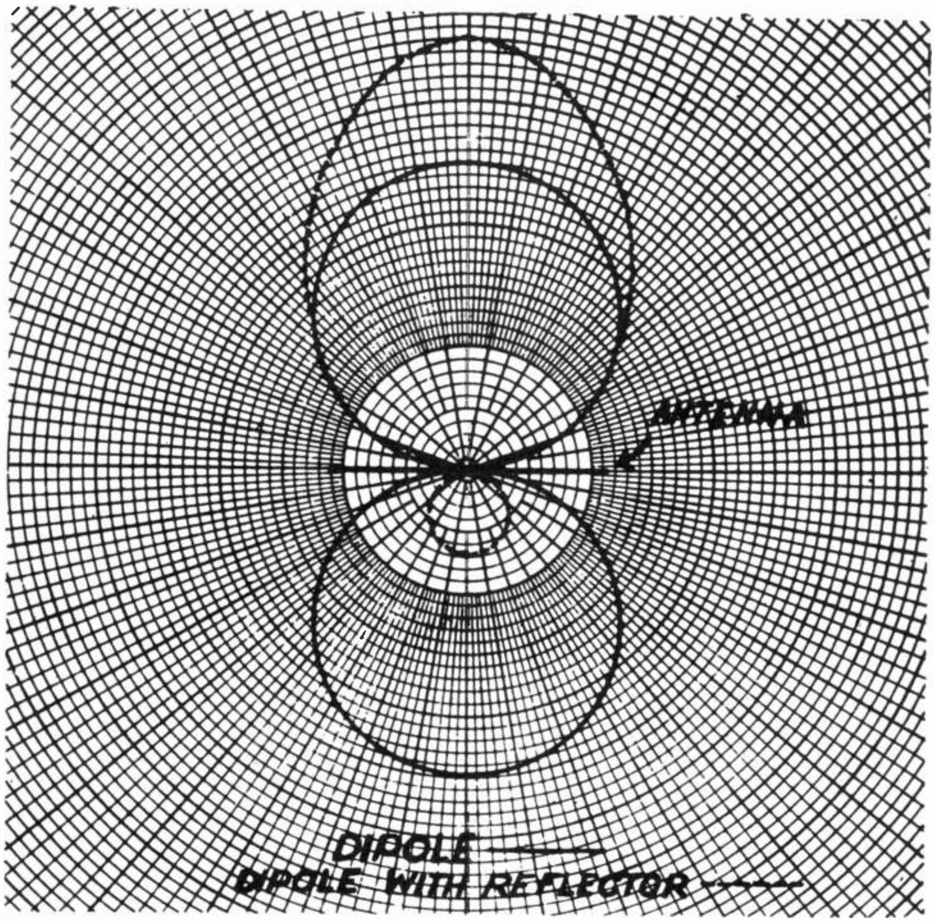


FIG. 46
TYPICAL HORIZONTAL-PLANE DIRECTIVITY FOR HORIZONTAL DIPOLE AND HORIZONTAL DIPOLE WITH REFLECTOR

In case a greater signal or greater directivity is required than that afforded by a single dipole a reflector may be added. The reflector should be parallel to the dipole and located on the side of the dipole away from the transmitter. Under optimum conditions a reflector gives 3 db gain in signal strength, and a substantial increase in directivity which is useful in decreasing noise and reflections. The directional characteristics are illustrated by the dashed curve of Figure 46. A dipole and reflector is shown in Figure 48.

In localities having high noise level and low signal strength the four dipole antenna array shown in Figure 49 will be useful. This antenna consists essentially of two dipoles and two reflectors properly spaced.

Certain locations having very low signal strength may require antenna arrays considerably more complicated than those just described. One of the best antennas where space is not at a premium is the diamond or rhombic. This antenna when properly designed is nonresonant and accordingly may be used over a very wide frequency range such as the seven lower frequency television bands. The design of such antennas is well covered by available literature and will not be duplicated here.

When installing simple antennas of the dipole type it is usually advisable to watch the results of rotating the antenna by viewing the screen of the television

FIG. 47
SINGLE DIPOLE ANTENNA INSTALLATION

receiver. This normally requires two men to make the installation, one on the roof at the antenna and the other at the receiver. An inter-communicating system is essential for communication between the two men. One of the most desirable methods is by means of the loudspeaker type inter-communication systems now widely used in offices.

As a general guide receiving antennas should be located as high as possible and as far from any noise source as feasible, always bearing in mind that the longer the transmission line the greater the line loss. One of the greatest sources of interference to television originates in automobile ignition systems. It is accordingly desirable to locate the antenna as far from streets as convenient and also back away from the edge of buildings sufficiently far to use the roof of the building as a shield from streets carrying heavy traffic. If reflections are a problem several locations on the roof should be tried with the antenna rotated in the horizontal plane at each location to determine the position and direction of minimum reflections. In some installations, moving the antenna a distance of from one to three feet has meant the difference between a satisfactory picture and one having sufficiently strong images to result in little entertainment value.

Another cause of spurious images on the screen may be the result of reflections in the transmission line itself. Unless the transmission line is properly terminated at the receiver, part of the signal reaching the input of the receiver will be reflected back up the transmission line, and then be reflected back down the transmission line from the antenna. In the case of long lines the difference in the arrival time of the original signal and the portion of the signal reflected in the line will cause a second image to appear on the screen. Since the path of the second signal is from the receiver to antenna and back to the receiver the time difference will be the time required to travel twice the length of the transmission line. For practical purposes it can be assumed that the signal travels in the line with the same velocity as in free space. Thus Fig. 45 can be used to check for reflection in the line. For example, if an immage were observed as being displaced 1/10 inch on a twelve inch tube, this would indicate a path difference of approximately 600 feet and if the line were in the vicinity of 300 feet in length it could be suspected as having reflections.

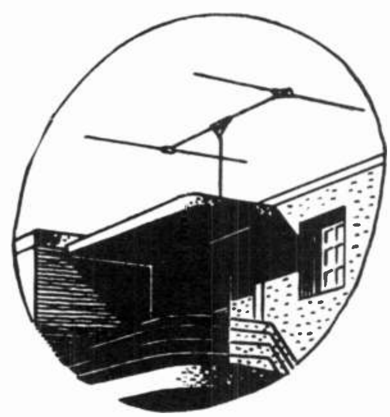


FIG. 48
DIPOLE ANTENNA WITH REFLECTOR

Still another cause of spurious images may be reflected signals picked up on the transmission line itself. While normally the input of the receiver is designed to balance out any balanced signal picked up on the transmission line, a slight

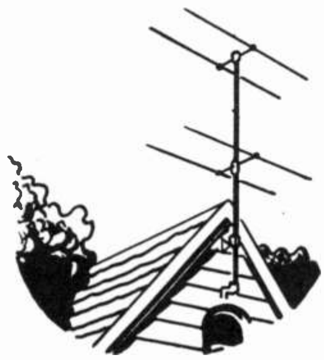


FIG. 49
FOUR DIPOLE ANTENNA ARRAY

unbalance may exist either in the line or the receiver. Under conditions of high signal strength a shielded transmission line grounded at the receiver will minimize such difficulties. It should be kept in mind that the losses in a shielded line are higher than in an unshielded line of comparable construction.

In regions of very high signal strength it may be desirable to use an antenna pad to cut down the signal strength and thus prevent overload in the receiver. An antenna pad in order to eliminate reflections in the transmission line should be designed so that the line is terminated in its proper impedance. Such pads are available with 10, 20, 30 and 40 lb. attenuation.

It should be evident from the above discussion that a proper antenna installation for television usually involves considerably greater detail than is true of a broadcast antenna. When spurious images are present the importance of trying several locations and varying the direction of the antenna in the horizontal plane at each location cannot be overemphasized.

TELEVISION INSTALLATIONS

Much of the material presented above under antennas deals directly with the installation of the antennas and will not be repeated in this section.

Probably the first step in installing a television receiver should be to make a survey of the sight to determine the signal strength and the type of an antenna installation that will most likely be required. In this connection a table model television receiver can be put to good use as a field strength meter and to determine the extent of reflections and interference. Such a test receiver may be easily equipped with a meter to give readings proportional to the amplitude of the sync pulse peaks and thus serve to give a measure of the signal at the input of the receivers. With this information and a little experience with the various model receivers it should be possible to make a good estimate as to the type of antenna required for a particular television receiver. Just as in broadcast receivers, there will be found to be a wide range in the sensitivity of various models television receivers and it is entirely possible that at a particular location one receiver will operate unsatisfactorily while another model will give a useable picture. The test receiver will thus give an indication of the model receiver which should be installed for proper entertainment value. After considerable experience has been had in a particular locality it should be possible to have sufficient knowledge of the problems for that area to eliminate the importance of using a test receiver.

The location of the receiver in the home is also one of some importance since this involves the amount of light falling on the viewing screen and also the proper viewing distance. The eye has the interesting property of being able to adapt itself to wide variations in illumination. This is accomplished by contraction or expansion of the pupil. In a darkened room the sensitivity of the eye increases very greatly over that in the sunlight, and this increase may be as much as 7000 or 8000 times. Thus in a darkened room much less maximum light intensity is required in order that the eye may interpret the variations in light as being from dark to bright. The exact amount of light that should be present in the viewing room is not particularly critical as long as the light caused by the spot on the picture tube screen materially exceeds the external illumination falling on the screen. This condition is not difficult to meet in the average home even in the daytime provided the receiver is placed in a position so that the maximum illumination in the room does not fall on the screen. In dealer demonstration rooms any spotlights on the front of the cabinet should be particularly avoided during demonstrations. At night when operating the receiver it usually is desirable to eliminate any lights shining directly on the viewing screen but it is unnecessary to completely darken the room.

Experience has shown that the most desirable viewing distance in motion picture theaters is when the viewer is 5 to 6 times the picture height from the screen. In 16 and 8 millimeter home type motion pictures having somewhat less detail, the most desirable viewing distance seems to be 6 to 8 times the height of the picture. Since the detail in 525 line television is closely comparable to that found in home motion pictures the most desirable viewing distance is usually found to be 6 to 8 times the picture height. At this viewing distance the resolution of the eye is such that the individual lines of the picture are not discernible and the scene appears as a flat field. In a 5 inch picture tube giving a picture 3-1/4 inch in height the most suitable viewing distance will usually be found to be between 18 and 24 inches. Similarly with a 9 inch tube the desirable viewing distance is from three to four feet, and with a 12 inch tube between four and five feet.

In the instruction booklet supplied witn each receiver the function of the various front panel controls are fully explained. However, it is advisable that the operation and effect of these controls be carefully demonstrated to the customer at the time the receiver is installed in the home. In this way repeat service calls will be avoided and the full capabilities of the receiver more closely approached. Probably the most common misadjustment is to increase the brilliancy control beyond its proper setting. While this gives a brighter picture, the contrast is usually lacking and much detail is lost because the greater current in the electron beam increases the spot diameter excessively. By decreasing the brightness control the illumination will be lessened but this is easily accommodated by the eye in a few seconds, and the resulting picture will be found to have a much greater amount of detail and contrast.

When the receiver is initially installed in the customer's home, the vertical and horizontal size controls should be adjusted so that the picture is slightly larger than the opening in the mask. By doing this, minor variations in the picture size will be unobjectionable.

SAFETY PRECAUTIONS

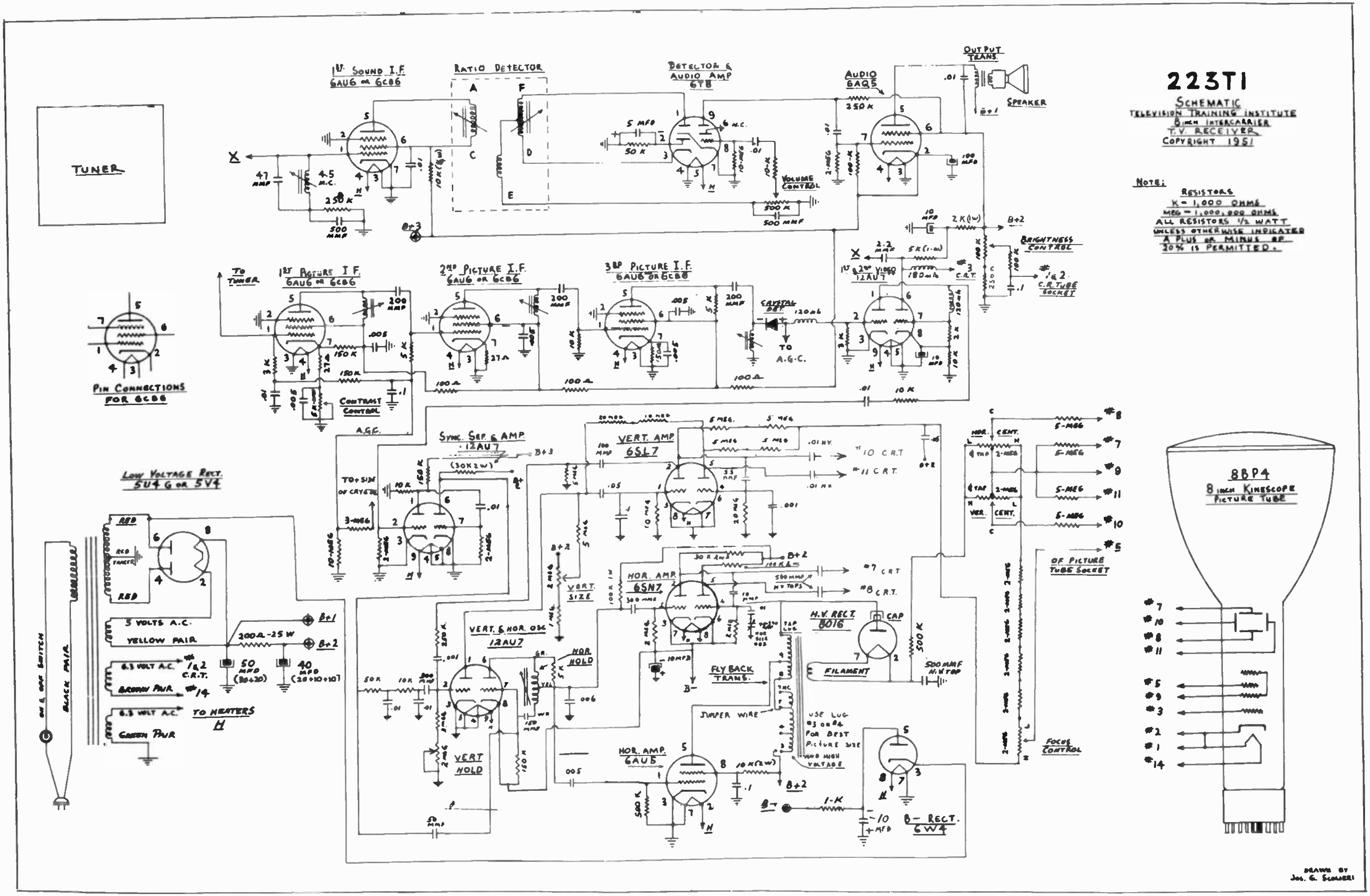
Television receivers utilizing potentials as high as 15,000 volts, require precautions unnecessary in broadcast receivers. Thus, the receivers are protected with back covers and interlocks which remove power to the chassis when the back cover is removed. Before any attempt is made to service a television receiver the service engineer should study the service instructions and read the cautionary notes found on the chassis. The high voltage circuits may then be made inoperative so that the only potentials in the chassis are in the range normally utilized in broadcast receivers.

It is unwise to attempt to measure the high voltage found in television receivers because of the danger involved and the difficulty in making the measurement with the usual service instruments. Resistance measurements with a wide range ohmmeter are usually sufficient to locate any defective part and no danger is involved if the high voltage circuits have previously been made inoperative as outlined in the service instructions.

High voltage filter capacitors, unless fully discharged, may give a dangerous or at least a very annoying shock. Momentarily shorting such a capacitor fails to remove the complete charge and it is accordingly advisable to place a jumper across the terminals and leave it there for several seconds.

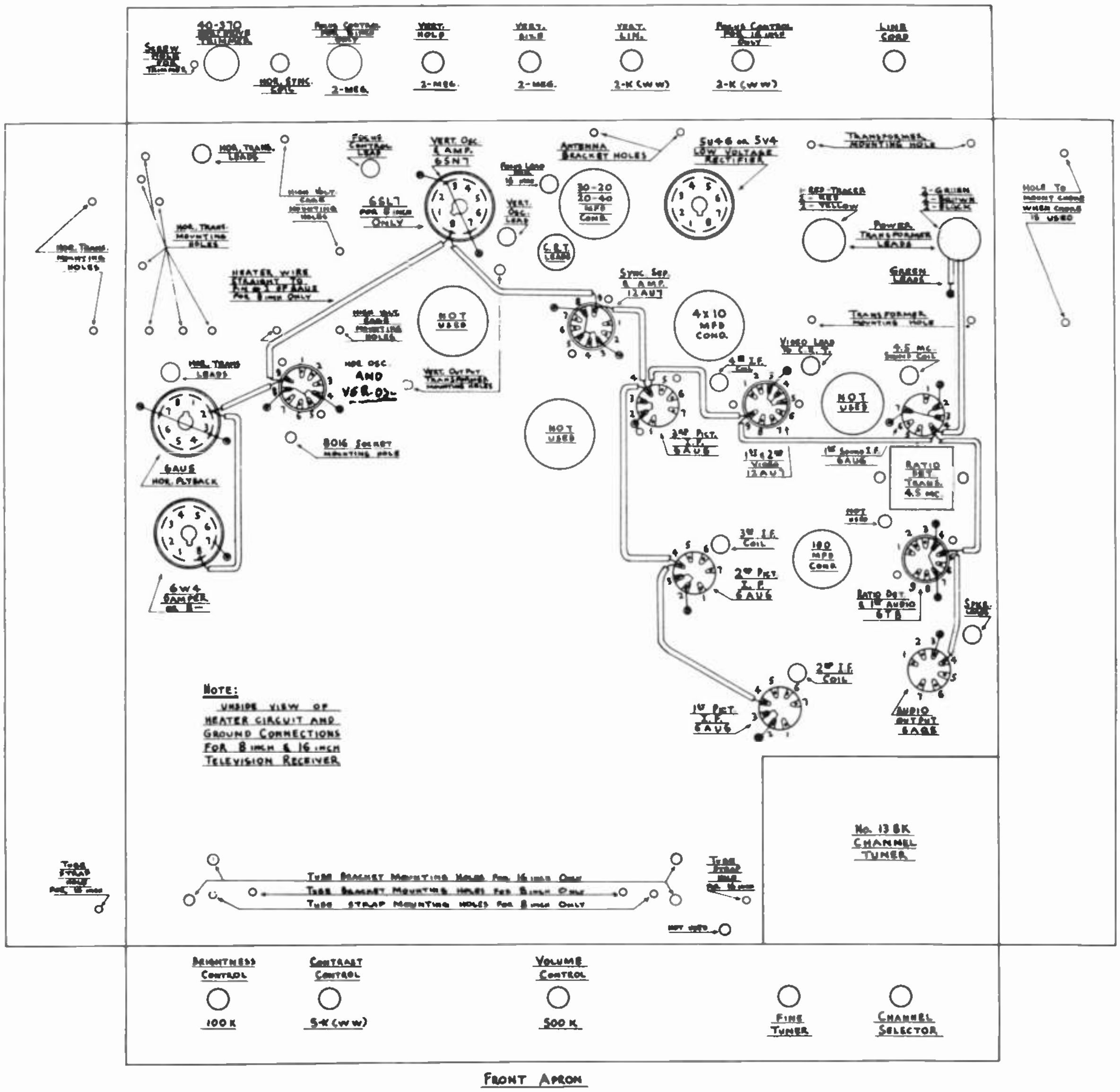
Under certain circumstances a defective high voltage power transformer may place the chassis at high potential with respect to an external ground. To eliminate such a hazard a good ground should always be attached to the receiver before power is applied. This is true, whether the receiver is in the home or on the service bench.

