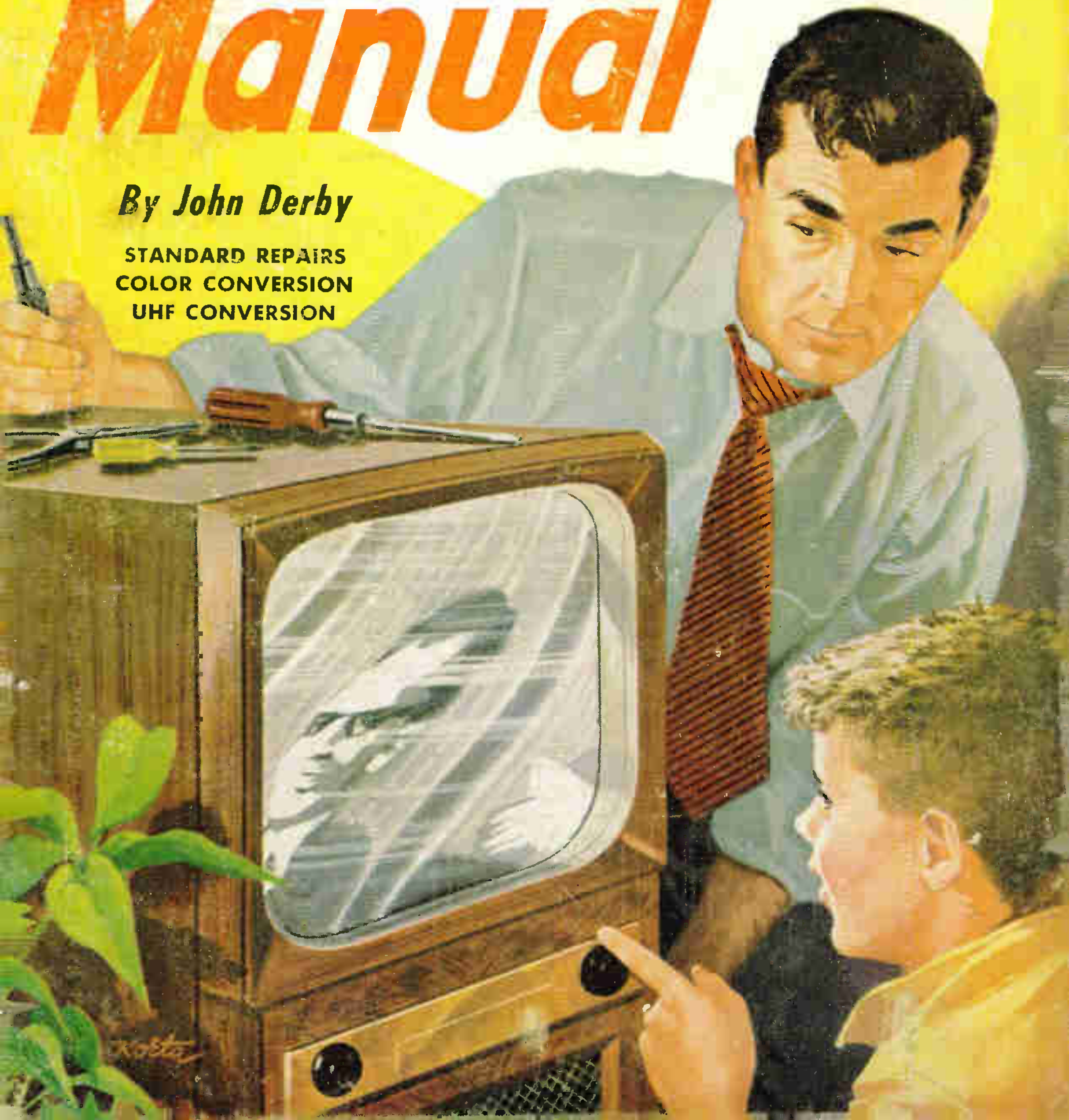
POPULAR MECHANICS

FIX-IT-YOURSELF Television Manual

75c

By John Derby

STANDARD REPAIRS
COLOR CONVERSION
UHF CONVERSION



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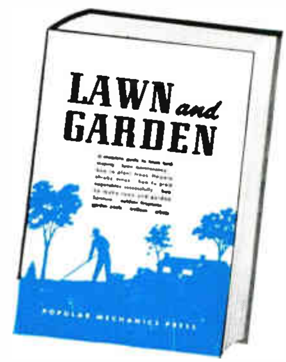

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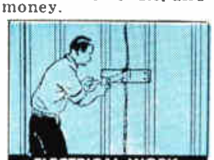

Popular Mechanics
FIX-IT-YOURSELF

Television Manual

By John Derby

Major Contents

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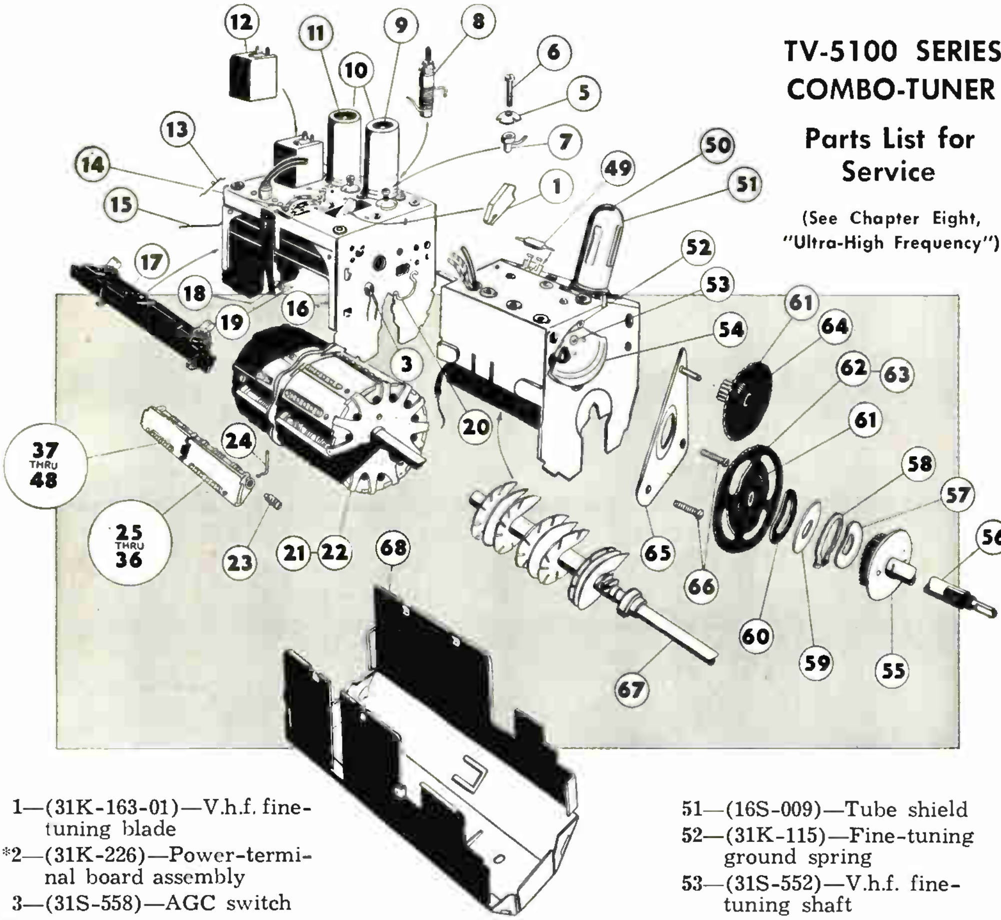
TV-5100 SERIES COMBO-TUNER

Parts List for Service

(See Chapter Eight, "Ultra-High Frequency")



1—(31K-163-01)—V.h.f. fine-tuning blade

*2—(31K-226)—Power-terminal board assembly

3—(31S-558)—AGC switch

*4—(31K-212)—Contact-board assembly

5—(10E-401)—Trimmer-spring nut

6—(9YS436-10PC-7)—Trimmer screw

7—(31A-056-1)—Trimmer dowel

8—(Specify set model)—I.f. assembly

9—(6U8)—Tube

10—(16S-010)—Tube shield

11—(6BZ7)—Tube

12—(31K-225-02)—Antenna input-filter assembly

13—(31K-525)—I.f. rocker spring (rear)

14—(31K-142)—3-prong power plug

15—(31B-137-03)—Spring-drum retainer (rear)

16—(31B-138-02)—Spring-drum retainer (front)

17—(31K-1006)—Block-spring retainer assembly

18—(31B-005)—Spring detent

19—(31B-016)—Roller detent

20—(31K-108)—Fine-tuning and rocker-grounding spring

21—(31S-539)—Coil-drum assembly

22—(31S-527)—Coil-drum assembly

23—(31B-041)—Tuning slug

24—(31A-010)—Slug and coil retainer spring

25-36—(13M-113-2U—13M-113-13U)—R.f. and oscillator-coil board assemblies, v.h.f. (suffix denotes channel)

37-48—(13M-013-2U—13M-013-130)—Antenna coil-board assembly (suffix denotes channel)

49—(31K-111)—U.h.f. crystal mixer (1N82A)

50—(6AF4)—Tube

51—(16S-009)—Tube shield

52—(31K-115)—Fine-tuning ground spring

53—(31S-552)—V.h.f. fine-tuning shaft

54—(31S-553)—V.h.f. fine-tuning sector

55—(31K-174)—Fine-tuning shaft retainer spring

56—(31S-554)—Fine-tuning shaft

57—(31S-117)—Washer

58—(31S-079)—Retaining ring

59—(31S-080)—Washer clutch

60—(31S-089)—Washer-clutch spring

61—(31S-115)—Gear-tension spring

62—(31S-113)—U.h.f. shaft gear (front)

63—(31S-113-01)—U.h.f. shaft gear (rear)

64—(31S-551)—Idler assembly

65—(31S-550)—Idler-support assembly

66—(9A-814-3)—Screws

67—(31S-548)—Shaft and rotor assembly

68—(31S-044)—Cover

* Not shown on drawing.

Chapter One

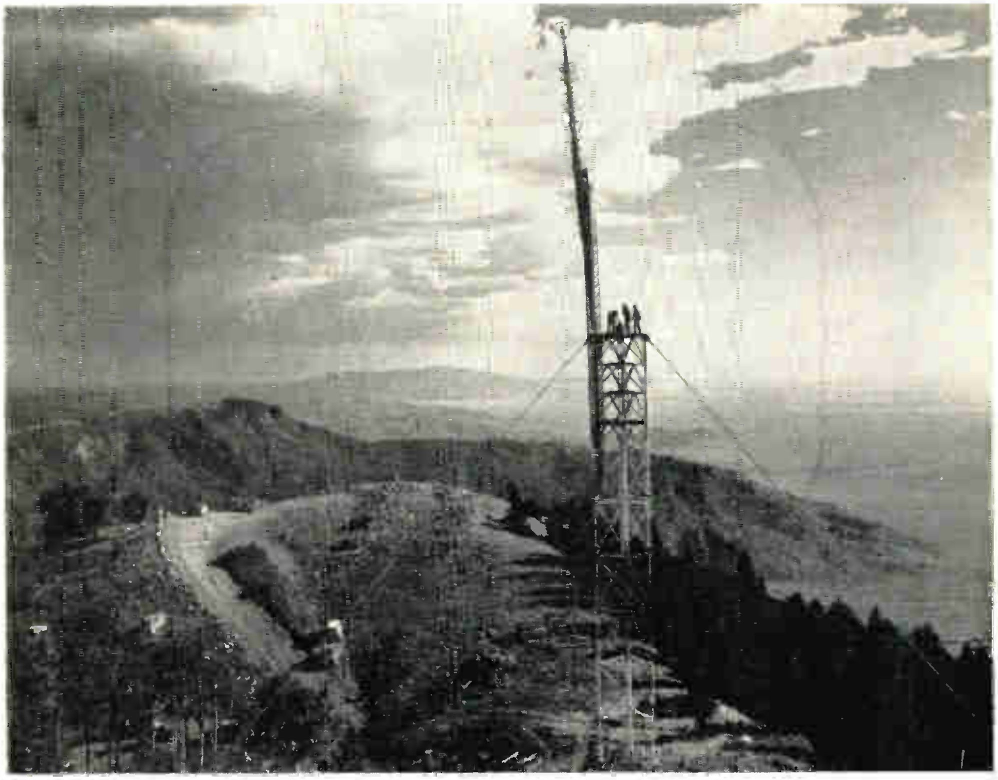
How Television Works

THE QUESTION is often asked, "Who invented television?" The correct answer is not given by those who supply a name, but by those who reply, "Why, I really don't know." Television is a monument to many men and women of science who each have contributed important parts to the development of a whole—some parts more significant than others, but all important contributions just the same. Faraday, Henry, Maxwell, Marconi, DeForest, Fleming, Zworykin; less well-known names in the field of optics, and the business men who provided the money and the facilities for research—all these have been contributors to television.

Even the word television does not come from one source. It is a combination of the Greek *tele,* meaning "far off," and the Latin verb, *video*—"to see." Defined, it is the electronic photographing and projection—at the speed of light—of a scene to a distant point and its reproduction on a screen at that point.

Research work on television was being performed in the laboratories simultaneously with the rapid development of radio broadcasting in the period after the first World War. By the late thirties tremendous progress had been made. In 1939 television was made available to the public when RCA marketed a 12-inch receiver and the National Broadcasting Company began beaming television programs to metropolitan New York.

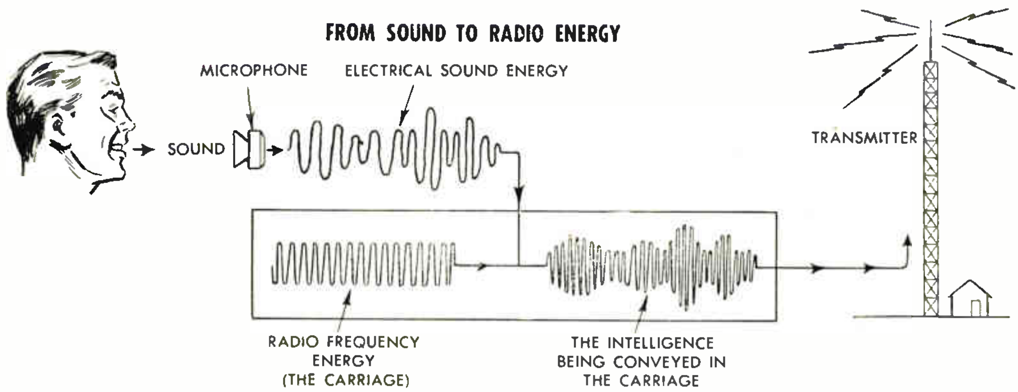
Active broadcasting ceased during World War II, but the end of hostilities brought television to full flower in those areas that



were already equipped with broadcasting and receiving facilities.

Relay towers and coaxial cables spread the TV network across the nation, and now no hamlet is too small to boast at least a few receiving antennas. Now also the miracle of color television, long a dream of the electronics experimenters, is a practical everyday matter—the major networks regularly schedule color telecasts. If you do not have a color set, it is only a matter of time until you will—and can use the color-television material in this book.

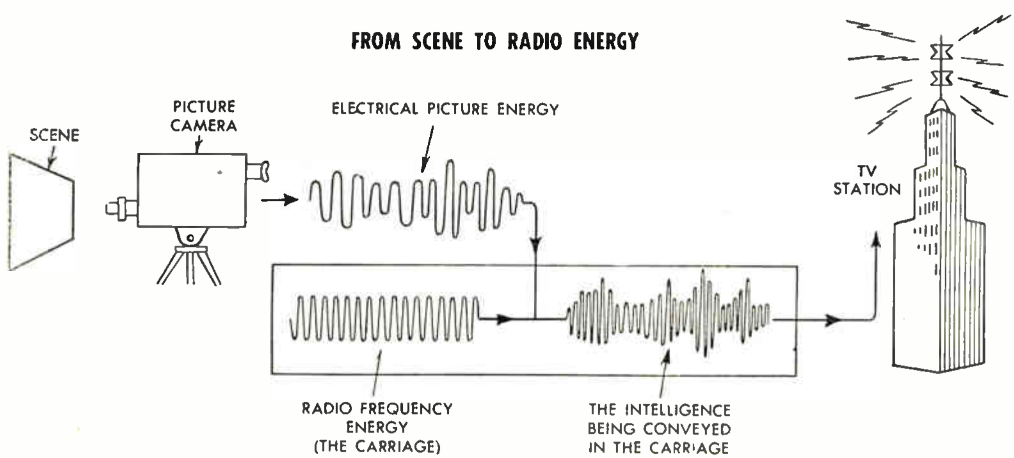
Above, workmen putting finishing touches to the highest transmitting antenna in the nation. Tower located outside Albuquerque, N. Mex., is 11,000 ft. above sea level. Left, TV, radio and record-player combination can be operated by dialing remote-control signal unit located in chairside cabinet



How the Picture Travels

The starting point in television, as in photography, is the camera. Unlike photography, however, there is no film, no permanent record of the scene to be reprinted again. Instead, a scene is pictured, sent over the air waves, registered on the screen of the receiver and then replaced with the next scene. To do this requires tremendous quantities of expensive equipment, complicated circuits and a great deal of technical skill.

But to understand *how* it is done requires no technical knowledge or mechanical aptitude. It is unnecessary for a housewife to be well versed in the chemical composition and reactions of the ingredients she uses in baking a cake. It is just as unnecessary for the layman to know the action of a multivibrator, the theory of space charges, what thermionic emission is or how to design a filter circuit in order to have a basic understanding of television and to be able to service his own set. That knowledge can be left to the designers, engineers, technicians and professional servicemen.



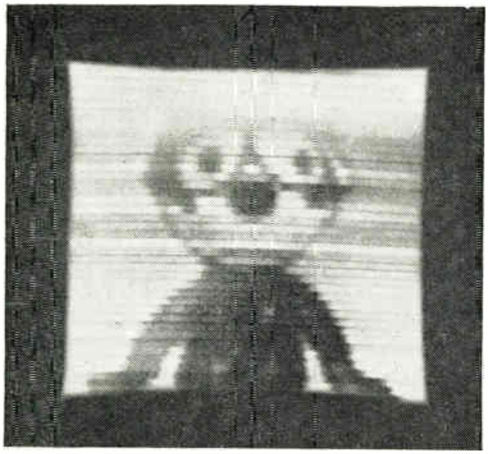
When the television cameraman focuses his camera on a scene, he is "taking" a picture in the true sense of the word. However, instead of the scene being recorded on a film negative, it is transformed into electrical energy for transmission to the receiver. Of course, for some special applications, television can be and is transmitted over wires or coaxial cables, but for our purpose at the moment let us assume that the wireless beam is the means of carrying the picture from one point to another. Most of us are familiar with the fact that in radio sound is picked up by a microphone which transfers this sound into electrical energy. This energy is of such a nature that it cannot be sent directly into the transmitting antenna. It must have a "carriage" on which it can ride. This "carriage" is provided by the transmitter, which generates radio-frequency energy, mixes it with the electrical-sound energy, amplifies the two and sends the finished product to the world at large through the antenna.

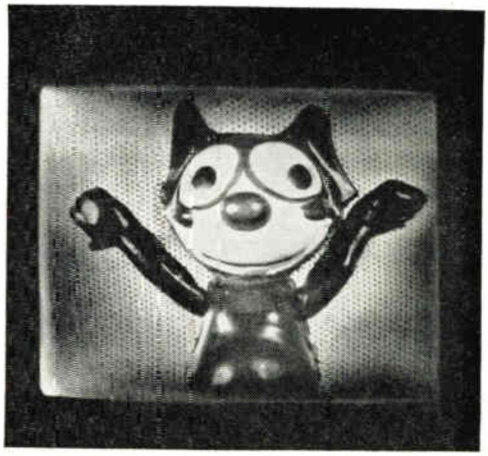
Television corresponds to radio in most respects. Substitute light for sound and camera for microphone and the system is the same—light is transformed to electrical energy and impressed on radio-frequency energy, which, with its ability to "spread" from an antenna, provides the "carriage" which conveys the picture in its energy form.

Upon arrival at the receiving station, the reverse procedure takes place. The radio-frequency energy which has "carried" the picture is no longer needed, so it is separated from the desired elements and cast aside. The remaining electrical energy is transformed to a duplicate of the original scene by impressing it on the face of the receiver picture tube.

The television camera, as was mentioned before, is the starting point of the picture. Just as in an ordinary camera, we have a lens. However, instead of focusing the picture on a film, the scene is focused on a "mosaic," or target. This target has photoelectric characteristics, which means it translates light into electrical energy. The amount of energy on any one spot depends entirely on the amount of light that spot is receiving through the lens from a small section of the scene being photographed. Therefore it can be seen that the target has electrical energy whose strength varies in different sections, depending on whether the section of the scene is a dark dress, a light shirt, a face, etc. Thus we have our picture, as desired, transformed into a constantly fluctuating form of electrical energy.

The next step is to see that this energy is put aboard the radio-frequency "carriage." Inasmuch as the energy is not uniform throughout but varies as the lights and darks of the picture vary,





RCA

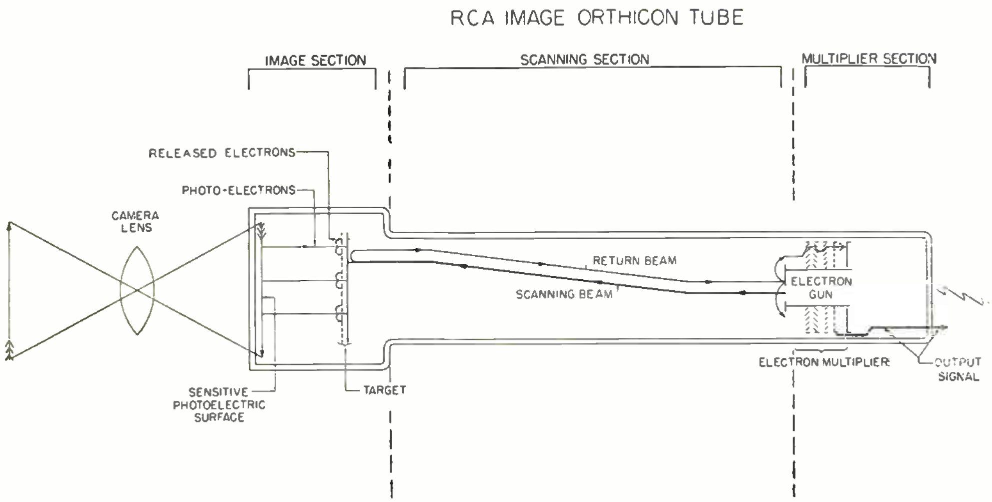
Left, result of scanning a picture on 60 lines. Right, same picture scanned 342 lines

we cannot send the whole scene at once. In that case, one would only get an average amount of electrical energy. So each tiny segment of the picture must give up its energy in turn and it must do this in an orderly fashion.

The Scanning Beam

If you will look at your daily newspaper, you will notice that the pictures seem to be made up of many, many little dots. For our purpose, the picture intelligence impressed on the target of the television camera can also be said to be made up of many dots, each one with its own quantity of electrical energy. Some device is needed to take the energy from each dot in turn and carry it to the "carriage." This is done by a scanning beam, which travels across the target just as your eyes do in reading a printed page. Each scene is divided into 525 lines, an arbitrary figure chosen by the television industry and the Federal Communications Commission for engineering reasons. The use of fewer lines would result in loss of picture detail; the use of more is not feasible in an engineering sense. To use our previous illustration, the "carriage" isn't large enough to carry a larger load of picture intelligence. Pictures illustrating the results of scanning at different levels are shown above.

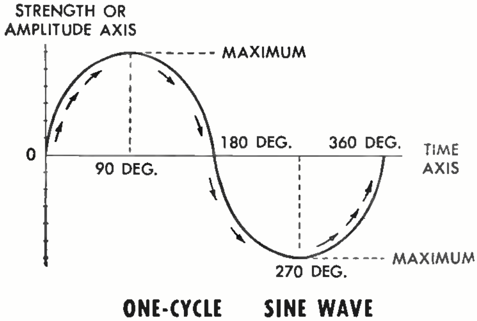
A complete picture is developed when the scanning beam has traveled across each of the 525 lines once. The next picture results when the beam goes back to the beginning and starts all over again. As anyone who has ever seen a movie film or riffled the pages of a comic "movie book" knows, showing pictures rapidly results in an illusion of motion. So we know that if we "show" the television pictures rapidly enough, the result will be a moving scene.



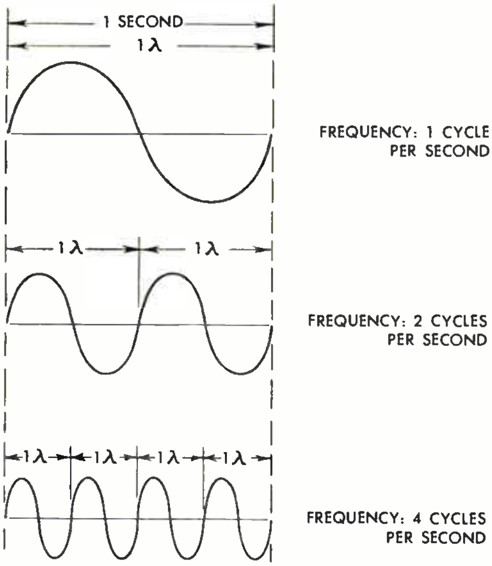
Again for engineering purposes, those in authority have chosen an arbitrary figure and stated that all television in the United States should show 30 pictures, or frames, per second. This has been done for a number of reasons. Most important of these is the fact that when fewer frames per second are shown, the image flickers. Another primary reason is that most American homes have alternating current at the rate of 60 cycles per second; this synchronizes easily with the television frequency of 30 frames per second.

Actually, the scanning beam scans the odd-numbered lines first and then returns and scans the even lines. This "interlaced scanning" gives, in effect, 60 frames per second. The same idea is used in motion pictures, where the picture rate is 24 frames per second but a rotating disk with two slots lets the picture through twice for each frame for a net result of 48 frames per second.

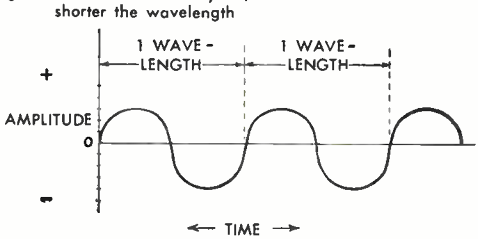
A mobile unit televises a parade. Below, frequency in radio and television refers to the number of sine waves generated per second, unless otherwise stated



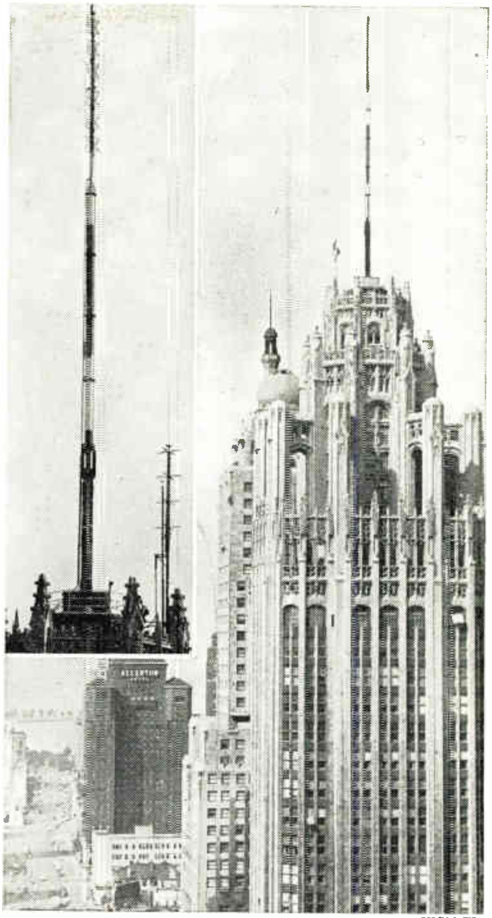
FREQUENCY AND WAVELENGTH COMPARISON



Note: The Greek letter "lambda" is used here as the symbol for wavelength. It will be noticed that the greater the number of cycles, the shorter the wavelength



WAVELENGTH



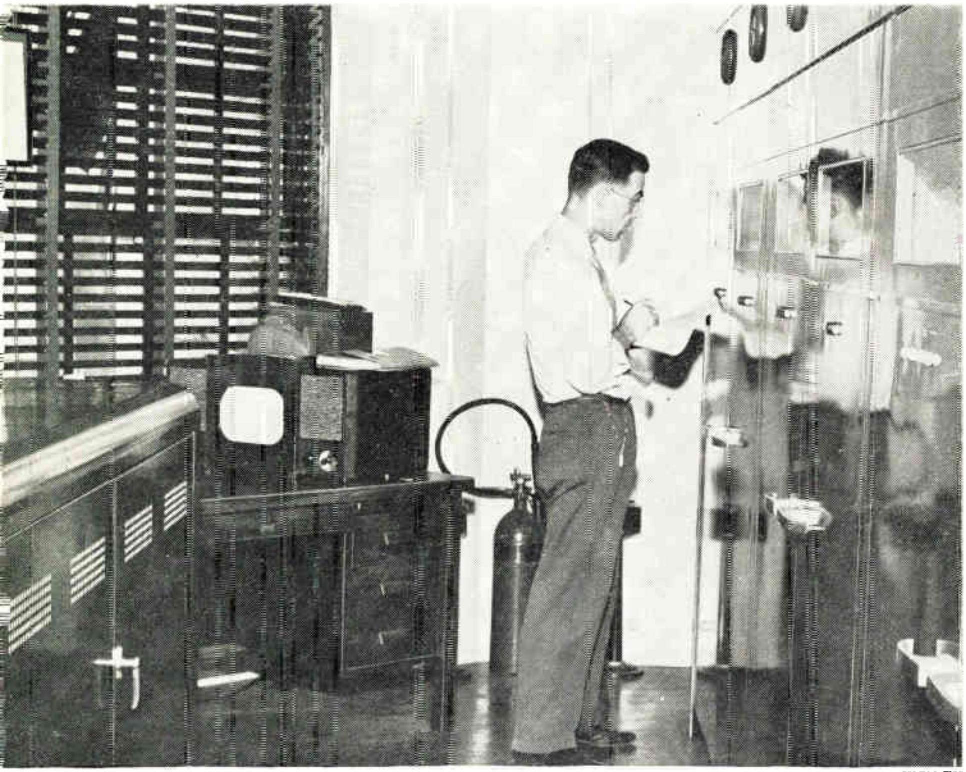
WGN-TV

WGN-TV's antenna, familiar sight to Chicagoans, stands atop the Tribune Tower, 610 feet above street

To summarize, the television picture is divided into 525 horizontal lines which are scanned—just as you scan the words on a page—at the rate of 30 times per second.

High-Frequency Waves

At this point the complete picture is ready for its journey through space. But, as has been pointed out, it must be provided with a "carrier." For that a radio wave of a high frequency is used. Inasmuch as the phrases "high frequency," "very high frequency" and "ultra-high frequency" are part of the current technical terminology, a few simple explanations are in order. Frequency, of course, refers to the rate at which things occur. A chain smoker smokes at a high frequency rate compared to other smokers. The beacon on a lighthouse rotates at a certain frequency—perhaps twice a minute. A motor turns at the frequency of 1750 revolutions per minute.