Because picture tubes are highly evacuated there exists a pressure difference between the inner and outer surfaces of the glass envelope. The earth's atmosphere exerts a pressure inward of approximately 15 pounds on every square inch of the tube's outer surface and this pressure must be borne by the glass itself since there is nothing within the tube to give an outward pressure. This inward force on the glass amounts to an amazingly high figure for the larger picture tubes. For example, with a twelve inch tube the pressure on the viewing end alone is 1700 pounds, and is several times this amount for the entire tube. With such high pressure on the tube, precautions must be taken to avoid the possibility of injury if the tube should explode or rather implode, as the result of a sudden failure in the glass envelope. For this reason the viewing end of the tube is protected in the receiver by means of a non-shatterable plate glass safety window. Whenever a picture tube is handled, gloves and shatterproof goggles should always be worn. It is also, of course, particularly important that the tubes be carefully handled so as to avoid striking or scratching the tube's surface.



CHAPTER 10 - PRACTICAL DATA ON TYPICAL TELEVISION RECEIVERS

SOCKET LAYOUT FOR T. T. I. 223T1 (8 Inch) RECEIVER



CABINET VIEW OF FINISHED 223T1 RECEIVER

DIRECTIONS

For Conversion of 8 Inch (Model #223T1)
TTI TV Receiver To Large Screen Operation.

STEP #1. Dismantling.

Disconnect and remove all condensers and resistors from the following tube sockets and circuits, but do not remove heater (filament) leads or connections.

1. Vertical and horizontal oscillator (12AU7)
2. Vertical amplifier tube (6SL7)
3. Horizontal amplifier tube (6SN7)
4. B-Rectifier 6W4

Remove high voltage board, centering controls and focus control. Do not remove vertical size or hold controls. Do not remove horizontal size trimmer or horizontal synchrolock coil.

STEP #2. Mounting of replacement units.

Remove self tapping screw from front hole of high voltage shield plate and loosen other screws. Now place vertical output transformer on chassis so that mounting hole in vertical output transformer falls under mounting hole in high voltage shield plate. Make sure vertical leads of transformer face rear of chassis Replace self tapping screw down thru hole in high voltage shield plate and thru vertical output transformer mounting hole. Retighten other screws in high voltage plate. Other lug of vertical output transformer can be soldered to the chassis (If preferred chassis may be drilled and a self tapping screw inserted). Mount vertical linearity control (5KWW) and focus control (2KWW) in rear holes of chassis as shown on layout sheet. Mount horizontal size and linearity coils in holes located on rear of high voltage shield plate. These coils should be soldered in place. Mount the 3X.1 bathtub under chassis and locate and place this condenser near 12AU7 tube socket and also close to open socket hole originally used as hor. amp 6SN7. Make sure all wires and picture tube socket is removed. Also remove 200ohm 25 watt resistor before wiring in focus coil and control. Mount filter condenser (30-20-20-40mfd) in chassis hole near video output amplifier (12AU7). Caution! When connecting this condenser for smoother filtering of B+1 and B+2, be sure that the 40 mfd-25V section is not used for this purpose as B+ would be short circuited.

STEP #3. Wiring.

Wire in new circuit (enclosed in red on your circuit diagram) neatly, keeping all leads as short as possible. Use the 3x.1 mfd bathtub condenser in the horizontal oscillator circuit where .1 mfd bypass condensers are called for. Make all leads from yoke to chassis about 10" in length and from picture tube socket to chassis about 16" in length. (This is in addition to under chassis runs). When wiring for 17, 19 or 20 inch tubes where console cabinet suspension of tube is anticipated, the above lengths must be increased accordingly, extreme care must be exercised when wiring resistors and condenser into yoke, leads must be kept short and parts kept against the inside perimeter of the housing in order that the tube neck enter the yoke hole unimpeded. However, when doing this do not allow the pigtails to short out to nearby lugs. Although an octal socket and male plug is not supplied with the kit they may be used for all yoke and focus coil connections.

(OVER)

STEP #4. Mounting picture tube.

Mount yoke hood on side of high voltage cage using top forward hole in cage. Use self tapping screw and brass washer. Mount focus coil "L" bracket right behind yoke hood. Be sure to select right hole in bracket so that when mounted the tube holes in yoke and focus coil line up. Picture tube, when mounted, should have high voltage anode terminal close to high voltage rectifier socket.

STEP #5. Adjusting and testing.

After all wiring and testing is completed, slide beam bender on neck of picture tube and connect picture tube socket. Turn set on for a full minute's time for warm up. Advance all controls on front of chassis fully clockwise. Raster can be brought into view by adjusting the beam bender. This adjustment consists of rotating the beam bender while moving it along the neck of the tube at the same time After raster appears it can be adjusted for maximum brightness by careful adjustment of beam bender.

STEP #6. Adjusting and testing.

Adjust centering of picture by manipulation of the focus coil. If any shadows appear in corners of picture tube it will be necessary to remove rubber bumpers from yoke hood in order that tube can be pushed as snug as possible against yoke. Raster tilt can be corrected by rotating yoke slightly after loosening wing bolt. Before tightening wing bolt be sure that yoke is still snug against tube bulb

STEP #7. Adjusting and testing.

Speaker can be mounted on one of the lamination bolts of the low voltage transformer by adding another nut. 300 ohm ribbon transmission line is used to strap tube to block. All adjustments on the rear of the chassis are the same as for the electrostatic set except for the horizontal drive trimmer. The correct adjustment of this trimmer is to tighten same to the point where all vertical white lines in the left side of raster disappear. Adjustment of all other controls must be made after video content appears in raster, in the conventional manner.

VOLTAGE CHART FOR BIG SCREEN CONVERSION

ALL VOLTAGES MEASURED

WITH V. T. V. M.

ALL VOLTAGES MEASURED

WITH RESPECT TO CHASSIS

AS GROUND OR MINUS

B+ 1 390 volts B+ 2 350 volts
B+ 3 155 volts

FRONT CONTROLS FULL CLOCKWISE

A.C. LINE VOLTAGE 112V-60 C.P.S.

TESTS MADE WITH NO PICTURE

NORMAL RASTER

TUBE TYPE	PURPOSE	PIN NUMBER OF TUBE								
		1	2	3	4	5	6	7	8	9
6AU6	1st Video I.F.	-1.5	0	0	6.3 AC	150	150	+.3		
6AU6	2nd Video I.F.	-1.5	0	0	6.3 AC	150	150	+.3		
6AU6	3rd Video I.F.	0	0	0	6.3 AC	100	150	+1.5		
12AU7	1st & 2nd Video Amp.	40	0	0	0	0	300	40	48	6.3 AC
12AU7	Separator and Sync. Amp.	10	-1	0	0	0	90	-1	0	6.3 AC
6AU6	Sound I.F. Amp.	-.5	0	0	6.3 AC	85	85	0		
6T8	4.5 mc Ratio Detector and 1st Audio	-.5	-.1	-.5	0	6.3 AC	0	0	-1.5	125
6AQ5	Audio Output	145	155	0	6.3 AC	360	350	145		
6SN7	Vertical Osc. & Amp.	-5	28	0	0	330	11	0	6.3 AC	
12AU7	Hor. Osc. and A.F.C. Cont.	150	-30	-5	0	0	220	-45	0	6.3 AC
6AU5	Horizontal Output	-24	6.3 AC	0	0	XX	0	0	180	
6W4	Damper	0	0	500	0	350	0	0	6.3 AC	
5U4	Rectifier	0	380	0	330	0	330	0	380	
12AT7	R.F. Osc. & Mixer									
6AG5	R.F. Amp.									

NOTE
VOLTAGE ON PINS #1 OF 1st AND 2nd VIDEO I.F. AMPLIFIERS IS A.G.C. VOLTAGE AND THEREFORE DEPENDS ON STRENGTH OF SIGNAL.

CAUTION
DO NOT MEASURE PIN #5 OF 6AU5, AS 6000 V AC IS PRESENT AT THIS POINT XX

PARTS USED FOR CONVERSION OF MODEL #223T1

TO BIG SCREEN OPERATION

ALL PARTS LESS PICTURE TUBE

AMOUNT	NAME OF PART
1	70° Deflection yoke
1	Metal-yoke hood and wing screw
1	Vertical output transformer
1	Focus coil (RCA Type) and wing nut
1	Focus coil bracket and washer
1	Focus control 2K WW
1	Horizontal width coil
1	Horizontal linearity coil
1	Beam bender
1	Picture tube socket for 14"
1	40" picture tube mounting strap 300 ohms
1	Vertical linearity control 5K WW
2	Self-tapping screws and washers
1	Hook-up wire 12'
1	High voltage anode connector
1	High voltage lead
1	30-20-20-40 mfd can condenser

SMALL RESISTORS AND CONDENSERS

AMOUNT	CONDENSERS	AMOUNT	RESISTORS
1	3x.1 bathtub	1	500 ohm $\frac{1}{2}$W
2	50 mmf	1	500 ohm 2W
1	150 mmf	1	1 K 1W
1	200 mmf	3	1 K $\frac{1}{2}$W
1	500 mmf	1	5 K $\frac{1}{2}$W
3	.001 mfd	1	5 K 1W
1	.0015 mfd	3	10 K $\frac{1}{2}$W
2	.005 mfd	2	20 K $\frac{1}{2}$W
3	.01 mfd	1	30 K $\frac{1}{2}$W
1	.02 mfd	1	50 K $\frac{1}{2}$W
1	.05 mfd	2	100 K 1W
2	.1 mfd	5	150 K $\frac{1}{2}$W
		2	250 K $\frac{1}{2}$W
		2	500 K $\frac{1}{2}$W
		1	1 meg $\frac{1}{2}$W
		2	2 meg $\frac{1}{2}$W
		3	3 meg $\frac{1}{2}$W

INSTRUCTIONS FOR BUILDING THE #19C UNIVERSAL TELEKIT

General:

The #19C Universal Telekit is an entirely new model television receiver in kit form and represents the most advanced ideas and trends in the reception of clear, stable television pictures. The methods as outlined should be followed religiously if a satisfactory, trouble-free set is desired. The layout and step by step procedure in the building of this receiver is the result of a thorough program of research and development by the instruction and technical staff of Television Training Institute. All techniques other than those recommended should be avoided and any attempts at originality in layout will only result in unsatisfactory performance.

Method of Using Manual:

The manual is bound in such a manner that it may easily be disassembled and only the sheets being referred to at any one time need be used. It is good practice to cross out the steps as they are completed. This will prevent any possibility of errors of omission and will lend encouragement as the job proceeds.

Placement of Parts:

The physical placement of the condensers, resistors, coils, transformers, etc. should be exactly as shown in the illustration figures. This is necessary because of the high frequencies involved and of the extremely high voltages used. Ground connections should be made at the points indicated. The inclusion of excess ground lugs, terminal strips and long ground wires should be avoided. Every extra bit of wire used over the recommended amount adds inductance to the circuits and can detune them appreciably.

Contents of Packages:

The packages are numbered from #1 to #10. The numbering system follows the construction outline so that when the operations are completed progressively the corresponding packages are emptied. This eliminates the cluttering of the workbench with partially emptied packages and as work progresses makes the job look less formidable. Resistors are color coded with the proper values and a familiarity with the color code or constant reference to the color code guide is required. All condensers are identified as to proper value by being stamped. Controls are also stamped.

FINAL SUGGESTIONS PRIOR TO ACTUAL ASSEMBLY

1. Checking Packages

Remove the packages from the kit and arrange them in numerical sequence for easy checking. There should be a total of 10 packages.

2. Tools

Be sure to have these tools on hand:

1. A 100 Watt Soldering Iron
2. A 4 inch Screw Driver and an 8 inch Screw Driver
3. 1 pair long nosed pliers
4. 1 pair slip joint pliers
5. 1 pair 6 inch Diagonal Cutters
6. 1 piece Steel Wool
7. Emery cloth or medium sandpaper
8. 1 Medium file (for tinning iron)

3. Tinning Iron Tip

To tin iron, plug in and allow the iron to warm up for five minutes. File the tip until the bright metal appears. Apply rosin core solder to tip and allow to run over the bright metal. Wipe clean with steel wool.

4. Care in Selection of Proper Parts

Whenever more than one unit is contained in a package be very careful to return the unused units to the package immediately to avoid loss or mixing of units.

5. Cold Solder Joints

Avoid "cold" solder joints by applying plenty of heat to the joint before applying the solder. After the solder is applied, keep the iron on the joint until the vapor boils off. Use a minimum of solder and, above all, avoid large droplets of solder hanging on joints.

6. Lug Joints

When making joints to socket lugs, first lay the part in the proper spot and gauge the length of wire (pigtail) required to make the shortest connection. Allow a little for insertion into the socket lug hole and crimping. Snip off the unwanted wire and insert the wire into the top hole of the proper lug (away from socket). Bend the wire which protrudes through hole around lug and squeeze tight (crimp) with long-nosed pliers. The mechanical strength of the joint should depend more on the crimp than upon the solder. Apply solder to the joint.

7. Chassis Joints (grounds)

When making chassis connections (grounds) first select the spot on the chassis where the ground is to be made. When working on sockets, be sure to make grounds close to the sockets. With the emery cloth clean very vigorously the spot where the joint is to be made. Apply the flat side of the iron tip to the cleaned spot and allow plenty of heat to flow into the area. When good and hot, apply solder to the spot at the junction of the hot iron tip and the chassis. Allow a more generous amount of solder to flow than when making a lug joint. Work solder into the spot by slightly moving iron tip under pressure. Remove iron and allow to cool. The spot is now tinned. Apply hot iron tip to wire and press firmly into tinned area. Apply a small amount of fresh solder to joint. Before removing iron tip from joint, press the wire into the joint with screw driver tip. Hold screw driver in this position for about 20 seconds after removing iron tip from joint.

8. Cleanliness

The importance of constantly wiping iron tip with steel wool to clean tip before making joints cannot be over-emphasized. Also, all wires must be cleaned with emery cloth before making joints. This is done to remove dirt, wax and oxidation. All of which contribute to the making of poor solder joints. Unless metals are cleaned before application of solder, poor electrical connections will result. Remember, WORK CLEAN!

9. Following Layout Diagrams

Although the schematic wiring diagram IS furnished, it is merely to check wiring. By following the instructions and referring to the layout diagrams for assembly information, a perfect job will be the result. When each step is completed, mark off the paragraph and proceed to next step. Take your time and check each step very carefully.

10. Hookup Wire

The wire furnished with the kit is the insulated stranded variety. It is best to tin the bare end of wire with solder before connecting into circuit. This will prevent fraying out of the stranded ends of wire while making joints. To tin end, lay wire on clean tip of soldering iron and apply a small amount of solder to wire.

11. Hardware

All the necessary nuts, washers and self-tapping screws will be found in the kit. To use self-tapping screws properly, place the unit on the chassis over the screw holes which are drilled into the chassis. Using an 8 inch screw driver, drive screw very firmly into hole. The thread of the self-tapping screw will tap its way through the metal. Be sure to drive screw into hole STRAIGHT!

12. Hole Designations

You will note that in the step-by-step instructions there are references made to chassis holesthroughout. These hole designations appear on illustration figure #1 in the back of the book. Your chassis should be placed in the same direction as the one in the figure and you must mark all of the holes with either pencil or ink. It is only necessary to mark the holes on the inside of the chassis.

13. A Word of Caution

Work slowly and carefully. Be sure to follow the instructions to the letter. The success of your construction job will depend entirely upon your patience and thoroughness. Your reward for a neat job will be a perfect, trouble-free television set, long hours of relaxed enjoyment in watching the television programs and a feeling of satisfaction in a job well done.

14. Universal Chassis

As the job progresses you will notice that some of the numbered holes are unused. This is because the chassis is a universal one which is used for various models. Merely use the holes which the instructions call for.

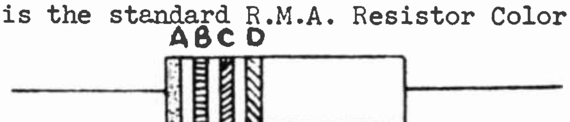
15. Wiring Photograph

Figure #2 in the back of the book clearly indicates the placement of each part and the route taken by each wire. However, in order to make this clear in a drawing it is necessary to move parts and wires slightly in order to show them all. The photograph of the wiring which is shown on the back of the schematic wiring diagram gives the actual view of how the finished job should look. Use your drawings as your guide in accuracy and your photo as your guide in neatness.