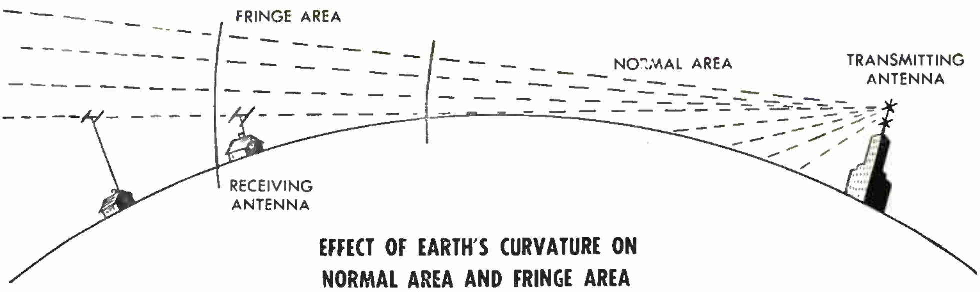
WGN-TV

Station transmitting engineers constantly check equipment to make sure it is working properly

In electricity, frequency is measured in cycles. The cycle starts at a point of "zero" energy. It increases in value with time. When it reaches its maximum value, the energy then falls off to zero again. However, instead of building up to a maximum in the same direction, the energy continues on past zero in the opposite direction to reach another maximum before falling off to zero again, thus completing a cycle. The process is then repeated. This procedure can be charted. The resulting figure is called a "sine wave," because it resembles a wave.

Unless stated otherwise, frequency in radio and television refers to the number of sine waves generated per second. Because the energy travels in two directions, this is called alternating current. Those who live in localities where the normal house current operates at a frequency of 25 cycles per second will notice a flickering effect. This occurs because the current which lights the bulb periodically returns to zero strength before building up again.

It takes time for the energy to undergo a complete cycle. Because of the speed with which the cycles occur, the time base used is the second. In your home the electrical current probably has a frequency of 60 cycles per second. This means that a cycle is



EFFECT OF EARTH'S CURVATURE ON NORMAL AREA AND FRINGE AREA

completed every 1/60 of a second. The frequency of radio energy is measured in exactly the same way, but in order to be useful a great many cycles must be used—thousands and millions. Each thousand of cycles is a kilocycle; a million cycles are a megacycle.

For practical purposes, the energy can be compared to a railroad coach. The greater the number of seats there are in a railroad coach, the more passengers can be carried. In the same manner, the more cycles there are available, the greater the amount of picture intelligence that can be carried. In sound, for example, not many cycles would be necessary for a single note. But to carry all the notes, overtones and harmonics in the music of a symphony orchestra requires a great many more "seats" in the radio-frequency "coach." And in color television three "coaches" are required—one for each primary color.

In television, the picture is composed not of sounds but of varying shades of color. In black-and-white television, this runs from absolute black through various shades of gray to absolute white. To send all these shades of picture intelligence requires a great many "seats." For this reason, television channels are allotted a band width of six megacycles. This band width carries both the sound and video signals. In other words, television stations are given the use of a multiple-track railroad right of way. The transmitter provides the "seats" and the camera provides the "passengers." The channels allotted are in the high frequencies, where there is more room than in the lower-frequency bands.

The reason for this is obvious. If each station has a band width of six megacycles, seven stations can be squeezed into a portion of the spectrum between 174 megacycles and 216 megacycles. If we were to use the old AM broadcast band, which goes from .54 to 1.6 megacycles, we couldn't even get one station in! So much room is necessary and so many channels are being sought that the Federal Communications Commission has found it necessary to go still higher and make further allocations for additional TV stations.

Wavelength

Radio waves travel at the speed of light, or 186,000 miles per second. If, therefore, a transmitter sends out energy at a frequency of 1000 cycles per second, the first cycle will have reached a point 186,000 miles away just as the last cycle has been completed. The distance will be divided evenly into 1000 cycles, each 186 miles long. This length is called the wavelength.

The wavelength of radio energy is expressed in terms of meters—a distance of 39.37 inches. A wavelength of one meter, for example, means that one complete cycle covers 39.37 inches. An understanding of frequency and wavelength means little to most television-set owners, but is quite important for those who will erect their own antennas. Knowing the fundamental principle involved will enable you to do a much better job of antenna installation and thus bring a clearer, steadier picture to the receiver.

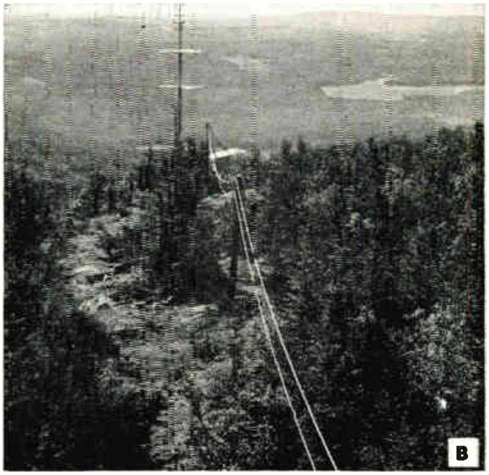
The meter is used as the international standard of measurement in television and radio for the sake of convenience. If a broadcasting station is transmitting on a frequency of 30 megacycles—or 30 million cycles—dividing 186,000 miles by 30 million will give the wavelength in terms of miles. The answer in this case would be .0062 miles, certainly a clumsy figure and, when one realizes that modern radio frequencies can be hundreds or thousands of megacycles, an absurd measuring gauge. For that reason, by international agreement and custom, the basic measuring unit used is the meter.

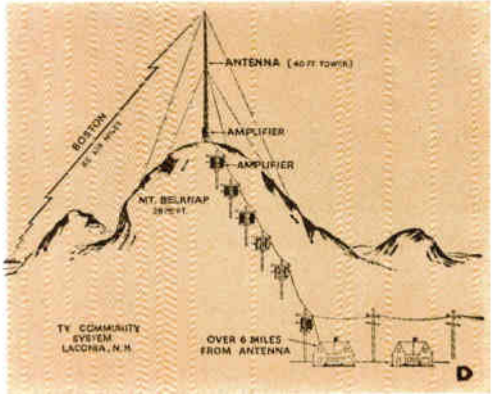
Since a meter is 39.37 inches long and 1609.35 meters equal one mile, it can readily be seen that 300 million meters are roughly the equivalent of 186,000 miles and dividing 300 million by 30 million cycles gives an answer of 10 meters. This is a much handier figure to use and for those unfamiliar with the metric system is easily translated to feet or inches. The formulae can be written thusly:

$$\textit{Wavelength (in meters)} = \frac{300{,}000{,}000}{\textit{frequency (in cycles)}}$$

$$\textit{Wavelength (in inches)} = \textit{wavelength (in meters)} \times 39.37$$

The ability to understand the relationship between frequency and wavelength is important in the case of antennas. This is because an antenna, to be efficient, should be a fraction of, equal to, or a multiple of the wavelength of the desired signal. The lengths of the arms of a television antenna are not guessed at, nor are they the result of "cut and try" experiments. They are calculated mathematically. Generally speaking, an antenna used





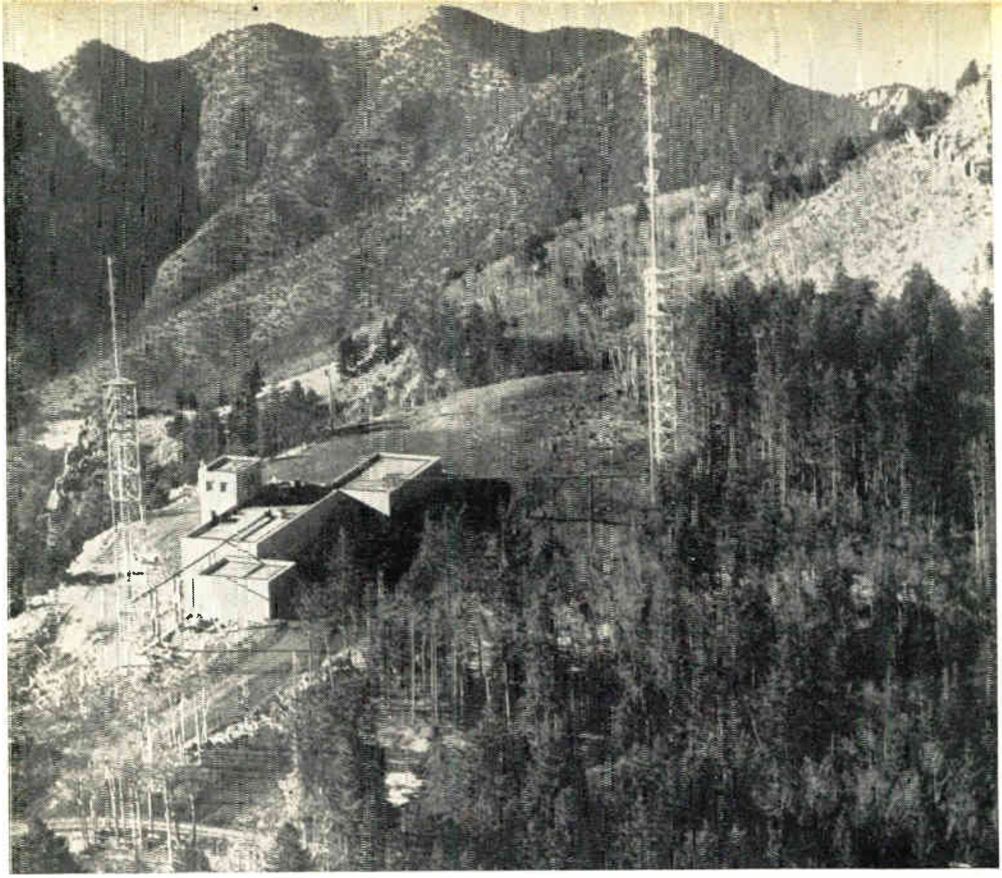
Community TV-antenna system, photo A, tapped to bring signal into a home. Photo B shows coaxial cable coming over and down a mountain. Tower amplifier station is shown in photo C. D illustrates system

in television is one-half wave long. This will be brought out in detail and with practical applications in the chapter dealing with antenna selection and installation.

Summarizing again, it can be said that the carrier path for television is a radio-frequency wave which oscillates or "cycles" at a rapid rate; that this wave travels at the speed of light; that the more rapid the rate per second the shorter the wavelength, and finally that antennas, for best results, are equal to, a fraction of or a multiple of the wavelength of a signal.

The Television Beam

In the television broadcasting station, a transmitter and its companion units perform the next function. These devices gen-



Highest transmitter in nation, shared by two stations, signals most of northern New Mexico

erate the cycles which make up the radio-frequency wave. The electrical energy which comprises the picture is imposed upon the wave and sent to the transmitting antenna. This in turn casts the energy to the ether.

The higher the frequency of radio energy the more the "ray" travels like a beam of light. It tends to follow a straight line and can be bent, or reflected, just like a light ray. Unlike a light ray, however, it will penetrate certain opaque substances such as the walls of buildings, etc. This is why we are able to use indoor antennas in strong signal areas. Nevertheless, the television beam is reflected by some structures, blocked by hills, weakened by rolling terrain and subjected to other influences. Transmitting antennas therefore are erected on high buildings and mountains to enable the signal to pass over such obstacles and also to increase the distance between the transmitter and the horizon. Although some of the energy follows the curvature of the earth, this is not enough for practical purposes. The bulk of the energy follows a straight line and passes off into space at the horizon.

To increase the distance of reception, receiving antennas in the area where the curvature of the earth is a factor are erected

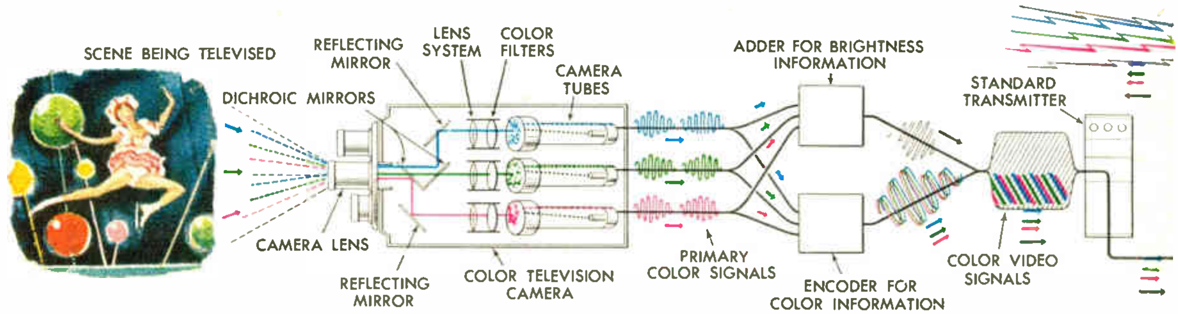
Control room during color telecast. Screen at lower right is black-and-white picture of scene in center, which is on the air. Engineer can switch on either of the other two scenes

high above the ground. This attempt to overcome the curvature becomes impractical beyond a certain point, of course, since the antenna height required would become tremendous.

Color Telecasting

It might be well to incorporate a few of the fundamentals of color telecasting at this point merely to compare the operation with black-and-white television.

The color TV sets look exactly like black-and-white receivers but the cabinets are somewhat larger. Actually, color TV signals are identical to black and white. But instead of a single signal carrying a single picture there are three signals riding together,



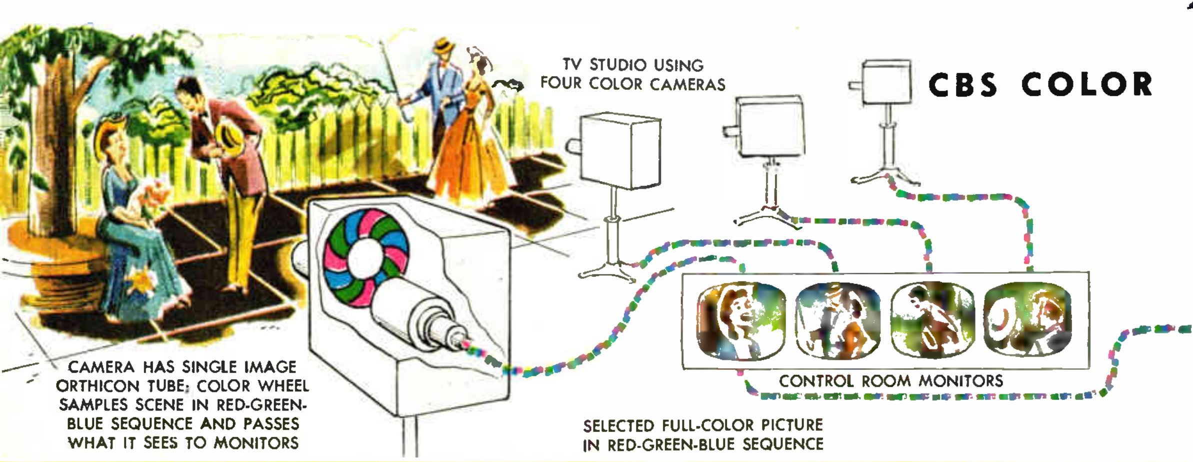
RCA COLOR TELEVISION

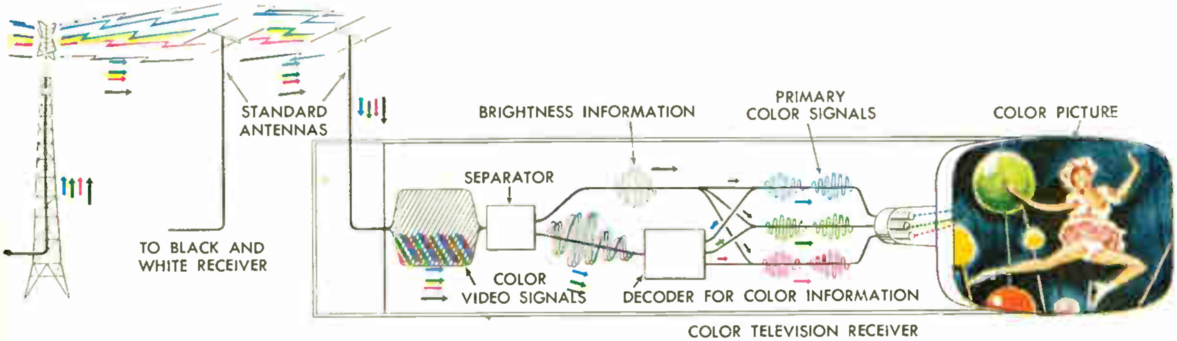
In RCA system, full-color image is focused on special mirrors which reflect one color, allow other two colors to pass. Color images then are focused on three camera tubes, which produce three color signals. Samples of signals are combined to add black-and-white signal. Process is reversed during reception

Before a telecast, each camera must be "tuned in" for delicate shadings of flesh tones. Here a cameraman focuses on a girl beside a color wheel to adjust camera for perfect color pickup

The brightly colored scenes shown on these pages are the same color signals that are streaming down your own antenna some of the time. While your black-and-white set can't translate the signals into color on its screen, it still can produce a perfect black-and-white picture from the color telecast, no matter which network is beaming the show. At one time special adapters were required

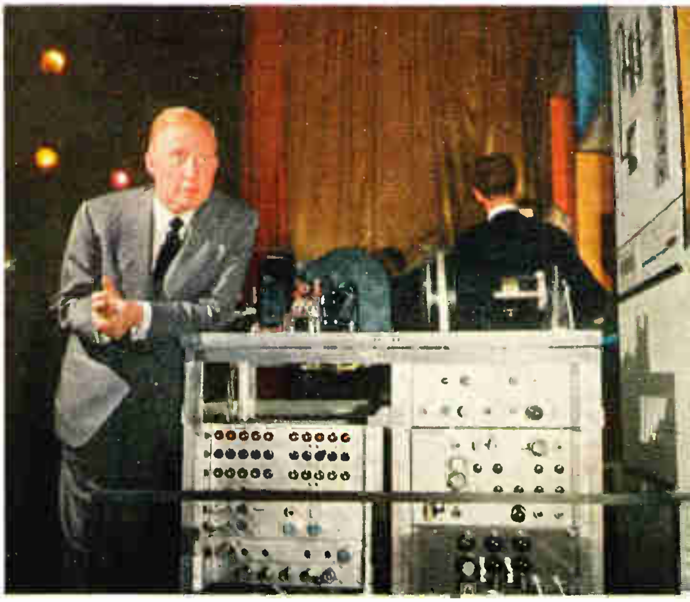
CBS COLOR





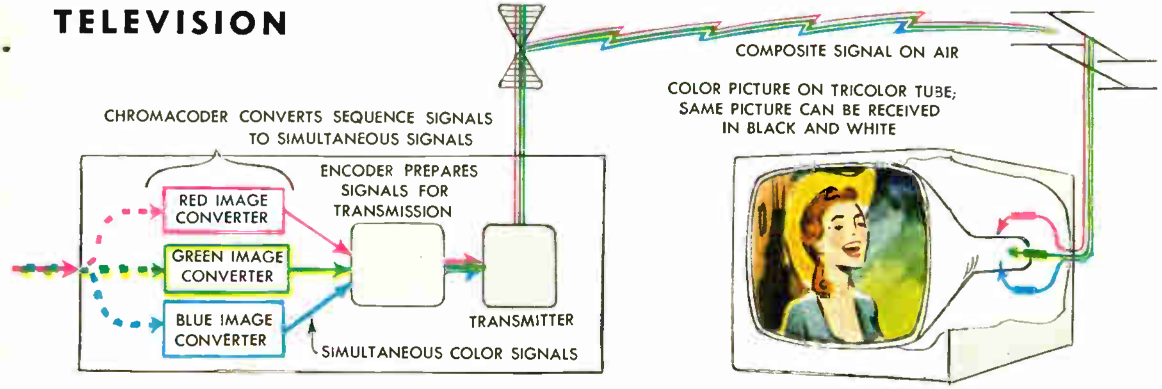
↓Dr. Frank Stanton, president of CBS, shows heart of CBS system, the Chromacoder. This electronic panel converts sequence signals, representing colors, into simultaneous signals for the air

Each network has its own color cameras and gear for breaking the scene into the three primary colors. When the signal leaves the transmitter, it is the same for all networks—three color signals riding in close frequency to black-and-white signals. This electronic information is picked up by the color receiver and the impulses for each of the colors are collected and sent to the picture tube



↓In CBS system, camera sees through a rapidly rotating color wheel. Signals from the camera are in a red-green-blue sequence. After passing through control room, signals go to Chromacoder which converts them into three simultaneous signals for transmission. On the air, signals of CBS and RCA systems are identical

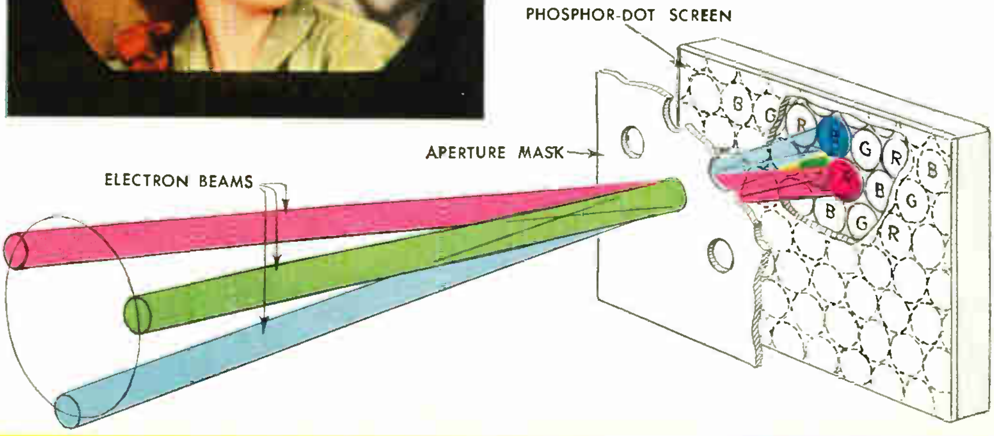
TELEVISION



RCA demonstrator shows in large scale how beams pass through mask to affect pattern on screen. Inner face of TV tube is coated with tiny dots of red, green and blue phosphor arranged in triads. A shadow mask perfectly registered over triads allows the beams to hit only the right phosphors

Engineer checks light prior to telecast. Poor lighting can turn blues to reds, give flesh a green tone. Flesh is the key to all color TV. If black, white and flesh are right on the monitors, the engineers are confident of a good telecast

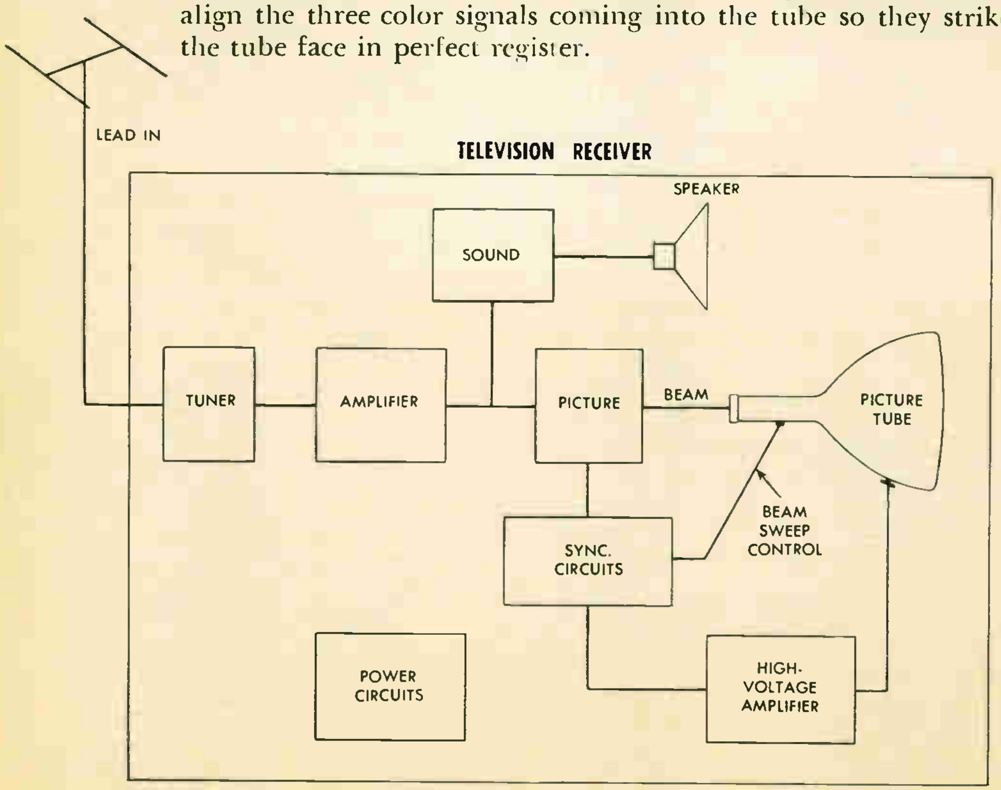
Diagram shows how each of the holes in aperture mask permits each of the electron beams to affect only the right phosphor. When the eye sees these glowing phosphors it combines them into a full-color scene, such as photo shown at the left



carrying three separate images. One shows all the red values in the scene being shot, another all the green, a third all the blue.

The following chapter on color television will explain just how these colors are produced at the transmitting station and sent out into the air where they are picked up by your antenna. The full-color illustrations which appear in this chapter will give you an excellent briefing on the color process, and you will want to come back to these diagrams and pictures while reading the chapter on color.

Of course, the color picture tube is different. A color-television picture screen is composed of tiny phosphor dots of three different colors: red, green and blue. The screen dots match the colors used at the TV station and now the trick is to sort out the colors and blend them into an intelligible image. This operation is done in the receiver and is easily accomplished by adjusting dials. The dials are no different from those found on most modern black-and-white TV sets. A typical set has five or six knobs. Four are the familiar ones on your standard black-and-white set: channel selector, brightness contrast and focus control. One new one is the "chrome control." This control shades the picture to suit the individual taste. The other is a "convergence" control to align the three color signals coming into the tube so they strike the tube face in perfect register.



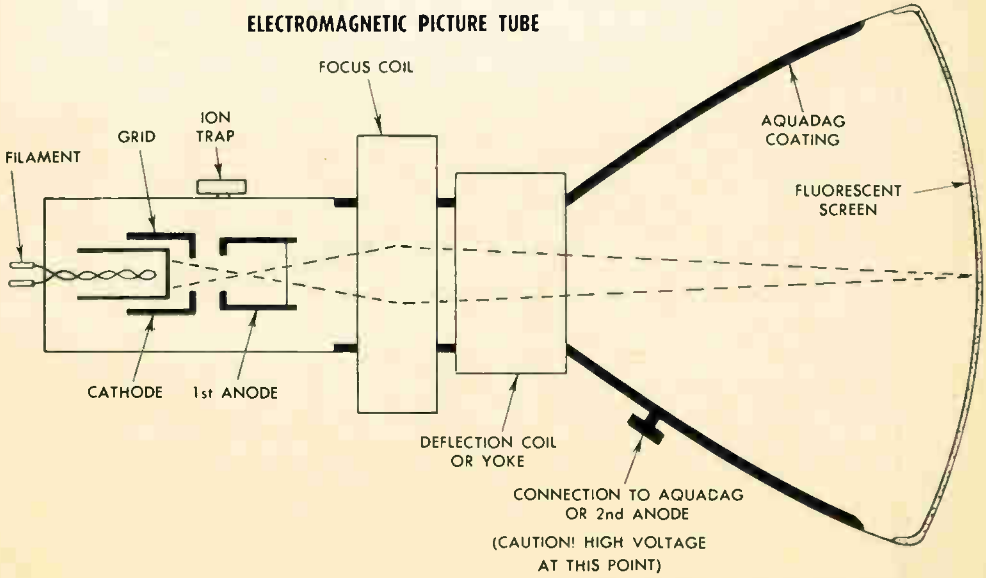
Receiving the Signal

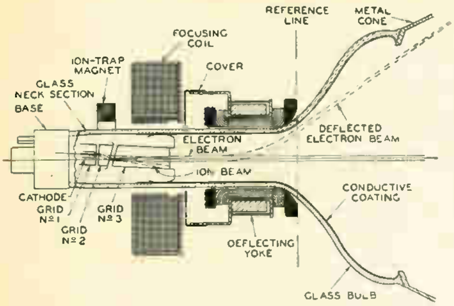
Once the TV "picture" has been taken and broadcast, the next step is to receive it and, by reversing the processes already gone through, to impress it on the picture tube in the home receiver. To do this, an antenna is aimed in the direction from which the strongest signal comes.

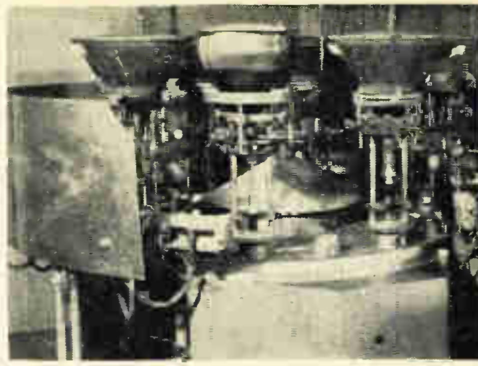
There are many different antennas of the indoor, built-in and outdoor types. These will be gone into in detail later on. At this point, it is enough to say that the antenna "catches" a quantity of the electrical energy in the air. It was previously mentioned that the most efficient antenna, or the one that captures the largest amount of a desired signal, is one that bears a fractional or multiple size relationship to a wavelength. This does not mean that the antenna which is a half-wavelength long with respect to Channel 5 signals will not receive signals sent on Channel 9 or Channel 2. It will, but not quite as efficiently. In normal areas, however, this is compensated for by erecting the equivalent of two antennas on one mast, both feeding one lead-in wire.

Once caught by the antenna, the black-and-white signal is fed into the lead-in or transmission line, which carries the signal to the television receiver. Here we have a situation which is much the same as the transmitting process except that it is in reverse. We have a picture tube which has the target at the face instead of the inner end or the back. We have an electronic beam to "paint" the picture on the face of the tube. We have sweep circuits which move the electronic beam across and up and down the target. These circuits are synchronized with the beam at the

ELECTROMAGNETIC PICTURE TUBE







Precision machinery presses the electron gun into a picture tube

Rauland

transmitter. We have amplifiers to make the signal strong. We have power circuits—just as in a radio—to provide the different voltages necessary to operate the tubes and to light up the picture. We have sound circuits to receive and amplify the sound and send it to the speaker. And we have a tuner which enables us to differentiate between one station and another.

A diagram on page 21 shows the workings of a television receiver. Both sound and picture signals travel together through the tuner and are amplified. At a certain point in the receiver they are separated: The picture signal is fed to the picture tube and the sound signal goes to the speaker. The synchronization and sweep circuits control the beam on which the picture is "riding," causing it to move across the face of the tube "in step" with the beam which is in the camera at the transmitting end.

The Picture Tube

The picture tube is coated with a substance that will glow to greater or lesser degree in accordance with the amount of electrical energy hitting it. The electron beam contains differing amounts of electrical energy as it bombards this coating. These amounts, of course, are determined by the amount of energy the camera tube has fed to the carrier wave. The stronger the bombardment, the more the tube lights up; the black-and-white picture results.