16. Resistor Color Code Data

The assembly of the #19C Universal Telekit requires a knowledge of the standard R.M.A. Resistor Color Code in order to avoid costly errors in construction. If you, as an experienced radio man, are thoroughly familiar with the color code, then you may regard this sheet as being for the amateur builder. However, our experience in servicing these kits and in answering queries from all types of builders has shown that even the experienced man slips up occasionally and installs the wrong unit in a critical circuit. We find that the vast majority of troubles encountered in these well designed Telekits can be traced to wrong values of resistance in one or more circuits. This does not mean, however, that precision resistors must be used. The set will perform just as well if the resistors are within 20% plus + or - of the value called for. This gives a very liberal 40% range of resistance. The usual errors are in reading the color of the third color band which gives the multiplying value of the resistor. For example: a 100,000 ohm resistor mistaken for a 10,000 ohm, or a 200 ohm mistaken for a 20 ohm, etc. As you can see, this type of error is far in excess of the tolerance allowed and can prevent the receiver from performing properly. Therefore, all builders should study this sheet thoroughly.

The following chart is the standard R.M.A. Resistor Color Code:



It will be noted upon observation that a resistor has certain colored bands of paint on its body. These bands are used for identification purposes. Holding the resistor in the position shown above with the first band "A" to the extreme left, we can "read" the numerical value of the resistor in ohms. The first three bands, "A", "B", "C", will tell us the value of the resistor in ohms, while the last band "D" will tell us the tolerance value of the resistor. The wattage rating is not identified by this method, therefore, a special paragraph is devoted to this subject.

"A" First Band		"B" Second Band		"C" Third Band (Number of Zeros)		"D" Fourth Band +	
Black	0	Black	0	Black	----	Gold	--- 5% Tolerance
Brown	1	Brown	1	Brown	1 Zero	Silver	" 10% Tolerance
Red	2	Red	2	Red	2 Zeros	No Band	" 20% Tolerance
Orange	3	Orange	3	Orange	3 "	(Blank)	
Yellow	4	Yellow	4	Yellow	4 "		
Green	5	Green	5	Green	5 "		
Blue	6	Blue	6	Blue	6 "		
Violet	7	Violet	7	Violet	7 "		
Gray	8	Grey	8	Gray	8 "		
White	9	White	9	White	9 "		

TYPICAL EXAMPLES

Colors	Value in Ohms	Tolerance
Red, Black, Black, Gold	20	- + 5%
Red, Red, Brown, Silver	220	- + 10%
Red, Red, Red, Gold	2200	- + 5%
Red, Red, Orange, Blank	22,000	- + 20%
Green, Red, Yellow, Blank	520,000	- + 20%
Red, Red, Green, Silver	2.2 Meg. (2,200,000)	- + 10%
Green, Black, Green, Blank	5 Meg. (5,000,000)	- + 20%
Brown, Black, Blue, Blank	10 Meg. (10,000,000)	- + 20%
	(Meg. means 1,000,000)	

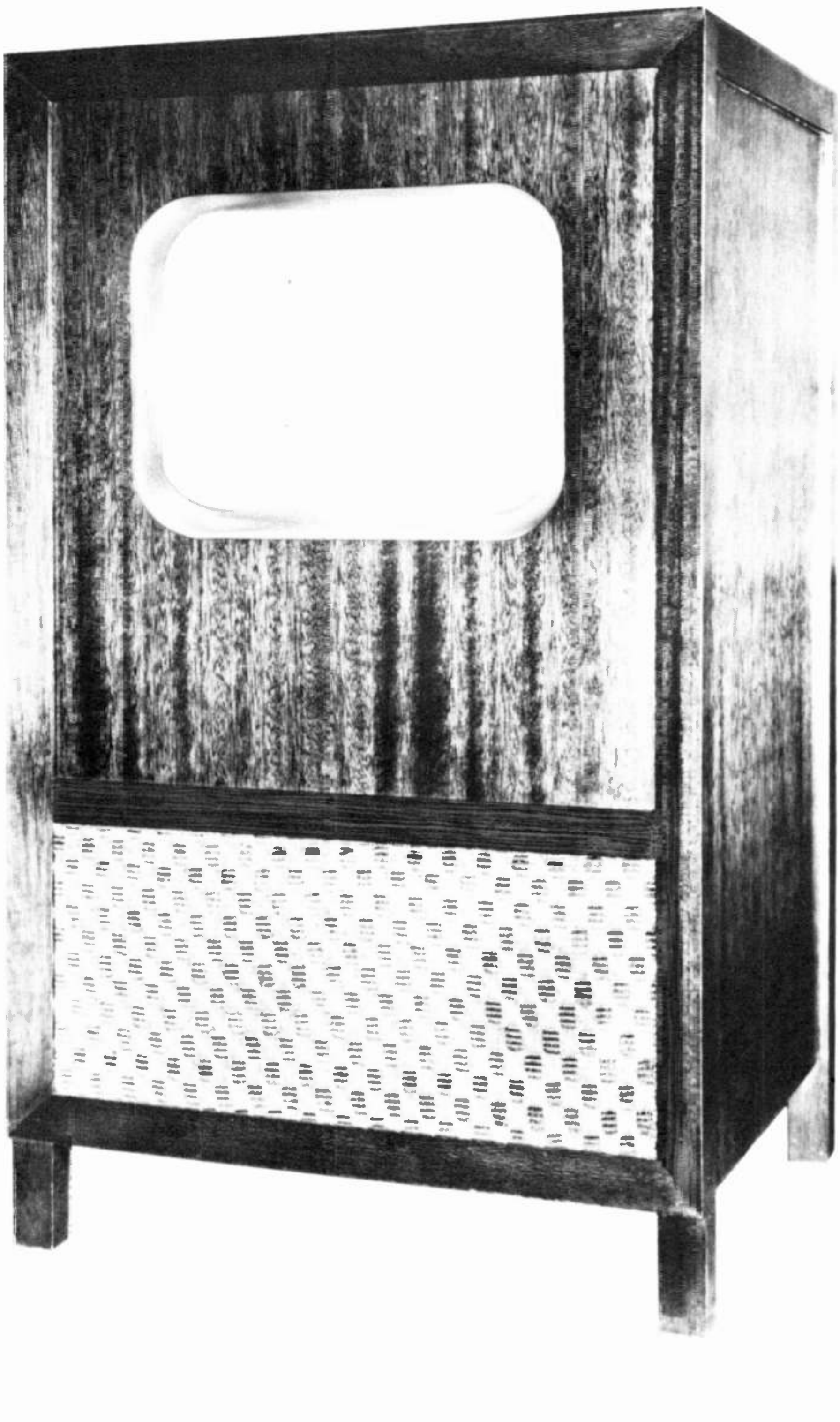
Since the Telekit will perform satisfactorily with resistance within the 20% tolerance range, the fourth band may be disregarded; therefore, its presence or absence is relatively unimportant.

WATTAGE RATINGS

You will observe that a wattage identification follows each resistor value in the instructions. The wattage rating is based upon the physical size of the unit.

17. Telekit Guaranteed

Your Telekit is guaranteed to perform and ELECTRO-TECHNICAL INDUSTRIES will back up this claim (see guarantee sheet.) However we cannot emphasize too strongly the necessity of following these instructions to the letter. It only takes a little longer to wire the job properly and your patience will save you many hours in trouble shooting and perhaps many dollars in service fees. With the foregoing facts and bits of information in mind you are now ready to begin the first assembly operation.



CABINET VIEW OF FINISHED #19C UNIVERSAL TELEKIT
(OR #223T1 CONVERSION)

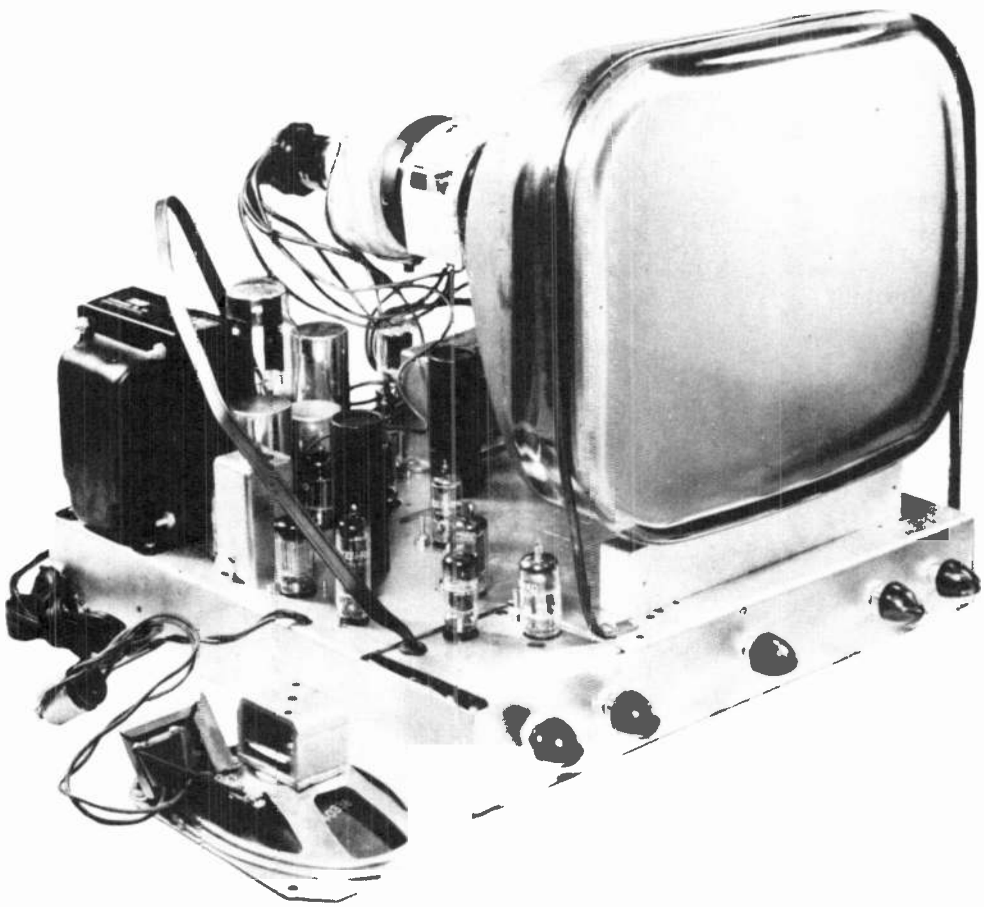
Instructions for Building the #19C Universal Telekit

Fourteen Inch Rectangular Tube Instructions

1. All instructions for the 14 inch installation are the same as above with the following exceptions:

    1. Wood block mounts on chassis with narrow side down over holes #73 and #77.
    2. Yoke hood hole #108 must coincide with plate hole #86.
    3. Focus coil mount hole #105 must coincide with plate slot #88.
    4. Cut 5 inches off tube strap before mounting.

Instructions for console cabinet installation appear later in manual after all tests are described.



VIEW OF TELEKIT SHOWING 14 INCH RECTANGULAR TUBE MOUNTED ON CHASSIS

PACKAGE PARTS LIST

Package # 1 Sockets and Wire

5 - Minature 7 pin Sockets (w/rings*)
3 - Octal Sockets (w/rings*)
1 - Octal Ceramic Socket (w/ring)
4 - Minature 9 pin Sockets (w/rings*)
* - 25 sm. self tapping screws (for flange type sockets)
5 - ft. Ground Wire
50 - ft. Hookup Wire
1 - Chassis and Fittings
1 - Hank Solder
1 - Manual

Package #2 Horizontal Sweep

1 - 10,000 ohm $\frac{1}{2}$ W resistor
1 - 20,000 ohm $\frac{1}{2}$ W resistor
1 - 100,000 ohm $\frac{1}{2}$ W resistor
5 - 150,000 ohm $\frac{1}{2}$ W resistors
1 - 250,000 ohm $\frac{1}{2}$ W resistor
2 - 500,000 ohm $\frac{1}{2}$ W resistors
1 - 2 megohm $\frac{1}{2}$ W resistor
1 - 50 mmf condenser
1 - 150 mmf condenser
1 - 200 mmf condenser
1 - 500 mmf condenser
1 - .001 mfd condenser
1 - .0015 mfd condenser
1 - .01 mfd condenser
1 - Bathtub condenser (3 x .1 mfd)
1 - 40-370 mmf trimmer condenser (w/bracket)
1 - Syncrolock coil

Package #3 Vertical Sweep & Separator

1 - 500 ohm $\frac{1}{2}$ W resistor
1 - 5000 ohm $\frac{1}{2}$ W resistor
2 - 10,000 ohm $\frac{1}{2}$ W resistors
1 - 20,000 ohm $\frac{1}{2}$ W resistor
1 - 50,000 ohm $\frac{1}{2}$ W resistor
1 - 150,000 ohm $\frac{1}{2}$ W resistor
1 - 250,000 ohm $\frac{1}{2}$ W resistor
1 - 500,000 ohm $\frac{1}{2}$ W resistor
3 - 2 megohm $\frac{1}{2}$ W resistors
1 - 3 megohm $\frac{1}{2}$ W resistors
1 - 1000 ohm 1 W resistor
1 - 30,000 ohm 2 W resistor
1 - .001 mfd condenser
2 - .005 mfd condensers
3 - .01 mfd condensers
2 - .05 mfd condensers

Package #3 Cont'd

1 - 5000 ohm w.w. control w/ground lug
1 - 2 megohm control w/ground lug
1 - 2 megohm control
1 - 30-20-20-40 mfd can cond.
1 - Vertical output transformer
1 - 10-10-10-10 mfd can condenser
1-2x100 mfd can condenser
2 - Self tapping screws

Package #4 Video Detector & Amp.

1 - 2000 ohm $\frac{1}{2}$ W resistor
1 - 3000 ohm $\frac{1}{2}$ W resistor
2 - 10,000 ohm $\frac{1}{2}$ W resistors
1 - 1 megohm $\frac{1}{2}$ W resistor
1 - 3 megohm $\frac{1}{2}$ W resistor
1 - 10 megohm $\frac{1}{2}$ W resistor
2 - 5000 ohm 1 W resistors
1 - .01 mfd condenser
1 - .1 mfd condenser
1 - 2.2 mmf condenser
2 - 120 uh peaking coils
1 - 180 uh peaking coil
1 - Crystal detector
1 - I.F. coil
1 - 30-20-20-40 mfd condenser

Package #5 Video I.F. Amplifier

2 - 27 ohm $\frac{1}{2}$ W resistors
3 - 100 ohm $\frac{1}{2}$ W resistors
1 - 150 ohm $\frac{1}{2}$ W resistor
1 - 3000 ohm $\frac{1}{2}$ W resistor
2 - 5000 ohm $\frac{1}{2}$ W resistors
1 - 10,000 ohm $\frac{1}{2}$ W resistor
2 - 150,000 ohm $\frac{1}{2}$ W resistors
3 - 200 mmf condensers
5 - .005 mfd condensers
1 - .01 mfd condenser
1 - .1 mfd condenser
2 - I.F. coils
1 - 5000 ohm w.w. control w/ground lug

Package #6 Audio I.F. Detector & Amp.

3 - 10,000 ohm $\frac{1}{2}$ W resistors

PACKAGE PARTS LIST (Cont'd)

Package #6 Audio I.F. Detector & Amp. (Cont'd)

1 - 20,000 ohm $\frac{1}{2}$ W resistor
1 - 30,000 ohm $\frac{1}{2}$ W resistor
1 - 50,000 ohm $\frac{1}{2}$ W resistor
2 - 100,000 ohm $\frac{1}{2}$ W resistors
2 - 250,000 ohm $\frac{1}{2}$ W resistors
1 - 2 megohm $\frac{1}{2}$ W resistor
1 - 10 megohm $\frac{1}{2}$ W resistor
1 - 5 mfd condenser
2 - 500 mmf condensers
1 - .001 mfd condenser
4 - .01 mfd condensers
1 - .02 mfd condenser
1 - .1 mfd condenser
1 - 100 mfd can condenser
1 - 4.5 mc. sound I.F. coil
1 - Ratio detector transformer
1 - 500,000 ohm control w/sw and w/ground lug
2 - Speaker leads (one 17" and one 22")
1 - 100,000 ohm control
1 - Terminal strip
1 - Speaker male plug

Package #7 Low Voltage Supply

1 - 500 ohm 2 W resistor
1 - 2000 ohm w.w. control
1 - Power transformer
1 - Line cord and plug
4 - Lg. self tapping screws
2 - Sm. self tapping screws
1 - Sm. terminal strip
1 - Octal socket w/ring

Package #8 High Voltage Supply

1 - 10,000 ohm 2 W resistor
3 - .1 mfd condensers
1 - Width coil
1 - Linearity coil
1 - Horizontal output trans. assembled
1 - Picture tube socket
1 - High voltage mounting plate
4 - Self tapping screws
1 - Antenna post
1 - 16" high voltage wire
1 - 9" high voltage wire
1 - Anode connector
1- 1X2A socket W/ condense r
1 -.05 mfd condenser

Package #9 Channel Tuner

1 - 13C tuner w/2 knobs and dial
3 - Knobs

Package #10 Picture Tube Components

3 - 1000 ohm $\frac{1}{2}$ W resistors
1 - 50 mmf condenser
1 - Speaker and output transformer
1 - Speaker male plug
2 - Small wood screws for speaker
1 - Focus coil
1 - Wing nut
1 - 70° yoke
1 - Wing bolt
1 - Octal plug
1 - Yoke hood
1 - Beam bender
1 - Focus coil bracket
6 - Small washers
1 - Large washer
8 - Self tapping screws
2 - Insulating sleeves
1 - Tube block
1 - Tube strap - 40"

ALIGNMENT AND OPERATING INSTRUCTIONS FOR COMPLETED #19C TELEKIT

Preliminary Checks

1. Retrace all steps in the instruction sheets and layout figures.

2. Check all connections with the aid of the schematic diagram. Do not be alarmed if you find some unused lugs on some of the tube sockets.

3. Be absolutely certain that there are no bare wires touching others or chassis (causing "shorts") and that all joints are securely soldered.

4. Turn set over, pick up and shake vigorously in order to remove all snippings of wire, bits of solder and other debris which accumulates during construction. These small bits are "poison" to a television receiver, because they can cause "shorts" when the power is applied and ruin expensive components.