Because of its importance in the television scheme, we shall give a detailed explanation of the picture tube at this point. Let us start with the "electromagnetic-deflection" type of picture tube, the most common in use.

"Electromagnetic deflection" is one of those terms which sound very impressive and intricate. Actually it is fairly simple and can be readily understood by accepting certain basic facts. Recalling high-school physics experiments, remember that when a bar magnet is placed underneath a piece of paper and the paper then sprinkled with iron filings, one end of the magnet attracts the filings and the other end repels them. The stronger the magnet, the stronger the attraction and repulsion and the more filings can be controlled. In exactly the same way, if a positive electrical voltage is placed on a metal plate, electrons will be attracted to the plate. If a negative voltage is applied, repulsion will result. The higher the voltage, the greater the attraction or repulsion. This is called electrostatic control.

Now, instead of applying voltage to a metal plate, suppose we were to take a piece of wire, wind it into a coil, and apply current. Invisible lines of force which the iron filings outlined on the paper now surround the coil. These lines of force have the power to control electrons and deflect them into certain paths. The closer the electrons to the coil, the greater the strength of the force. Also, the higher the current the greater the strength of the force. Understanding this principle, which is used in the ordinary doorbell, will assist in understanding what takes place in a black-and-white television picture tube. This principle is called electromagnetic control.

In the television picture tube, the picture is "painted" on the screen by an electron beam whose strength in terms of electrons varies with the incoming signal. It is necessary, first of all, to manufacture an electron beam. The television picture tube has a filament, just as does an ordinary vacuum tube. The sole function of this wire is to provide heat. It will be noticed that the filament is inserted inside a cylinder called a cathode. The cathode is coated with a substance which is thermionic, or which has the property of throwing off electrons when heated. As a result, when the filament is lighted, electrons are freed from the cathode in quantities and float in the surrounding space.

The next step is to gather these electrons into a beam and send it toward the fluorescent face of the picture tube. The grid, which surrounds the cathode as the cathode surrounds the filament, confines the flow of electrons. The grid is a closed metal cylinder with a small aperture at the end which faces the tube screen. The amount of voltage applied to this grid controls the number of electrons which pass through the aperture. Thus the grid makes use of the electrostatic-control principle. In this respect, one can compare the grid to a faucet and the electrons to water. Turning the handle on the faucet controls the flow of water; varying the voltage on the grid controls the flow of electrons.

The next component in the line is the first anode. This is also a cylinder with small apertures at the screen end. If an even,

Worker uses knuckle-handled brush to apply electrical conductive coating inside picture tube. Right, welding tricolor picture tube to main cone of tube

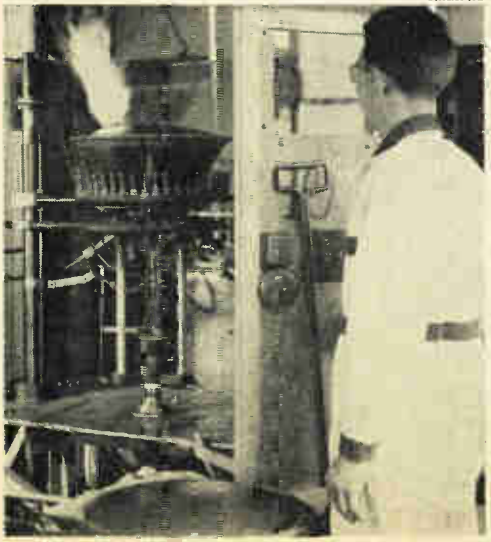
nonfluctuating, high voltage is applied to the first anode, the strength of its attraction will be such that it pulls the electrons through the grid aperture at high speed. For that reason the first anode is called the accelerating grid. Because of its construction, it also helps concentrate the electrons into a smaller beam. Just as a very sharp pencil can draw finer lines and greater detail, so does a small beam "paint" a finer picture in greater detail.

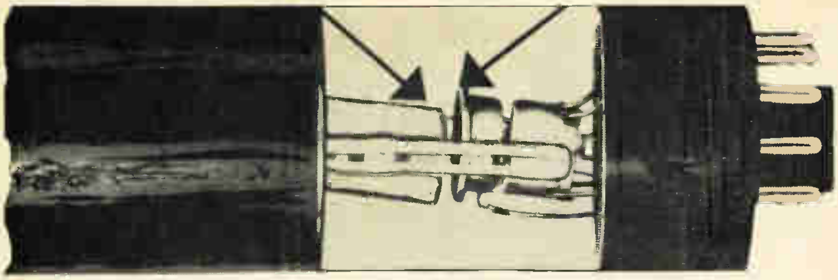
At this point we have created an electron beam. It is still a coarse, broad affair, however. In order to develop it into a pinpoint and focus it exactly on the screen, we must have an electronic "lens." This lens function is performed by the focusing coil which is found around the neck of the picture tube. This is simply a wire coiled around an iron core. Current passed through the wire sets up a magnetic field. This field has the ability to deflect the electron beam and control its size, depending on its position and its strength. If a pocket lens is used to focus the

RCA

Below, fusing the glass face to the metal cone of a television picture tube. Right, finished picture tube is given final check by skilled inspector

Rauland





In one type of picture tube, a glow appears at the limiting aperture of the electron gun to signal any misadjustment of the ion trap. Arrows show the aperture at which glow appears

sun on an object, the size of the spot, its intensity and its sharpness will depend upon the position of the lens. In like manner, the position of the focusing coil will determine the size, position, sharpness and concentration of the electron beam.

Generally the beam is focused by the positioning of the coil around the neck of the tube. However, varying the strength of the current through the coil will change the focus as well. That is done by varying the focus control, usually found at the rear of the television receiver and which is used as a "fine" control.

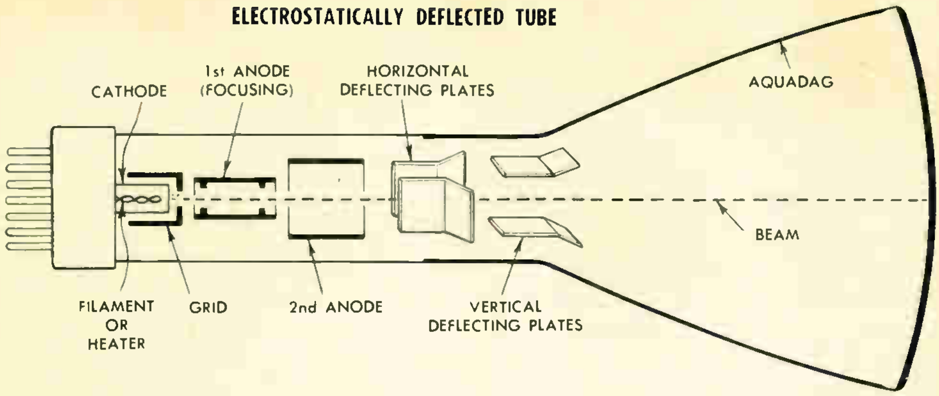
The electron beam, now extremely small in size and focused properly, strikes the screen and, if sufficiently strong, causes it to glow. After having struck the screen, the electrons are attracted by the second anode and led to a return circuit.

The second anode, which is operated at very high voltage, is coated with a graphite mixture called Aquadag. This coating, on the inside of the cone, is maintained at a high voltage through a connection piercing the glass tube. A lead from the high-voltage supply of the receiver is led directly to this connection and snapped on. The connector, covered with a rubber suction cap to hold it in place and provide insulation, bears a decided resemblance to the snap on a woman's dress.

On metal picture tubes, the metal cone itself acts as the second anode and is covered by a sheet of plastic insulation. The high voltage applied to the second anode adds a great deal of strength to the force with which the electrons strike the screen of the picture tube.

After the electrons have performed their job of causing the screen to glow they are attracted and led off by the voltage of the second anode. If the electrons were allowed to float around in the tube vacuum, those comprising the electron beam itself would hit them and the result would be distortion and lack of signal strength.

The next step is to move the beam back and forth across the screen so that it can impart the picture intelligence it carries.



Also, it must be moved from top to bottom in order to cover the whole face of the picture tube.

We stated earlier that the picture is divided into 525 horizontal lines which are scanned at the rate of 30 times a second. In scanning each line 30 times each second, the electron beam must travel across the screen 15.750 times per second. The television part which does this job is called the deflection yoke. Like the grid, the deflection yoke is a coil of wire around the neck of the picture tube. A circuit in the receiver provides this coil with electric current, then abruptly releases it, at the rate of 15,750 times a second.

As current is applied, the beam is pulled over the side of the screen; when the current is stopped, the beam flies back and the process is repeated. This operation is called horizontal deflection.

The deflection yoke has a second coil winding which serves to move the beam from top to bottom at the rate of 30 times a second. To this coil is applied current with a frequency of 60 times a second. Were this not done, the beam would return to the same spot after each horizontal sweep, and a single line would appear.

Inasmuch as the odd-numbered lines are scanned first, then the even-numbered lines (to help prevent flicker); the vertical-deflection frequency must operate at 60 times per second, which will give 60 "half pictures" or 30 complete pictures. Therefore, 60 times per second, the field built up by current applied to the vertical coils pulls the beam from top to bottom, a line at a time. At the same time current is being applied to the horizontal-deflection coils at a rate designed to "paint" 525 lines each 1/30 of a second.

In the meantime the electron beam in the camera is being deflected at exactly the same rate and in the same way. When the home receiver is synchronized with the camera, a picture results. If the horizontal-deflection sweep is not "in step," lines appear across the face of the picture tube and the owner adjusts the horizontal "hold" control. If the picture rolls around and around, the vertical deflection sweep is "out of step" and the vertical "hold" control then must be reset.

Little has been said about the screen. The inside of the face of the picture tube is coated with a special phosphorescent substance which glows when bombarded with electrons in sufficient strength and quantity. The amount of glow depends on the number of electrons which strike the coating. The human eye has a quality called retentivity of vision. This quality, coupled with the glow persistence of the screen, gives us a complete picture instead of one "painted" line by line.

It is interesting to note that the "color," or more properly the contrast, of the television picture can be controlled by the substance used in coating the face of the picture tube. This makes the difference between "black" tubes and "daylight" tubes. In a television showroom, the difference in shading can be noted when a number of sets are in operation.

The Ion Trap

A device called an ion trap is found around the neck of a majority of picture tubes using magnetic deflection. This generally consists of one or two small permanent magnets. For various reasons, a varying number of ions are present in a picture tube. Ions are electrically charged particles which, unless deflected, will bombard the screen and cause an ion spot—a brownish circle—to appear in the center of the screen.

To prevent this, some tubes have a face coating of thin aluminum through which the electrons can pass but which bars ions. The most common method is to bend the electron-emitting section of the tube so that the beam is aimed at the side of the tube. The ion trap then bends the electron beam back into its proper path, but the heavier ions travel straight on and hit the side of the tube without doing harm.

The need for careful adjustment of the ion trap cannot be overemphasized. If the beam is not properly deflected, the electrons will strike the anode aperture and tear ions loose. These in turn will follow the beam and strike the screen, causing blemishes in the picture.

Most picture tubes have two small pole pieces called flags located on the electron gun. The ion trap should never be placed forward of these locators. Although in some cases a picture may be obtained when the ion trap is misadjusted, it will not be the clearest or brightest possible and is almost sure to cause spots eventually.

One type of picture tube has a first anode built into the electron gun and coated with a fluorescent substance around its limiting aperture. If electrons strike this aperture, a glow results which is visible on the screen. The glow indicates maladjustment of the ion trap, as the electrons are striking the sides of the aperture instead of passing through the dead center.

Cathodes and Grids

It can now be understood that once an electron beam traverses the screen, the screen will glow in accordance with the strength of the beam. Therefore, if we impress the incoming electrical picture energy on some strategic section of the picture tube, we can vary the strength of the beam. This can be done in one of two places—the cathode or the grid. Inasmuch as we already have compared the grid to a faucet, let us continue the metaphor. The greater the strength of the incoming signal, the more the grid will attract electrons from the cathode and permit them to pass on through the aperture. As the strength decreases, the attraction decreases and fewer electrons are permitted to pass. Thus the strength of the electrical energy present in the picture signal controls the electron flow. As it varies, the electron flow varies. The signal strength also varies with the amount of light the transmitting camera "sees" as it "takes" a scene. Thus the television picture is "painted."

Electrostatic Deflection

One other basic type of picture tube is used in television receivers—the electrostatically deflected tube. There are no units around the neck of the tube. Instead, focusing is done by the first anode. Varying the voltage between the first and second anodes will focus the beam on the screen. To replace the horizontal and vertical-deflection coils, two sets of plates are used inside the tube and the voltages which "pull" the beam are applied to these plates.

There is no ion trap. The heavy ions are attracted to the second anode and the deflection plates, and thus can do no harm. Although this type of tube would seem to have certain advantages, actually its use in tubes larger than 7 inches thus far has not been practical because of the high voltages necessary on the deflection plates. They are used chiefly in portable TV sets and studio monitor screens.

In laboratory experiments, however, the electrostatically focused picture tube has been greatly improved, and this could well be the most commonly used tube in the future insofar as focusing is concerned. The servicing required to maintain proper focus is highly simplified.

Chapter Two

Color Television

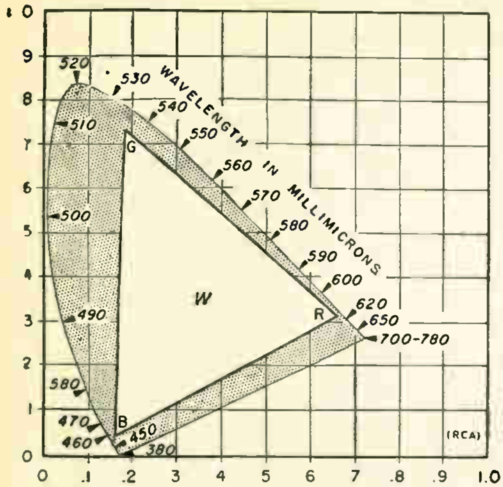
CONFUSION is a mild word for the state of color television only a few years ago. At least three major, and quite different systems of color telecasting were proposed, and each was touted as best by its backers. Had all been allowed to proceed, many black-and-white sets would have been rendered useless during color telecasts, and the public outcry would have been great.

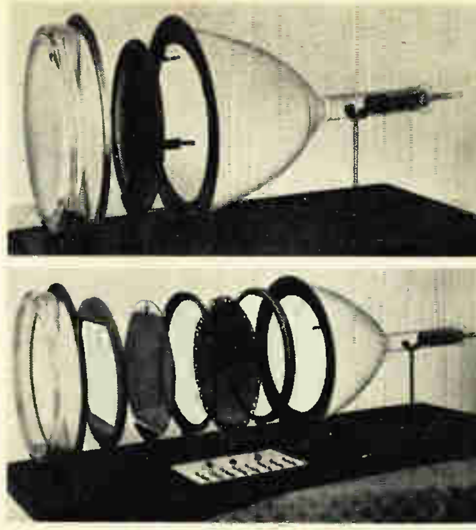
Through the efforts of the Federal Communications Commission and the National Television Standards Committee, an industry group, these problems finally have been solved. The system arrived at is "compatible," meaning that standard black-and-white receivers are able to get a good picture while color is being telecast. At the same time, color receivers record black-and-white programs when color is not being transmitted.

There were other important rules laid down. The color signal has to remain within the six megacycles allotted to each station. Colors have to be true and bright, and definition and contrast good. It must be possible to transmit color signals over the same coaxial and microwave systems as used by black-and-white signals. And finally, the transmitting and receiving systems must be as simple and inexpensive as possible.

Basic Color Theory

To understand color television—in whole or in part—it is necessary to have some knowledge of basic color principles or





Left, "color map" standardized by International Commission on Illumination. Right, simplified CBS color tube shown on top is less expensive than former model shown at the bottom

"colorimetry." Fortunately, color is a function of light. and light is a form of radiant energy just as are radio waves.

When electromagnetic radiation occurs at certain frequencies, the eye responds to it and we call it "light." The frequencies of light are extremely high and the wavelengths correspondingly short. In television and radio we work with wavelengths measured in "angstrom units"—one is the ten-millionth part of a millimeter or a millimicron—the micron being the millionth part of a meter and the millimicron being the thousandth part of a micron. The band of light covered by visible light is called the "color spectrum" and ranges from approximately 380 millimicrons to 700 millimicrons in wave length. The color of light depends upon its wavelength; at the 380-millimicron end we have purple, at the 700-millimicron end we have red. In between these two are the other colors in the order shown:

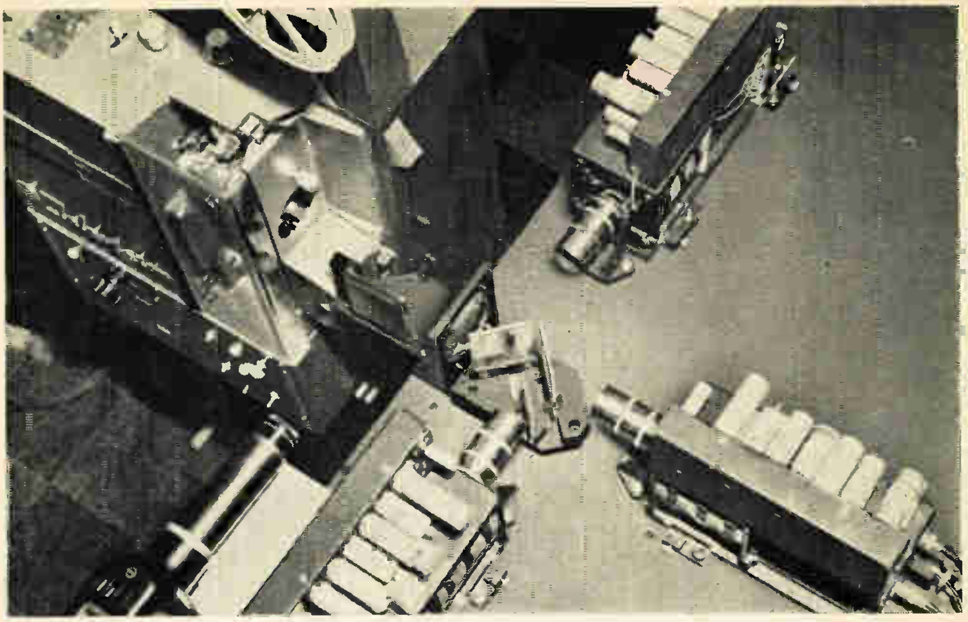
Infrared .... *Invisible light*

Red
Orange
Yellow .... *Visible light*
Green
Blue
Violet

Ultraviolet .... *Invisible light*

White light is the result of a combination of these colors—or of some of them—in almost equal amounts.

What the human eye does in receiving these frequencies and transmitting the intelligence to the brain is not known. Experi-

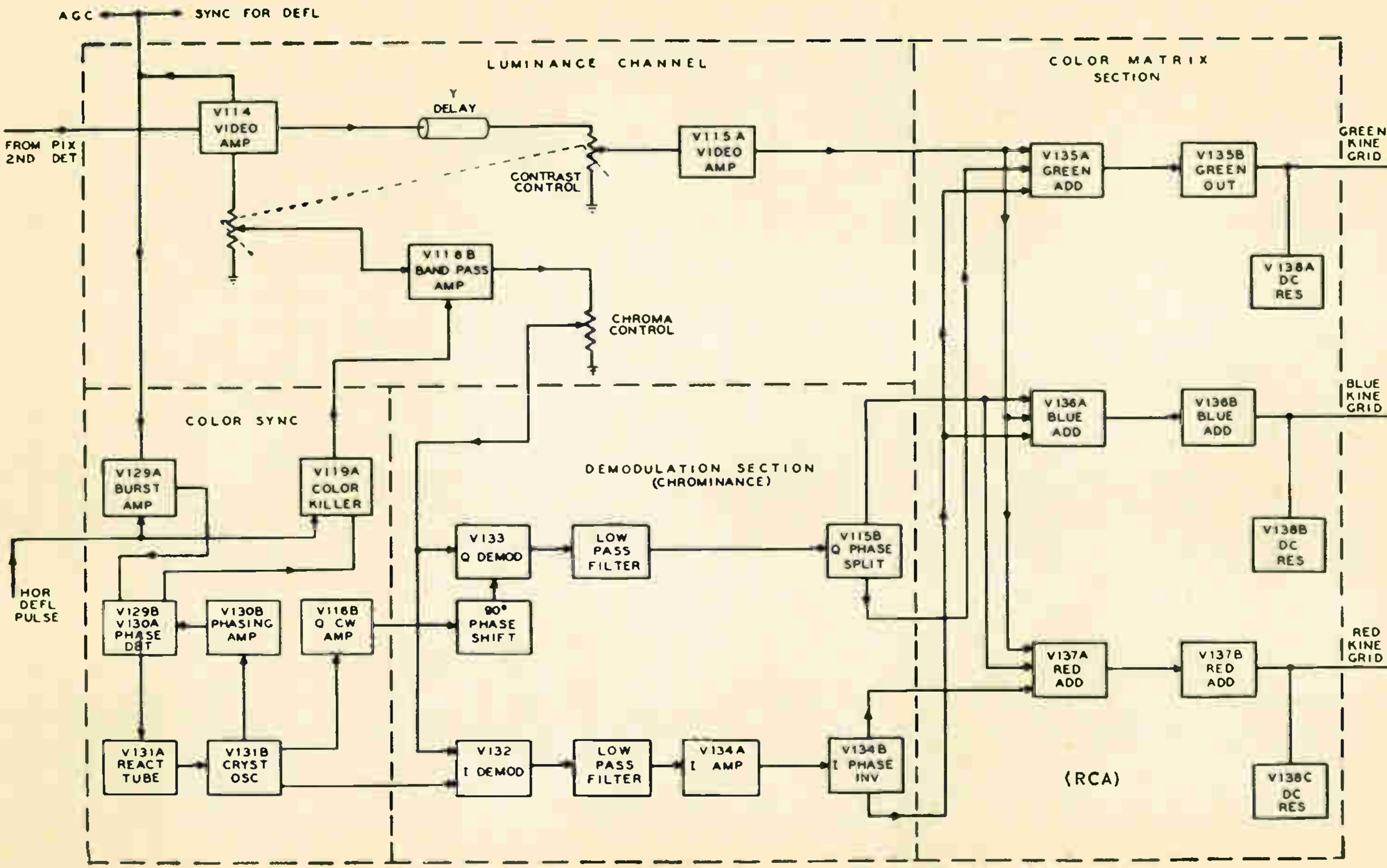


RCA 3-V camera televises color film through a light-splitting optical system that uses Vidicon tubes. Each Vidicon chassis filters its own color portion of original image

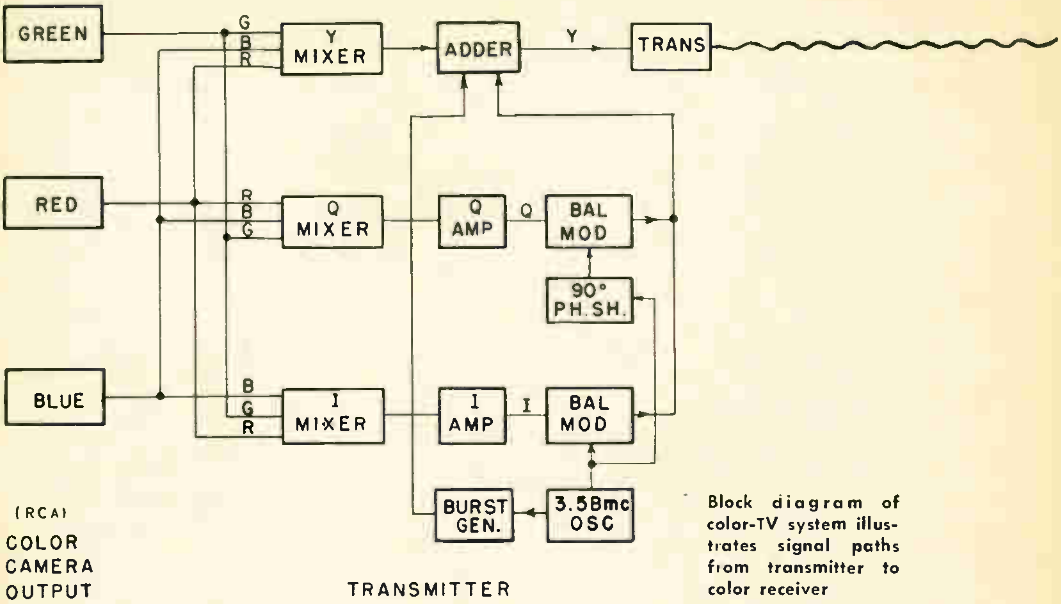
ments have shown, however, that if certain things are done, certain results follow. For example, if red and green light waves are mixed, the result is yellow; a blue-green mixture produces a color called "cyan," and red and blue together make up magenta. Together, red, green and blue produce white light. Because these three colors mixed do produce white light they are called "primary colors." And because the white light is produced by adding rather than subtracting colors they are called additive rather than subtractive primaries. The subtractive primaries are used in printing and photographic work but not in television and will not, therefore, be discussed here. Any group of three additive primaries can be used in television as long as no two of them added together produce the third. Because blue, red and green properly matched will provide the greatest range of common colors, they have been chosen as the primaries for color TV.

When we speak of red, green, blue, yellow, purple, etc., we are referring to only one of three characteristics of color itself—the "hue." Instead of saying "Look at that lovely red dress," we could say this, "Look at that dress whose hue is 7594 angstrom units." Sounds silly, but it helps clarify, perhaps, what is meant by the term hue. It refers to the wavelength of the color involved.

The other two characteristics of color are (1) *saturation*, sometimes called "chroma" and (2) *brightness*, sometimes called "luminance." A basic understanding of these two terms is necessary



Video section of color receiver. Each block represents a tube, tube section or circuit



Block diagram of color-TV system illustrates signal paths from transmitter to color receiver

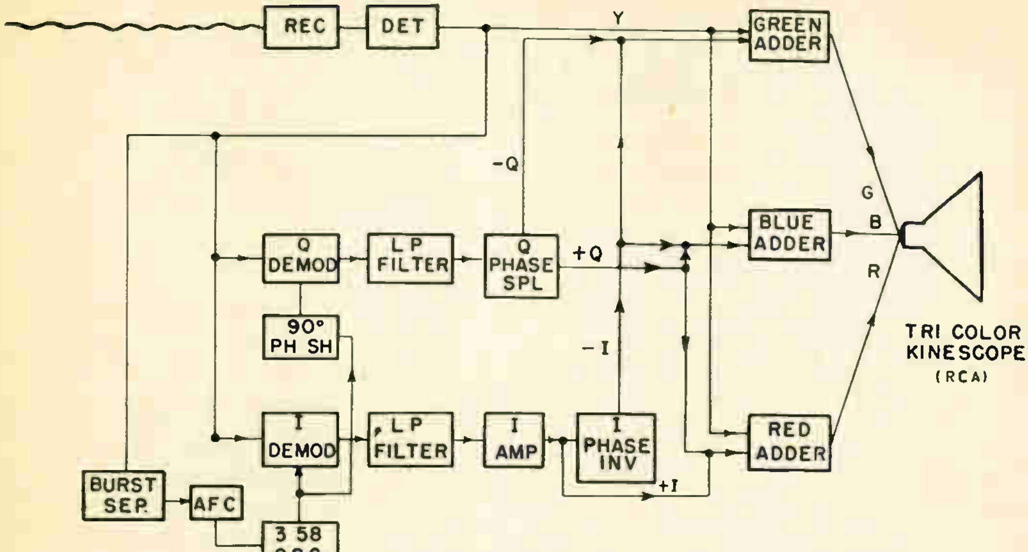
for anyone engaged in engineering or servicing color TV and desirable for those who will use and operate color TV receivers.

Saturation is a measure of the dilution of a hue, the diluting substance being white light. For example, a vivid, true, blazing red can be said to be 100 percent saturated. Mix it with varying percentages of white light and we get varying shades of pink. The pastel shades are hues mixed with white light.

Brightness is a term familiar to all who own black-and-white TV receivers and therefore needs very little explanation. It is, by definition, a measure of the intensity of a color. It is a most important characteristic, however, for only by varying brightness can the three primary colors be changed.

The average human eye—that is, one which is not hypersensitive to color or insensitive to certain colors as is the case with the color-blind—can be likened in some respects to a radio receiver. It is not tunable as a receiver is: in other words, in viewing a group of colors one cannot, without some external means such as a filter, shut off some colors and let others come through. Therefore, the eye has no selectivity. It is, however, able to detect varying brightness and saturation. The eye cannot "tune," but it will respond to differences in "volume."

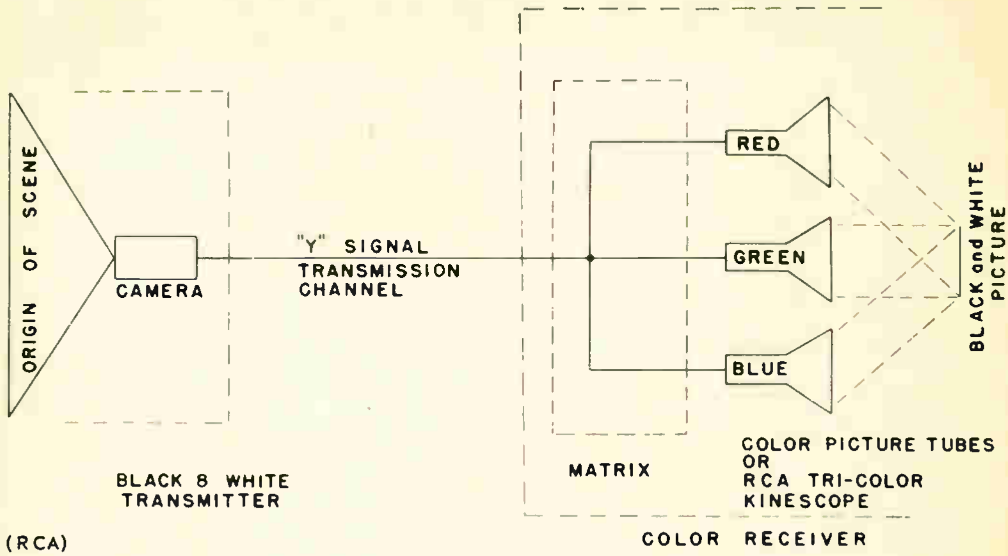
Of great importance in color television are the results of experiments conducted by the International Commission of Illumination (*Commission Internationale de l'Eclairage;* abbreviated *CIE*). One of these experiments showed that the eye responds



RECEIVER

differently in terms of brightness to different colors. Of the three primaries used in color TV, blue is the least bright, green is the brightest and red falls in between. Because of that factor, one cannot mix one-third green light, one-third red light and one-third blue light and come out with white light. Careful checking has resulted in the adoption of a standard by the television industry of the following percentages of the three primaries to provide white light—30 percent red, 59 percent green and 11 percent blue. These figures are important in discussing the operation of color-TV transmission and reception.