5. Be sure that all controls are securely fastened to the chassis and that transformers, can condensers, coils, etc. are seated firmly in their respective places.

Placement of Receiving Tubes

1. The receiving tubes shall be placed in the following sockets:

SOCKET	TUBE TYPE
A	6AU6 Sound I.F.
B	6T8 Sound Detector and Audio
C	6AQ5 Audio Output
D	6AU6 First Video I.F.
E	6AU6 Second Video I.F.
F	6AU6 Third Video I.F.
G	12AU7 First and Second Video Amp.
H	12AU7 Sync. Separator and Amp.
I	6SN7 Vertical Osc. and Amp.
J	5U4G Low Voltage Rectifier
K	12AU7 Horizontal A.F.C. and Osc.
L	6AU5 Horizontal Amplifier
M	6W4 Damper
High Voltage Transformer	1X2A High Voltage Rectifier

Setting Up of Picture Tube for Testing Purposes

In order to test and align the Telekit it will be necessary to have the picture tube on your work bench, (console model Telekits) or mounted to the chassis (see "Table Model Telekits"). To test Telekits which are to be installed in console cabinets the picture tube should be removed from the carton and placed on your workbench with screen forward and neck supported by cardboard boxes or other soft support. Also, place something in front of screen end of tube to keep tube from slipping off table. Slide yoke on neck of tube and bring forward until coils are snug against bulb and sliding bracket of yoke is on top. Now place focus coil behind yoke (smooth, rounded end forward) and bring up against rear of yoke. Bend pieces of thin cardboard and insert them in space between focus coil hole and neck of tube so that coil fits snug to neck. These pieces are referred to as shims. If you are going to use a metal shell picture tube with your Telekit it will be necessary to place the insulating ring over the rim of the screen end and to change your Telekit high voltage anode connector (read section "Console Cabinet Mounting" which describes this operation) in order to engage spring clip high voltage connector which comes with this tube. The beam bender which is in package #10 should now be slipped on neck of picture tube. The adjustment of the beam bender will be determined later when testing for raster of light, its function being to insure brightest illumination on screen. Do not connect picture tube socket or high voltage connector yet. CAUTION: DO NOT PLUG SET INTO A.C. OUTLET YET.

Location and Function of Controls

1. Sound Volume and A.C. Switch:

   This control is mounted in hole #66 on front apron and its function is identical to that on radio receivers. By turning knob clockwise it snaps on the power and after set warms up further clockwise rotation of this knob will increase the volume of received sound.

2. Contrast:

   This control is mounted in hole #65 on front apron and its function is to control picture gain. By advancing the control clockwise the intensity of the picture elements (blacks and whites) will increase.

3. Station Selector:

   This control is mounted in hole #68 on front apron and its function is to switch in the desired television channel. This receiver is designed to receive all television channels available in your locality. Sound and Picture will both come in together, locked in tune, when switch is turned to proper positions.

4. Fine Tuning:

   This control is mounted in hole #67 on front apron and its function is to give the clearest picture on the channels switched in by the station selector. It is adjusted while picture is being observed for best detail.

5. Brightness:

   This control is mounted in hole #64 on front apron and its function is to adjust the overall brightness of the picture to the viewers satisfaction.

6. Focus:

   This control is mounted in hole #8 on rear apron and its function is to sharpen the line formation of the raster which will insure clearest picture detail. After once being set it will require no further attention.

7. Horizontal Hold Control:

   This control is mounted in hole #3 on rear apron of chassis and it consists of a threaded shaft adjustment which is turned with the aid of a small screw driver or a tuning stick. Its function is to provide a single stable picture in the horizontal direction and can only be adjusted when a picture is being received from the local station. When out of adjustment the picture will be broken up into a lot of horizontal bars slanting down to the left or to the right. When approaching correct adjustment the bars will be broader and fewer until one picture will pull into place and fill the screen. Once adjusted no further attention need be given this control.

8. Horizontal Drive:

This control is in the form of a trimmer condenser in hole #2. When properly adjusted with blank raster it will provide maximum high voltage to the picture tube. When out of adjustment the raster will be dim, and white vertical bars will appear in left side of raster. When properly adjusted raster will be brightest and no bars will be apparent. Adjustments to this control will slightly affect the focus so that focus control will have to be readjusted. Once set, drive control needs no further attention.

9. Horizontal Width:

This control is in the form of a threaded shaft adjustment and is mounted in hole #96 of high voltage shield. Its function is to vary the width of the picture. Clockwise turning of shaft will increase picture width. Once set no further attention is required.

10. Horizontal Linearity:

This control is in the form of a threaded shaft adjustment and is mounted in hole #97 of high voltage shield. Its function is to correct the effect of stretching or crowding on either side of the picture and is best adjusted when station test patterns are on the air. Adjust for roundest circles in test pattern. Once set no further attention is required.

11. Vertical Hold:

This control is mounted in hole #5 on rear apron and its function is to hold the picture in a vertical direction. When improperly adjusted the picture will be observed to slip either upwards or downwards or perhaps fold back from the top so that many bright lines will appear on the picture. Adjust control until a stationary frame appears on the screen. After setting no further attention is required.

12. Vertical Size:

This control is mounted in hole #6 on the rear apron and its function is to adjust the height of the picture. This control will work in conjunction with the vertical linearity control to secure both correct height and correct linearity. If picture slips vertically during adjustment reset vertical hold control.

13. Vertical Linearity:

This control is mounted in hole #7 on the rear apron and its function is to adjust the linearity (vertically). It is used in conjunction with the vertical size control as mentioned above. After setting the two controls no further attention is required.

<u>First Hot Check</u> (Heaters) For all troubles refer to service notes in technical section.

Remove the 5U4G rectifier tube from its socket. Plug the A.C. cord into a 110 volt A.C. 60 cycle outlet. Turn on A.C. switch on front apron. Observe the glass tubes closely and look for the heaters to light up. If a short circuit exists in the heater circuit, a sharp hum will be heard coming from the low voltage transformer and one of the heater wires may smoke and burn up. If so, turn set off immediately and check entire heater circuit. If everything is normal proceed to second hot check. **<u>Turn off switch</u>.**

Second Hot Check (B+ Low Voltage Supply) For all troubles refer to service notes in technical section.

Remove the 1V2 tubes from their sockets. Be sure that the speaker is connected. Advance the volume control to maximum clockwise position and stand chassis on its side in such a way that the underside components as well as the 5U4G tube can be seen at the same time. Be sure also that yoke and focus coil are plugged into socket #85, and are in position on neck of picture tube. Do not connect picture tube base socket or high voltage anode connector yet. Replace the 5U4G tube into its socket. Turn on the A.C. switch and observe the 5U4G tube and also the 6AU5 (Horizontal Output tube). Heaters inside glass envelope should light up, but heavy plates around heaters should not begin to glow a cherry red. If plates begin to glow it indicates a short circuit in the B+ circuit (if 5U4G tube glows) or the fact that the horizontal oscillator is not working (if the 6AU5 tube glows). If any component under the chassis begins to smoke or sizzle, turn set off and find short circuit. Recheck entire set and find trouble before turning set on again. If all is normal and B+ and horizontal section are O.K. a thin, high pitched singing note can be heard coming from the horizontal section. This indicates that horizontal oscillator and amplifier are working. Take a screw driver and touch the grid (lug #8 of socket B) of first audio tube. This should produce scratching sounds in the speaker and it is an indication that the audio section is working. You are now ready for the third hot check. Turn off switch.

Third Hot Check (High Voltage)

You must be very careful with this check as there will be high voltage on the high voltage terminals and a burn will result if you make physical contact with them. Proceed to connect picture tube socket to kinescope. Plug high voltage anode connector into receptacle on side of picture tube bulb. Insert the tubes back into high voltage transformer. Stand chassis on side to observe underside components. Turn set on and wait a minute or so for it to warm up. Direct your attention to the sockets in high voltage transformer which are the 1V2 high voltage tube sockets. If you find the sockets dirty or have other wires too near these sockets you may experience an arcing at this point. If you do, refer to technical section after you turn set off. If all is normal up to this point, advance brightness control fully clockwise. Manipulate the Beam Bender on the neck of the tube as per technical section instructions, to secure maximum brightness on picture tube. Set horizontal and vertical hold controls to obtain a rectangular pattern of light. This is known as the raster. If any trouble is experienced in this operation, refer to the technical section. You are now ready for the alignment of sight and sound.

Alignment of Picture and Sound

Before attempting alignment, be sure that your antenna lead-in is connected.

1. Check with your local television station to find what hours during the day the static test pattern and sound signal is being transmitted. The station provides this service to assist in the alignment of receivers.

2. Procure these items:

One (1) Pair Earphones
One (1) .1 Condenser at 400 V.
One (1) Tuning Stick (preferably plastic, non-metallic)

3. Proceed to Align Receiver as Follows:

(a) Turn set off, connect the .1 condenser to one of the earphone leads. Leave the other lead of the condenser open. Attach an alligator or similar clip to the other earphone lead and another clip to the open lead of the condenser. Clip the earphone lead to the chassis and the condenser lead to the #6 lug of socket G. Turn the channel selector to the number of your local television station. Turn on set. You can now "listen in" on the picture signal when it comes through. Be sure that volume control and contrast control are at full clockwise setting.

(b) Rotate fine tuning condenser shaft and listen for buzz in earphones. If buzz gets too loud or blocks out reduce contrast control setting slightly. Keep brightness about halfway.

(c) If no buzz is heard on this channel position of tuner, try same procedure on the channel above and channel below the channel number of your local station. If signal is heard there then it indicates that your I.F. Coils are set too high or too low. If results are negative then check antenna connections and positioning. If everything appears normal but still no buzz then check wiring and refer to technical section of your service notes.

(d) If buzz is heard picture content should appear on raster but probably will be streaking or jumping. Adjust vertical hold control to keep picture from jumping or sliding. If picture elements are streaking across screen then try to stop them with horizontal hold control.

(e) If a vertical bright bar appears on the left side of picture then slowly adjust the horizontal drive trimmer until it disappears. This trimmer also aids in adjusting for maximum high voltage. Adjust slowly until picture appears brightest. This adjustment should be clockwise.

(f) Adjust focus control until clearest line formation is obtained on picture. Adjust brightness control until satisfactory brilliance is achieved. Do not make too bright as it will impair picture quality.

(g) Remove earphone clip from set and locate ratio detector transformer in hole #59. Slowly adjust bottom slug until shaft is about 1 inch out of its clip and sound is at its loudest. Be sure that your adjustment goes through the loudest point. Adjust slug in top of can until sound is clearest and buzz disappears. The shaft should be about ½ inch out of clip when buzz disappears. (A.M. null point). Locate sound take off coil in hole #60 and adjust slug for maximum volume of sound. If buzz reappears readjust top slug of ratio can until null point is reached again. For all difficulties encountered, refer to technical section for service notes.

(h) The next phase of the coil alignment is the adjustment of the video I.F. coils. The first I.F. coil in the 13C Telekit tuner has been adjusted in the factory and therefore will not require any readjustment. This leaves the second, the third and the fourth video I.F. coils to be adjusted. A simple and effective method of doing this is by measuring the brass tuning shafts from chassis to tip with a ruler. The Telekit is properly aligned when the measurements are as follows:

(h) Continued.

COIL	INCHES
Hole #53 (2nd Video I.F.)	5/8 inch
Hole #52 (3rd Video I.F.)	9/16 inch
Hole #51 (4th Video I.F.)	1/2 inch

These adjustments should provide you with pictures and sound of excellent quality. The fine tuning control will enable you to tune for the best picture definition without affecting the sound. For more precise information on coil alignment look under "Alignment of Telekit with Instruments" in technical section.

(i) The Telekit receiver will perform best with an outdoor television antenna kit and a 300 ohm transmission line. This kit may be purchased economically from the Telekit factory. For location close to the transmitter (metropolitan and suburban) indoor antennas may be used. For "fringe" areas special antennas which are designed for "pulling in" weak signals are necessary and your local parts jobber can give you excellent advice on what is required in your area.

(j) Always locate your television receiver in a part of the room where no direct light falls on screen. After set is mounted in cabinet it should be placed in its permanent place and should not be moved about. Always be sure to turn off your set when not in use. This will extend the life of your picture tube.

(k) After Telekit is performing satisfactorily it can be installed in its cabinet and placed in the desired viewing location. Instructions for console cabinet installation immediately follow. Remove picture tube from bench and replace in carton.

Console Cabinet Mounting
(All Tube Types 14" up to 20")

1. Remove cabinet from carton. Lay carton on floor and place cabinet on top of carton face down. Remove picture tube from carton and place in cabinet so that edge of tube rests on block (or blocks) which is fastened inside panel. If a metal shell tube is to be used be sure that plastic insulating ring is in place on rim of tube and that spring anode connector is in place on the left side of the tube looking from the back. Also be sure that when using the round picture tubes that the key on the base of the tube also faces to the left. Tubes which are constructed of all glass will have the anode receptacle in the glass bulb itself and this must also be to the left when the tube is inserted in the cabinet. The spring anode connector which comes with the insulating ring (used on metal shell tubes) should be examined. Notice that the small metal button on the end snaps out of the clip. With the aid of a screw driver snap the button out of the clip. Remove the anode connector originally installed on the end of the high voltage lead of the Telekit with the aid of a soldering iron. Solder the button lug to the end of the high voltage wire. This button then becomes the anode connector when Telekit is to be used in conjunction with metal shell tubes. The clip itself is snapped on the rim edge of the picture tube under the insulating ring on the left side of tube. After chassis is inserted into the cabinet the anode connector of Telekit can then be snapped into clip, however,

do not insert chassis into cabinet until further directed.

2. Remove the wooden T board from the cabinet. Remove the small envelope containing the screws from the board. You will notice that these screws are of various sizes. Select the yoke hood and two ½ inch screws. (Note: if metal shell tube is to be used snip off the large contact spring from yoke hood so that there is no danger of this spring contacting shell and shorting out high voltage). You will notice that two corners of the T board uprights will be cut off. This will establish the rear of the board as contrasted to the other end which will be called front. Place the hood under the uprights so that the ears of the hood are flush to the bottom of the uprights and slotted hole in top of hood is between uprights. Front of hood must face front of T board. Now adjust hood so that front edge is 3/4 inch behind front edge of uprights. Drive a screw through slot in each ear and into bottom of upright. Be sure it is tight.

3. Remove yoke and focus coil plug from chassis and fasten yoke into yoke hood with wing bolt and two small washers (package #10) through slot in top of hood and into hole of sliding bracket in yoke. Be sure that exposed coils of yoke face to front.

4. Select focus coil mount (L shaped bracket), wing nut and large washer from package #10. Insert threaded stud of focus coil through hole #103 (coil being outside of L bracket and upright of bracket to your left facing rear of coil - rear being side of coil where seam of shell is made). Tighten wing nut and insert "L" bracket between uprights behind yoke so that focus coil mount hole #105 is flush against left upright and focus coil front is snug against rear of yoke. Place small washer on the thin screw. Adjust focus coil so that large hole in center of coil is in line with large hole in center of yoke. Drive screw and washer through hole #105 of L bracket and into wood.

5. Remove yoke and focus coil from their mounts (by removing wing bolt and nut) and place T board into cabinet allowing neck of tube to pass through yoke hood. The long cross board of the T mounts to the side braces in the ceiling of the cabinet. Slide the entire assembly forward as far as it will go so that front edge of hood contacts bulb of tube. Select the two 3/4 inch screws and drive one into each end of T cross piece and into ceiling braces of cabinet. Whether you are installing a 14 inch tube or a 20 inch tube or any intermediate sized tube the tube necks will be in the same place and the act of sliding the board forward as far as it will go against tube will establish the correct yoke and focus coil positions. Replace yoke and focus coil into their mounts and adjust wing bolt of yoke to allow yoke to fit as snugly against tube as possible. Cabinet can then be stood upright and front inspected to see that tube is positioned in mask properly.

6. Speaker can be mounted against small hole behind grille with the two 1/4 inch screws. The large hole in the grille is provided for a larger speaker if such is desired.

7. If all tests and adjustments have been made and the Telekit is operating satisfactorily remove knobs from front apron controls and slide chassis into console cabinet, allowing control shafts to enter the panel holes and move forward as far as it will go. Replace yoke and focus coil plug into socket #85. Place beam bender on neck of tube and connect picture tube socket to base of picture tube. Replace knobs on front of cabinet and plug in speaker. Connect antenna lead-in to antenna board and plug set into A.C. outlet. Turn on set and allow for warm-up period. Manipulate beam bender for appearance of

light on picture tube. Adjust focus coil by tilting forward or backward in order to center picture. A sidewise rotation of the coil may also be necessary in order to achieve satisfactory results and sometimes cardboard shi[illegible] are necessary to get best results. Shadowing in the corners of the tube can be overcome by seeing that yoke is as snug as possible against front of tube. Best results can be observed by setting up a mirror in front of the cabinet and making all adjustments in rear of cabinet while observing mirror image. After final adjustments are made for centering (focus coil) and brightest illumination (beam bender) no further attention need be given to these units.