The eye's inability to select different hues at will actually is of advantage to color TV. It has been found that the smaller an object is, the less necessary it is to use three primaries to match its color. A mixture of two primary lights is sufficient to satisfy the eye. With very tiny objects, we normally can see no color at all, and only the brightness perception remains. This reduces the necessity for transmitting and receiving hue and saturation information for very fine detail. In other words, to transmit in great detail the color information in a picture requires quite a sizable band width. However, by law, the total band width permitted a station is six megacycles, approximately two-thirds of which is allotted to the picture and one-third to sound, spacing, etc. Of the four megacycles used to convey picture intelligence, only a portion is available to transmit color and this is divided into two channels to carry the hue and saturation information.



Black-and-white signals are picked up equally as well on the color-television receiver

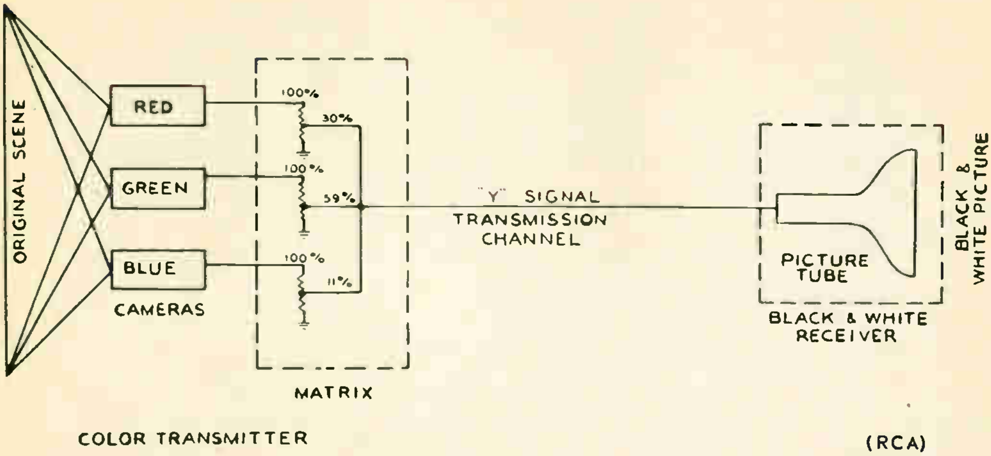
Thus, the inefficiency—if one wishes to call it that—of the eye in being unable to detect color in fine objects is used in making practical a color-TV system within present band-width confines.

Suppose that we have three hues in the proper percentages to produce white light—30 percent red, 59 percent green and 11 percent blue. If we reduce the brightness of the blue to zero so that none remains, only red and green will remain and the result will be yellow. If red is removed and the green and blue remained at equal strength the blue-green hue called cyan would be the result. Remove green and the red and blue would produce magenta. These additional three colors—yellow, cyan and magenta,—are the complementary colors of color TV.

Now if the brightness of the various primaries is varied singly or together, the result will be variations in all color characteristics—hue, saturation and brightness. The RCA Tricolor Kinescope is a device that permits brightness changes in red, green and blue simultaneously, just as the black-and-white picture tube permits brightness changes in one color.

The RCA Color Tube

Physically, the RCA color tube bears a close resemblance to the conventional black-and-white picture tube. Electrically, it also bears a close resemblance to the black-and-white tube in that an electron gun emits energy which upon striking a phosphor causes it to glow. At that point, however, the resemblance begins

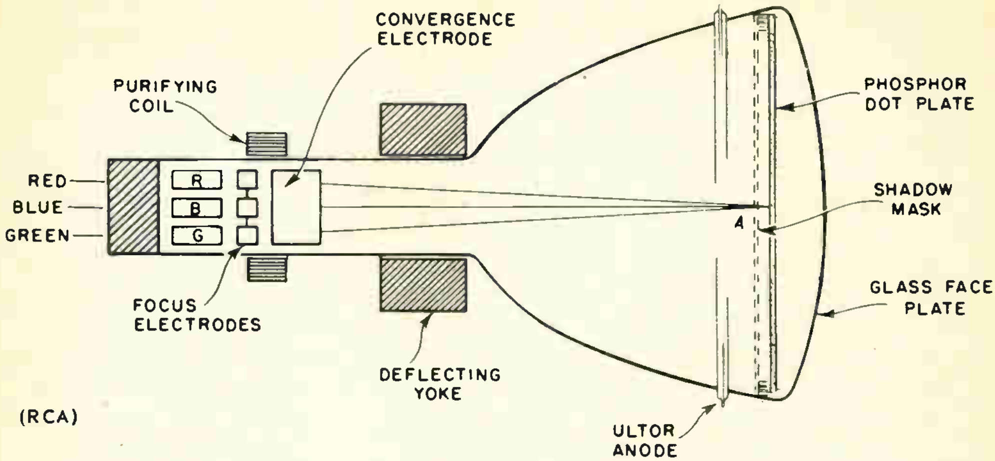


A color-TV system also provides monochrome pictures for the black-and-white receiver

to fade rapidly. At the front end of the tube, going from front to back, are three parts of an assembly all enclosed within the glass envelope—a decorative mask, a viewing screen and an aperture mask. Entering the neck of the tube—still going from front to back, we find another group, first the converging lens, then the focus electrodes and, finally, not one but three electron guns.

In conventional black-and-white television, the viewing screen is coated entirely with a single-color phosphor to provide black-and-white pictures. It could have been just as easily coated with a phosphor to produce black-and-red or black-and-green pictures. In the RCA Tricolor Kinescope, however, the viewing screen is covered with very tiny dots arranged carefully in groups of three, called trios. Each trio consists of a dot which emits red when struck by the electron beam, a dot which emits green and a third which emits blue. The dots are interlaced but do not overlap. Here, then, are the potential sources of the three primary colors already discussed. Because large dots would not provide good picture detail, very tiny dots are used—almost 600,000 on the average color screen. This permits excellent detail. The dots are far too small to permit the eye to separate them at any normal viewing distance and permit the presentation of varying shades and hues in a very satisfactory manner. Thus, when the green and red dots in a trio are lighted and the blue is left dark, the viewer sees a yellow hue rather than two separate hues.

An aperture called the shadow mask is located immediately behind the viewing screen. It has been punched full of round holes equal in number to the trios of phosphor dots and located in such a manner that each hole is centered at the center point



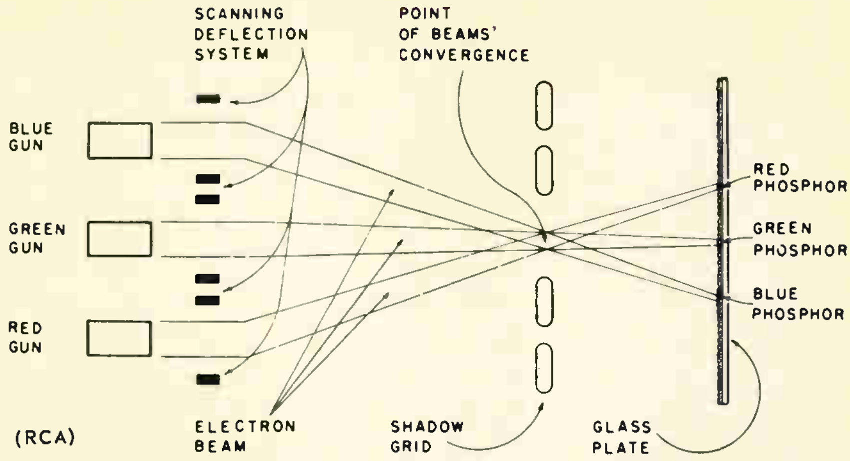
Operating components of the Tricolor Kinescope used in RCA color-television receivers

of the trio it applies to. The function of the shadow mask is to prevent the electron beams from striking the wrong phosphor array. Needless to say, very careful assembly of the viewing screen and the shadow mask is required to obtain the very precise alignment necessary.

At the neck of the tube, three electron guns are arranged in a parallel manner, spaced 120 deg. apart. The function of each gun is to provide a stream of electrons for each of the three phosphor colors. They are known, of course, as the blue, red and green guns.

Just as in black-and-white TV, the electron beams must be focused on the viewing screen. Each electron gun is provided with a focusing electrode—grid No. 3 in the illustration. The focusing is controlled by a voltage adjustment for each grid. As the viewing surface is flat, the distance from the electron gun to each trio is different, and the focusing voltage must be varied in accordance with the position of the trio being illuminated at any particular moment. This is accomplished by applying an additional voltage to the focus grids. The added voltage is supplied by the horizontal and deflection circuits.

Because the beams from the three guns must pass through the same aperture in the shadow mask for each trio of dots, there must be some means of converging the beams at that point. Therefore, grid No. 4, common to all guns, is used. In this case, the voltage difference between the grid itself and grid No. 5, the neck coating, is varied. The shadow mask also is a flat surface, so that here again the voltage must be varied in accordance with the aperture being used. The additional voltage again comes



Shadow-mask line-scanning system uses picture screen dotted with the three primary colors

from the deflection circuits. One other adjustment is provided for convergence, this one to compensate for the convergence differences which are inevitable in any manufacturing process. This adjustment is made by three external magnets located near the electron guns.

Grid No. 2, the accelerating electrode, performs the same function as its counterpart, anode No. 1 in black-and-white picture tubes. It accelerates the beam and "fines" it down. Grid No. 1, the control electrode, is the one to which the color signal is fed. Thus, each electrode gun has its own grid which controls the amount of beam current, or electrons, that particular gun can send toward the viewing screen, thereby controlling the brightness as previously discussed.

It is no secret that the major factor in the high cost of color-TV receivers has been the complexity of the color-picture tube. Besides having a complex viewing screen and shadow mask assembly that require extremely high production standards, the tolerances necessary in other portions of the tube are likewise a production manager's nightmare.

The RCA Tricolor Kinescope has other external parts in addition to the external convergence magnets previously mentioned. One is the deflection yoke, about which little need be said except that its function is basically the same as its counterpart in black-and-white television. That is, it provides the means of sweeping the electron beams across the viewing surface as well as down and up. However, there are two other external units used only in color tubes—the purity coil and the magnetic shield. These units purify and guide the signals to their proper dots.

To revert to color theory, you will recall that a pure color is a hue that contains no contamination from another hue. If we wanted pure red but inadvertently mixed in a little green or blue, the red would no longer be pure. This would be the case if any of the electron beams struck the wrong phosphor dot or passed through the wrong hole in the aperture mask. To help prevent this from happening, a purity coil is provided around the neck of the tube. By varying direct current through the coil and at the same time varying its position on the neck of the tube, the beam can be adjusted so that it strikes only its own dot. This operation is performed for each of the three colors.

Inasmuch as all electron beams are subject to the influence of magnetic fields, care is taken so that no stray field can affect the proper course of the beams. This is done by a metal shield which is placed around most of the kinescope to block such fields. It might be pointed out here that it is possible to have the purity coil properly adjusted and all stray fields completely blocked and still not have purity of hue if the convergence controls have not been properly adjusted. The conclusion to be drawn is that the installation and adjustment of a color-television receiver are so complex that generally the skill of a practiced technician is required for even minor adjustments. In addition, in order to make sure of proper registration of colors, it is often necessary to use test equipment of the sort not generally found in even the most elaborately equipped basement workshop. It might be wise, therefore, to advise most color-set owners to leave the color-tube adjustment controls alone.

The Tricolor Kinescope with its three electron guns permits a fully "simultaneous" system as opposed to a "sequential" system. In the simultaneous method, all the primary colors are presented at one time or as they are controlled by the incoming signal voltage. In the "sequential" system, each color, whether it be by lines or by dots, is shown in turn. The latter method depends on the retentivity of vision of the eye to help blend the colors desired, despite a slight time lapse. Simultaneous systems have an advantage in that they do not depend on this human characteristic.

From Scene to Viewing Screen

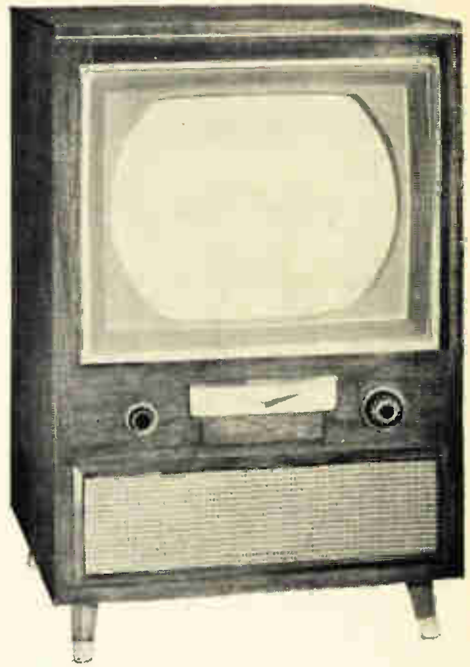
Now that a little is known about the color properties of a scene and the make-up of a device which is capable of reproducing that scene in color at a remote point, the next step is to discuss the various means used to transmit.

Illustrated is a diagram of a color-TV camera as currently used. It has the conventional lens just as has its black-and-white

Above, CBS color camera at right is about the same size and shape as conventional black-and-white camera at left. Instead of a single signal as in black and white, color TV requires three signals carrying three separate images. Left, receiving tubes for color receivers and broadcast equipment promise greater flexibility in circuit design

brother. However, it contains not one, but three camera tubes. By means of dichroic mirrors or lenses, each camera tube is fed only the light energy of one of the three primary colors used. A dichroic mirror is one which will pass all colors except one which it reflects. In "shooting" a scene, the red camera is fed energy proportionate to the amount of red in the scene; the blue and green cameras receive the same for their respective colors. Obviously, if any color is missing, no energy is received by that particular camera. The net result is three individual signals varying in strength according to the amount of their own particular color in the scene being scanned at that moment.

Because the FCC has properly insisted that we have a compatible color-TV system, it is necessary that some part of this group of color signals also be used to provide signal intelligence to black-and-white receivers. You will recall that color has three characteristics—hue, saturation and brightness. White light, which is used in black-and-white TV, lacks hue and saturation but does have a brightness characteristic. Therefore, if we use the brightness portion of the three-color signals we can satisfy requirements. Neither hue nor saturation can be used, for if we selected the output of either from any one camera tube, we would be at a loss for a signal if the color to which it is sensitive were missing. It has been stated that a mixture of 30 percent red, 59 percent green and 11 percent blue light will produce white light. So, the output from the camera tubes is fed into a circuit called a "matrix" which takes these proper percentages of each color, adds them together and produces the white signal, which for identifi-



Above, electronic components for color receivers. Right, first RCA Victor 21-in. color receiver

cation purposes is called the "Y" signal. This signal is transmitted and occupies the allotted band width for the picture-carrier section of a channel. It provides all the information necessary for a black-and-white picture and is also the brightness characteristic of the same picture in color.

We now have left three colors and two of their attributes—hue and saturation—which must be sent to the color receiver. It could be done by transmitting each one on its own carrier frequency, but that would require an additional frequency band width.

While working on this problem, electronics engineers discovered that the black-and-white signals did not occupy their whole space of 4.25 megacycles. Instead, they tended to bunch up, and between these groups was space for other signals.

The situation could roughly be compared to a train of cars in which the first group of seats in each car was occupied by passengers carrying black-and-white information. But the last group of seats in each car was empty. The engineers decided to make use of these seats by filling them with passengers carrying hue and saturation intelligence for color TV.

The space the engineers found to transmit the hue and saturation values for the three colors was a band width of 1.3 megacycles. Experiments disclosed a satisfactory frequency for doing this was a carefully calculated multiple of one-half the line frequency—or 3.579545 mc. Further research showed that this frequency could be modulated by two signals 90 deg. out of phase with each other. The phasing cancelled the color signals when they reached black-and-white receivers, although traveling along the same allotted band width.

Hue and saturation together are called *chrominance*. To understand fully how the chrominance information is transmitted and received is the most difficult part of color television. We shall attempt to do it as briefly as possible and with a minimum of mathematics and formulas. Let us start by showing the relative values of the luminance (brightness) and chrominance signals.

Imagine the telecasting of a drapery in vertical stripes of red, green and blue. Suppose that as each color was scanned it produced for its camera a signal strength of 100 units. A total of 300 units is fed to the "matrix," which takes 30 of the red units, 59 of the green and 11 of the blue for a total of 100 and feeds them to the luminance circuit for brightness. This provides the signal for the black-and-white receivers as well as brightness for the color TV receivers. Now the camera is scanning only one color at a time. This means that as the red color is scanned only 100 units are fed to the matrix and 30 of them are given to the luminance circuit. The green and blue camera tubes are receiving no light as the camera sees only red and red is reflected away by the dichroic mirrors applying to each of the other camera tubes. So, the luminance signal is now only 30 units strong. If 100 units of brightness gave full bright light, as it would in the case of fully saturated red, blue and green hues, then the 30 units must give a result between white and black, or some shade of gray. When the green section of the drape is being scanned, however, 59 units are fed to the luminance signal and the shade of gray will be lighter. And the red stripe, providing only 11 units to brightness, will be very dark. These are the results as they would appear on a black-and-white receiver. But for a color-TV receiver, those portions of the signals which have been removed at the transmitter end are added to the color signals containing only hue and saturation information, and the drapery is reproduced in all three brilliant primary colors.

The luminance signal, designated as the Y signal, is added to what the engineers call R, G and B signals, resulting in R-Y, G-Y and B-Y signals. These signals are called "color differences" and can be calculated mathematically. For example, the red signal consisted of 100 units. Thirty were removed for the luminance circuit, which also required 59 units of green and 11 of blue which were not there. Therefore, the Y signal now consists of 30 units of R, minus 59 units of green and minus 11 units of B. The chrominance signal of R remaining is then $R - Y$ or $70R - 59G - 11B$ units. In the same manner, the chrominance values of green and blue can be calculated. In TV engineering, it is customary to refer to such equations with decimal points preceding the numbers, thusly: $.70R - .59G - .11B$. This enables them to be translated more readily into percentage figures.

It has been shown that by producing a subcarrier of 3.58 megacycles we have a means of transmitting chrominance information. Also, it can be seen that if there are three variables of which two are known and the third can be quantitatively determined when its percentage of a total of the three is known (as is the case in the luminance circuit) that we can subtract one of the variables at one end and add it at the other. For that reason the green signal, which requires greater room for the detail it can portray, is left out in some systems. In others, a combination is used. The combination system is the most advantageous, providing greater color detail than that in which one complete hue would be used.

In this system, two separate signals are formed—the I signal and the Q signal.

The I signal consists of the following values of the chrominance signals:

$$I = +.60R - .32B - .28G$$

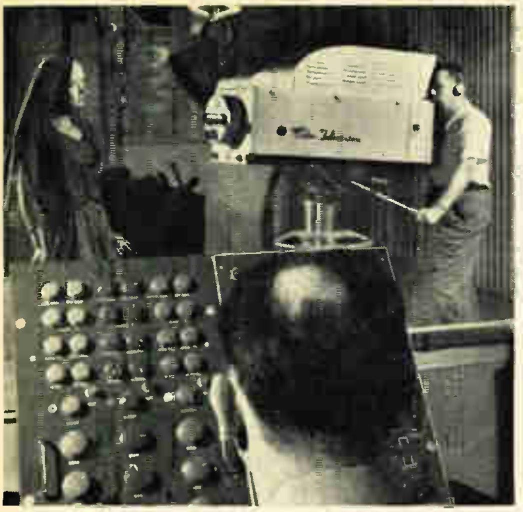
The Q signal is:

$$Q = +.21R + .31B - .52G$$

The Q signal is shifted 90 deg. out of phase with the I signal to provide two different modulating frequencies and used to modulate the 3.58 color subcarrier. Before the actual modulating is done, however, both the I and Q signals are passed through filters which limit their band width to .5 mc. for the Q signal and 1.5 mc. for the I signal to keep them within the prescribed channel limitations.

After further processing, the I and Q signals are added to the Y signal and the resultant used to modulate the transmitter.

Before leaving this discussion of the transmission end of the color TV signal, two further points should be made. First, before transmission, the 3.58 subcarrier frequency is removed from the circuit by electronic means. However, it must be brought into existence again in the receiver so the I and Q signals can be detected and their chrominance information used. In the receiver



RCA

Left, cameraman and video operator test color camera. Right, television's version of the walkie-talkie

this is done by means of a crystal oscillator circuit operating at the standard 3.579545 mc. In order to synchronize this frequency with the same one in the transmitter, a portion of a 3.579545 mc. signal consisting of only 9 cycles is sent out with every horizontal sync pulse. Its location, incidentally, is that portion of the sync pulse called the "back porch." It may be noted here that this sync impulse is necessary in color and not in black-and-white. In black-and-white receivers, the 60-cycle line frequency is used for synchronizing. In color, because of the location of the 3.58 mc. frequency, the sync pulses would not quite match as they would fall about every 59.4 cycles. The wide tolerances in black-and-white receivers permit this difference in technique from that used in color telecasting.

The second point to be made is this: When a scene is pictured, strong hues make for a higher camera-tube output than less saturated hues. Therefore, the amplitude of the I and Q chrominance signals is determined by the saturation of the hues pictured. Next, as we use red, blue and green for our primaries, the three colors which are at either end and the middle of the spectrum, all other usable colors must fall in between, and can be formed by combinations of the primary colors. In other words, certain percentages of two or more colors are added to form a third color. If this were plotted and mathematically proved, the different colors would have different phase angles. Knowing this and with the formulae given before, it is possible to see how the varying hues will alter the phase angle of the I and Q signals. For that reason, the phase angle of the chrominance signal varies with the hue and the amplitude phase angle varies with the saturation.

The Color TV Receiver

Let us now go into the matter of getting a color signal on the viewing screen. In many respects, the color receiver is the same as the black-and-white set. It has the same type of sound circuits, the same type of power circuits, tuning, IF amplification, video amplification, horizontal and vertical deflection circuits, detection circuits and the like. There are some minor differences and refinements, but the principles used and often the circuitry are the same. The basic difference lies in the picture tube and the color circuits which give it the required intelligence. The color section is discussed here without detail which would tend to confuse rather than enlighten.

Upon entering the color section of the receiver, the luminance portion of the signal is separated from the chrominance portion. The 9 cycles are removed from the back porch of the horizontal-sync pulse and fed to the color-sync circuit where they lock the local 3.58-mc. crystal oscillator in step properly. This frequency is fed to the demodulation section of the receiver where it is joined by the chrominance information, mixed, and the I and Q signals detected. Thus far we have the Y, I and Q signals. After being split in phase so that hue information can be detected, the I and Q signals are sent to the adder tubes where they are joined—in some circuits by their share of the Y signal. Some receivers, however, feed the luminance signals directly to the cathode circuits of the color kinescope. The resulting signals are the R, G and B signals as picked up by the camera tubes. These are fed to the control grids of the color kinescope and control their respective beams as in black-and-white receivers. (In receivers feeding the luminance signal to the cathodes, the signals fed to the control grids are the R-Y, G-Y and B-Y signals.) These signals, now controlling the electron beams from the three color guns of the color kinescope, reproduce the original scene in color. In the event that the original scene was not transmitted in color, the Y or luminance signal provides red, blue and green information in the 30-59-11 relationship to provide a black-and-white picture.

A Typical Receiver

Of interest to the reader may be some of the details of the RCA Model 21-CT-55 color-television receiver which is illustrated on page 42. It uses the RCA Tricolor Kinescope No. 21AXP22. This is a 21-in. receiver providing compatible black-and-white and color reception as well as VHF-UHF channel coverage. Those who remember the original 630 TS RCA chassis

NBC

Brilliant scene in spectacular production is reproduced in vivid color for television

as a standard for the black-and-white television industry might do well to view this as a standard for the color-television era. The operating controls are as follow:

Channel selector Fine tuning	Dual control knobs
Brightness Sound volume On-off switch	Dual control knobs
Horizontal hold Vertical hold	Dual control knobs
Contrast	Single knob
Hue	Single knob
Color	Single knob
Tone	Single knob

(The hue control determines redness, blueness, etc. The color control determines saturation. Technicians advise that these be set to provide the most pleasing flesh tones)

The receiver also has the conventional height, linearity, width, focus, centering controls and the like. In addition, there are various controls associated only with the color section which are classified as nonoperating and which enable the technician installing a set to adjust it properly for its particular location, etc. To cite some of these for general information, they are:

Screen controls for red, blue and green; blue and green background; blue and green gain, R-Y gain, red, green and blue vertical amplitude; red, green and blue horizontal amplitude; red, green and blue phasing; purity control, beam positioning, magnetic-field equalizer, etc. This list alone should convince the skeptical that a pretty adequate knowledge of electronics is necessary before an individual relies on himself rather than a trained technician for adjustments. Furthermore, the high-voltage supply is delivering 25,000 volts to the kinescope, and this is not to be treated lightly.

It is not to be assumed from the foregoing discussion of color TV and this particular receiver that the ultimate has been reached. On the contrary. The RCA Model 21-CT-55 has 35 tubes besides the kinescope. This number will undoubtedly be cut down. Refinements in the color kinescope itself can be expected, all tending toward better reception as well as lower cost.

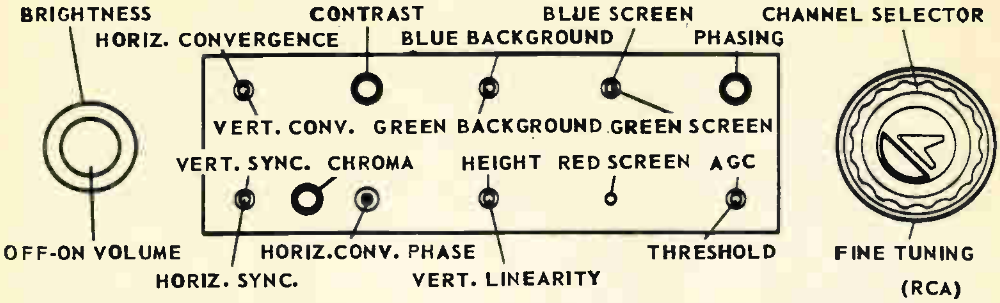
How to Operate an RCA Color Receiver

Of possible interest to some readers is an explanation of the steps necessary in setting up a receiver and tuning in color reception for the first time. For this, we will run through the steps used in adjusting the RCA Model 21-CT-55, a 21-in. color receiver.

All operating controls for this receiver are located at the front. These are the combination on-off switch, volume and brightness controls, located at the left, and the channel selector and fine-tuning controls at the right. Behind a tilt-down cover and removable panel are located the contrast, hue, color, vertical and horizontal hold, and tone controls, all of which are readily accessible and are to be used in the normal operation of the set. It will be noted that the only additions to the controls found on a normal black-and-white receiver are the "saturation" control, to regulate the strength of the color, and the hue control, to vary the redness, blueness, etc. Nonoperating controls found in the front are green, blue and red screen controls, blue and green background controls, green and blue video-gain controls, height, vertical linearity and automatic gain control. These are not used for normal operation of the receiver, and are altered only in the initial installation or in the course of repairs.

RCA gives the following instructions to be followed in tuning in a color picture:

1. Adjust the receiver for a good black-and-white picture
2. Set the channel selector to the desired channel broadcasting a color program
3. Advance the color control approximately two-thirds from its maximum counter-clockwise position
4. Carefully advance the fine-tuning control clockwise until the picture just begins to disappear, then slowly counterclockwise to the position where the sound bars just disappear from the screen and color is in the picture



Front panel of RCA color-TV set has two more controls than black-and-white receiver

5. Adjust the color control for the desired saturation of color
6. Adjust the hue control for hue quality. A good rule of thumb to follow here is to adjust the hue control until the most pleasing flesh tones are achieved

Properly installed by a technician, the color-television receiver should operate properly when these instructions are followed. In some cases the owner may install the receiver himself, in which case a few other points of information may be valuable to him. Locating the proper controls is not always easy without a guide, so it is strongly recommended that any steps taken beyond the normal operating instructions accompanying each set should only be with the assistance of a diagram of the particular set circuit.

If it is impossible to synchronize the picture, the difficulty may be caused by improper adjustment of the automatic gain control or the horizontal oscillator. Access to both these controls on this receiver is gained through the metal control-cover box at the front of the receiver. Careful adjustment should synchronize the receiver provided no parts have failed. Further adjustment of the horizontal frequency and locking controls must not be done without proper instructions.

At the rear of the receiver chassis are found controls with names familiar to the operators of monochrome receivers—vertical and horizontal centering, horizontal linearity, width and focus controls. These are adjusted as explained in the discussions of black-and-white receivers. RCA has also incorporated an FM trap in this receiver designed to eliminate interference from a strong FM signal. This trap is fastened to the antenna transmission line inside the receiver and is adjusted as follows: Tune in the station on which the interference is observed. Adjust the trap for minimum interference.

Although it is possible for the nontechnician to make other adjustments on a color-TV receiver, it is definitely not advisable

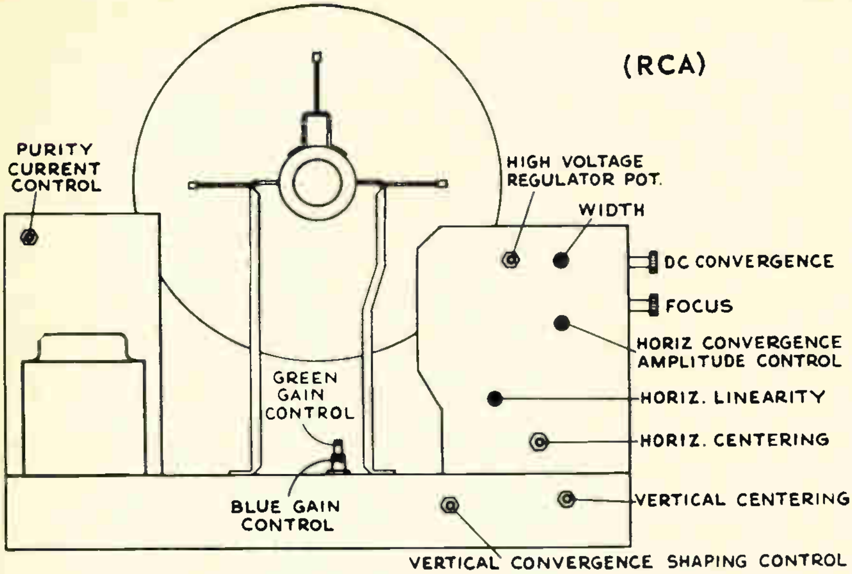


Diagram of rear apron panel shows additional controls necessary for color receiving

for him to do so unless he has had a great deal of experience. In addition, complete adjustment of a color receiver requires a considerable amount of equipment not generally found in most home workshops. Two such expensive but necessary items are a color-bar generator and a dot generator.

It is to be expected that many of these controls will become quite unnecessary and almost purely automatic as improvements are made in color-TV receivers. Those who have had black-and-white receivers since the early days can remember when it was necessary to readjust the horizontal and vertical controls many times during an evening. Now months pass by before any adjustment is made on a modern set. And the same should hold true for color.

Chapter Three

How to Choose A Set

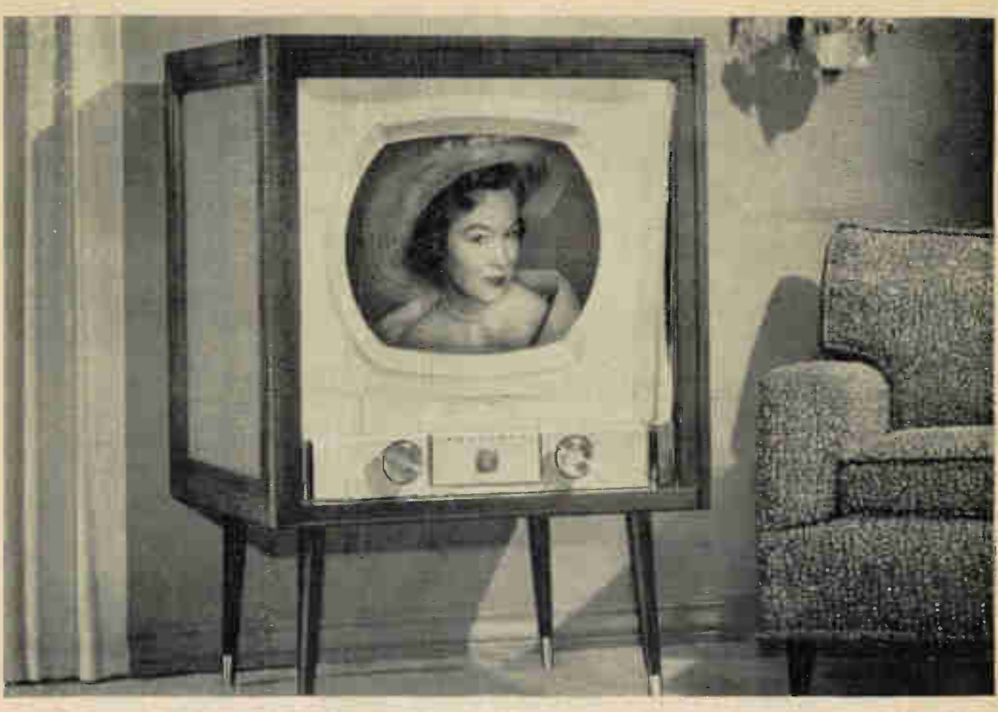
THE BASIC FUNDAMENTALS of television have been presented. Now we shall discuss the various types of television receivers and the principal parts in order to help the prospective purchaser choose a set.

It will be assumed in the following discussion that the buyer is purchasing a receiver from a reputable dealer who (1) has erected a fair number of efficient antennas in the particular locality, (2) inspected and made post-shipping adjustments to each receiver displayed and (3) allows the buyer to see performing the receiver in which he is interested. It would be unfair to criticize a television set because the dealer was not giving it the opportunity to perform efficiently.

The desirable television receiver is one which gives a clear, steady, detailed picture with pleasing, hum-free sound. When the picture-carrying electrical energy sent out by the various television stations enters the receiver via the lead-in, some means must be provided to separate the energy sent out by the desired station from that transmitted by others. This work is performed by the tuner assembly, usually designated on a receiver as the "channel selector."

Types of Tuners

In some models, the stations are selected by means of a switch with a fine-tuning adjustment. In others the selector is continuously rotary like the action of a radio-tuning control.



Tricolor picture tube with large screen is featured in this Motorola color-TV receiver

The tuner separates the desired signal from the undesired. It amplifies this signal which is very weak, to make it more usable. The amplified signal is then altered by "mixing" it with a locally generated signal. The resulting frequency, which is always the same regardless of the channel selected, is called the intermediate frequency, or just plain "i.f." This is fed to a series of amplifier stages called i.f. amplifiers, each one of which increases the strength of the signal. It is this system of conversion to one frequency—regardless of the station—which enables the set owner to tune the desired signal by using only one control.

Were this method not used, each individual amplifier would have to be tuned every time a new station was selected. Instead the amplifiers are pretuned at the factory and then only occasionally realigned by a serviceman. The same principle is used in radio to permit one-knob tuning. Those who remember the days before the super-heterodyne will recall radio receivers which had numerous tuning knobs on the panel, plus honeycomb coils, all of which had to be adjusted for a change of station.

Purchase of a television receiver with a poor tuner would certainly be a mistake. However, it is nearly impossible for a buyer—regardless of his knowledge of electronics—to walk into a dealer's store, examine various models and their tuners and from that inspection decide which is best.

Fortunately this is not necessary; modern television receivers are almost all produced with good basic tuner assemblies. Granted there are differences in quality; obviously a low-cost receiver will not have the high-quality parts and circuits of a receiver which costs a great deal more. But as far as the purchaser is concerned, there are only two points for consideration. The first is sensitivity. In some cases, manufacturers have installed tuners which are excellent in their ability to pass on to the next stages the complete band width of the picture signal. This shows up in very good picture detail. At the same time, however, such a tuner often is unable to pick up weak signals satisfactorily. A set of this sort would be a poor buy if it is to be operated in a fringe area. An excellent rule for fringe-area purchasers is to buy a television receiver from a dealer in their own vicinity so that they can watch a demonstration of its ability to receive the weaker stations.

The second point to watch is shielding. A few tuners are not as well designed and shielded as others. The result is a radiation of the oscillator signal to such an extent that these receivers interfere with neighboring television sets. This can best be checked by watching nearby receivers for interference as the channel selector of the set in question is changed from station to station in the dealer's store.

The switch-type tuners can be divided into two groups—one in which the parts are in one fixed piece except for some few alignment units, and the other, usually called the "turret-type"

Left, recent improvements in TV sets include convenient top-panel tuning. Another feature of this receiver is the Unit-ized chassis which consists of individual plug-in units. Below, a decorative touch in indoor antennas. This type of antenna is claimed to provide ideal reception in city areas on all channels including VHF and UHF

Left, earphone attached to a thin 25-ft. cable enables wearer to view TV and listen without disturbing others in the room. Above, built-in TV unit is mounted on a roller-and-track system for easy servicing. Sound system is mounted separately

tuner, in which there is a separate, replaceable plate for each television channel. These replaceable plates will make it possible to adapt the tuner to new television stations when the Federal Communications Commission makes new frequencies available for them. In that sense, the turret type is the best of the switch tuners.

Although the continuous-type tuner appeared in a number of receivers for a period of time, it is no longer used to any great extent in v.h.f. tuners. The flexibility of the turret type in changing channel strips to provide reception over a greater number of channels is too advantageous to be overcome. However, the continuous-tuning principle is widely used in u.h.f. tuners as discussed later.

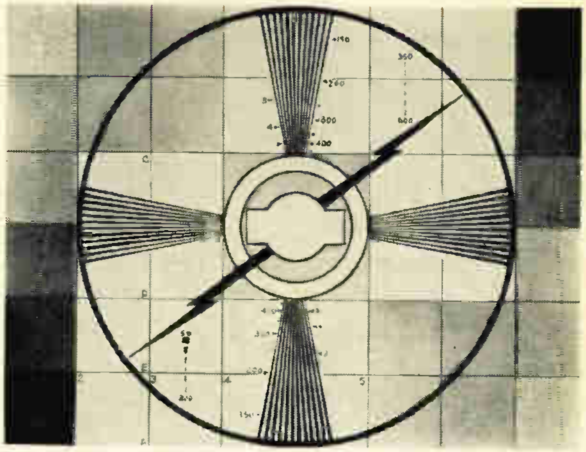
As a rule, tuners are a subassembly mounted on the receiver chassis. In the event they become permanently defective, the complete unit can be replaced.

Amplifiers

The chosen signal is fed by the tuner into the intermediate-frequency amplifiers. Each amplifier consists of a tube and its associated components—resistors, condensers and coils. Its purpose is to amplify the strength of the energy it has received without blocking any of it in the process. To make certain that this is the case, the i.f. amplifiers are usually "stagger-tuned," which means that each is tuned to a slightly different frequency that overlaps that of the others so that the net result is as complete a passage of all the picture details possible.

One of the characteristics of a vacuum-tube amplifier is that the "sharper" it is tuned, the more it amplifies. "Sharp" tuning, however, will not permit all the elements in the signal to pass through. For that reason, receivers in the more expensive brackets

This is a typical test pattern, broadcast on various channels when not in program use. It is wise to learn how to interpret a test pattern and try any TV receiver on it before you make your purchase



will average five i.f. stages. Each one is operated at less than its full ability to amplify, but as a consequence provides more of the elements that make for fine picture detail. On the other hand, low-cost receivers usually have only three i.f. stages. Each is set for maximum—or close to maximum—performance, with the result that each blocks some of the fine-picture elements.

For these reasons the number of i.f. stages a television receiver has is an important item for the buyer to consider *in relation to* the size of the picture tube in the set being examined. The larger the screen, the more detail is necessary to give a satisfactory picture. When purchasing a receiver, then, it can be said that the detail on a 12½-inch screen will be quite good with only three i.f. stages, but that a 21-inch screen should have five.

Detectors

Having passed through the i.f. stages and been sufficiently amplified, the next process undergone by the signal is "detection." This consists simply of removing the electrical energy which comprises the picture from the radio-frequency carriage on which it has been riding. The circuit which does this is the second detector, and is made up of a tube—or crystal diode—and associated parts. The output of the second detector is electrical energy, the strength of which is varied by the strength of the light energy which the camera beam is "seeing" on its target. This energy is still a little bit weak, so that one or more video-amplifier stages are necessary to make the signal strong enough to control the electrons in the beam of the picture tube. The principles of i.f. amplifiers also hold true in video amplifiers. They must pass all the signal to give good picture detail; if tuned too sharply they will fail to do so. Low-cost sets usually have only one video-amplifier tube; costlier receivers will have two. These are often loosely called "power tubes."

Sweep Circuits

There are other circuits in the receiver which affect the picture, but only two can be investigated by the ordinary buyer. These are the horizontal and vertical-sweep circuits. These should be of sufficient quality to hold the picture steady so that it does not "roll" vertically or form lines horizontally.

The efficiency of these circuits can be checked readily by asking the salesman to turn the "hold" controls from one end to the other. In a good location, with strong signals, the vertical hold should give strong, positive locking action. If this does not result, and other receivers in the area do operate properly, it can be assumed (1) that the receiver is not adjusted properly, (2) the design is faulty or (3) the set is not sensitive enough to bring in an efficient signal. In weak-signal areas, of course, it is more difficult to synchronize the picture due to the inability of the synchronizing impulses of the transmitter to lock in the receiver sweep circuits.

Test Patterns

After having satisfied himself that the receiver is sensitive and has good synchronization, the prospective purchaser should then see if detail is good and the proper shades of black and white are present in the picture. This is most properly done by means of a test pattern.

At certain times of the day each television station transmits a test pattern. This enables station engineers to observe the quality of their signal and servicemen to properly adjust non-operating controls, and also provides the buyer with a means of judging the quality of any receiver. It is wise to postpone the final selection of any set until you can view a test pattern on its screen.

There is a trick to interpreting the quality of performance from the test pattern. Note that the pattern shown on these pages has a number of concentric circles, each of a different shade. Also, there are four wedges made up of lines wide at the edge and narrowing toward the center. If the receiver is working properly, the adjustment of the contrast control will show the difference in brightness between any two adjacent rings to be constant. If the contrast control cannot be adjusted to bring about this result, the set is either not operating properly or is improperly designed.

The wedges are used to determine horizontal and vertical resolution—by studying these, you can determine the amount of detail a picture will show. If, on viewing a test pattern, you are able to distinguish clearly between lines from the outside of the circle to the point where they intersect the bull's eye and absolutely no blurring is present, you are watching a receiver giving very nearly perfect detail. The farther away from the center the test lines begin to blur, the poorer the amount of detail that can be expected. This applies to both the horizontal and vertical wedges.

Some television stations show small dots alongside the wedges of their test patterns. Each dot marks a point at which resolution is measured in terms of lines. Since practice varies with different stations, however, these have little value for the layman.

It can readily be seen that a test pattern can be quite valuable in purchasing a television receiver. Because it provides a non-changing image, it is much easier to check the steadiness of the deflection and sweep circuits on a test pattern than it would be on a changing broadcast image.

Also, comparing the same test pattern on several different makes of receivers will readily show which set has the best detail and contrast control. Of course, a poor antenna installation will distort the pattern in many ways, but it can usually be assumed that the dealer will have an excellent installation in order to show his wares to best advantage.

Sound Circuits

We have thus far gone into the details a purchaser can observe insofar as the picture section of the receiver is concerned. There remains the sound section.

In all TV receivers the sound is tuned in by the same knob which tunes in the picture. Both signals enter together and pass out of the tuner assembly together. How this is done will be gone into later in the chapter on servicing. Here it is necessary to take it up briefly because unpleasant sound can ruin an otherwise excellent set.

There are two systems currently in use for separating the sound signal from the picture signal and sending the sound to the speaker. In one system, the sound is fed to its own i.f. amplifiers at a point immediately following the tuner. From then on it is treated just as it would be in an ordinary FM radio receiver. In the other system, the sound continues to travel through with the picture signal to a point following the video detector, then is taken off by itself to a fewer number of stages.

The latter method is called the intercarrier method. Although frowned on at first, it has since become very practical and widespread in use. A small amount of picture detail is lost in the intercarrier method, but the sound tends to remain in synchronization with the picture. In other words, if the receiver is properly adjusted, the sound will be at its best when the clearest picture is tuned in. Since fewer stages are needed, the cost of manufacturing an intercarrier receiver is less.

On the other hand, a perhaps better sound quality and no loss of picture detail can be obtained from a set using separate i.f. amplifiers for the sound. There is, however, the danger that changes in the values of circuit components will cause the sound to go out of synchronization with the picture.

Taking these factors into consideration, it is difficult to state flatly that one system is the best. Here the buyer's own ear is the best critic and judge.

As for speakers, it is generally true that the larger speakers found in console models provide the best sound. Some table-model sets have two *small* speakers to make up for their inability to contain one large speaker. Here again, use your own ear.

Dealers and Manufacturers

Several other factors enter into the purchase of a television receiver. First and perhaps most important is the dealer who sells the set. Service contracts to the contrary, nothing can replace a good dealer who values your business and wishes you to be so satisfied that you will return to him for all your future TV needs. He is interested in seeing that you are a happy customer, not an unhappy one. Such a dealer will not consider a sale completed until the customer is satisfied with the performance of the set.

A second consideration is the manufacturer. A great many companies are producing television receivers. Some of these are large and well-known firms; others are small and obscure. Some of their products are good; some bad. *In no case should it be assumed that because a manufacturer is large, well known and does a great deal of advertising that every one of his products is good.* He too can make mistakes. On the other hand, it is *not as likely* as in the case of the smaller maker, who doesn't have as much of a reputation to uphold. But there are small manufacturers in the market whose pride is quality, not quantity, and these must not be overlooked.

But don't let these opposing factors bewilder you. You can easily check on the performance and durability of a set the price and appearance of which you like by finding a friend or a friend's friend who has had one for a fair length of time. His candid opinion will be valuable.

Since most dealers sell many makes of receivers, you can also ask the advice of one you know and trust. In no case, however, should you purchase a set that does not bear the famous "Underwriters' label." Some cities have ordinances which prohibit the sale of electrical appliances without this surety that it has been inspected by an unbiased expert and pronounced free of fire and shock hazards.

Other Factors in Buying

What size of picture to buy? This is largely determined by the size of the room in which the receiver will be located, the eyesight conditions of consistent viewers and other factors which vary with the buyer. The same applies to cabinets. These should be selected with a view to keeping intact that furniture motif of the room involved.

It will be noticed that some receivers have a ring of foam rubber around the picture tube and pressed flat against the safety glass of the cabinet. This is merely a kind of washer, used to prevent dust particles from circulating past the face of the tube and gathering on the inner side of the safety glass. These particles will gather until they reach a density through which the picture can scarcely be seen. Often a serviceman is called to repair a set because the picture has become too dim, only to find that the receiver is functioning perfectly and the trouble is caused by a thick coating of dust. This is prevented, or at least the trouble is decreased, in sets which have the foam-rubber washers.

Many TV-receiver buyers are apartment dwellers whose landlords refuse permission to erect an outside antenna. Because there are locations even within very short distances of television stations where the signal cannot be received properly without such an antenna, it is wise to insist that a receiver be delivered for trial with an indoor antenna before making the purchase final. There is no point in investing a sizable sum of money in a set which cannot be operated efficiently enough to give full viewing pleasure. Reliable dealers realize that and are usually cooperative enough to test a set in your specific location.

The results that one's neighbors get on their receivers are not necessarily a true indication of the reception conditions throughout a building. These conditions vary from floor to floor as well as from side to side. The only real test is to try it and see.

Above, tiny new receiving tube for color-TV sets regulates the brightness of the three primary colors on picture screen. The large wheel is televised in test patterns. Right, entire top of color-TV set lifts up for easy access to chassis

Antenna Installation

Having decided on the make and model of receiver, the purchaser is then confronted with the problem of antenna installation and service costs. Additional sums for the erection of an outside antenna, a parts warranty and a service contract can push up sharply the initial cost of a set.

This is a part of television expense you can save yourself. As a general rule, installing an antenna requires little technical knowledge; the cost is merely a matter of materials. Most owners will be quite capable of erecting their own, and a section of this book is devoted to telling you how it is done.

Warranties and Contracts

Parts warranties and service contracts deserve a little more consideration. As a rule, the manufacturer guarantees all parts used in his receiver to be free from defect for a period of 90 days after the purchase. He will replace a defective part free of charge within that time. The defective part must be returned with the sales slip or other proof of the date of purchase. The customer pays for the labor involved. This labor may be performed by a service company, the dealer's service department, the manufacturer's or distributor's service divisions or the customer himself.

Because it has become very difficult, and therefore expensive, for servicemen to obtain a part immediately, many service companies charge a flat fee for such a replacement which is over and above the labor charge. This is because many manufacturers put all their parts into new production to the detriment of stocks for service replacement. Many of them require an excessive amount of red-tape forms and waiting periods. This has made it necessary for service companies to build up their own inventories of parts.

To recover some of the cost of this inventory, the service company may add a flat fee.

Should the buyer desire, he can extend the warranty on the parts in his receiver for one or two years. These long-term warranties are sometimes issued by service companies and sometimes by dealers and manufacturers. The cost varies with the size of the picture tube. This is not because a set with a large picture tube has any more trouble potentials, but because the picture tube is the most expensive part covered by the warranty and its cost increases with size.

Parts warranties extending the normal 90-day period to one year will average from $10 to $30 a year, depending on the size of the picture tube. The purchase of such a warranty is advisable *only if moderate in cost* and only when obtained from a reliable source. This is because the majority of trouble in a television receiver makes itself evident in the first 60 to 90 days of use.

The television-set owner must face the fact that television service costs are much greater than those of radios. It is only natural that television troubles should be more frequent. The frequencies at which television operates are so high that small changes in values cause trouble which would not be apparent in a radio. The careful synchronization required of the sweep circuits is critical. High voltages are more apt to cause insulation breakdowns. Television receivers generate a great deal of heat, which tends to dry out condensers, melt the wax used in their construction, change the value of resistors, etc. Television tubes don't last as long as those of radio.

But the television set of today is much less susceptible to trouble than those of 1947 and 1948. Today the same thing holds true of a new television set as does of a new automobile—the majority of difficulties will show up in the first few weeks of operation. Normal maintenance following that period is relatively small. *Therefore, the need for the service contract has definitely lessened.* And, as this need has decreased, fewer contracts have been sold, and the companies issuing them have had to maintain fairly high prices for their guarantees.

Another important factor in the decreased sale of service contracts has been the tremendous number of service firms that have come into a blooming market and operated with poor efficiency, unskilled help and often downright dishonesty. The buying public has been forced to penalize service companies in general because of the tactics of a minority.

Meanwhile, the reliable service companies have looked more and more with favor at short-term service contracts and post-contract service done on a cash basis—that is a certain charge per call. Practically, this is the best system. If most defective parts go bad within 90 days—the period covered by the manufacturer's guarantee—and most other troubles requiring the services of a trained technician show up in the same period, this is obviously the danger period and the one to have protection.

Still another factor speaks against the high-priced, long-term contract. Much of the trouble which develops in a television receiver is due to one of the small tubes going out. *These can be readily replaced by the set owner,* who can save himself a four, five or six-dollar labor charge connected with such a service call. How to replace these tubes and take care of other troubles is dealt with elsewhere in this book.

Summary for Buyers

It is not the purpose of this book to list particular television receivers which are "good buys" or "bad buys." It is expected that the information previously given will enable the purchaser to make a wise selection. Factors such as picture size, cabinet type and finish, cost and the like are to be decided by the buyer himself. But it would be well to summarize here the important buying guides:

1. Inspect the sets owned by neighbors to see what type of reception may be characteristic of your neighborhood, and which sets perform the best.

2. Select a reliable dealer from your own locality. This applies particularly to suburban dwellers, who are advised to buy their set from a tradesman in their own town rather than one in the "big city." This would be wiser even if the latter offers considerable "discount."

3. Insist upon knowing the age and check carefully the performance characteristics of sets offered below list prices. It is still true that one receives very little in this world for nothing. Such low-priced sets may be excellent and the dealer reliable, but be careful nevertheless.

4. Do not expect much from trade-ins. Used television receivers are difficult to sell. An extra-large trade-in allowance may mean that the set the dealer is trying to sell is a white elephant in some respect.

5. Inspect the set carefully in the light of picture detail, test pattern, sound and other points previously discussed in this chapter.

6. Make sure the receiver carries the usual manufacturer's parts warranty.

7. Beware of any dealer's part warranty offered. Do not pay extra for it if it means that parts will be replaced under it *only if the dealer's own servicemen make the repair.* If such is the case you cannot get a new tube for an old one and replace it yourself.

8. Purchasing under the installment plan needs no discussion. The American public is well aware of the fact that payments under this method contain interest and carrying charges. If you must buy this way, make sure these charges are not excessive.

9. In paying for antenna erection, check carefully to see just what you are getting. But do not feel you are being put upon if it states "standard installation." That means you get a regular fixed-type antenna with an adequate amount of lead-in and that is all. It is usually enough. Should your receiver require special antenna or work to bring in a good picture it will cost extra. Be willing to pay what extra charges are necessary. It will be worth it if the company is reliable. In good signal areas, you can easily install your own antenna. There are some locations, however, where no one can guarantee a good picture on all available channels.

10. Check carefully before buying a service contract. See if it covers *both* parts and labor. Determine just who will do the work —the dealer's own servicemen, the manufacturer's service division or an independent group. One can be just as reliable as the other. Note that you probably will receive service only during the normal working week—not at night or week ends and holidays. *It is possible that your contract may be voided* if you call another serviceman for an emergency repair. Even reputable service firms require this clause because they cannot afford to spend hours correcting mistakes others have made.

11. Bear in mind two things—first that the reliable dealer who charges you the regular price for a receiver usually is cheaper to deal with in the long run than the discount house, warehouse salesroom or unidentified merchandise store, and second that a television receiver is an item costly enough not to be bought casually.

12. In purchasing a three-way combination — radio, record player and television—remember that the record player should be able to handle all speeds of records. Perhaps all your own records are 78 r.p.m., and you intend to buy none but that speed. Still, some kind friend might give you a lovely album in 33⅓ r.p.m. As for the radio, make sure it has the FM band as well as the AM band. Otherwise you will have only half a radio. And finally make sure the television tubes do not burn all the time the radio and record player are in operation.

Chapter Four

Installing the Receiver

THREE LOCALITIES are possible for a television receiver—a close-in area, a moderate suburban area or a fringe area. The first step in installing a receiver, therefore, is to obtain and erect the proper antenna for the particular area. This is treated in a separate chapter. No such preliminary is necessary, of course, if the indoor or built-in type of antenna is to be used.

The second step in installing a television receiver is placement of the set. In the majority of cases it is safe to say that the particular model selected has been chosen partially for its ability to fit the furnishings style of the room. But final placement is not always an easy decision to make. As one service technician puts it, there are three places where a television receiver may be located: where the man of the house wants it, where the lady of the house wants it and the right place! The fortunate family is the one in agreement on all three counts.

The main thing to keep in mind is that a television set is primarily meant for viewing a picture. The sound is secondary and the appearance in the room a poor third. Therefore, the proper spot for the television receiver is the one which gives the greatest viewing pleasure to all concerned. If you sit too far to the side of a television screen, the picture will be unsatisfactory. The maximum angle for good viewing is not more than 40 or 45 degrees. If, then, the majority of viewing seats are within that angle, the placement is correct.

The size of the screen must also be taken into consideration. The smaller the screen, the closer you must sit before the lines making up the picture blend together to make a complete image. Just how far away this should be is impossible to say; that is a matter to be decided by the eyesight of the people who will watch the screen most consistently.

Dozens of formulas have been put out for determining the best viewing distance. The best one is that which says "sit where the picture pleases you the most."

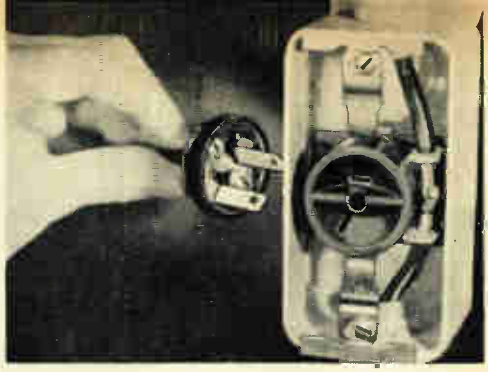
It is not wise to place the receiver where light falls directly upon the face of the screen through a window or from a lamp. Lamps can be turned off or moved, but a window will be more troublesome. Therefore the relation of the receiver to the windows is most important. For most satisfactory daylight viewing, locate the receiver so that no direct outside light will fall directly on the screen. Manufacturers have done a great deal of research seeking a glareless picture tube, but thus far no entirely satisfactory solution has been reached.

The picture should not be viewed in a dark room. Some other light should be turned on lest considerable eyestrain result. "Television lamps" are available for placing on top the receiver to provide light in the room without ruining the picture. Basically, the same thing can be done with any small lamp, of course. The point to bear in mind is that although a lamp may not show a reflection to all the viewers, the reflection it does give the screen may be offensive to some sitting elsewhere.

The receiver should be placed in such a way that there is sufficient ventilation space between the back of the cabinet and the wall. Quite a bit of heat is generated in a television set and this must be dissipated. Unless proper ventilation is provided, this heat will cause rapid deterioration of parts and resultant operation failures.

It follows, too, that a television receiver should not be placed near a radiator or other heat outlet. In commercial installations, the farther away the receiver is from neon signs, cash registers, cooler motors and the like, the more satisfactorily it will operate. Interference from such devices can ruin an otherwise perfect picture.

Few homes have rooms especially built for television. Therefore, it is seldom that the placement of a receiver is not a compromise location. If common sense is used, there is no need to observe distance formulas, viewing angles, special lights and the like.



Left, primary controls are usually at the front of set. Right, tap-off device in master antenna system

The main points to remember in placing a receiver are: proper ventilation, avoidance of reflections, correct background lighting, avoidance of interfering devices and above all the greatest pleasure to the greatest number of viewers.

The Lead-In

Having erected the antenna and placed the receiver, the next step is to connect the lead-in wire. In some receivers this is simply done by twisting the two conductors of the lead-in to the corresponding two conductors which stick out of the receiver cabinet. In most sets today, however, a terminal strip with two or three connecting screws is used. Full directions for connecting the antenna lead to the receiver are given in the antenna section.

Safety Precautions

In connecting the power cord to a wall receptacle, some elementary safety precautions should be taken just as they would be in plugging in any electrical appliance. Not only is a long power cord an unsightly mess, but it constitutes a fire and shock hazard as well. A wall receptacle should be near the receiver. If none is available, it is best to install one. If it is absolutely necessary to use an extension, it should be run through the proper length of "channel run," which is made for just such purposes and is obtainable at hardware and electrical-supply stores. Make sure the wire contained in such "channel run" is heavy enough to stand the amount of wattage it will have to carry. The wattage demand of the television receiver is always stamped on the chassis. Convenience outlet channels are rated in the same way, and those safe to use will bear the label certifying that they meet Underwriters' Laboratory specifications.

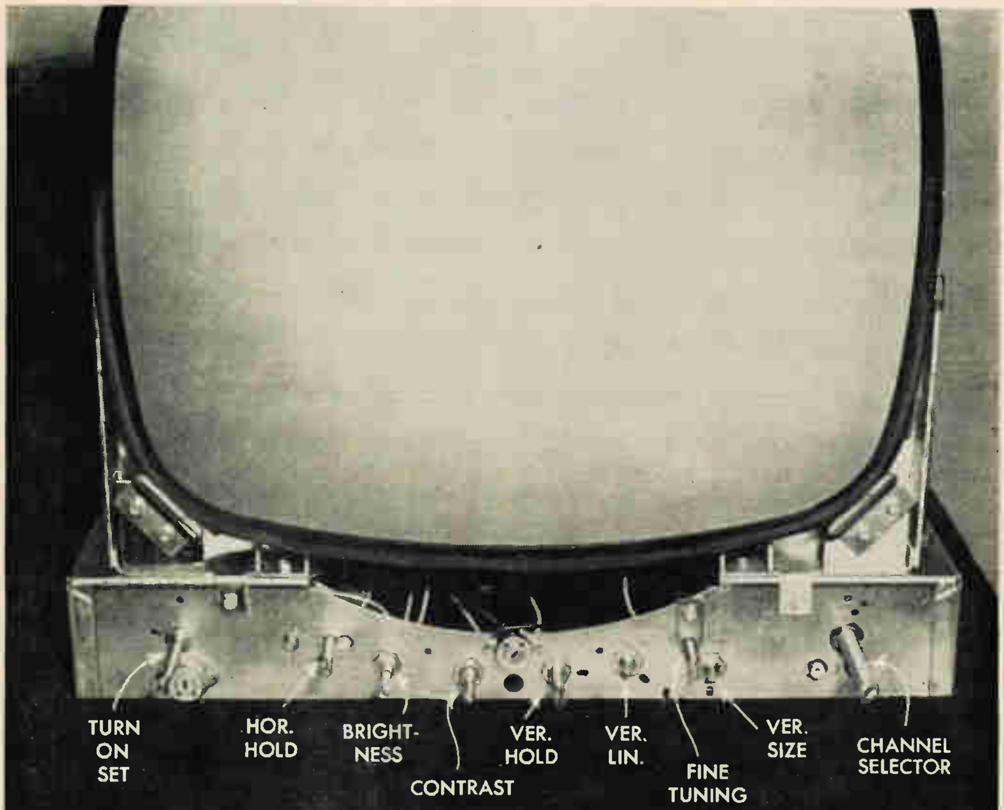
Adjusting the Set

With power cord connected, the set is ready to be turned on. The switch for doing this is usually incorporated with one of the front-panel controls for volume, brightness or contrast. All television receivers come with directions for operation and will tell exactly how to do this. Read these instructions carefully; they are published for your benefit and not because the manufacturer likes to have literature printed at some expense.

Allow the set to warm up, a matter of a minute or so. Carefully watch for signs of arcing or any smell of burning. Occasionally, but very seldom, a receiver will develop a short circuit in shipping. If this happens and you smell burning or hear a crackling sound in the cabinet indicating arcing, turn the set off immediately and return it for replacement.

After the warm-up period, select any station in your area on the channel selector and turn up the volume control a little, also the brightness and contrast controls. As the brightness is advanced from the "off" position, which is generally found fully clockwise, the raster will begin to glow. The raster is the rectangular area which is scanned by the electron beam. Tune the station in until the sound is heard and a picture image appears on the face of the screen. Continue to adjust the brightness and contrast controls until the image—when perfectly tuned in—is pleasing to the eye.