The #19C Telekit as a 10 or a 12 Inch Receiver

The #19C Universal Telekit can also be operated in conjunction with a 10BP4, 10FP4, 12LP4, 12KP4 and similar type smaller screen picture tubes for those schools, clubs or individuals who have those tubes at hand and do not wish to make an immediate change to larger screen tubes. Although the above tubes are designed for 52° deflection angle and the Telekit is designed for 70° deflection angle the picture spread can be reduced merely by adjusting the width and drive controls for the proper horizontal spread and adjusting the height and vertical linearity controls for the proper vertical spread. No wiring changes whatsoever are necessary in order to operate the Telekit with smaller screen picture tubes. Physical changes necessary for mounting a ten inch tube to the chassis are as follows:

1. Wood block mounts on chassis with narrow side down over holes #73 and #77.

2. Yoke hood hole 108A must coincide with plate hole #86.

3. Focus coil mount hole #105 must coincide with plate slot #88.

4. Cut strap to fit snugly around tube before fastening.

Physical changes necessary for mounting a twelve inch tube to the chassis are as follows:

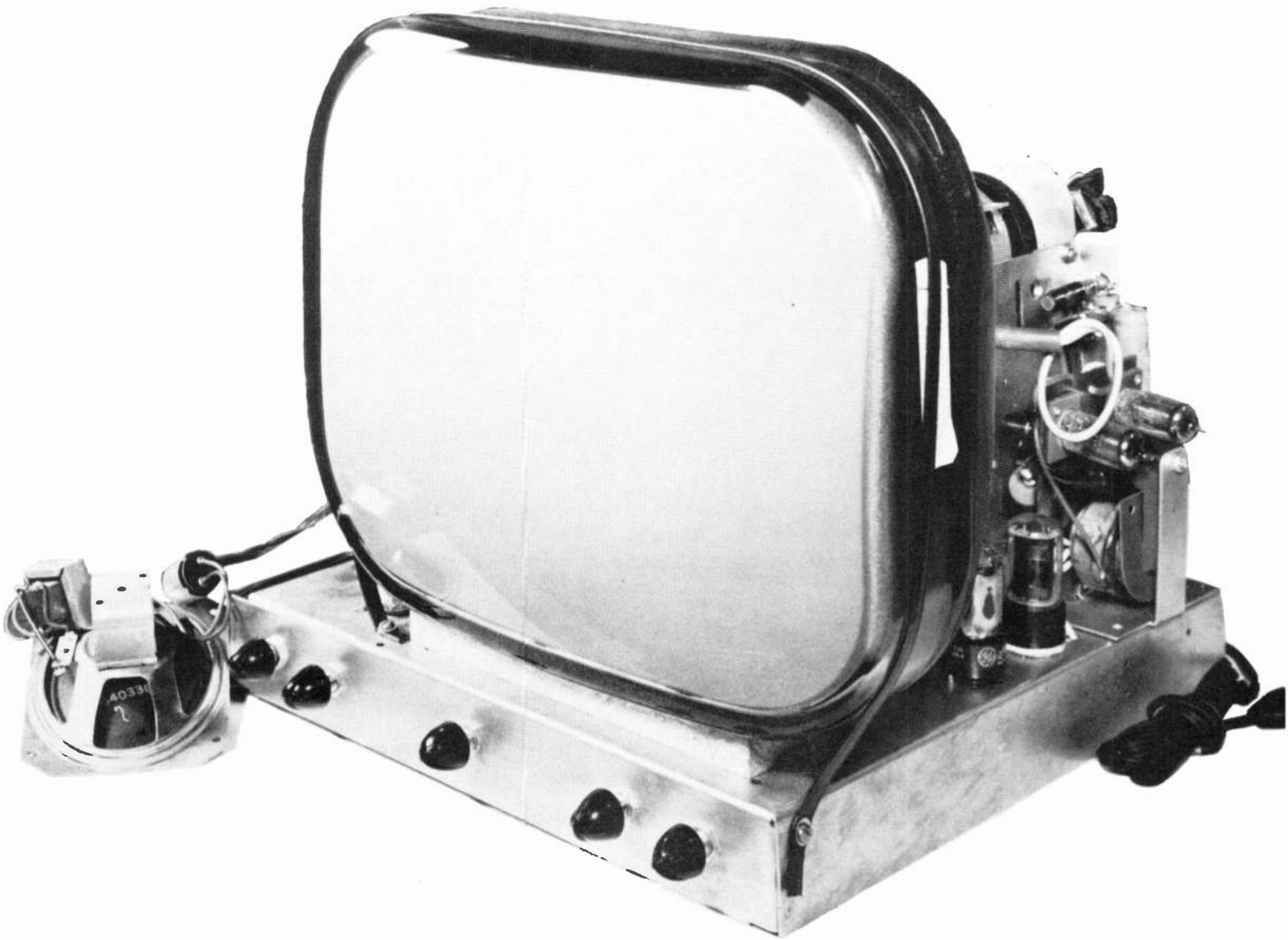
1. Wood block mounts on chassis with flat side down over holes #73 and #77.

2. Yoke hood hole 107A must coincide with plate hole #86.

3. Focus coil mount hole #105 must coincide with plate hole #89.

4. Cut strap to fit snugly around tube before fastening.

The Telekit can also be tested and aligned with a small screen picture tube even if it is intended to be used in conjunction with a large screen picture tube, if so desired.



VIEW OF TELEKIT SHOWING 16 INCH RECTANGULAR TUBE MOUNTED ON CHASSIS

TECHNICAL SECTION FOR THE TELEKIT

The following is a list of possible failures and an indication of procedure for their correction. Check voltages with aid of voltage chart in rear of book.

Indication	Possible Trouble
A. No raster on screen No light	(1) No high voltage - see notes on "Checking High Voltage". (2) Open syncrolock coil. (3) Open linearity coil. (4) Incorrect adjustment of beam bender. (5) Drive trimmer installed improperly with wrong plate grounded. (6) Wrong or defective connections on picture tube socket. (7) Defective horizontal oscillator, amplifier or damper tube.
B. Bars or wrinkles on left side of raster	(1) Drive trimmer incorrectly adjusted. (2) Resistors and condensers in yoke improperly installed or defective. (3) Defective horizontal amplifier tube or damper.
C. Trapezoid or keystoned raster	(1) Defective yoke. (2) Short circuit in yoke due to defective wiring during resistor and condenser installations.
D. Bright horizontal line (No vertical sweep)	(1) Defective 6SN7 vertical tube. (2) Vertical controls improperly set. (3) Yoke plug or socket #85 improperly wired.
E. Poor vertical linearity (See chart fig. #41)	(1) Check to see that both condensers (100 + 40 mfd) are connected to cathode of vertical amplifier (6SN7). (2) Check 10 mfd condenser on vertical output transformer (red lead). (3) Check .05 mfd condenser in vertical oscillator plate circuit. (4) Change to another 6SN7 and reset controls (some tubes are critical here). (5) Low B plus voltage due to low A.C. line voltage or defective rectifier (5U4G).
F. Poor horizontal linearity: (See chart fig. #61)	(1) Horizontal drive trimmer adjustment incorrectly set. (2) Horizontal linearity control incorrectly set. (3) Horizontal linearity coil incorrectly wired. (4) Defective horizontal amplifier tube.

TECHNICAL SECTION FOR THE TELEKIT

	Indication	Possible Trouble
G.	Raster - no image, but accompanying sound: (See chart fig. #39)	(1) Check for open .1 mfd coupling condenser between 2nd video and picture tube. (Lug #6 tube G). Check the 1 megohm resistor too. (2) Poor picture tube socket connections.
H.	Signal on kinescope grid, but no sync: (Cannot hold picture) (Similar to fig. #26)	(1) Check sync amplifier tube and circuit. (2) Check plate voltages on both sections of sync tube. (3) Reduce contrast control as signal may be too strong.
I.	Signal on kinescope grid and horizontal sync only (Picture rolls vertically) See fig. #28	(1) Check vertical tube and associated circuit. (2) Check vertical oscillator input network for wiring mistakes. (3) No A.G.C. voltage or signal too strong.
J.	Signal on kinescope grid and vertical sync only. (See fig. #26)	(1) Check horizontal hold control adjustment. (2) Check horizontal oscillator input network for wiring mistakes. (3) Check drive control trimmer adjustment. (4) Check horizontal oscillator tube grid circuit resistors.
K.	Picture stable but poor resolution (not clear) (See fig. #58) (Be sure that station selector is on proper channel position).	(1) Check grid resistors for proper value on all video I.F. tubes. (2) Test all peaking coils for continuity. (3) Check plate resistors of 1st and 2nd video amplifiers for proper value. (4) Be sure that focus control operates on both sides of proper focus. If focus point cannot be reached within range of control try reversing focus coil leads. NOTE: Low A.C. line voltage or low B plus will affect focus. (5) If focus sharpens line structure but pictures are still not clear realign I.F. coils. (6) Peaking coils mixed. Change to proper places. (7) Poor antenna system or transmission line looped or coiled.
L.	Picture smear:	(1) This trouble can originate at signal source, in relay medium or at transmitter itself. Be sure that this trouble is not present on local

TECHNICAL SECTION FOR THE TELEKIT

Indication	Possible Trouble
L. Picture smear: (Cont'd)	sets which are operating normally before proceeding.
	(2) Check for defective electrolytic condensers on cathode and plate of 2nd video amplifier.
	(3) Open peaking coil.
	(4) Improper I.F. alignment causing regeneration. Realign.
	(5) Long, loose leads dangling near I.F. coils. Shorten and redress leads down on chassis.
	(6) Regeneration in Telekit tuner. Try cutting antenna leadin about one foot shorter and reconnect.
M. Picture Jumpy:	(1) Can condensers not soldered to chassis. Any other poor connection in set can cause picture to jump and sound to become noisy.
	(2) Vertical controls improperly set or contrast control set too high (too much signal).
	(3) Antenna system has loose connections. (Jumping more evident in wind).
	(4) Local electrical disturbances (flashing signs, worn brushes on electric motors, ignition interferences, distant lightening, etc.).
	(5) Defective 6SN7 vertical tube.
	(6) Noisy (microphonic) tube or tubes anywhere in tuner, I.F., video, sync or sweep circuits. Trace by tapping lightly on tubes. Don't condemn tubes too quickly, however, as the noise (poor solder joint) may be under chassis at that point.
	(7) Voltage on plate of separator tube too high. Check wiring.
N. Oscillation, picture breakup or blocking when contrast control is advanced.	(1) Improper alignment of I.F. coils.
	(2) Open or poorly soldered bypass condenser on lug #6 of one or more of the I.F. tubes.
	(3) Excessively long leads in I.F. section, leads dangling near I.F. coils, I.F. tube grid resistors too high in value. Instructions not followed.
	(4) A.G.C. circuit not functioning.
	(5) Telekit tuner oscillating. Grasp lead-in in fist and run along line toward set to see if it stops. At point it stops (if this is the trouble) recut and connect to set.
	(6) Poor chassis ground connections in

TECHNICAL SECTION FOR THE TELEKIT

Indication	Possible Trouble
N. (Cont'd.)	I.F. section.
O. Arcing in high voltage section. (Audible cracking sound).	(1) Wired components on transformer too close due to movement during shipment or wiring operations. Locate point arcing occurs, turn off set and move parts or wires apart carefully. (2) Loose anode connection. (3) Small piece of solder lodged in one of the high voltage sockets. (4) A wire touching shell of metal picture tube (if used). NOTE: Entire shell is charged and therefore all metallic objects must be kept free and clear of tube excepting high voltage wire.
P. Corona in high voltage section. (An almost inaudible fizzing sound with a dim blue glow and accompanied by an odor of fresh air (ozone), causes interference in picture and loss of high voltage.	(1) Sharp points of solder or small stranded ends of wire cause this. Extinguish all external lights and examine components on high voltage transformer while set is on to locate point of discharge. Sometimes clips of high voltage condensers will discharge from a sharp edge. Round off with solder. Look for corona around wires where they come close to chassis or shield.
Q. If picture is too small horizontally only.	(1) Horizontal drive trimmer screwed in too tight. (2) Width control not adjusted to full. (3) Gassy horizontal amplifier tube. (4) Low A.C. line or B+ voltage. (5) Increase the two 500 mmf series condensers between lugs #3 and #4 of wired high voltage transformer to two 1000 mmf condensers.
R. If picture is too large both horizontally and vertically.	(1) Lack of sufficient high voltage due to leakage in high voltage section (corona). (2) One of the two 500 mmf condensers (lugs #3 and #4) may be shorted. Check and replace. (3) One or both high voltage rectifiers defective. (4) Decrease value of two 500 mmf condensers (lugs #3 and #4) to two 250 mmf condensers. This will increase high voltage.

TECHNICAL SECTION FOR THE TELEKIT

R. (Cont'd.)

(5) One or more defective high voltage (ceramic) condensers.

S. <u>If picture lacks height but width is normal.</u>

(1) Defective 6SN7 vertical tube. Replace.
(2) Vertical controls misadjusted.
(3) Open condenser on cathode of vertical amplifier.
(4) Low A.C. line or B+ voltages.
(5) Defective damper.

T. <u>Picture cannot be centered or shadows exist in corners of picture.</u>

(1) Picture tube not pushed into yoke as far as it will go.
(2) Focus coil misadjusted. Readjust.
(3) Beam bender misadjusted. Readjust.
(4) If round tube is used, rotate tube and check alternately until picture centers properly.
(5) Cardboard shims inserted between neck and focus coil hole are sometimes necessary.

U. <u>Raster - no sight nor sound.</u>

(1) Defective oscillator (12AT7) in Telekit tuner.
(2) Defective tube in I.F. or video sections.
(3) Defective audio tube (6AQ5).
(4) Wiring error in I.F. or video sections. Attach earphones to lug #6 of 2nd video tube and scratch grids of 2nd video, 1st video, 3rd I.F., 2nd I.F., 1st I.F. and antenna post in that order with metal screw driver. Listen for section where noise disappears. Trouble should be in that section.

<u>Remedies for Indicated Test Chart Faults</u>

Figure 24	(a)	Look for nearby high buildings or objects that would cause reflections of signal.
	(b)	Installation of a reflector on dipole may improve condition.
Figure 32	(a)	Set brightness control and contrast properly.
Figure 33		Turn fine tuning knob slightly or readjust I.F. tuning.
Figure 34		Turn yoke to properly orient picture.
Figure 35		Adjust width coil or adjust drive control.
Figure 36		Adjust focus coil.
Figure 37		Adjust vertical size control.
Figure 39		Correct raster.
Figure 41		Adjust vertical linearity.
Figure 42		Adjust contrast control.
Figure 56	(a)	I.F. out of alignment.
	(b)	R.F. out of alignment.
Figure 58	(a)	Poor I.F. alignment.
	(b)	Poor focus adjustment.
Figure 59		Leaking coupling condenser in video.

TECHNICAL SECTION FOR THE TELEKIT

Remedies for Indicated Test Chart Faults (Cont'd)

Figure 60		Bad 6W4 damper tube or drive condenser set wrong.
Figure 61	(a)	Adjust drive control and linearity coil.
	(b)	Check damper tube 6W4.

Circuit Description of Horizontal Deflection & High-Voltage Circuits.

A 6AU5 beam deflection tube is used for producing the necessary amplitude of the sawtooth currents in the deflection coils. The high voltage for the second anode supply is also produced from the energy stored in the deflection inductances during each horizontal scan. The sawtooth voltage applied to the grid of the 6AU5 deflection amplifier produces a sawtooth of current in its plate circuit. The plate of this tube is connected to the primary winding of the deflection transformer. A sudden change of current in the primary will produce a high inductive pulse on the plate of the tube 6AU5. The sudden ceasing of plate current caused by the cutoff of the tube during retrace will cause the circuit to oscillate. The voltage across the yoke must be maintained uniformly constant during trace. In order to obtain this uniformity the 6W4 damper tube is connected across the deflection coils to remove the oscillation following the retrace pulse. Thus, during the trace period, the voltage is constant across the yoke which produces the desired linear sawtooth of current through the yoke for deflection. The pulse voltage on the plate of 6AU5 is stepped up and rectified, and the rectified voltage is filtered, and applied to the second anode of the kinescope.

Returning to the 6W4 damper, the B plus voltage is supplied to the 6AU5 through this tube which is conducting over the major portion of the trace. The condenser in the cathode circuit (.1 mfd.) is fully charged during this period and at the time when the damper is not conducting, this charge is sufficient to supply the 6AU5 plate.

The width control functions to increase or decrease horizontal scanning as required by variations of tube and circuit constants. Capacitor and resistor on the horizontal yoke coil and the resistors across the vertical coil serve to decrease the effects of crosstalk between the horizontal and vertical yoke coils, eliminating the effect of ringing of the horizontal output transformer due to leakage reactance.

Checking Horizontal Oscillator and High Voltage

1. Equipment necessary:

    1 pair earphones
    1 .005 - 600 volt condenser
    1 Neon test lamp (readily obtainable - 59 cent variety)
    1 20,000 ohm per volt volt-ohm-meter (volt-meter scale to 600 volts)

2. The neon lamp will be used to test for high A.C. voltage. The lamp will glow because of the high frequency of this voltage (15,750 cycles). It is only necessary to hold lamp (glass end, not leads) within $\frac{1}{4}$ inch of the 1X2A tube base mount on H.V. condenser, being cautious not to get fingers near terminal, as your finger will draw an arc from this terminal if high voltage is present.

3. Assuming you have no light on picture tube and you have tried all preliminary adjustments of beam bender etc., it is necessary to determine whether or not you have high voltage. Use the above test with neon lamp to find out if high voltage is present.

TECHNICAL SECTION FOR THE TELEKIT

Checking Horizontal Oscillator and High Voltage (Cont'd)

4. If neon lamp does not glow at all when held close to this terminal, it is safe to assume that no high voltage is present. You must now determine the cause of the missing voltage. Referring to the circuit diagram, you will note that the development of high voltage depends upon the proper functioning of the horizontal oscillator and amplifier circuits. The pulses from the horizontal circuit produce the high voltage. It is necessary, therefore, to check each stage to see if it is operating correctly.

5. To determine if oscillator is working, connect a pair of earphones with a .005 mfd condenser in series with one lead to pin #7 of horizontal oscillator tube 12AU7. Connect the condenser end to pin #7 and the other end of earphones to chassis. Turn set on. If a high pitched squeal or note is heard and if it changes in frequency as horizontal oscillator hold control is varied, the horizontal oscillator tube is operating.

6. If you do not hear the above-mentioned note in your earphones, you have localized the trouble as being in the horizontal oscillator circuit. You should then check voltages on this tube (12AU7). Refer to voltage chart. If this fails to bring the trouble to light, it will be necessary to turn set off and check component parts of the circuit.

7. Assuming you have heard the note in the earphones, the next step in localizing the trouble is to remove the earphone lead (with condenser) from pin #7 of 12AU7. Connect lead to pin #1 of horizontal amplifier tube (6AU5). This check is to determine whether or not coupling condenser is functioning properly. Turn set on. The same note should be heard. If not, turn set off and replace coupling condenser.

8. After this procedure, earphones can no longer be used as a test instrument. Caution: Never connect earphones to pin #5 of 6AU5 horizontal output tube, as there is high A.C. voltage present which would be dangerous to earphones as well as yourself !

9. Now that you have arrived at this point in the checking procedure and still have no high voltage as evidenced by the neon lamp not glowing (when held near 1V2 socket on horizontal output transformer), proceed to the next step in trouble-shooting.