Some receivers have the secondary controls on the front in addition to primary controls



If the picture rolls around and around vertically, the vertical sweep circuit is not properly adjusted. To remedy this, make the necessary adjustment with the vertical hold control. Turn the control so that the picture is just barely drifting down. Then reverse the control slightly, moving the picture upwards, and it will snap into place.

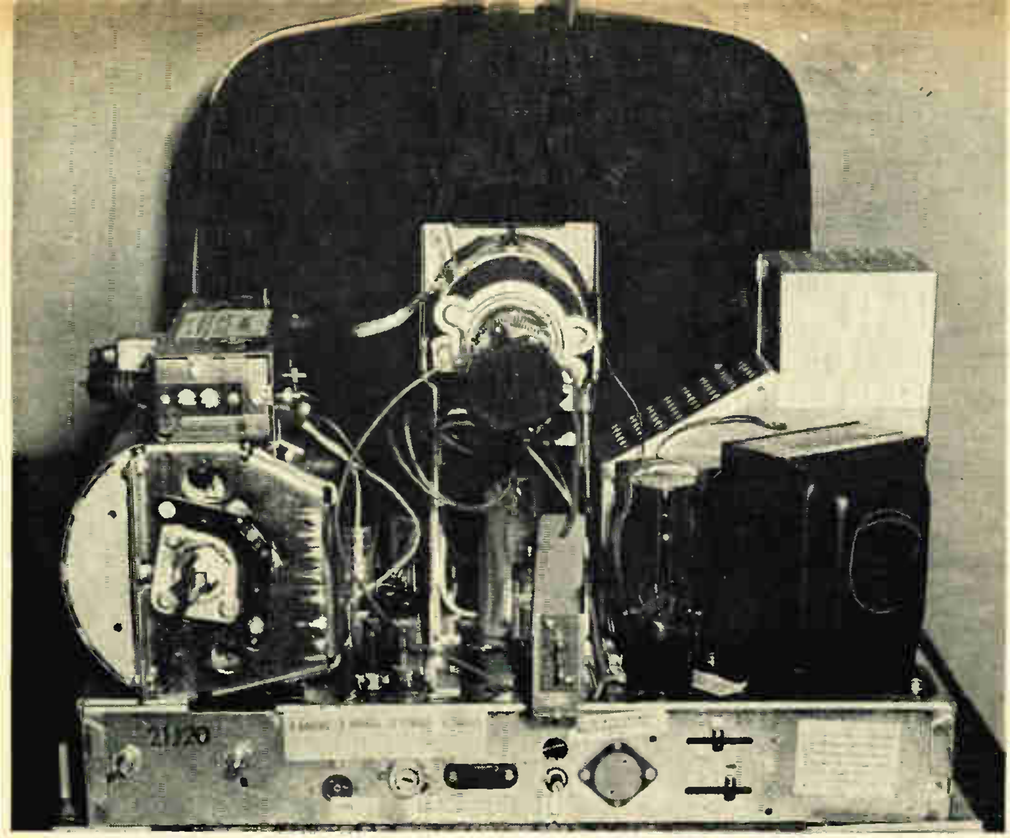
If the picture seems to be moving sideways, or is "pulled" like taffy from side to side, or consists of a number of coarse, horizontal lines which obscure the picture, then the horizontal hold must be adjusted. Turn it slowly, observing that as synchronization of the horizontal sweep circuits is approached, the lines tend to become fewer and more vertical until suddenly they disappear and the picture appears. Continue on past this point until synchronization is lost in the opposite direction. Reverse the control to a point midway between that where it goes out of synchronization in one direction and where it goes out in the other. This will be the proper setting for the horizontal hold control.

Once a picture has been tuned in this manner, no further adjustments should be made on the receiver itself for the moment until the antenna has been given its final orientation in the desired direction. Final orientation is described in the chapter on antennas. Unless the antenna is properly oriented to bring in the strongest and most ghost-free signal, adjustments made with any controls on the receiver can do more harm than good.

Test-Pattern Adjustment

Now, with the antenna oriented and a picture on the screen, is the time to make any final adjustments necessary. Here again there are two ways to do this adjusting. The wrong way is to make these adjustments with an ordinary picture on the screen. The right way is to be patient until a test pattern is available. Without a test pattern, it is impossible for the linearity, height, width and focus controls to be adjusted properly. Some images may look all right with adjustment faulty, but others most definitely will not. An image is not to be relied upon. There are servicemen who are quite skilled in adjusting these controls without a test pattern, but even these prefer to wait until the pattern is available and the job can be done properly and a great deal easier.

Pictures of test patterns and images are shown in Chapter Seven to illustrate the defects evidenced on the screen by incorrect adjustment of secondary controls. In making these adjustments, always try the simple things first, the complicated corrections last when other attempts have failed. A good, clear detailed picture will result if the test pattern is circular in shape, if the wedge



Secondary controls on most sets are behind the cabinet and adjusted with a screwdriver

lines showing horizontal resolution are well defined toward the center of the pattern, if the shades of gray in the center concentric circles are sharply marked, if the whole picture is contained within the mask with no black edges and there are no "ghosts" present.

In almost all cases, the presence of ghost images is indicative of a poor antenna installation. Poor definition of the black, white and gray shades is due to poorly adjusted brightness and contrast controls. Very poor horizontal resolution is caused by misalignment and the correction is a job for a qualified serviceman equipped with test instruments. If the pattern does not fit snugly into the area marked off by the mask, or if the test pattern is not circular in shape, adjustment of the secondary controls and the components around the neck of the picture tube is indicated. These are adjustments that most set owners will be able to learn to do themselves.

Adjusting Secondary Controls

A preliminary word of warning before you touch the secondary controls. There is always the chance that your diagnosis is incorrect, and that a particular control is set correctly and should not be changed. When this happens, you will want to return it to its original position. Before altering the position of any secondary controls, therefore, it is wise to mark each one in such a manner that it can easily be reset as it was. On threaded controls, this is best done by measuring with a ruler the distance the shaft sticks out from the chassis. The other type of adjustment screw, which has a smooth shaft and either a screwdriver slot or a knurled head, should be marked with a soft pencil or a crayon to show its position. Bringing back the controls as they were then becomes a simple matter.

Another important warning is necessary before you touch the controls around the neck of the picture tube—the ion trap, the focus coil and the deflection yoke. Any adjustment of these units must be done with the back cover of the receiver off and the power turned on. The chances are that your set or the instruction manual which came with it bears a warning that the back cover should never be removed except by a serviceman. It is this which frightens many people and which does present somewhat of a hazard when due caution is not exercised. However, it is done many times a day by servicemen and can be done with equal safety by an amateur.

The usual receiver has a special power cord which automatically disconnects when the cover is removed. It will therefore be necessary to get an extra power cord so that the set can be turned on when making tube-neck adjustments.

The contacts, or tie lugs, which are on the inside portion of the power-cord socket are often exposed. Do not brush up against these or touch them: they carry the normal 110-volt house current. Other dangers are slight. The high-voltage lead to the picture tube is generally well forward and out of the way of the neck units. The high-voltage power supply is itself always completely enclosed in a metal cage. Illustrations on pages 120-122 show the high-voltage points in typical television receivers. The units themselves are insulated and are quite safe to touch and adjust.

In making neck-unit adjustments and those necessary with the secondary controls, a mirror should be placed in front of the picture at an angle at which you can see the result of your adjustments while standing at the rear of the cabinet. To save wear and tear on your patience and disposition, it is best to prop the mirror on a chair or table. Members of the family drafted to hold the mirror are likely to get tired or shift the mirror too often.

The following picture defects are typical of those corrected by adjustment of the secondary controls and the units on the neck of the picture tube:

1. **Picture tilted up in one corner, down in another.** This is corrected by shifting the deflection yoke. These yokes are held in position on a metal frame. The yoke itself is held firm by setscrews or by bolts with wing nuts. To move the yoke, loosen the bolts which hold it to the frame. Rotate the yoke until the picture is level and tighten the setscrews. This is the only correction that can be made with the deflection yoke. This unit contains the two sets of coils which act to pull the electron scanning beam across the screen and from top to bottom. If they are tilted so that the beam is not carried across in a horizontal plane and pulled down vertically, then the picture will be tilted also.

2. **Pattern not centered vertically.** In receivers which have a rotary vertical-centering control, this is remedied simply by rotating the control until the picture is centered. (At no time should the picture or test pattern be centered either horizontally or vertically by using the height, width or linearity controls.)

Other receivers have a shaft sticking through the back cover of the receiver and marked "Centering." This shaft is fixed to the focus coil and enables the operator to adjust this coil without removing the back cover.

In receivers where there is neither a vertical-centering control nor a shaft control, the back must be removed and the focus coil adjusted by hand. The focus coil is generally fixed in place in the same manner as the deflection yoke, and may be shifted in the same way. In some receivers, however, a patented arrangement is used which permits the adjustment to be made by screws.

The focus coil performs the same function for the electron scanning beam that a lens performs for a flashlight beam. It must be centered perfectly so that the action of the deflection circuits is properly carried out through the deflection yoke.

3. **Pattern not centered horizontally.** The horizontal-centering control, the shaft-type centering control and the focus coil are used in making this adjustment just as they are in adjusting vertical centering. The theory is the same in both cases. Likewise, the width and horizontal-linearity controls are not to be used in making this adjustment.

4. **Poor focus; objects blurred.** This is almost always cared for by a simple adjustment of the focus control. If the focus control does not remedy the fault, the focus coil must be repositioned. When this is done, however, put the focus control at a midway position so that after final adjustment is made there is "play" in both directions for the focus control. In some cases of poor focus, adjustment of the ion trap is called for as noted in step 5, following.

5. One or more corners cut off. This defect usually calls for one of two adjustments, and sometimes both. Adjustment of the focus control should be attempted first—either directly or by means of the shaft labeled "Centering." If this fails to correct the trouble, it probably will be necessary to adjust the ion trap. The position of the ion trap on the neck of the tube is critical. The most common type is a ring which encircles the neck and which has welded to it one or two small magnets. If two, the smaller magnet is put toward the screen. Adjustment of the ion trap is made by rotating it slowly and carefully in both directions and by moving it back and forth along the neck. Do this until (a) all four corners of the picture are visible, (b) all parts of the pattern are in focus and (c) the picture is at its brightest.

Some receivers use a type of picture tube which has a built-in ion trap—this of course will not permit adjustment.

6. No picture, but sound is present. Adjust the ion trap. If this does not cure the trouble, refer to the chapter on servicing.

7. Pattern is distorted vertically. Adjust the vertical-linearity control and height controls carefully. This adjustment is one that will have to be repeated a number of times before satisfactory results are obtained. It is advisable to mark the position of the controls before repositioning them.

8. Pattern is distorted horizontally. Adjustment of the horizontal-linearity control and the width control is indicated here. Remember that these two controls and the horizontal drive affect each other so that it may be necessary to make readjustments each time one is changed.

9. Bright vertical line down one side of screen. This is caused by too much horizontal drive. Turn the horizontal-drive control counterclockwise until the line disappears. For other causes of this trouble, see the chapter on servicing.

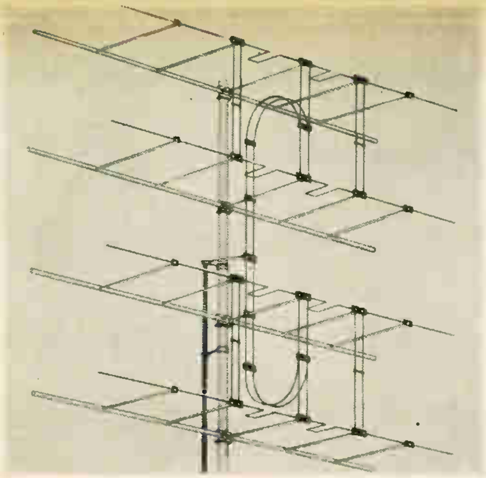
Chapter Five

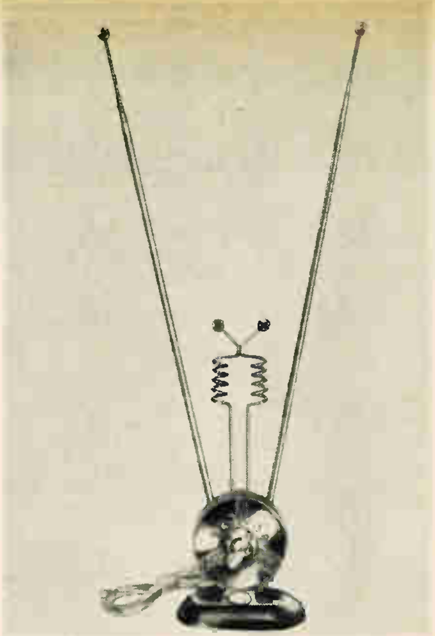
Erecting the Antenna

TIME SPENT IN STUDYING television antenna systems and in choosing the right one for your locality will be well spent. No matter how excellent the design and performance of a television receiver, the best picture and sound will not be obtained without a good antenna system. A poor receiver with a good antenna often will perform better than an excellent receiver with a poor antenna.

Situations in which indoor antennas work as well or better than outside antennas are very rare. This is so exceptional that it can be readily assumed that the best antenna you can use is erected outside a building at some height above the building itself and well clear of power lines and other obstructions.

Taking that as a starting point, you should then cast your eyes around the neighborhood to see what types of antennas are used by other television owners in the area. If at all possible, pay some calls on neighbors and watch the performance of their receivers. This will enable you to reach certain conclusions. If all the TV sets in the area receive one channel poorly and the rest well, that one channel obviously is not putting a strong enough signal into the area for good reception. If, however, several receivers get all stations well and one receiver shows poor results on one or more channels, the inference to be made is that either the wrong kind of antenna is being used or the antenna itself is not oriented correctly. To make sure, check with the owner to see if this poor reception on one channel has always been the case. It is possible that his receiver may be defective.





Fringe-area TV antenna must be carefully selected to receive all desired channels. One type, shown above, is a double co-lateral all-channel array for ultra-fringe areas. For those who must use a combination v.h.f.-u.h.f. indoor antenna, the type shown at the right has been tested with highly satisfactory results

If some of the owners in the neighborhood state that they can get good reception on all channels by changing the antenna position with each change of station, then an antenna with an antenna rotor or with several units which can be oriented separately may be needed.

You definitely cannot expect good pictures with a simple, low-mounted antenna if all other receivers in the area require an extremely high mast and multiple-unit antenna. Of course, the reverse also holds true: Fancy antenna structures are not required where most receivers are getting excellent results from attic antennas.

Skywaves and Groundwaves

A little basic antenna theory will help clarify the problem. When radio-frequency energy is broadcast by the antenna of a transmitting station, it behaves in accordance with certain natural laws. Some of it is aimed skywards and some of it goes straight out from the antenna. The former is called the skywave, the latter the groundwave. The lower the frequency, the more the skywave is reflected by the ionosphere, an electrically charged atmospheric layer beginning about 25 miles above the surface of the earth. The higher this frequency, the more this radio energy in the skywave tends to pierce the ionosphere until, at a certain point, none of it is reflected and that portion of the energy is lost. The frequencies of television are high enough for this to hold true. Therefore this portion of the television energy cannot be used. What is used is the groundwave, or the energy that is emitted straight out from the antenna. For practical purposes, when the term signal is used, that is the energy referred to.

This signal has another very important characteristic in common with light energy other than its ability to travel at 186,000 miles per second. It is that, like light, it is reflected by solid objects. If a light bulb is so placed that it shines on a number of objects, it will readily be noticed that immediately behind the object on the side away from the bulb there is a deep shadow. As one progresses farther away from the object, the shadow tends to lose its "deepness" until it seems that the light has "bent" around it and the light from each side of the shadow is joining together to provide some illumination despite the obstruction. Also, the farther away from the light you get, the weaker the illumination becomes.

The television signal behaves in exactly the same way. If a solid metal wall were to be constructed at the same height as the television antenna, there would be no signal immediately behind it. At some distance farther on, however, traces of the signal would begin to appear until it had reached a strength that would be equal to that one might expect at that distance had no obstruction been present in the first place. Thus, one can expect the signal to be stopped by certain substances just as light is stopped.

Secondly, place a mirror in front of a light and the mirror will reflect it. Other objects also will reflect light; the whiter and glossier the surfaces the more light is reflected. In the same way, television is reflected by objects it strikes; some reflect more than others. It is these characteristics of the television signal—or rather the frequencies at which it operates—that make a television-antenna installation a matter of great importance to good-quality picture reproduction.

Ghost Images

Let us suppose that a television antenna is receiving a signal directly from a television station. This signal is traveling at the rate of 186,000 miles per second. It takes a certain amount of time —very short, of course—to reach the antenna.

Now let us suppose that off to one side of the direct path of the signal is a large building. The signal also is reaching this building. Because it can be reflected, however, some of the signal is bounced off and reflected to the receiver antenna. But the reflected signal travels a longer distance than that which goes directly to the receiver antenna and must take a longer time. It enters the tuner of the receiver a bit later than the direct signal, travels through the receiver at the same distance behind it and arrives at the electron beam still the same distance behind the direct signal.

The result is a picture that is misplaced on the screen of the receiver tube. Because it has lost some of its energy in being reflected, it is also a weaker signal than the direct one. The "second" picture is then a bit weaker than the main picture. This phenomenon is called an echo, or more familiarly, a "ghost."

Other defects or troubles can cause ghosts, such as mismatched impedances, but these are uncommon. Primarily, ghosts are caused by reflected signals, and the most effective means of eliminating them is a suitable and properly installed antenna.

It is most important, therefore, in areas where there are many objects to reflect the television signal, that an antenna be used which has the ability to receive only the signal desired and to reject all others.

Some ghost images are so faint they cannot be distinguished on the screen, but they do blur the picture. Others are so distinct that it is like watching two characters in a scene, one the twin of the other, where only one should be. Under such circumstances the picture cannot be enjoyed and you might as well not have a television receiver.

Technical Factors

The purpose of an antenna system then, is to pick up all the desired signal possible, to exclude any signal not wanted—such as interfering signals from the rear—to amplify the signal if possible and carry it down to the television receiver itself.

It would be advisable at this point to review the characteristics of the radio-frequency energy which is sent out by the television transmitter and on which the electrical energy comprising the picture and sound is "riding." We have seen that radio energy travels with the speed of light, or 186,000 miles per second. For the purposes of radio engineering, this is translated into the international measuring unit—the meter. The meter is 39.37 inches long; 1609.35 of these are equal to one mile. Therefore, the round figure— 300,000,000 meters—is given as equal to 186,000 miles. So, radio energy travels at the rate of 186,000 miles or 300,000,000 meters per second. If a transmitting station is sending out energy at a rate of 100,000,000 cycles per second, the first cycle will have traveled the 300,000,000-meter distance just as the last one has been completed and started on its way. Thus, we have a distance of 300,000,000 meters containing 100,000,000 cycles. Dividing the distance by the frequency:

$$\frac{300,000,000}{100,000,000} = 3$$

Thus, each cycle is 3 meters long. This distance is called the wavelength. The frequencies of television signals are so high that to use the unit of the cycle would be unwieldy, so the term "megacycle" is used instead. A megacycle is one million cycles, so that the illustration of 100,000,000 cycles used above would be referred to as 100 megacycles. This enables us to reduce the figure 300,000,000 to 300. Therefore the equation just given would be:

$$\frac{300}{\textit{frequency in megacycles}} = \textit{wavelength in meters}$$

The term megacycles is usually abbreviated thus: *mc.* Inasmuch as feet and inches are more commonly used in general measuring than meters and centimeters, the following formula can be used for ease in calculation:

$$\textit{Wavelength in ft.} = \frac{984}{\textit{frequency in mc.}}$$

In order that those who desire to make their own antennas can do so without excessive calculations, the following factors should be mentioned. The most commonly used measurements in antenna design are the half wave and the quarter wave. Because of certain characteristics, the practical lengths used in antennas are about 95 percent of the actual wavelength. Therefore, the length of a half-wave antenna for a signal of 100 megacycles would be determined in this manner:

$$\textit{Wavelength} = \frac{984}{100} = 9.84 \textit{ ft.}$$

$$\tfrac{1}{2} \textit{ wavelength} = \frac{9.84}{2} = 4.92 \textit{ ft.}$$

$$\textit{Length of half-wave antenna} = .95 \times 4.92 = 4.68 \textit{ ft.}$$

The fundamental half-wave antenna length can be obtained directly by this formula:

$$\textit{Antenna (half wave in ft.)} = \frac{468}{\textit{frequency (mc.)}}$$

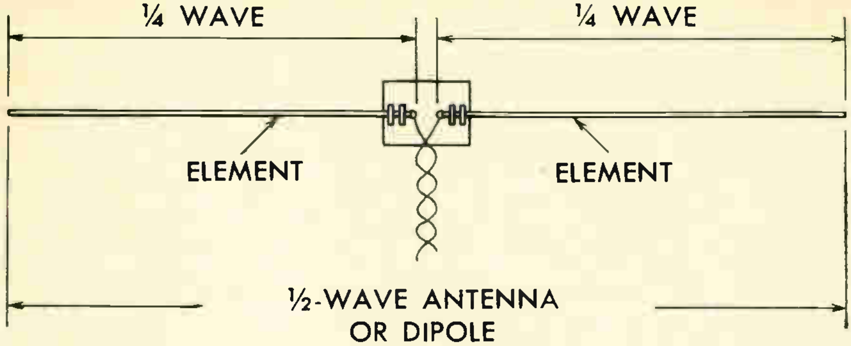
or,

$$\textit{Half-wave antenna (in.)} = \frac{5616}{\textit{frequency (mc.)}}$$

and the length of a quarter-wave antenna would equal:

$$\textit{Antenna (quarter wave in in.)} = \frac{2808}{\textit{frequency (mc.)}}$$

Thus, at 100 megacycles, a quarter-wave antenna is 2808 divided by 100, or 28.08 in. This fundamental quarter wave is important. Larger antennas are, as a rule, made up of a number of quarter-wave elements. The half-wave antenna, which is generally termed a "dipole," consists of two quarter-wave elements



laid end to end about an inch apart. These elements are made of tubing, aluminum alloys being the most common materials because of their light weight, rigidity, weather resistance, etc. They are clamps at the ends of a block of insulating material such as Bakelite or one of the newer plastic compounds. A two-wire lead-in is connected, one wire to each element.

The Dipole Antenna

This is the basic antenna used in television, and all others are the half-wave or quarter-wave antenna in one form or another. The basic antenna has the ability to receive signals with equal strength from front or back. Signals from the directions to which the ends are pointed will not be received. Thus, one of its characteristics is one highly desired: It is directive and must be "aimed."

Secondly, an antenna cut to a half or quarter wave of one specific frequency is decidedly more responsive to that frequency than to any other. In other words, an antenna which is a half wave long in respect to 100 megacycles will receive signals at that frequency better than those at any other frequency. An antenna cut to size for Channel 5 will work well for that frequency but will not receive signals on Channel 8 nearly as efficiently.

One of the characteristics of any antenna is its "impedance." The impedance of a dipole antenna is 72 ohms. This can be compared to an ordinary water pipe. Let us suppose water is flowing in the pipe and is to be drawn off at mid-point—the same point where the television lead-in draws off the energy received by the antenna. The pipe into which the water will be fed is 1 inch in diameter. Obviously, a fitting with a 1-inch thread must be used if a smooth and efficient flow of water is to be obtained. Likewise, in radio and television, impedances must be matched to enable a maximum transfer of energy.

Inasmuch as television lead-ins of various types all have a characteristic impedance of their own, the proper one must be chosen. For a dipole antenna with an impedance of 72 ohms, one would use either a 72-ohm coaxial cable or a "twisted-pair" line, both of which are obtainable at a radio-parts store.

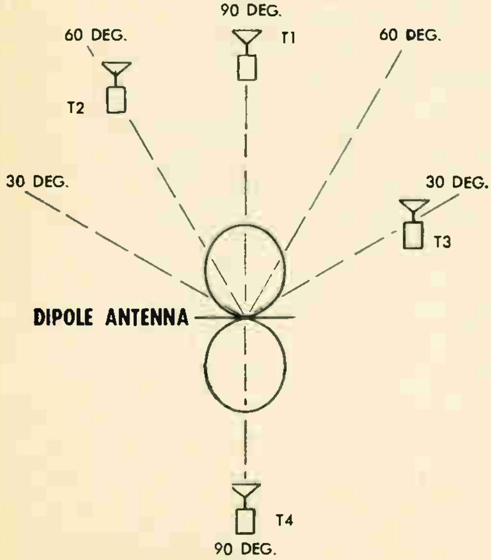
The Folded Dipole

It has been stated that television channels are 6 megacycles wide. The five channels in the lower band cover a frequency range of 54 to 88 megacycles. Under normal circumstances, the signal is strong enough to overcome the "sharp-tuning" of an antenna if helped out just a little bit, so that a single antenna can receive all the stations on one band. One method of "helping" the antenna for broader tuning is to use a "folded dipole."

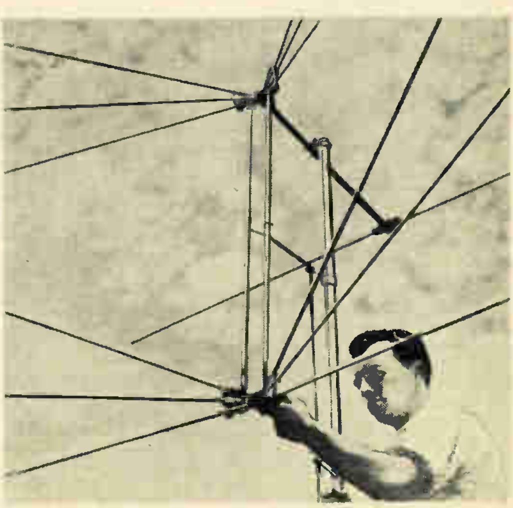
A folded dipole is basically two half-wave antennas or dipoles with their outer ends connected. There are two advantages in using a folded dipole: (1) it has an impedance of 300 ohms, thus making it more desirable from an engineering standpoint and (2) it will receive efficiently over a wider band of frequencies.

The standard flat-tape lead-in made of two parallel wires held a fixed distance apart by a plastic compound is usually of 300 ohms impedance. Also, the normal input impedance of most television receivers is 300 ohms. Therefore, using an antenna system which has an impedance of 300 ohms simplifies things considerably. By the same token, a water system using a 1-inch pipe throughout would be simpler than one requiring reducers here and there to enable the fitting together of pipes of various sizes.

The folded dipole is like the basic dipole in that it will receive signals equally well from the front or the rear. This is not always desirable, particularly where an echo signal may be interfering



Below, conical array, v.h.f., stacked fringe-area antenna is notable for its high gain and low-loss qualities



with the desired station. To prevent this, a reflector is added to the antenna. A reflector is an additional element about 5 percent longer than the antenna itself and spaced one quarter of a wavelength behind the antenna. Two advantages come with the use of a reflector: (1) it stops signals from the rear and (2) it tends to add what it receives of the desired signal to the antenna so that it increases the gain.

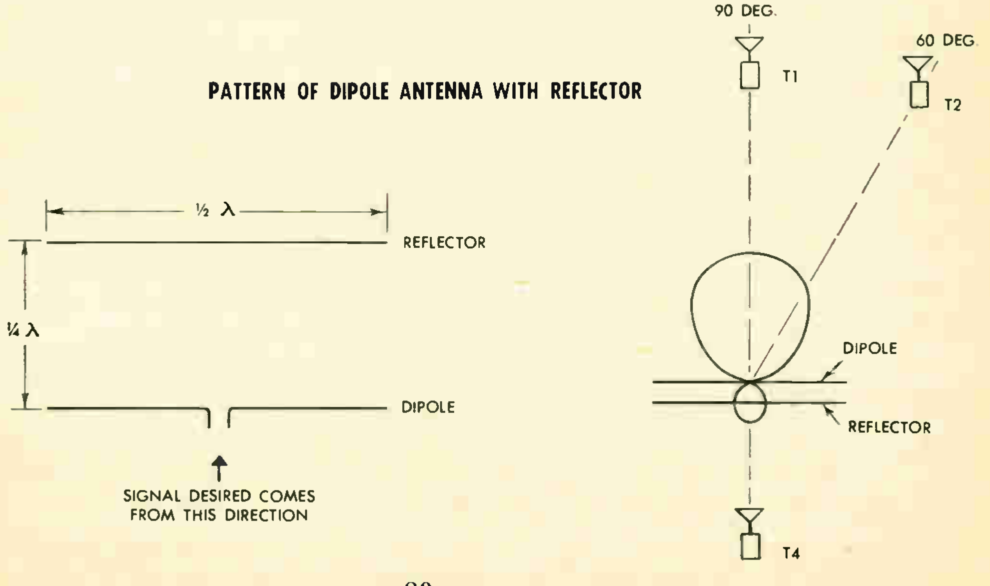
Antenna Patterns

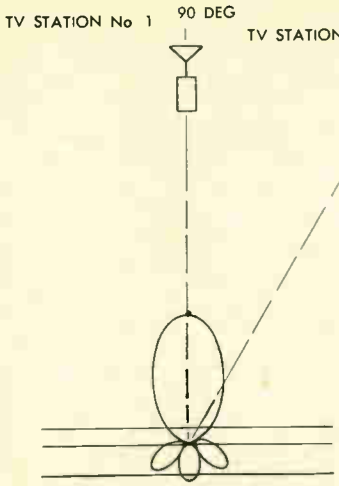
By using test receivers, transmitters and other measuring devices, radio engineers have been able to draw patterns showing the manner in which various types of antennas will receive signals. The pattern on page 79 shows a simple half-wave antenna—or dipole—and the strength or ease with which it receives signals from various directions.

T-1, T-2, T-3 and T-4 are points from which a signal is sent. They could be transmitters, or, because objects reflect television signals, they could be reflecting surfaces. Notice that the antenna receives signals of the greatest strength from T-1 and T-4, which are points at 90-degree angles with respect to the line of the antenna. The signals decrease in strength, or, more accurately, the antenna decreases in sensitivity, as the angle with respect to the antenna line becomes less than 90 degrees. At 60 degrees a weaker signal is received: at 30 degrees (T-3) the signal is still weaker and at a point in line with the antenna is not received at all.

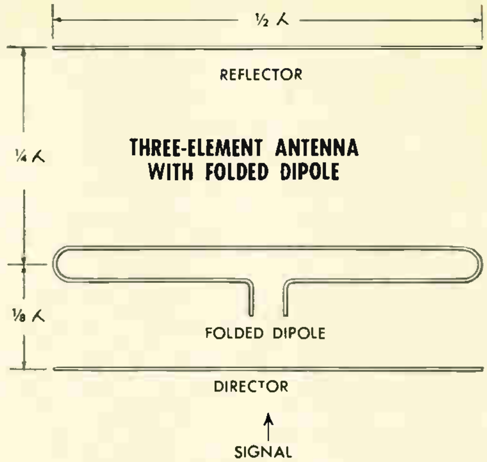
If each of these signal-generating points were a reflecting object, it would be unlikely that T-3 would cause a ghost image since

PATTERN OF DIPOLE ANTENNA WITH REFLECTOR





ANTENNA WITH DIRECTOR AND REFLECTOR



Left, this antenna is sensitive to signals from front. Above, sharp tuning is attained with folded dipole

the signal is received so weakly. The signal from T-2, however, would be received with sufficient strength to cause a bad ghost. If we assume that T-1 is the desired television station, T-4 would likely be the worst ghost offender, as the signal which hits it and bounces back to the antenna is received at a strong point. Because it takes longer to reach T-4 and back to the antenna than it does directly from T-1, this reflected signal will reach the receiver later and cause a definite ghost on the screen. To stop this signal from the rear, the reflector is used with the accompanying resultant pattern.