10. Turn off set and check component parts of horizontal output circuit and tube 6AU5. Make certain that circuit is wired properly according to wiring diagram. If all is well, turn set on and check for voltages on this tube (6AU5). There should be 210 volts on pin #8 of 6AU5 which is screen grid and 400 volts on pin #5 of 6AU5. Take care in measuring these voltages, so as not to make physical contact with yourself and the voltage points.

11. To check damper circuit 6W4 take two voltage readings - one from pin #5 on 6W4 tube to ground (340 to 400 volts) and one from terminal #3 on horizontal output transformer to ground (chassis). This voltage should be about 50 volts more than the preceeding measurement (400 to 450 volts). If not, the damper tube is not functioning properly and tube and circuit should be checked.

12. These are the usual sources of trouble in the high voltage circuits. The correction of these faults should produce high A.C. voltage.

13. To check presence of high A.C. voltage, again use the neon lamp tester, a glow should appear in the neon lamp when held close to 1V2 socket of horizontal

TECHNICAL SECTION FOR THE TELEKIT

Checking Horizontal Oscillator and High Voltage (Cont'd)

output transformer. The high A.C. voltage is then rectified and doubled in going through the 1V2 tubes and the resulting D.C. voltage is applied to the second anode of the picture tube.

14. The only source of trouble encountered in the H.V. rectifier circuit will be:

(a) Bad rectifier tubes.
(b) Leakage or arcing of high voltage from tube filament lugs to mounted components.
(c) Corona effects.
(d) Open or short circuited components.

The first is self explanatory; check tube filaments for continuity. The second case can be corrected by keeping maximum distance between filament pins on 1V2 tube sockets and components. If dirt, grease or dampness accumulates on sockets, it will provide a path for the high voltage to arc to components. Clean sockets thoroughly with carbon tetrachloride. The third trouble, corona effects, will be noticed by turning off all lights in the room with set on and observing a blue glow existing on any of the wires in the high voltage circuits or coming from the filament pins of the 1V2 tubes themselves. Pay particular attention to the filament pins. If the blue glow or corona discharge comes from these points, it can be prevented very simply by resoldering these pins, making sure that the finished pin is round and smooth and has not sharp, projecting points or edges. Corona effects will become apparent at these points if joints are not carefully made. Open or short circuited components can be checked with an ohmeter.

15. This brings you to the final check which includes the picture tube and associated coils. Assuming you have tried to position your beam bender to secure brightest illumination on screen, you should next check the voltages on the picture tube socket. Be sure the pins are connected properly. If you still have no light, remove cover from yoke housing and check wiring. Be sure there are no short circuits inside, due to burning of the insulation when soldering lugs.

16. We are quite sure any trouble originating in the horizontal oscillator, amplifier and high voltage circuits will be found if the above step by step procedure is followed.

Voltage Analysis

1. Do not attempt to read high voltage on the television receiver unless you are familiar with high tension circuits and have the proper equipment to do so. In order to get accurate readings in the high voltage circuits, it is essential that an extremely high resistance voltmeter be used (20,000 ohms per volt or more). A vacuum tube voltmeter is preferred. In our laboratories we use a 20,000 ohm per volt movement, in conjunction with a General Electric high voltage multiplier probe which has an internal resistance of 200 megohms.

2. Remember - DO NOT tamper unnecessarily with the high voltage circuits because of the shock and burn hazard involved.

3. A low voltage and resistance chart is supplied with each Telekit for your convenience in locating trouble.

TECHNICAL SECTION FOR THE TELEKIT

Voltage Analysis (cont'd)

4. The readings for the voltage chart were taken under certain conditions. These conditions should be duplicated if identical results are to be obtained. The constructor should bear in mind that it is not necessary to obtain identical readings. All voltage readings are taken with a 20,000 ohm per volt meter which is readily obtainable. The readings are taken from the pin numbers to ground of chassis. Negative being chassis. The chart has been based on an A.C. line voltage of 112 volts. Consequently, if the line voltage is different, the entire set of voltages will be higher or lower in proportion to the line voltage change. All variable resistances (controls) should be turned in maximum clockwise direction (on full). No antenna or signal should be connected to the set.

Alignment of Telekit

We have found through experience that it is relatively easy to align the video stages to get a preliminary picture as the video I.F. system is sufficiently broad to pass some signal at almost any setting.

It is, however, more difficult to adjust the sound channel because these circuits are sharply tuned. We, therefore, advise that a signal generator be used for this purpose. Our sound channel will be tuned to exactly 4.5 Mc. To simplify this adjustment it is recommended that the following procedure be used. Signal can be observed with either the speaker or output meter.

1. Tune signal generator to 4.5 Mc. (Using a 400 cycle note or tone).
2. Connect hot lead of generator through a .005 mfd condenser to grid of sound I.F. tube (#1 pin). Connect ground lead to chassis. Turn volume control to full clockwise setting. Turn on set and allow a one minute warmup period.
3. Tune primary of F.M. Transformer, which is the lower slug, for maximum sound in speaker. If too loud reduce generator output.
4. Move generator lead with condenser to grid (pin #2) of first video amplifier tube.
5. Adjust slug which controls tuning of the sound I.F. coil (hole #60) for maximum intensity of signal.
6. Tune secondary of F.M. Transformer by means of the upper slug of ratio detector transformer mounted on the upper side of chassis for null point. You will notice in making this adjustment that you will get maximum signal response from loud speaker or output meter on two settings of this slug very close together. Between these two settings there will be a null point; that is, a point that is considerably lower in intensity than on either side of this adjustment. It is this point that is desired. When this is found the operation is completed. Notice the signal will not completely disappear with this adjustment if the volume control is turned on full. This completes the sound adjustment.
7. Connect signal lead of generator through the .005 mfd condenser to the grid lug (#1) of the first video I.F. tube (tube D). Clip the ground lead of the generator to chassis at base of tube D. Advance contrast control to maximum setting. Clip earphone lead through a .01 mfd to lug #6 of video output tube (tube G). Clip other earphone lead to chassis. You can now listen to the modulated signal as you make coil adjustments. An output meter connected through a .1 mfd condenser can be connected to the same points in lieu of earphones.

TECHNICAL SECTION FOR THE TELEKIT

Alignment of Telekit (Cont'd)

8. Set signal generator to 24.5 Mc. Adjust fourth video I.F. coil (hole #51) for maximum output at that frequency. Note that on these adjustments the coil should go through the desired points. Be sure that you can go through these points to be certain that the coils are in the correct frequency range. Then adjust to maximum or minimum as specified.

9. Set signal generator to 26 Mc. Adjust third video I.F. coil for maximum output at that frequency. If signal becomes too loud reduce generator output.

10. Set signal generator at 24 Mc. Adjust second video coil for maximum output at that frequency. If signal becomes too loud reduce generator output.

11. The first video coil (mixer output) is in the Telekit tuner. This has been adjusted at the factory to the frequency of 22.8 Mc.

12. The above adjustments will produce a broad band frequency response of 4.5 Mc. which will insure pictures of high definition and sound of excellent clarity.

TELEKIT GUARANTEE

ELECTRO-TECHNICAL INDUSTRIES guarantees the operation of your TELEKIT but this guarantee is automatically voided if:

(a) Acid-core solder is used any place in the set.

(b) A different chassis or parts layout is used other than that provided or specified.

(c) Wiring is not as specified.

(d) Hidden interlocking switches, original circuits, other make channel tuners, broadcast tuners or other devices which the kit builder incorporates in his TELEKIT.

VOLTAGE AND RESISTANCE CHART

FOR 19C TELEKIT — 20,000 Ohms Per Volt Meter — Line Voltage 112V A.C.

Turn all controls to the right (Clockwise)

Measured values are from socket pins to chassis

PIN NUMBER

TUBE			1	2	3	4	5	6	7	8	9
6AG5	R. F. Amp.	V	0	1.5	6.3AC	0	280	175	1.5	----	----
		R	200	100	0	0	100K	150K	100	----	----
12AT7	Mixer & Oscillator	V	280	-.5	0	6.3AC	6.3AC	175	-3	0	0
		R	100K	10K	2	0	0	130K	100K	0	0
6AU6	Ist Video I.F. Amp.	V	-1.25	0	0	6.3AC	150	150	.25	----	----
		R	3 Meg	0	0	0	40K	40K	27	----	----
6AU6	2nd Video I.F. Amp.	V	-.5	0	0	6.3AC	150	150	.25	----	----
		R	3 Meg	0	0	0	40K	40K	27	----	----
6AU6	3rd Video I.F. Amp.	V	0	0	0	6.3AC	110	150	1.5	----	----
		R	10K	0	0	0	45K	40K	150	----	----
6AU6	Sound I.F. Amp.	V	-.5	0	0	6.3AC	90	90	0	----	----
		R	250K	0	0	0	110K	110K	0	----	----
6T8	Det. and Audio Amp.	V	-1	-1.5	-1	0	6.3AC	0	0	-.5	115
		R	600K	50K	600K	0	0	0	0	10Meg	350K
6AQ5	Audio Output & B+3	V	138	150	0	6.3AC	385	340	138	----	----
		R	140K	40K	0	0	100K	100K	140K	----	----
12AU7	1st Video Amp. & 2nd Video Amp.	V	50	0	0	0	0	350	50	58	6.3AC
		R	12K	3K	0	0	0	250K	12K	10K	0
12AU7	Sync Sep.& Sync Amp.	V	10	-.75	0	0	0	90	-.5	0	6.3AC
		R	10K	2 Meg	0	0	0	130K	2 Meg	0	0
12AU7	Hor. A.F.C. and Osc.	V	130	-20	8	0	0	200	-75	0	6.3AC
		R	150K	750K	300K	0	0	400K	300K	0	0
6SN7	Vert. Osc. and Amp.	V	-3	75	0	0	400	9	0	6.3AC	----
		R	2 Meg	5 Meg	0	2 Meg	2.5Meg	500	0	0	----
6AU5	Horizontal Amp.	V	-24	6.3AC	0	0	***	0	0	210	----
		R	500K	0	0	0	250K	0	0	110K	----
6W4	Damper	V	0	0	***	0	340	24	0	6.3AC	----
		R	6	0	250K	0	100K	100K	0	0	----
5U4	Low Volt. Rectifier	V	0	390	0	380AC	0	380AC	0	390	----
		R	0	100K	0	55	0	50	0	100K	----

Pin Number

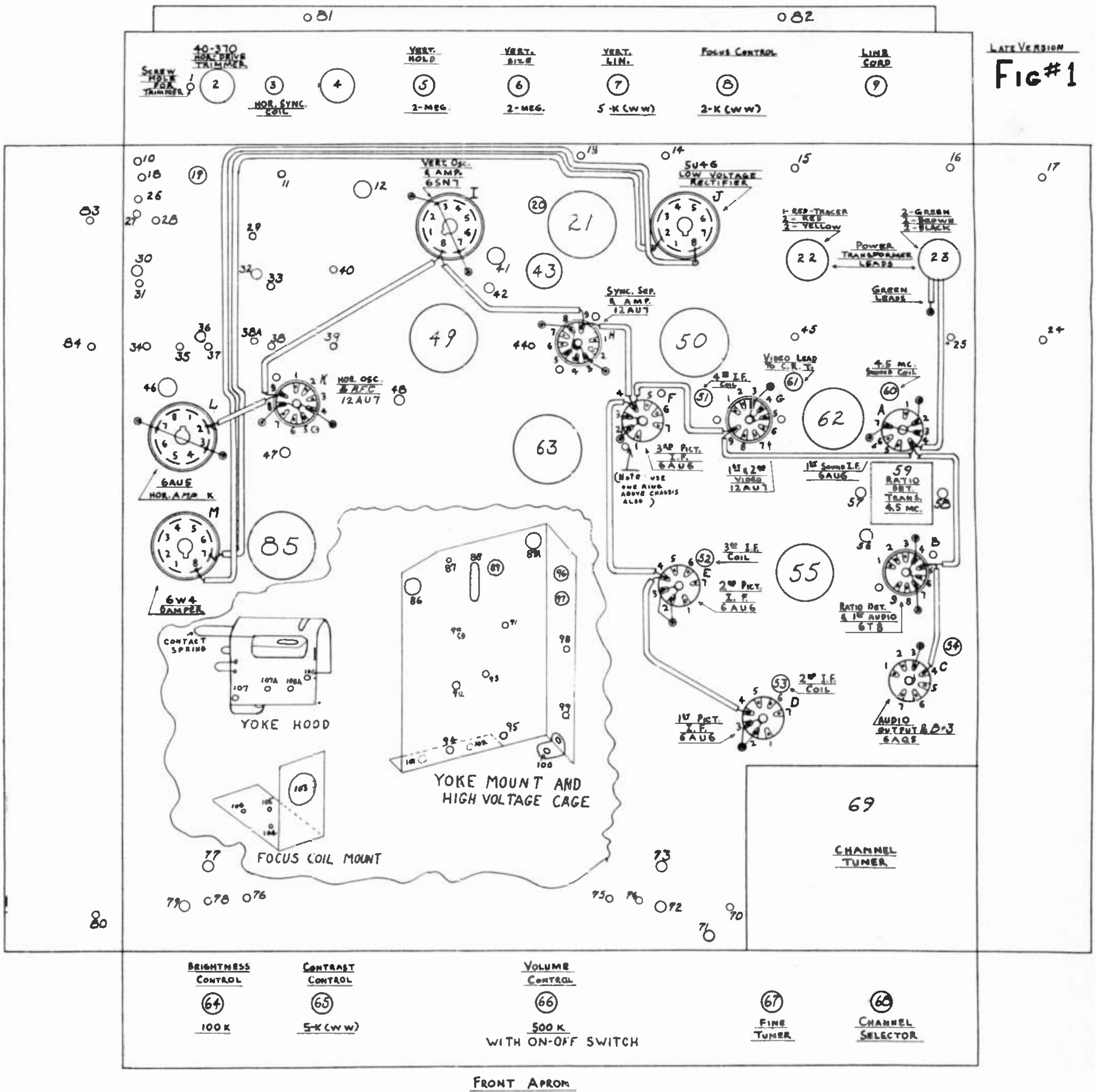
Picture Tube			1	2	10	11	12				
All Types	Picture Tube Soc.	V	0	0	340	9	0	----	----	----	----
		R	0	1 Meg	100K	120K	0	----	----	----	----

Caution

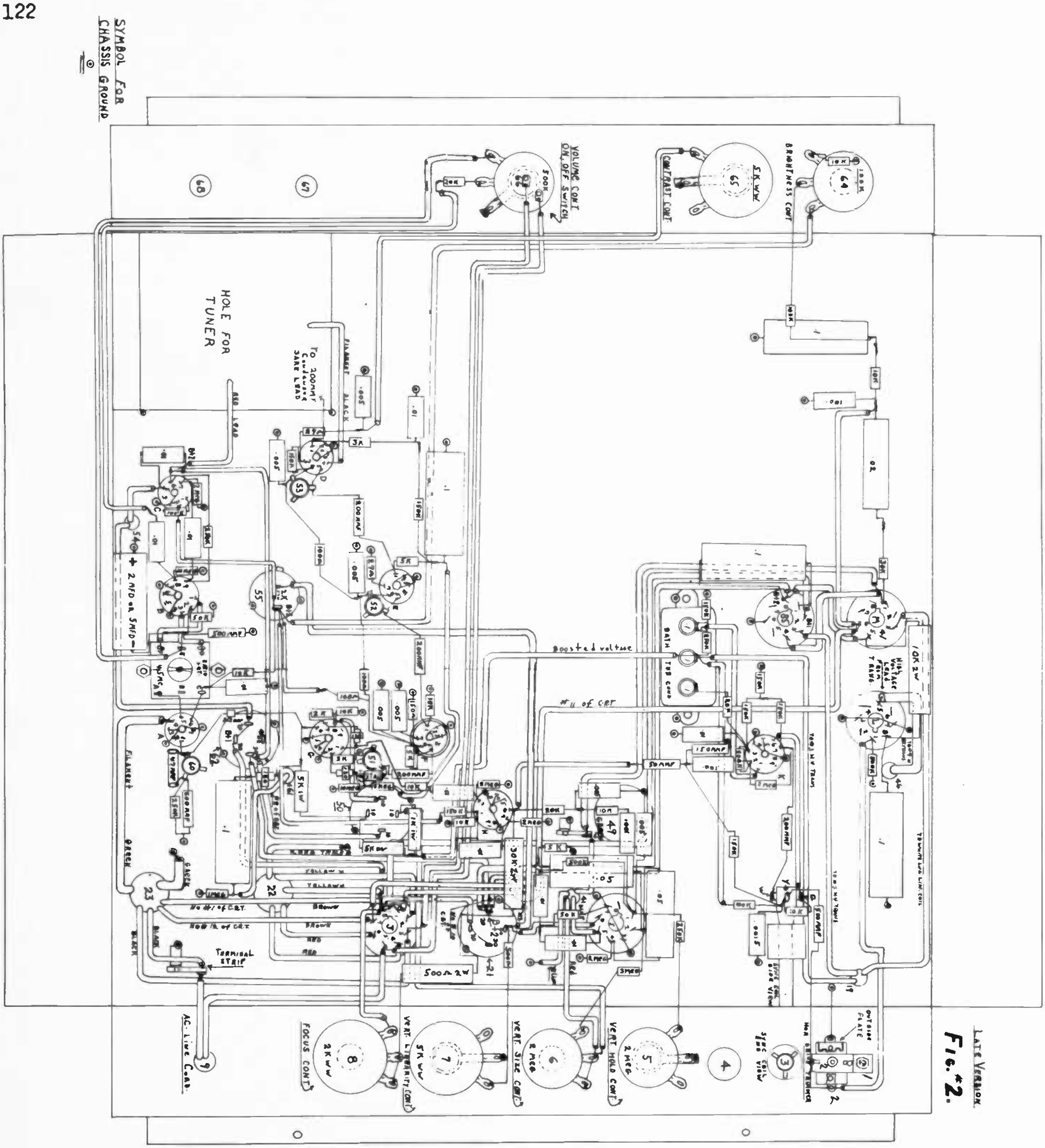
All voltages D.C. unless otherwise indicated.

*** A 6000 volt A.C. pulse is present at pin 5 of Horizontal Amp. also pin 3 of damper. Do not measure this with your Volt Meter.