Note on page 80 that signals coming from the rear are virtually blocked by the reflector element, which is about one half wave long and spaced one quarter wavelength away from the dipole antenna itself. It is not connected to the dipole antenna. Elements of this type used with an antenna are called "parasitic" elements.

The reflector has done a little more, however, than merely stop signals from the rear of the antenna. It has also increased its responsiveness to signals from the front slightly and has tended to "sharpen" the reception pattern. However, this may not have been enough to rid the receiver of the ghost image from T-2 at 60 degrees, so another means must be used in conjunction with the dipole and its reflector to make the dipole still more directional. This is done by adding another parasitic element. This is placed one eighth of a wave in front of the dipole and is called a "director."

Adding a director to the two-element antenna changes the pattern considerably. Signals off to one side are no longer received with sufficient strength to show up on the picture screen. Furthermore, the antenna has become more sensitive, with the result that it will now receive more efficiently any signal approaching it from the front. For this reason, multielement antennas are used with good results in fringe areas.

Certain disadvantages occur when elements are added to an antenna system. First of all, it becomes less responsive to signals on a frequency other than that to which the antenna was cut. Suppose, for example, that the three-element antenna shown has been built for the frequency of Channel 2. It will not receive Channel 3 quite as well, Channel 4 will be poorer still and Channel 5 still worse. As for the channels (7 through 13) on the high-frequency band, it is quite likely that the antenna will not respond.

In order to compensate to some extent for this sharp tuning, a folded dipole antenna is used in place of the simple dipole. In effect, this makes use of a bigger "basket" to catch the energy. The net results are the same as far as directivity and response to weak signals are concerned. Furthermore, the impedance of the folded dipole is 300 ohms, which is a direct match of the conventional 300-ohm flat-tape lead-in and with the impedance of the conventional television receiver, so that the same size "pipe" is used throughout the system.

Yagi Antennas

Additional directors may be added to an antenna. Each one sharpens the tuning so that it becomes less and less responsive to other frequencies. On the other hand, the antenna becomes more responsive to weak signals at the frequency for which it was cut. For this reason this type of antenna is used very frequently and with excellent results at considerable distance from the television station, or well out in the fringe area.

The general term used for the antenna which employs directors and reflectors is "Yagi." Five-element Yagi antenna systems are common sights in the fringe areas. The disadvantage of the sharp tuning characteristic of the Yagi antenna makes it necessary for a separate antenna system to be erected for each station received. In many sections of the country, however, only one television station is available anyway.

One matter should be clarified here. In the illustrations in this chapter, the reflectors, directors and dipoles have been shown as one half wave long. Actually the reflector is a little longer than a half wave, the dipole a little less and the director still less than the dipole in length. Rather than provide complicated formulas for these lengths, it is suggested that those who wish to experiment in the interesting pastime of making one's own antenna refer to the excellent *ARRL Antenna Handbook*. It is a fine source of basic antenna theory, dimensions and the like.

What Kind of Antenna?

The antenna theory given thus far still leaves the set owner with the problem of what kind of antenna to buy among the many on the market. We shall try to give that practical advice now.

What you want, of course, is good gain, good directivity, good impedance match, an acceptable transmission line and mechanical strength. The gain of the antenna—that is, its ability to amplify the signal it receives and passes on to the receiver, is of great importance as one goes farther away from the transmitter into the weak signal areas. In areas where buildings or other structures make it likely that ghosts will be a problem, a high degree of directivity is essential in the antenna. It is always important that the antenna be electrically correct, so that the impedance of the antenna matches the transmission line. Otherwise the benefits derived from the gain of the antenna might be entirely cancelled as well as the ghost-free benefits gained from directivity.

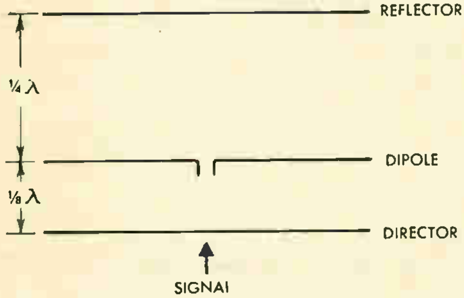
Finally, as the antenna is to be erected usually at a point where wind, ice, snow and other strains are to be encountered, the frame should be well-balanced and mechanically sound.

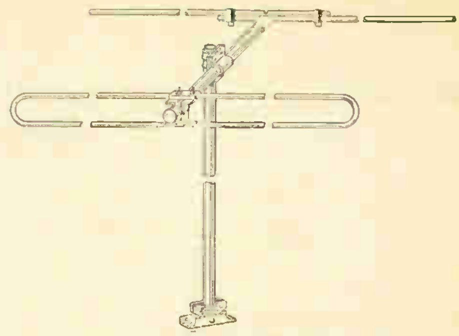
As in selecting a set, a visit to the neighbors is in order when selecting the antenna. Find out which sets get the clearest, most ghost-free pictures. In many cases there will be no apparent difference. In other areas, however, there will be marked differences, and if good receivers are at work, the inference to be made where the picture is poor is that the antenna is at fault. This can be either because of the antenna itself or some faults that have been allowed to creep in during its installation.

Decibels and Gain

Let us take time here to consider the gain of an antenna, which is measured in decibels, called "db" for short. This gain is measured against the gain of a standard dipole, or half-wave antenna, which was described previously. A decibel is an expression of power ratio. Without going into too much detail, it should be sufficient to say that an arbitrary standard is set up and actual ratings are determined on a plus or minus basis. For example, if 1 volt were applied to an amplifier and the amplification increased so that the circuit put out 10 volts, the result would be expressed in *plus* decibels. If the output were reduced to half a volt, the resultant gain would be in negative, or *minus*, decibels. Decibels are logarithmic expressions, and are determined by specific formulas. When voltages are known, the formula is:

THREE-ELEMENT ANTENNA AND PATTERN





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Right, folded dipole with reflector, useful in areas where TV stations are all on one band

$$db = \frac{20 \times \log \textit{voltage output}}{\textit{voltage input}}$$

Where power (in terms of watts, milliwatts, etc.) is known:

$$db = \frac{10 \times \log \textit{power output}}{\textit{power input}}$$

Thus, in the chart on page 87, the decibel gain of a reference dipole antenna is plotted along the zero line. The gain of the antenna is measured in terms of the difference between the db of the reference dipole and the 930-type antenna used as an example. Suppose that the gain of the reference dipole at 50 megacycles was 8 db and that the 930 antenna at 50 megacycles was 10. The net gain is 2 db and is so plotted. This procedure is carried throughout the frequency range being used. The results are plotted and a line is drawn through the points obtained. According to the reference given, the 930 antenna is better than a reference dipole at all the frequencies measured.

Knowing the decibel and gain-measurement procedure is especially valuable to the fringe-area resident. Obviously he wants the antenna which registers the highest gain. Gains of 10 to 12 db are possible with properly engineered antennas.

Also, as the gain increases, the directivity pattern usually sharpens. Directivity, of course, is always desirable wherever there is a bad ghost problem.

Which Antenna—and Where

The following antennas are typical of standard types whose use has been found effective in the areas and under the conditions listed:

Folded-dipole antenna with reflector. This is manufactured to cover one of the television bands—either the high-frequency or low-frequency band. It is effective in its impedance match to the standard 300-ohm flat-tape transmission line. Gain and directivity are good. Useful in areas where the television stations are all on one band and where the signal strength is good.

Hi-Lo (two folded-dipole antennas with reflectors). The same as the above with the addition of another folded dipole and reflector to cover the other band of frequencies. Gain and directivity are good, but it should be used only where signal strength is fairly high. An advantage is that the two bays, or sets of elements, can be oriented separately. This makes it a good antenna for areas where ghosting is a problem. Only one transmission line is needed to bring the signal down from the two antennas to the receiver. This is often called the "piggy-back" antenna.

In-line antenna (two folded dipoles and reflector all in the same plane). This is a variation of the Hi-Lo. The small folded dipole covers the high-frequency band and the low-frequency band is covered by the larger element. This antenna has good gain, good directivity and is very sound mechanically. It is to be used in areas where the television stations lie in one direction from the receiver. This makes it ideal for suburban installations. The same antenna can be used "stacked," or with an extra antenna mounted on the same mast. The signal received by one is added to that of the other to give additional strength in the receiver. Gain and directivity can be increased by the addition of a "director" element at the front of the antenna.

Lazy X. Another good all-purpose antenna. It has good gain through all channels. It also can be used stacked to provide greater gain in areas where signals are weak. Although it is not recommended for fringe areas where signals are exceptionally weak,

Left, Hi-Lo is two folded-dipole with reflector. Right, Lazy X can be stacked for high gain

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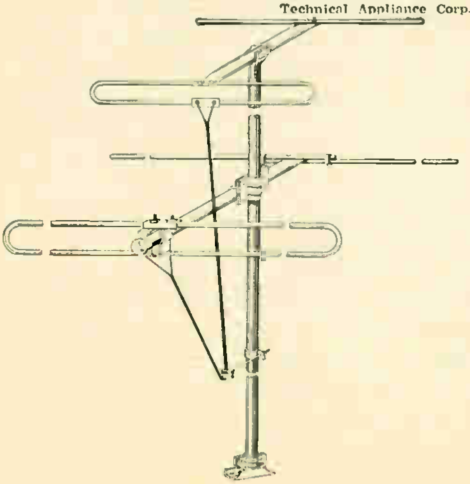
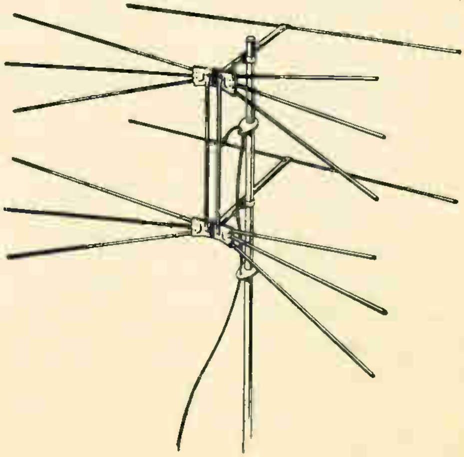
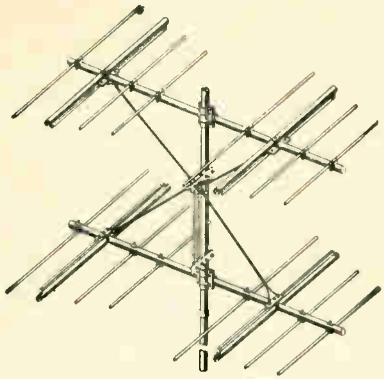


Technical Appliance Corp.





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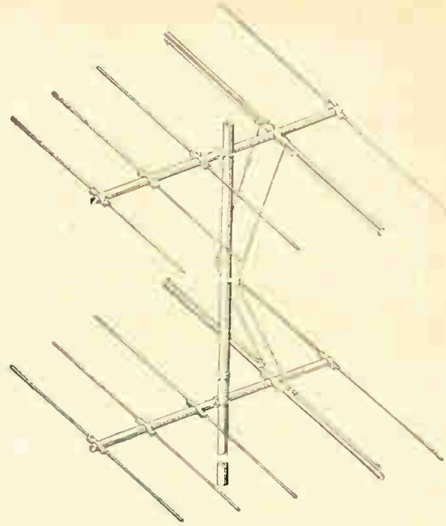


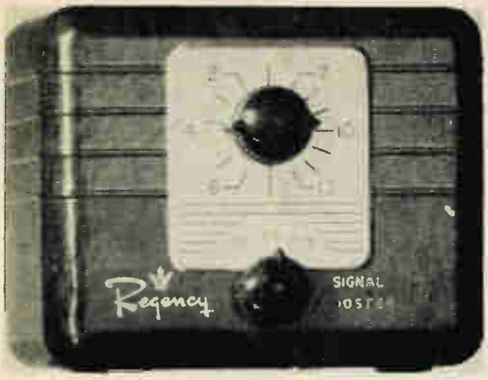
In fringe areas remote from TV stations, specially designed Yagi-type arrays are employed to advantage. Two well-stacked Yagi-type antennas are shown

four-bay stacks of Lazy-X antennas are often seen in such localities. This is recommended as one of the best suburban antennas.

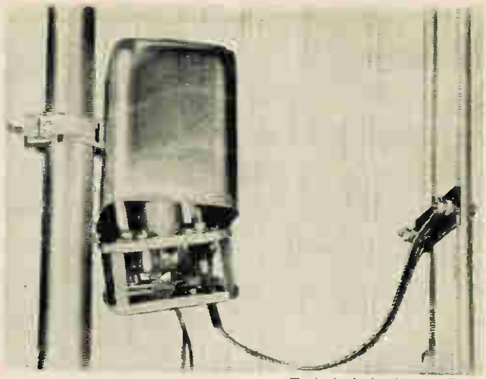
Yagi. Ideal for use in extremely weak signal areas, Yagis give the utmost increase in gain and directivity. The one great disadvantage stems, oddly enough, from these advantages. As additional elements are added to the antenna to increase gain and directivity, it becomes more and more effective at the frequency for which it is cut and less effective at other frequencies. Yagis, therefore, are generally used only for reception on a single channel. Complete additional antennas must be erected for receiving each channel on which signals are weak. As a rule this means a separate transmission line for each antenna, and the installation of an antenna-changeover switch for each channel.

In addition to fringe-area reception, Yagis are also used in localities where some stations are interfered with by signals from other stations at the rear of the antenna. In cities where reception is very noisy, Yagi antennas are recommended because their high gain and directivity will tend to minimize noise from unwanted signals. Yagis also are used for multiple-receiver antenna installations operated from a master system, as is done in many large apartments.

We believe the principles involved have been outlined sufficiently to permit anyone to make an intelligent selection of an antenna. The man in the city, who must pick up his stations from different directions, will obviously need an antenna with bays which can be oriented separately. The man who lives in a fringe, or weak signal, area, will select an antenna which has high gain and directivity. The man who lives in a strong signal area, in one direction from all the desired stations, will choose the

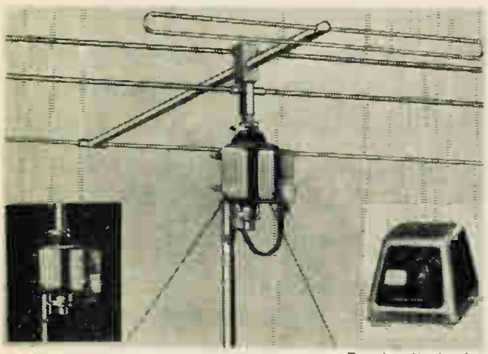


Signal booster mounted at receiver



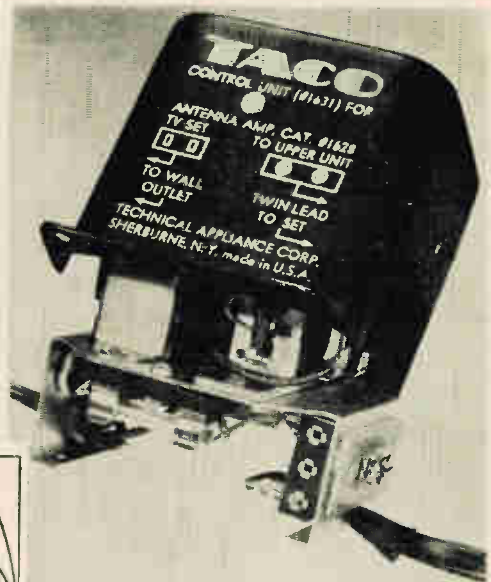
Technical Appliance Corp.

Signal booster mounted on antenna

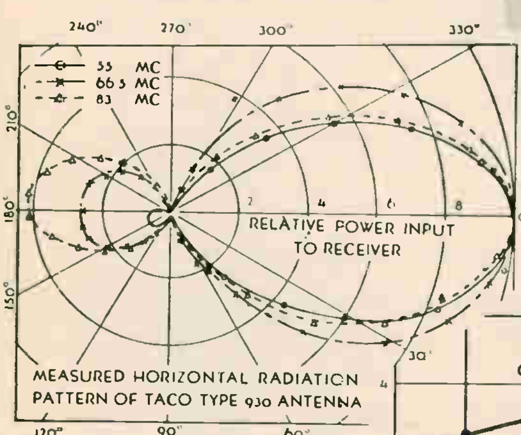


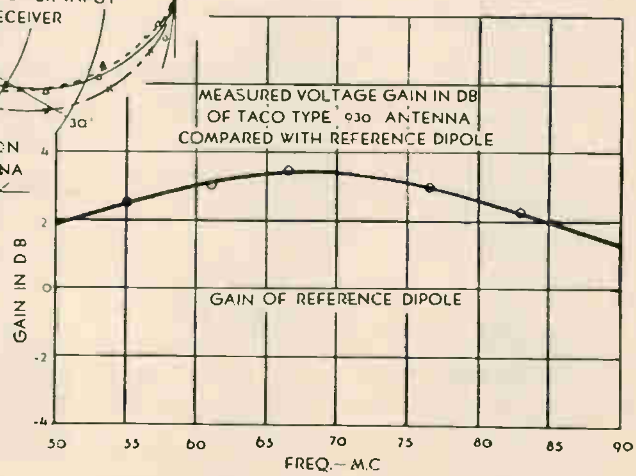
Popular Mechanics

Antenna with rotor and control box



Control for booster power supply





simplest and most inexpensive dipole. He may get along fairly well with a built-in or an attic antenna.

Boosters

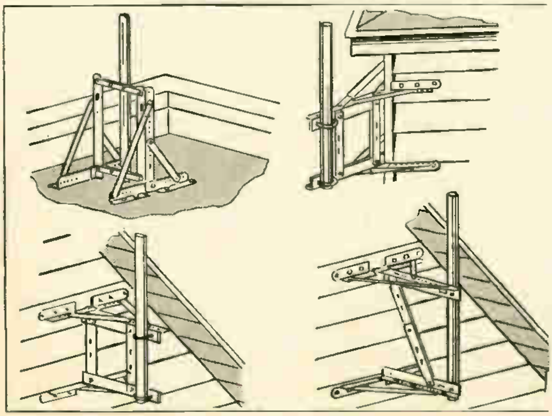
Television boosters are nothing more than an additional stage or stages of radio-frequency amplification. It will be remembered that one of the functions of the tuner in a TV receiver is to amplify the signal received from the antenna. In areas where the signal is very weak, the signal can stand a little extra amplification. This is provided by a booster.

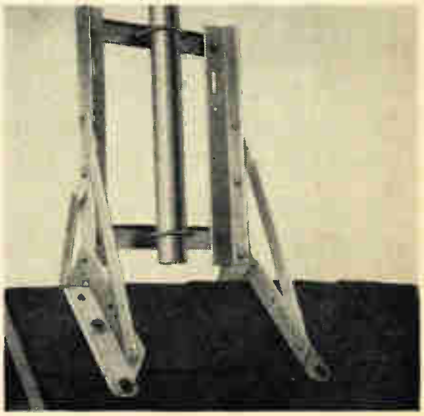
Boosters are of two main types—the most common, which is installed at the receiver end of the transmission line, and another mounted at the antenna itself. The first is a self-contained unit. Some models can be tuned to any of the standard TV channels, while others have only one switch which is turned to the low band or the high band. The best results are obtained from those which tune to each channel separately.

The type of booster that is erected at the antenna is to be recommended over those installed at the receiver. This is because the signal that is fed from the antenna to the transmission line is "purer" than the signal fed from the transmission line to the receiver. The transmission line picks up noises of various sorts—ignition, motors, radio signals, diathermy apparatus, etc. A booster located at the receiver will amplify these noises as much as it amplifies the desired signal. The antenna booster, on the other hand, amplifies the signal *before* it enters the transmission line. Extraneous noise is picked up by the transmission line in no greater volume than normally, and the result is a clearer and better picture.

There are two disadvantages to the antenna-type booster—it is tuned to one particular channel at which it is most effective,

How a single design of antenna mount can be used in various locations around the roof
Popular Mechanics





and it contains vacuum-tube circuits which sometimes require repairs at a very unhandy place, the top of the antenna mast. However, the advantages are so great as to make this type deserving of the highest recommendation. These are especially recommended for areas where signals are so weak as to require separate antennas for each channel received.

Don't be too quick to install a booster. Wherever possible, the use of a booster is to be avoided by bringing in a satisfactory signal by means of the antenna itself. Use them only when you are satisfied that the best possible antenna installation is in use and still more amplification is needed.

Antenna Rotors

In some locations it would be necessary to erect a number of antennas, all pointed in a different direction, to get good reception on all desired channels. This problem is solved by an antenna rotor, which turns the antenna toward any desired signal. All of those currently on the market are quite good, and full directions for mounting them come with the rotor kit. They can be used with equal effectiveness by city dwellers or those who live in fringe areas.

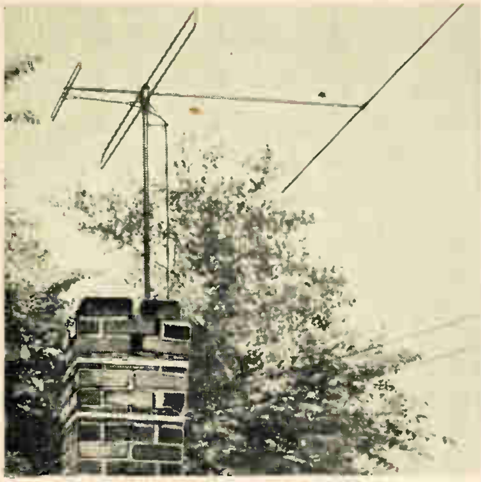
Care must be taken that the rotor chosen is strong enough to handle the antenna involved and that the installation is properly waterproofed. Strong winds can bend shafts to such a degree that rotor shafts will not operate. And rain, sleet and snow have an insidious habit of penetrating supposedly waterproof housings.

Up on the Roof

With the right antenna chosen, proper installation now becomes important. The chimney mount is the easiest type of erection, and is very satisfactory when the chimney is in good condition. A chimney-mount kit with full directions can be obtained for a few dollars, and the job will be considerably simplified.

Chimneys with mortar falling from the bricks or which show other signs of age should be avoided. In such instances, obtain special brackets and mount the antenna mast to the side of the house. Brackets of various lengths are obtainable to clear overhanging eaves and other obstructions.

If brackets are used, they must be mounted firmly so they can take quite a bit of strain. It is not enough to nail them on. They must be firmly anchored. If the walls of the house are of brick or building block, holes must be drilled for masonry expansion anchors. If the brick or stone is only a veneer, it may be necessary to drill through the veneering to the inside of the house and se-




Do not install antenna on damaged chimney and do allow sufficient clearance of power lines

cure the antenna brackets with bolts. If the veneer is solid and it is impractical to fasten bolts from the inside, toggle bolts can be used in the holes drilled. Wooden walls are the simplest. Here lag screws turned into the studding can be used, or toggle bolts after drilling completely through the wall.

The average antenna will operate satisfactorily when mounted on a standard 5-foot mast. If this does not give enough height, other mast sections, which usually come in 5-foot lengths, can be added. In such cases it may be necessary to add guy wires to support the mast and antenna. Mast guy anchors should be used rather than drilling holes in the mast itself. The guy wires should be strong and not brittle. Stranded steel wire of 14 or 16 gauge is recommended.

A group of three guy wires is enough for most antennas, although, if the height is increased, several more may be necessary to obtain the desired rigidity. The guy wires should be placed at an angle of 45 degrees to the mast and tied down 120 degrees apart. The anchor points to which the guy wires are fastened should be secured in the same manner as the mast brackets. It is not enough to fasten the guy-wire anchor to a simple eye screwed into a roof shingle. It simply will not hold against strong or gusty winds. The anchor must be fixed firmly to the studding below or to a bolt run through the roof and fastened from the attic.

If the guy wires are longer than 5 feet, they should be broken for the insertion of strain insulators. This is to prevent the absorption of the TV signal by the guy wires. Turnbuckles can be used to tighten the wires and to make it easier to take up the slack that will develop as time passes.

Often it is necessary to mount the antenna on the roof without using the chimney or side walls. This is done by mounting the antenna base on a 4 x 18-inch block of wood which is anchored firmly to the roof studs. The mast is then further supported by guy wires. Spread waterproofing compound on the bottom of the wooden base, and then paint it to match the roof color and to give it protection from the weather.

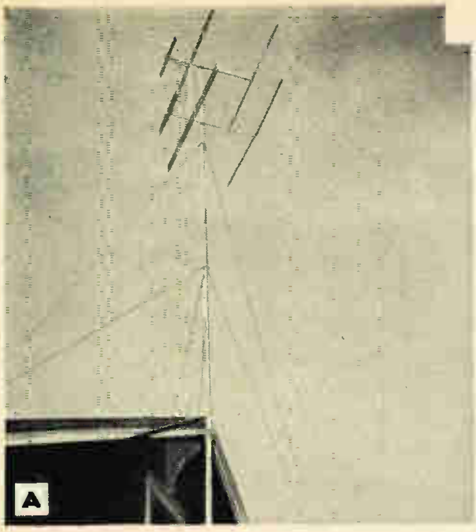
Locating the antenna in the best spot possible is more often a problem in close-to-the-transmitter areas than in those localities farther away. More structures are present to create ghosts and dead spots. This makes location of the antenna a job for more than one person, unless he wants repeatedly to set up the antenna temporarily, climb down from the roof and inspect the picture to see if he has chosen properly, and then climb back up again to make adjustments. For those installing their own antenna, therefore, some helpful hints are in order.

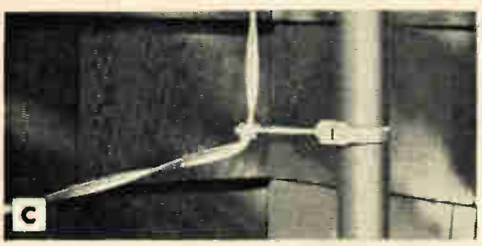
First, assemble the antenna with the mast on the ground. Connect one end of the transmission line to the proper terminals at the receiver and the other to the antenna posts. Inspect the general layout and determine the approximate roof location which would (1) give the shortest run of transmission line and (2) keep the transmission line as far as possible from neon signs, electric motors, elevator-shaft housings, highways, etc. By watching these factors, unwanted noise will be held to a minimum.

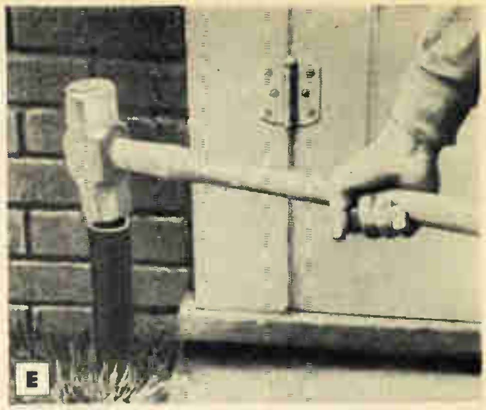
Now take the antenna assembly to the roof and hold it at the selected point while another person views the picture on the receiver. The antenna should be aimed, of course, in the general direction of the transmitting stations. If the picture is good on all channels and can be made excellent by rotating slightly to get the proper orientation, the antenna can be mounted at that spot on the roof. If not, it will be necessary to repeat these steps until the spot is found that gives the best picture on all stations—clear, steady, strong and ghost-free.

Professional servicemen use telephone sets which enable a man on the roof to talk to the man watching results at the television receiver. For the average householder, this equipment will have to be replaced by shouted commands. More than one amateur has used his entire family in the process—mother at the receiver, father on the roof and the children passing along the word in between.

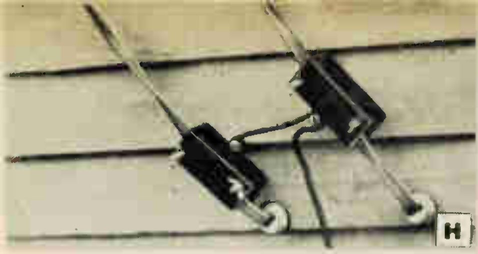
When the best roof location is established, the antenna can be mounted as previously described. When it is fixed firmly in place, final orientation is made by turning the mast slowly from point to point until the best picture is available on all channels.

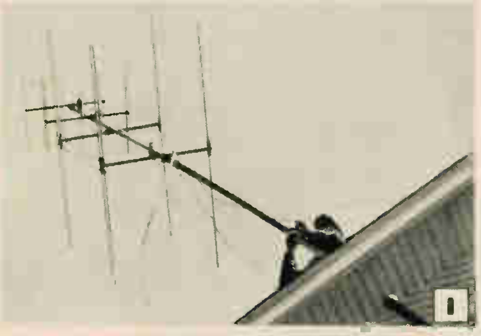


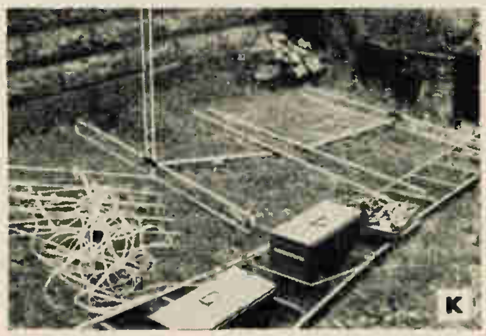




Two practical methods of mounting antennas without using the chimney are illustrated on these pages. Photo A shows tubing supported at end of roof ridge. Strap-iron bracket at attic window provides another support, photo B. Photo C shows how lead-in is fastened to tubing. Rings for guy wires, photo D, are fastened to underside of roof underhang. Pipe is driven 5 ft. into ground, photo E, and photo F illustrates optional cement base for tubing. Photo G shows completed installation viewed from ground





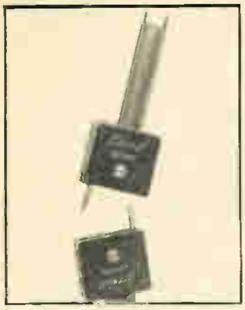


These photos show a much higher and heavier installation. Two twin-line lead-ins are used with lightning arresters in each lead-in as shown in photo H. These are mounted on the side of building and grounded. Lead-in enters building through porcelain tubes. Antenna is assembled on ground, photo K. Photo J shows lengths of pole bolted together ready for installation

This is quite difficult in places where the transmitting stations are not in line, and it is for those spots that the "piggy-back" antenna was developed. In that case, the individual sections are oriented for best results. As there is some interaction between the bays, any adjustment of one section will necessitate an adjustment on the other. Again, the family or some other means of communication must be used.

One point to remember: In aiming the antenna first at one point and then at another, it is necessary for the man on the roof to release his hold on the mast and step away, carefully, of course. His touch on the mast would affect picture results. Once the antenna is oriented, all holding screws, guy wires, etc., should be fastened—and firmly.

As a general rule, orientation and location of the antenna become less and less of a problem as the distance from the transmitters increases. This results in a narrowing of divergent angles as well as a reduction in the number of high structures which cause ghost and decreased signal trouble. Many an installer has decided offhand to locate his antenna on the chimney; has done so and pointed it in the same general direction as his neighbor's. and found the results excellent.