VIEW OF TELEKIT SET UP IN A 19 INCH CONSOLE CABINET



SOCKET LAYOUT FOR #19C TELEKIT CHASSIS



PICTORIAL DIAGRAM OF WIRED #19C TELEKIT

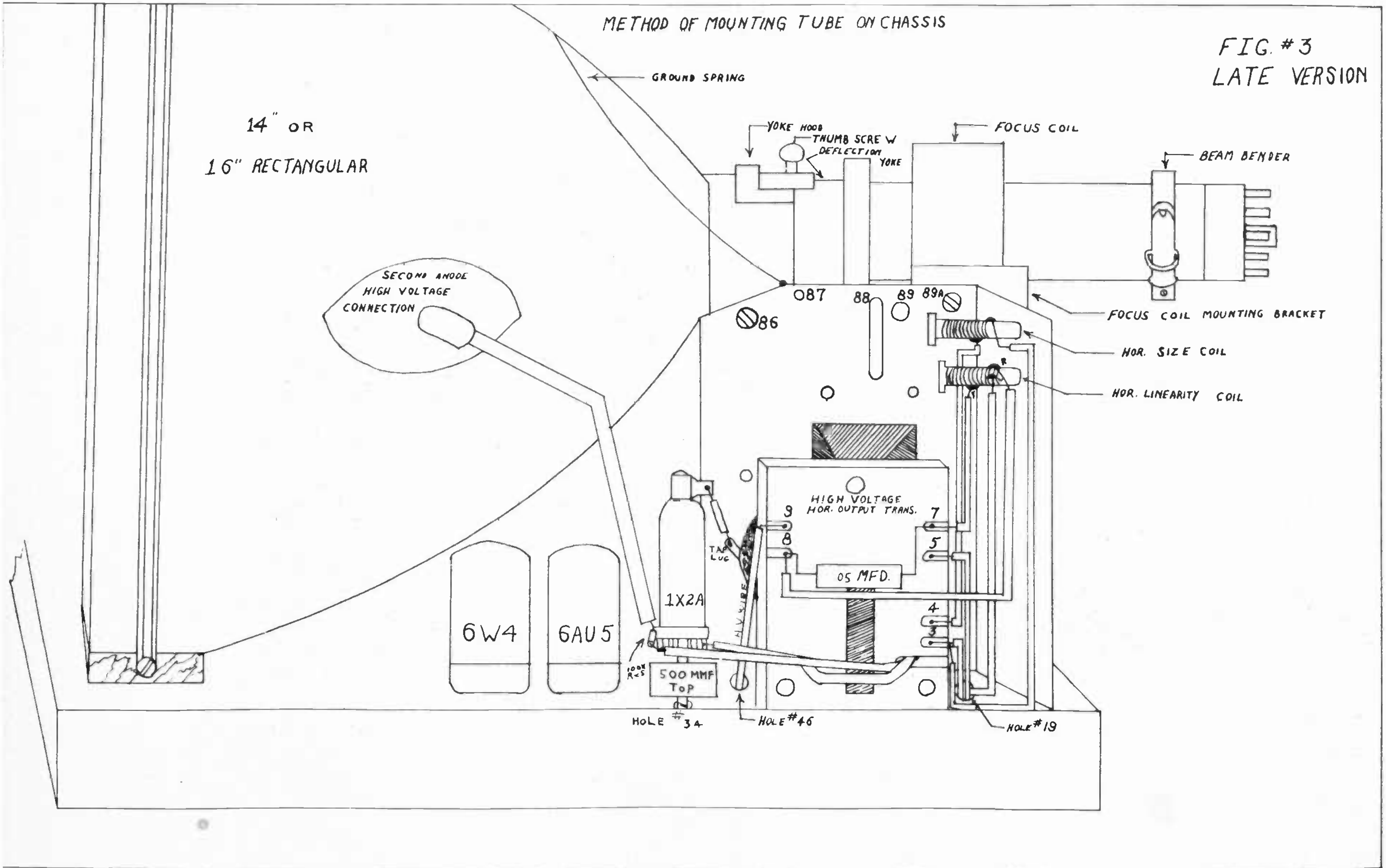


FIG. #3
LATE VERSION

View Showing Method of Suspending Tube in Console Cabinet

19 INCH TUBE ILLUSTRATED — IDENTICAL METHOD EMPLOYED FOR OTHER TUBES

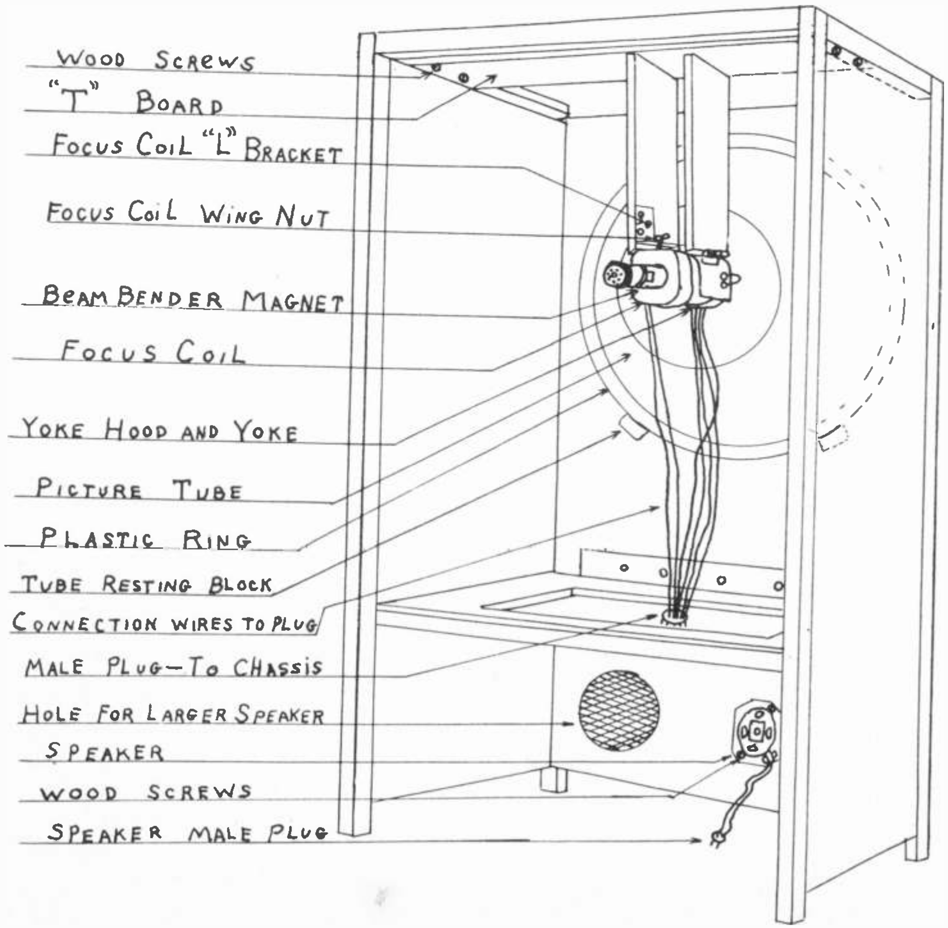
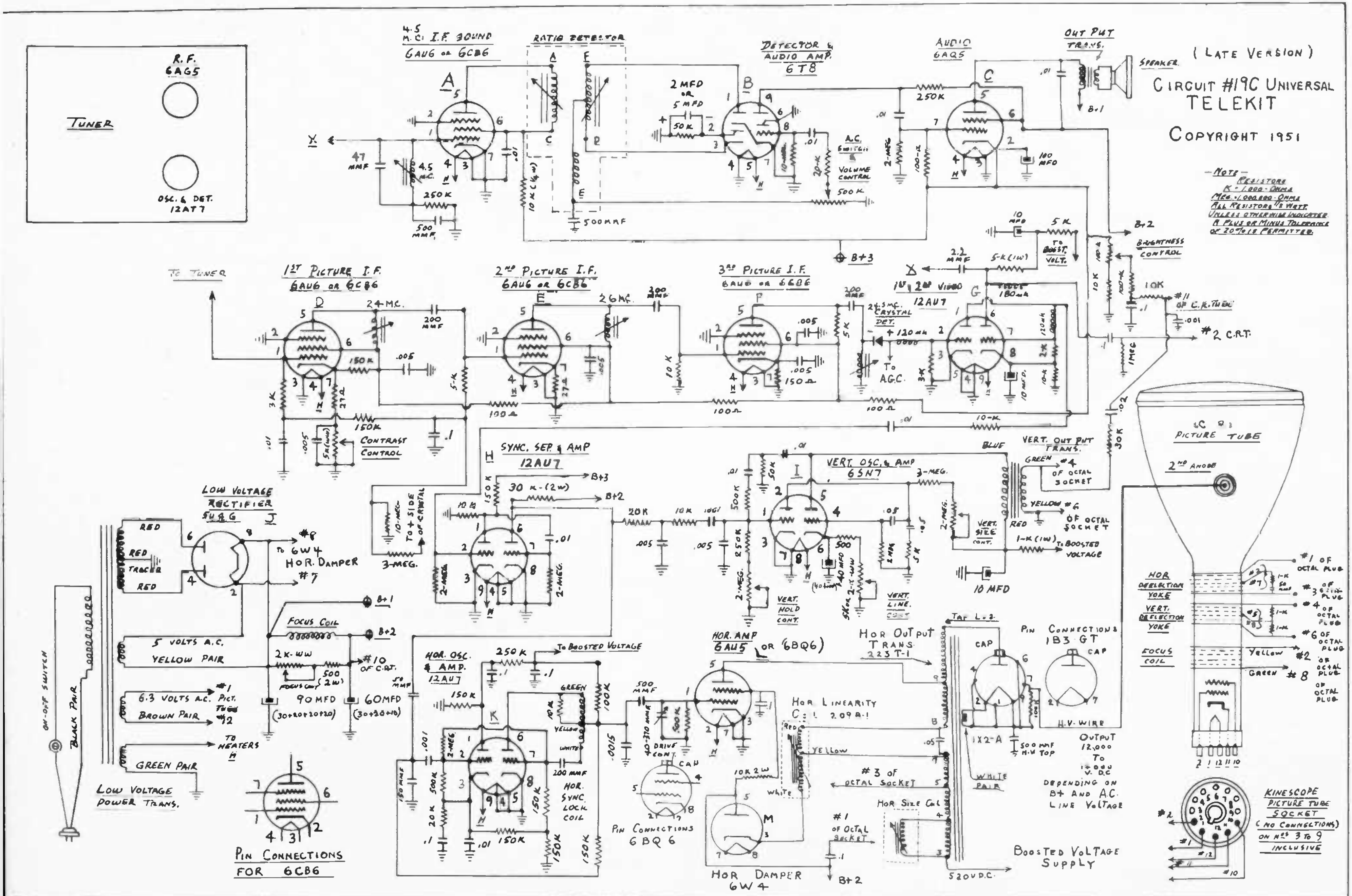
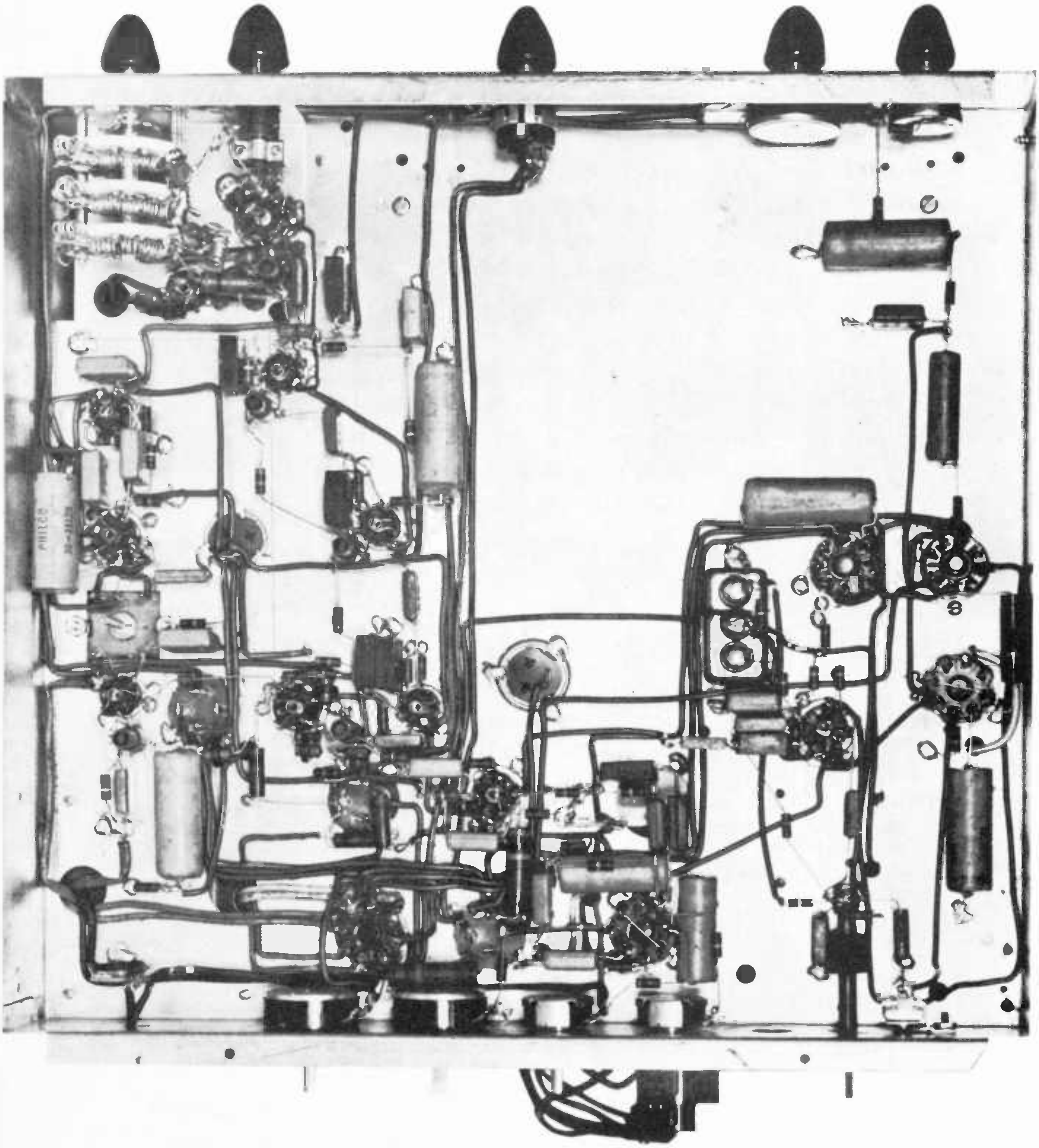


FIG #4

VIEW OF TELEKIT SET-UP IN A 17 INCH TABLE CABINET


(Late Version)
Circuit #19C Universal
TELEKIT
Copyright 1951
— Note —
Resistors
K - 1,000 - Ohms
Meg - 1,000,000 - Ohms
All Resistors ½ Watt
Unless otherwise indicated
A Plus or Minus Tolerance
of 20% is Permitted.
Tuner
R.F. 6AG5
Osc. & Det. 12AT7
4.5 M.C. I.F. Sound 6AU6 or 6CB6
Ratio Detector
Detector & Audio Amp. 6T8
Audio 6AQ5
Out Put Trans.
Speaker
1st Picture I.F. 6AU6 or 6CB6
2nd Picture I.F. 6AU6 or 6CB6
3rd Picture I.F. 6AU6 or 6BB6
1st & 2nd Video 12AU7
Brightness Control
Contrast Control
To Tuner
Sync. Sep. & Amp 12AU7
Vert. Osc. & Amp 6SN7
Vert. Out Put Trans.
Picture Tube
2nd Anode
Low Voltage Rectifier 5U4G
Low Voltage Power Trans.
5 Volts A.C. Yellow Pair
6.3 Volts A.C. Brown Pair
Green Pair
Black Pair
On-Off Switch
Focus Coil
Hor. Osc. & Amp. 12AU7
Hor. Amp 6AU5 or 6BQ6
Hor Out put Trans. 223T-1
Hor Linearity C.L. 209A-1
Hor Damper 6W4
Hor Size Coil
Pin Connections 1B3 GT
Pin Connections 6BQ6
Pin Connections for 6CB6
Boosted Voltage Supply
520 V.D.C.
Output 12,000 To 14,000 V.D.C. Depending on B+ And A.C. Line Voltage
Hor Deflection Yoke
Vert. Deflection Yoke
Focus Coil
Kinescope Picture Tube Socket (No Connections on Nos 3 to 9 Inclusive)



PICTORIAL PHOTO OF WIRED #19C TELEKIT SHOWING
PARTS PLACEMENT

Figure 32—Contrast & Brightness Controls Incorrectly Set Showing Vertical Return Lines

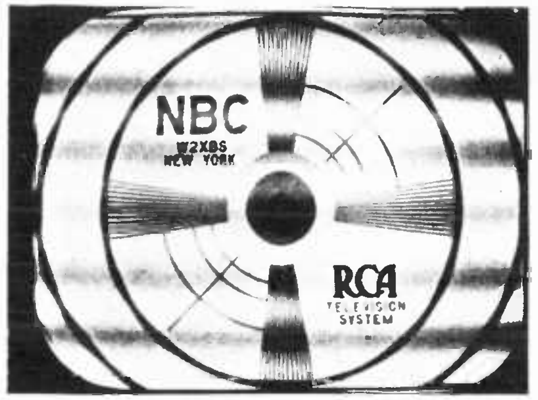


Figure 33—Sound Modulation in Picture

Figure 34—Picture Incorrectly Oriented

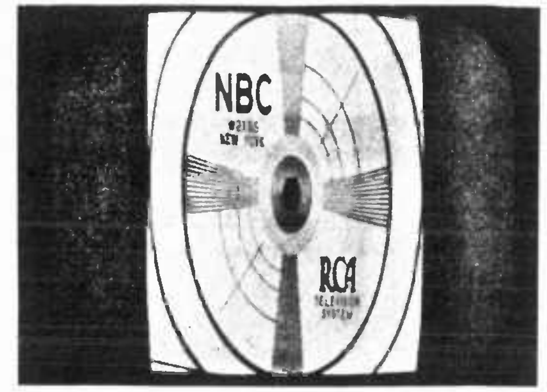


Figure 35—Horizontal Width Control Incorrectly Set

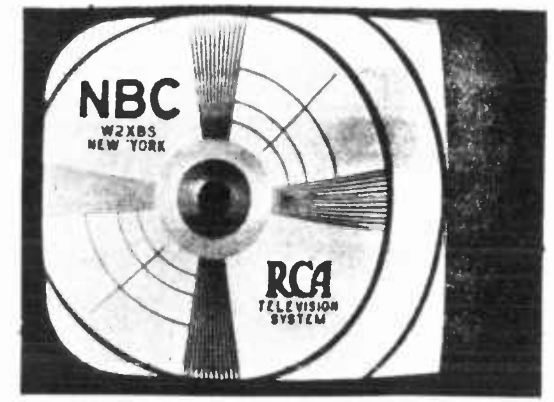


Figure 36—Horizontal Centering Control Incorrectly Set

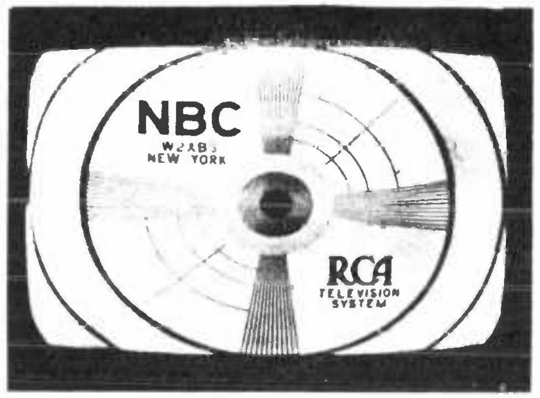


Figure 37—Vertical Height Control Incorrectly Set

Figure 38—Vertical Centering Control Incorrectly Set

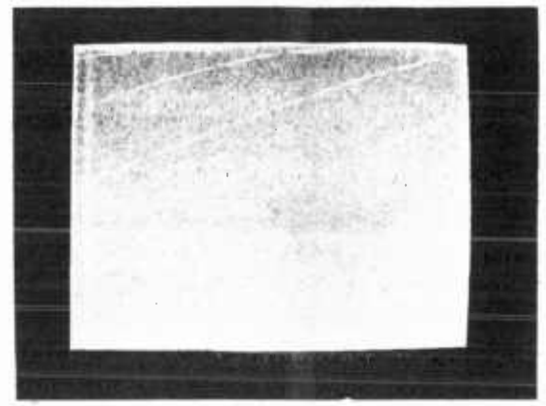


Figure 39—Scanning Raster Correctly Oriented

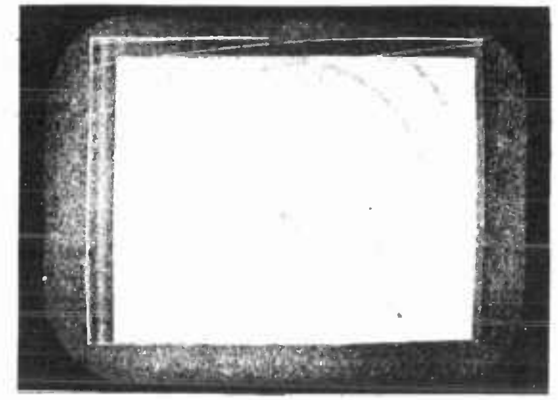


Figure 40—Action of Blanking on Picture Size

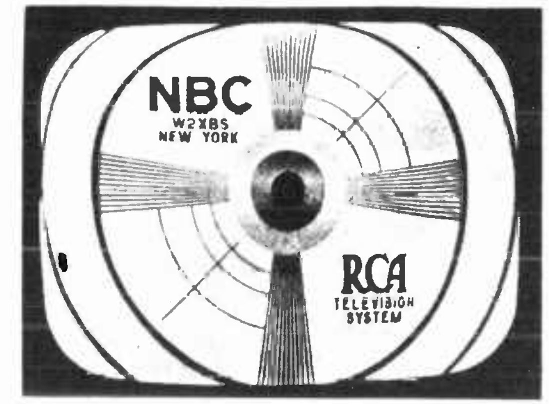


Figure 41—Vertical Linearity Control Incorrectly Set

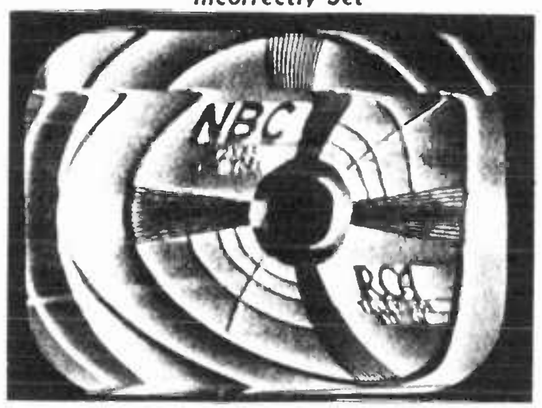


Figure 42—Effect of Too Strong a Signal

Figure 43—Effect of Too Weak a Signal

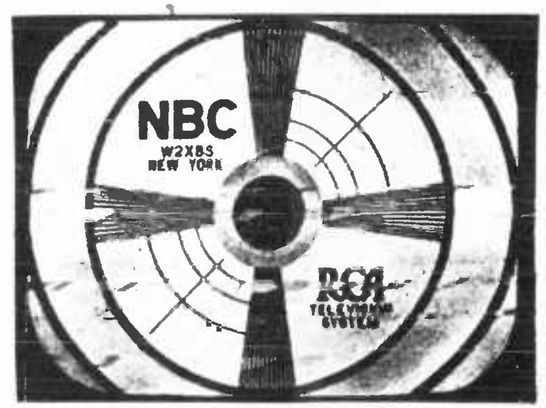


Figure 44—Excessive Auto Ignition Interference

Figure 45—Excessive Diathermy Interference

Figure 46—Beat Frequency Interference

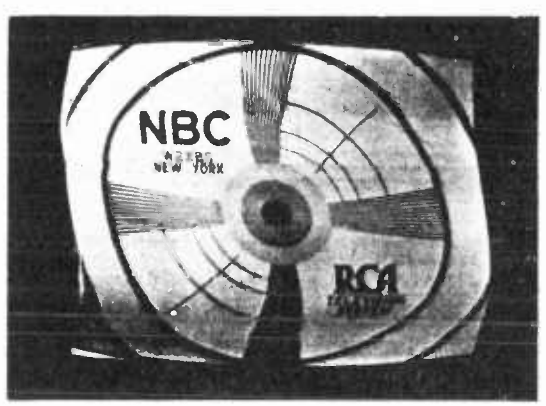


Figure 47—Excessive Ripple in Horizontal Deflection

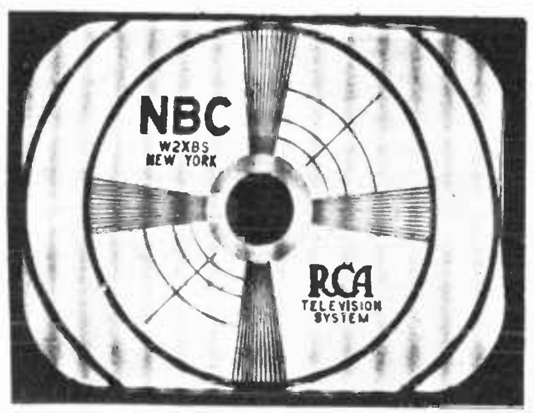


Figure 49—A 250 K.C. Sine Wave Signal with Test Pattern

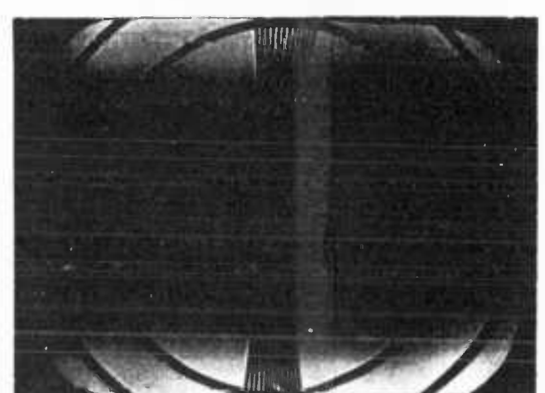


Figure 50—Excessive Ripple in Video Amplifier

Figure 51—Same as Figure 50 Except Opposite Phase

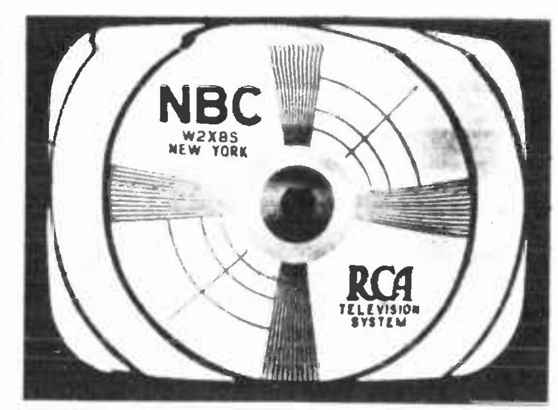


Figure 52—Unstable—"Tear-Out"—Horizontal Synchronization

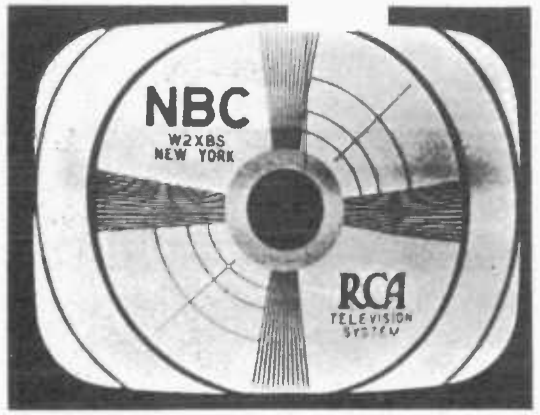


Figure 53—Loss of Interlacing

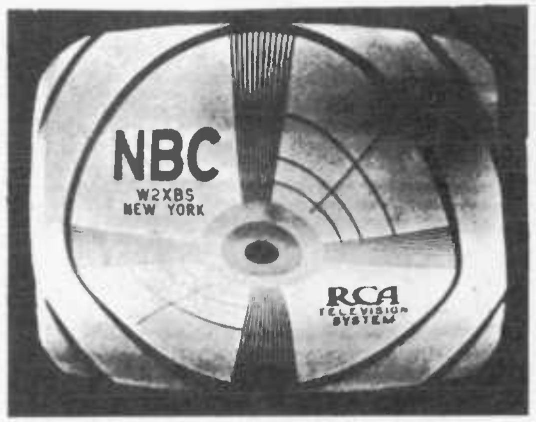


Figure 54—Excessive Ripple in Vertical Deflection

Figure 55—Vertical Distortion Caused By Defective Peaking

Figure 56—Transients in Test Pattern

Figure 58—Loss of High Video Frequencies

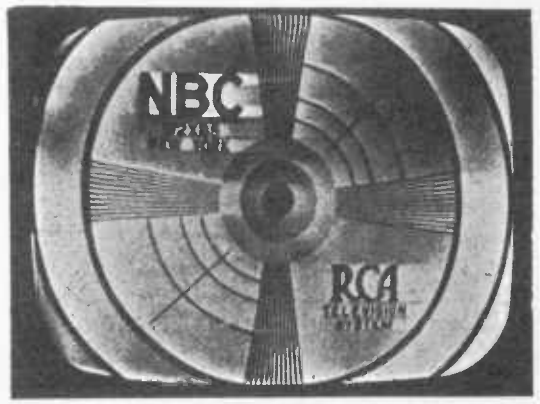


Figure 59—Phase Shift and Loss of Low Video Frequencies

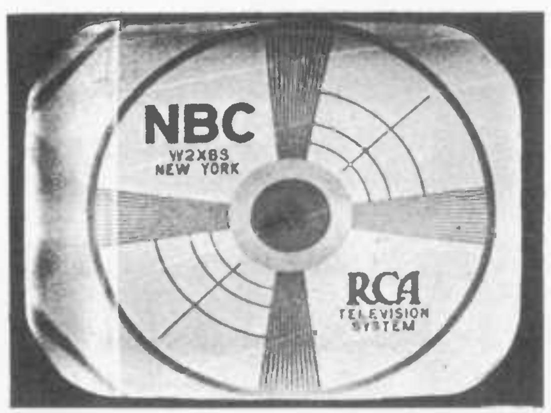


Figure 60—Effect of Damping Tube Failure

Figure 61—Non-Linear Horizontal Deflection

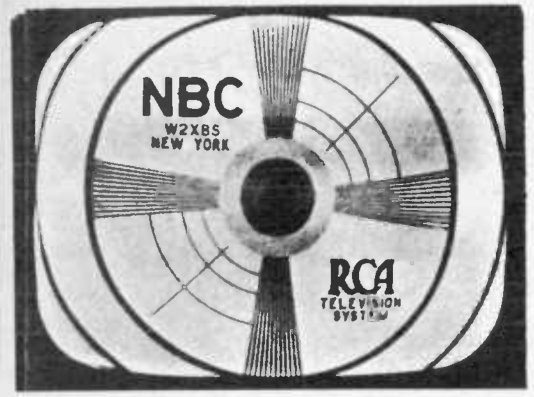


Figure 23—Normal Test Pattern

Figure 24—Test Pattern Marred by a Reflected or Multi-path Signal

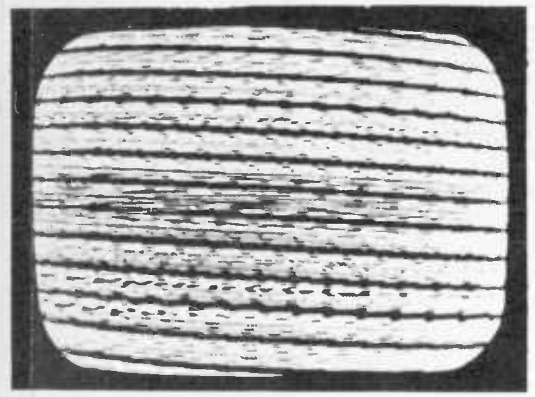


Figure 26—Horizontal Hold Control Incorrectly Set

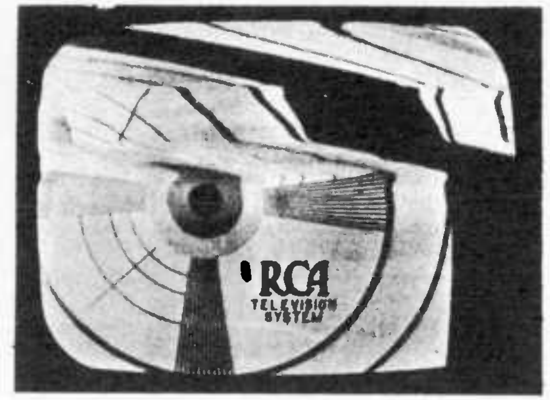


Figure 27—Horizontal Hold Control Incorrectly Set

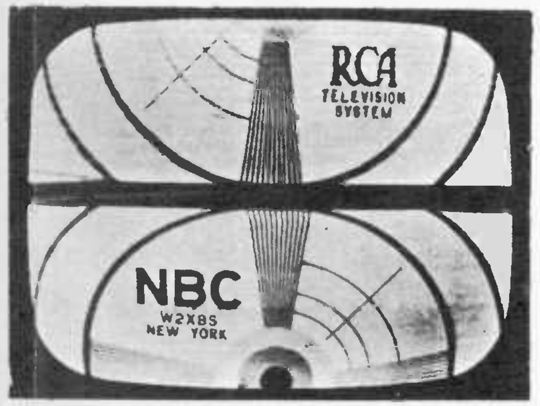


Figure 28—Vertical Hold Control Incorrectly Set

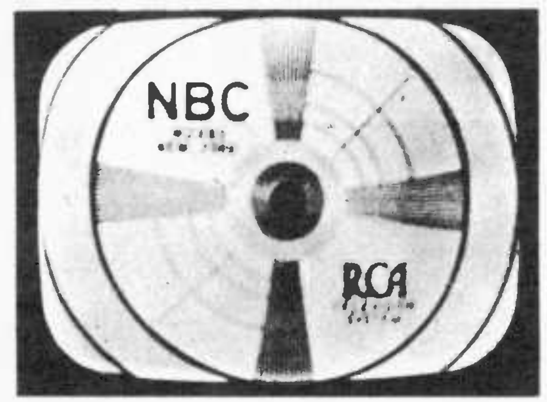


Figure 29—Focus Control Incorrectly Set

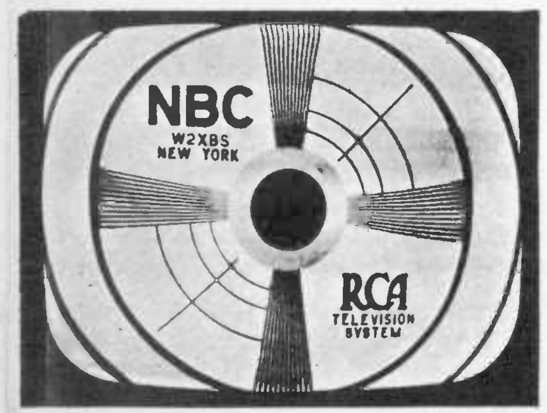


Figure 30—Contrast Control Advanced Too Far

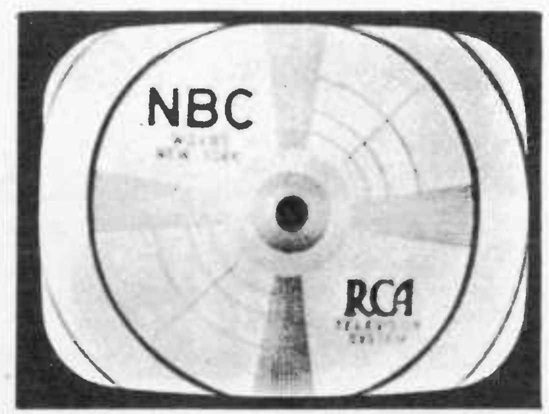


Figure 31—Brightness Control Advanced Too Far