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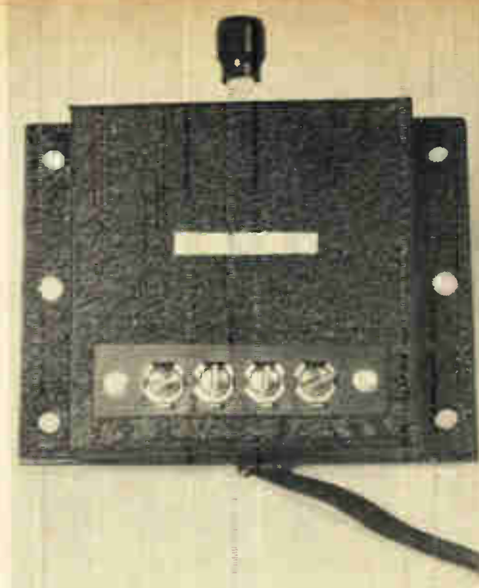
Above, a shielded twin lead-in line; left, flat-tape line with plastic connector; below, an air-spaced twin lead-in; right, approved antenna change-over switch and lead-in junction box



Taco

The Lead-In

Running in the transmission line, or lead-in wire, is next. This should be supported all the way by standoff insulators manufactured for the purpose. Several of these will be found in the antenna kit, but you may need more. If a gutter is to be crossed with the line, it is best to drill a hole through the gutter and bolt a long standoff insulator through the hole. This will support the line and keep it away from metallic substances which could affect the picture. As the line is carried down from the antenna and run through the insulators, it should be twisted every foot or so. This is an aid in electrically cancelling out unwanted signals.

The lead-in can be brought into the house in several ways. A hole can be drilled through the wall and the line passed directly through it, or a standard feed-through insulator may be used. Where holes are drilled, do not forget to calk the hole to prevent the entrance of moisture or air. Also be sure to drill at the bottom of a window frame or some similar spot so that the result is not unsightly.

The transmission line may be run through channels cut in a window frame so that the wire is not damaged when the window is closed. This method is *not* recommended on windows with metal frames or storm sash.

The lead-in may be run into the basement, along the basement ceiling and up through the baseboard into the desired room. Care should be exercised to avoid contact with, running parallel with or crossing house wiring, lest it affect the picture results.

If you want the lead-in extra long in order to allow moving the TV receiver about, DO NOT coil the excess neatly To do so will seriously affect the picture. Better just tuck it around in the back of the set.

Towers

In fringe areas, it is desirable to have the antenna as high as possible in order to overcome the curvature of the earth. Few people have either the equipment necessary or the know-how to manufacture a tower on which the antenna can be mounted. They are advised instead to purchase one of the many types of towers available for just such use. In some sections of the country, public utilities offer their services to the television user and will erect a standard pole for a fixed fee. Ofttimes this is the cheapest and best method. The antenna mast can then be fixed to the pole with special mountings similar to the standard chimney or wall-bracket mountings.

It is wise to be foresighted and make some provision either for lowering the antenna or gaining access to it by steps or rungs. It will be necessary from time to time to repair broken leads or connections, boosters, etc. A pulley and pivot point such as used by bird lovers who erect a bird house on a high pole will do the trick.

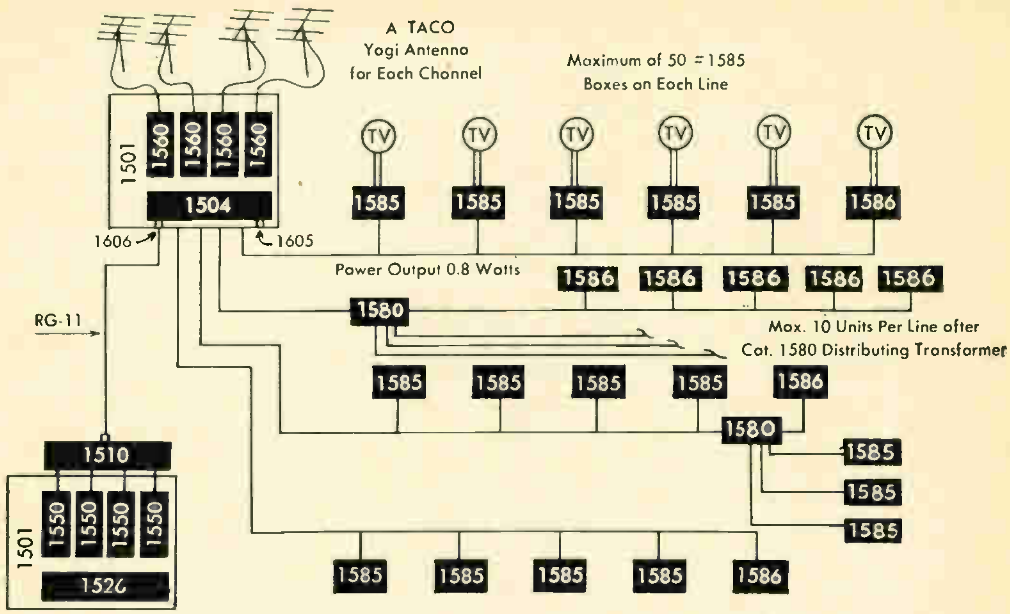
Lightning Protection

Be careful at all times to (1) erect the antenna so that if it falls, power lines will not be crossed or touched by any part of the assembly and (2), be sure the transmission line is held firmly by insulators so that it does not touch the power lines to the house.

A lightning arrester is advisable and simple to install. First, the mast should be grounded. This effectively grounds all parts of the antenna except the "driven elements," or those to which the lead-in is connected.

To ground the mast, drive a pipe or grounding rod into the ground and connect it to the mast with 12 or 14-gauge wire. This does not ground the receiver. To do this a lightning arrester must be purchased to fit the particular lead-in and mounted at the point where the line enters the house. Another rod is driven into the ground and the arrester is connected to that with the same kind of wire used to ground the mast. The transmission line is run through the arrester and the contact screws turned down.

Some installers connect the antenna mast directly to vent pipes on the roof in the belief that this is a good ground. Often it is, but equally often it is not. The pipe used in the vent



system may not be metal throughout, so that the ground connection is not made. For that reason, it is best to run the ground wire directly to earth-embedded pipe or rod. This should be at least 4 feet long and should be driven almost all the way in. Be careful not to drive it through some underground installation such as a sewer pipe, drain pipe or underground power inlet. Remember that both the mast and the transmission line should be given lightning protection. This is necessary because the elements connected to the lead-in are electrically insulated from the mast.

Safety Factors

Be careful in working on the roof that damage is not done to the roofing material which would void any guarantee it may carry from a roofing company. If there is a guarantee, and the antenna installation requires cutting into the roof, it is wise to obtain permission from the roofing company (in writing) before proceeding.

Working on ladders and roofs can be very dangerous. Wear rubber-soled shoes for traction. Use ropes anchored to some firm point such as the chimney. Or, if the roof is sloping, throw a rope all the way over the house and anchor it on the opposite side of the slope to be climbed. Regular roofing ladders which hook over the peak of the roof are ideal but not always available. The local roofing company may have one to loan you.

Attic Antennas

Any antenna can be mounted in an attic if there is not too much interference from gutters, flashing and electrical conduit. The only way to find out is by trying, and it will be worthwhile to assemble your antenna in the attic and see if picture results are satisfactory. If so, the antenna can be mounted by suspending it from the studding or braces or by bracing it to the rafters with guy wires. The transmission line can be run outside and down or through the walls.

Indoor and Built-in Antennas

Many TV set owners find it necessary to use an indoor antenna. Seldom, if ever, is picture reception as good as it would be with an outdoor installation. If one must be used, the owner must grin and bear it. The same applies to the antennas built into TV sets. It is entirely possible, however, that future advances will allow TV receivers to operate satisfactorily with such antennas, just as radios no longer require an outdoor antenna.

Master-Antenna Systems

For apartment dwellers, master antennas have been developed which serve a large number of receivers very well. A block diagram of such a system is shown in this chapter.

They are of two types. The first distributes the television signal to receivers along the line without any further amplification. The second type amplifies the signal.

The nonamplifying system is satisfactory only for a limited number of receivers, the number depending on the strength of the signal input. Where signals are strong—in other words where the sets are close to the transmitting station—as many as 12 receivers can be operated from a nonamplifying system.

It is possible for the owner of a small apartment unit to construct his own nonamplifying master system. He should first erect an antenna which brings in a strong signal—possibly stacking the antenna to increase the strength—then distribute the result through a special transformer which can be purchased from any supply house.

It is possible to build such transformers, but it takes a lot of know-how and tinkering.

Amplifying-system master antennas build up the signal before distributing it, and can serve an almost unlimited number of receivers.

Chapter Six

Inside Your TV Set

TELEVISION INSTALLATION and service were for a long time considered as things to be attempted only by the skilled technician. And, for a shorter period of time, many dealers regarded the installation of a television receiver they sold as a prerogative they should insist upon in order to make sure that the set operated satisfactorily and the customer was pleased by the service rendered.

Now, however, the picture has altered considerably. More and more television sets are sold at low cost, which leaves the dealer with no margin to use for such services as free installation and checkups.

After a few hardy souls showed the way, the erection of television antennas by rank amateurs became common. More recently, many set owners have undertaken to save themselves the relatively high costs of servicing. Some are successful, and some are not.

There is no reason why any television owner cannot perform many, if not most, service and replacement needs on his set. However, in order to do anything successfully, it is very desirable to know just a little bit about *what* you are doing. In this chapter the television receiver in general—and no one make or model in particular—is described by sections so that you can perform various operations on your receiver and know to some extent *what* you are doing and *why*.

There are a number of reasons why home television service is quite practical. Most important is the fact that the greatest majority of difficulties arise from the simple failure of one or more of the small vacuum tubes. Certain of these tubes cause definite effects on the face of the tube when they fail. Thus, by noting what the picture is—or is not—doing, the owner can determine the part of the circuit in which the trouble lies. Once this is determined, the simplest way to correct the trouble is to replace the defective part.

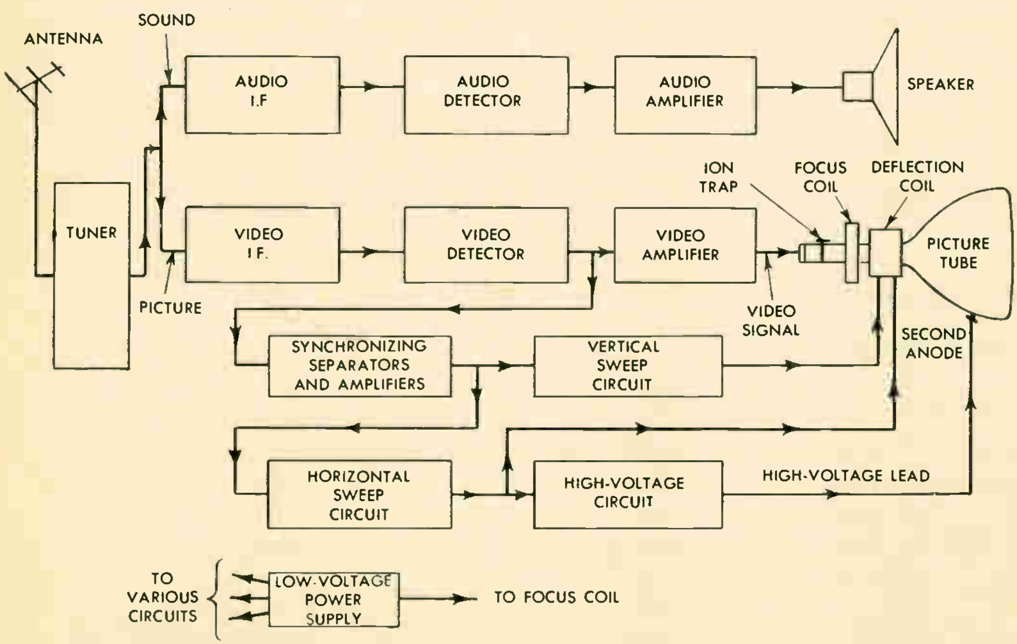
Know Your Circuit Layout

A block diagram of a typical television receiver is shown. This diagram is not of any one set, but a composite which shows the basic circuits, their functions and their relationship to other circuits and parts of the set.

Most television manufacturers have laid out diagrams for their particular sets for the convenience of servicemen. It may be possible for you to obtain one of these from the manufacturer of your set or from a dealer.

On the back of your receiver you will find a perforated cover. This cover is there to seal in the extremely high voltages present inside, and is perforated to provide ventilation for the heat generated in the set. A plug on the cover in turn plugs into a two-prong socket in the set. When the cover is removed, the circuit

BLOCK DIAGRAM OF TYPICAL TV RECEIVER



is broken and the receiver cannot be turned on. This device is called a "safety interlock."

Never take this cover off until you have learned where the high-voltage danger points are located and how to avoid them. This is most important, and will be discussed in detail later. The high voltage in even a small 7-inch receiver is as great as 4500 volts, while the projection-type receiver found in most homes will go as high—and sometimes higher—than 27,000 volts! Voltages of these strengths should be treated with respect.

The parts that make up a television receiver—tubes, resistors, condensers, coils, wiring and sockets—are mounted on a metal base called the chassis. In some receivers all the parts, including the picture tube and the speaker, are mounted on one chassis. In others, the speaker has its own chassis; still others have the picture tube mounted separately, and some have different circuits mounted on individual chassis. It is quite common to find the power transformer, rectifier tube, high-voltage tubes and transformer and damper tube mounted on one chassis—sometimes called the "power deck"—and the rest of the receiver mounted on another. In such cases the chassis are connected by cables which either join each other or plug into sockets mounted on the chassis themselves. In order to remove the receiver from the cabinet, it is often necessary to disconnect these cables. Before doing so, it is wise to mark each one and the socket into which it plugs so that the parts can be reassembled correctly.

It is not always necessary to remove the television receiver from the cabinet in order to replace tubes, and it should not be done if it can be helped. However, many receivers are mounted in such a way that it is impossible to replace certain tubes without at least removing the particular chassis to which that tube is connected. The high-voltage tubes, for example, are usually enclosed by a metal shield which must be uncovered or removed before the tube can be replaced. Also, some of the miniature tubes used are located in such a position that more time is wasted trying to fit the tube prongs blindly than would be spent in removing and replacing the chassis.

Removing the Chassis

Certain definite steps should be followed when the television receiver is removed from the cabinet. These steps are enumerated here; if carefully followed there will be no shock hazard:

1. Turn off the set and pull the power cord out of the wall receptacle.
2. Remove the knobs from the front controls. These knobs generally are of the push-on type and can be removed quite

easily. This must be done so that the shafts of the controls can be drawn through the holes in the front panel. Any special tools required to loosen set screws can be obtained cheaply at any radio-supply house.

3. Remove the back shield, which usually has the safety interlock riveted to it. This exposes the receiver and also completely disconnects the source of power. In some cases it will be necessary to disconnect the antenna before removing the back cover. Inasmuch as some receivers have antenna connections for either 300-ohm or 72-ohm lead-ins, it is wise to make sure which one is being used before disconnecting any antenna lead.
4. Carefully inspect the chassis and determine how it is mounted. Usually they are held by bolts, fed through a wooden base or mounting, which screw into the corners of the metal chassis. In some receivers, ordinary wood screws are used. These bolts or screws should now be removed.
5. Check the speaker mounting and connection. Unless the speaker is mounted directly on the speaker chassis, it must be disconnected. Various forms of connections are used: Some speaker leads plug into a socket on the chassis, others plug into one end of a cable leading from a chassis.
6. Inspect the picture tube to see if it is mounted independently of any chassis or if it is mounted on the same chassis that holds the other parts of the receiver. If mounted independently, it must be disconnected in the same manner as the speaker. If this is necessary, more steps must be taken at this point. The high-voltage lead which plugs into the side of the tube should first be disconnected and grounded to one of the chassis. An illustration on page 120 shows how this is done. Be very careful not to touch the metal tip of the lead, as there is enough charge in the high-voltage condensers to give you quite a "nip." Grasp the lead firmly at the base of the rubber suction cup when handling the lead and disconnecting it. Next, disconnect any other cables which connect the picture-tube unit to the other chassis. The parts around the neck of the picture tube, with the exception of the ion trap, are fixed firmly and should not be removed when taking out the receiver. The tube socket is taken off. This socket is "keyed" to fit on the tube base only one way, so you need not worry about getting it back incorrectly. As a further precaution against shock, it would be wise at this time to short-circuit the high-voltage coating on the picture tube by placing a length of insulated wire between coating and chassis. (See Fig. 23, page 122.)
7. If the chassis in the receiver are all separately mounted, they should be disconnected at this time.
8. The receiver is now ready for removal. This should be done carefully and gently—first to make sure it has been disconnected properly, and secondly because the receiver

is a fairly delicate instrument that cannot take too much bouncing and bumping.

9. Carefully reassemble the receiver. Be sure that all connections are together firmly and that a good contact is made. This applies especially to the high-voltage lead attached to the second anode on the side of the tube.
10. Inasmuch as the power cord and its safety plug are riveted to the perforated back cover of the set, it will be necessary to buy an extra one to operate the receiver while it is out of the cabinet. These can be obtained at any radio-supply house for less than a dollar.
11. Review all safety precautions. If properly observed, there need be no hazard attached to any following operations.

Despite many differences, all television receivers have essentially the same parts which perform the same functions. The major differences lie in the number of tubes, particularly those in the amplifier circuits; whether or not a dual i.f. system is used instead of the intercarrier i.f. system, and the individual refinements which various manufacturers have introduced in their quest for steadier and clearer pictures.

Many television receivers have a tube-layout diagram pasted on the inside of the cabinet. These diagrams show the position of the various tubes on the chassis. They do not, unfortunately, all show the *purpose* of the particular tubes so that the uninitiated can tell from such a diagram which tube is which.

It is recommended, therefore, that you write the manufacturer of your receiver, giving the model and serial numbers of your set, and ask him for a service bulletin or booklet. This should give you much information necessary, including very probably a schematic diagram of the set circuit showing all components, their values and their parts numbers. If it is inconvenient to write to the manufacturer, or if for some reason the request is not granted, such bulletins can be bought at most radio-parts houses.

Unless you are accustomed to reading circuit diagrams, much of the information in service booklets will be confusing gibberish. Don't let this bother you—use the information you need and ignore the rest.

Following the Signal

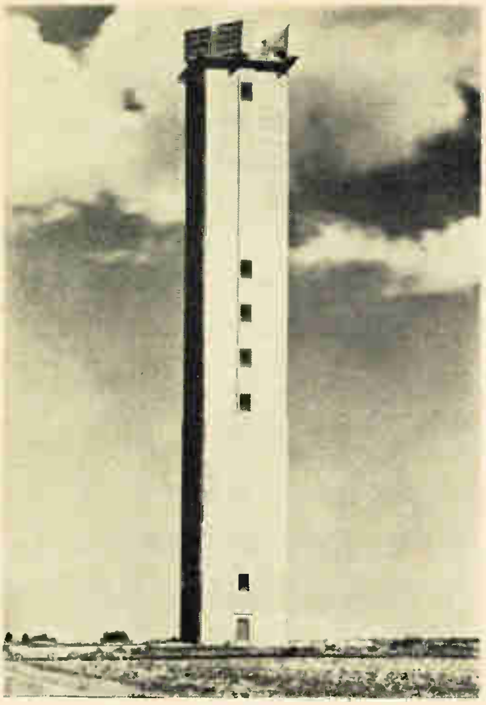
Let us refer to the block diagram of the typical television receiver on page 99 and trace the progress of the electrical energy emitted by the transmitter as it travels through the set to the picture tube and the speaker. The signal, as it is called, is made up of three types of intelligence: the sound, the picture and the synchronizing impulses.

The sound signal sent out by the transmitter is FM, or frequency modulated. This means that when sound enters the microphone and is sent through the amplifying circuits to the transmitter it affects the frequency of the radio wave. The simple sketch—without intervening circuits—shows a frequency-modulated wave. The advantages of this method have been made clear during recent years. Higher fidelity of sound is possible because the portion of the frequency spectrum allowed for FM signals is usually large enough to accommodate all the tones and harmonics desirable for quality.

Secondly, and of greater importance, is the fact that interference caused by static disturbances, ignition noises, etc., does not affect the frequency of a radio wave but does affect its amplitude. In the drawing, note that the amplitude, or strength of the sine waves which make up the signal, is not constant. Because we do not depend on a changing amplitude to give us the picture intelligence, this erratic portion can be cut off by a special circuit in the receiver and the resulting sound is clear and "smooth." Thus, when lightning or other disturbances change the amplitude of a frequency-modulated radio wave, the undesirable result is easily removed and a clear sound is reproduced.

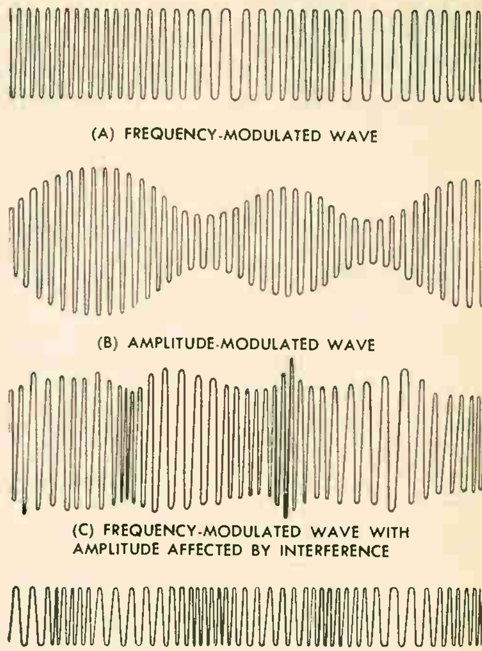
It has been pointed out before that the various shades of light and dark in a television picture require a relatively wide band in order that a maximum of intelligence can be conveyed. Because of this, it is impractical to use frequency modulation for the picture, or video, signal. Instead, the conventional AM, or amplitude modulation, is used. The transmitter has a circuit which generates—at a set frequency—radio waves of equal amplitude. On these is impressed the intelligence coming from the picture-amplifying circuits. This intelligence varies the strength of the sine waves which the transmitter is producing. An amplitude-modulated wave is the result. At the receiver, the circuits "inspect" this varying amplitude and carry the message to the picture tube.

The synchronizing impulses make up the third type of intelligence carried by the signal. It will be remembered that the electron beam scans the picture in lines, moving from top to bottom, first taking the odd lines and then the even. It then returns to the top and repeats the picture. In order that the receiver may intelligently picture the story the camera is "taking," the electron beam in the picture tube must move at the same rate and "in step," or synchronized, with the beam in the camera tube. The sweep circuits in the receiver perform this function and the synchronizing pulses carried by the signal tell them when



Typical radio-relay station contains receiving and transmitting antenna for each direction

TYPES OF WAVES



(A) FREQUENCY-MODULATED WAVE

(B) AMPLITUDE-MODULATED WAVE

(C) FREQUENCY-MODULATED WAVE WITH AMPLITUDE AFFECTED BY INTERFERENCE

(D) FREQUENCY-MODULATED WAVE WITH INTERFERENCE CUT OFF BY LIMITED STAGES

to move the beam from right to left and when it is to be moved from top to bottom and back again. These synchronizing pulses are superimposed upon the picture signal. In the receiver, they are removed and carried to their proper spots.

Thus far we have the television signal at the antenna and no further. In accordance with the principles outlined in the chapter on antennas, the signal is picked up and passed along the lead-in to the receiver.

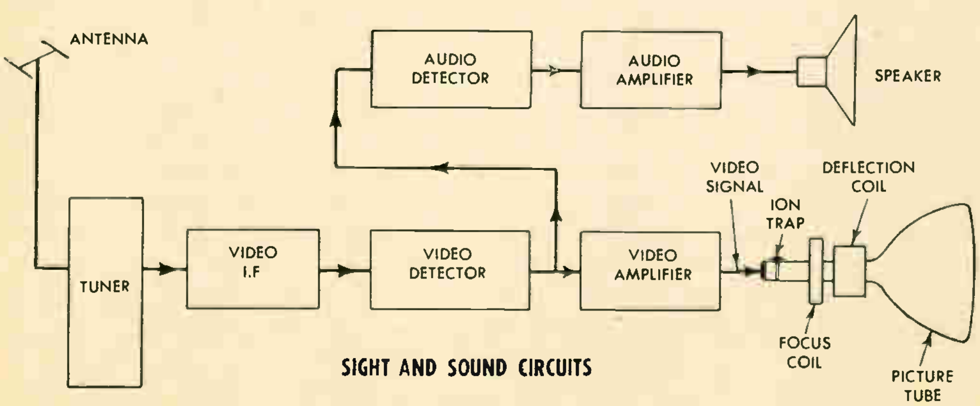
The first section of the receiver which the signal enters is the tuner. It must be remembered that although an antenna is made to be particularly receptive to specific frequencies, it still is capable of picking up other signals in greater or lesser degree. Therefore, the first function of a tuner is to separate the desired signal from the unwanted ones. For this purpose, a vacuum tube plus a "tuned circuit" is used. The tuned circuit is an arrangement of coils, condensers and resistors which makes the tuner receptive to one frequency, rejecting all others. The vacuum tube is called the radio-frequency amplifier, or r.f. amplifier. Working together, the vacuum tube and the tuned circuit receive all signals, pick out the one for which the tuned circuit is designed, block all others and then amplify the weak radio-frequency energy to a usable strength before passing it on to the next stage.

The oscillator and "mixer" stages come next. Theirs is a most important function. The job of the oscillator and the mixer is to take the signal received from the r.f. amplifier, combine it with another signal and, regardless of the frequency of the r.f. signal, send it on to the next amplifier as a signal that never varies in frequency.

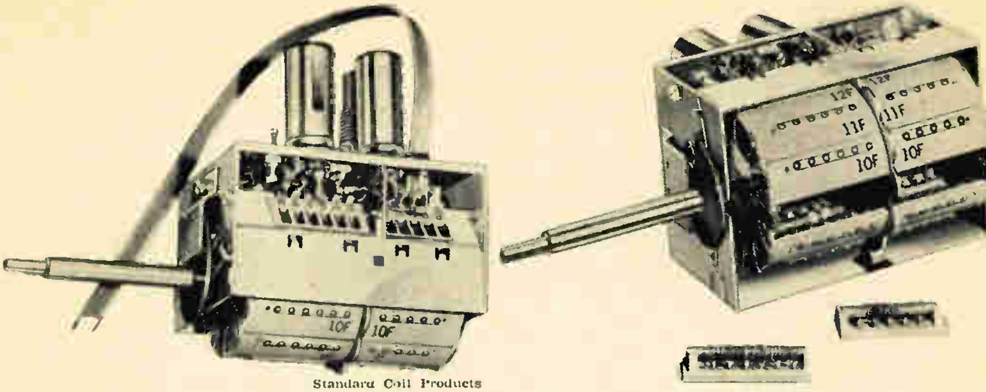
The advantage of this superheterodyne system has been cited before. Because the frequency produced at the oscillator and mixer stages never varies, the video and sound i.f. amplifiers can be pretuned at the factory and kept in tune by a serviceman with no need to retune every time a new station is selected.

Let us see exactly how this is done. On every television channel, two frequencies are established. One is the "picture-carrier" frequency and the other the "sound-carrier" frequency. On Channel 2, for example, the picture-carrier frequency is 55.25 megacycles and the sound-carrier frequency 59.75 megacycles. The channel itself covers a range from 54 to 60 megacycles. Now suppose that the picture intermediate frequency is set at 25.75 megacycles, a fairly common standard in TV receivers. It is therefore necessary to change the carrier frequency of 55.25 megacycles to 25.75 without in any way altering the intelligence carried by the signal.

To do this, use is made of the mixing characteristics of a vacuum-tube circuit. If two different signals are fed to such a circuit, four will be available at the output—the two original frequencies, a frequency equal to their sum and a frequency equal to their difference. It is this last frequency that is desired. A small r.f. generator is therefore built into the receiver. This is called the oscillator, and is one of the most sensitive parts of the set.



SIGHT AND SOUND CIRCUITS



Standard Coil Products

Side view of Standard Coil tuner. Right, tuner with oscillator and r.f. sections removed

The photo at the right shows the sections removed from a tuner. The oscillator section is shown in the photo at the left. It is made up of components so fixed in value that when they are coupled to the oscillator tube a signal of fixed frequency is generated. If the set is operating on Channel 2, the oscillator frequency necessary is 81, to produce a difference of 25.75 megacycles from the carrier's 55.25 megacycles. The incoming frequency of 55.25 and the oscillator frequency of 81 are both fed to the mixer tube. The difference frequency resulting is passed on to the next stages of the amplification process.

In some receivers, one tube performs both the oscillator and mixer functions; in others, two tubes are used. That is why some tuners have two vacuum tubes and others have three. As far as the owner is concerned, the principal advantage of the two-tube tuner is that there is one less tube to go bad.

There is still another difference frequency that is passed on by the mixer section. That is the difference between 81 megacycles and the sound-carrier frequency of 59.75 megacycles for a result of 21.25. This is the intermediate frequency of the sound signal. Notice that it is separated from the picture i.f. by 4.5 megacycles. This prevents interference between the two.

In the photo of a tuner, it will be noticed that each channel has two sections. The one on the left has been pointed out as the oscillator section. That on the right is the r.f. section. In this turret-type tuner, each channel has two strips. The r.f. strip is tuned to the frequency of the channel for which it was constructed. The oscillator strip is tuned to give a frequency which differs from the r.f. frequency by the frequency to which the intermediate amplifier stage following the tuner is adjusted.

On Channel 7, the picture-carrier frequency is 175.25 and the sound-carrier frequency 179.75 megacycles. In receivers which use the 25.75-megacycle intermediate frequency, the oscillator is tuned to 201 megacycles. The difference frequencies in this case are 25.75 for the picture and 21.25 for the sound.

No matter what the incoming frequency, then, when the owner turns the channel-selector switch on his television receiver he throws into the circuit a radio-frequency amplifier tuned to that frequency and an oscillator which manufactures a signal that mixes with the incoming signal to produce one for which the next stage is tuned.

Tuner Adjustment

The tuners of television receivers are all carefully adjusted before the sets are shipped from the factory. The tuning adjustments made on them are critical in the highest degree. Unless he is very well equipped with test instruments, even an experienced serviceman will make no attempt to adjust the tuning of this circuit because of its delicate balance.

There are but two repairs the home owner should attempt on the tuner section of his receiver. One is the replacement of defective tubes. The second is adjustment of the oscillator. The first is simply a matter of pulling out the defective tube and inserting a new one. Adjusting the oscillator requires a little more care and some explanation.

With few exceptions—notably the continuous-type tuners—the tuners used in television receivers have fine-tuning controls. These usually are found at the front end of the tuner-assembly shaft. The purpose is to enable the owner to tune sharply the station he selects. In this way he can compensate for changes in the values of condensers and resistors because of age or other factors, all of which alter the tuning of the receiver.

At times, however, no matter how the fine tuning is adjusted, the picture cannot be brought in clearly with good detail and contrast. Or, what is worse to some people, the sound and picture are not synchronized. Tuning in a good picture results in poor sound, and vice versa. Any of these can occur when the oscillator or mixer tubes are changed. The difficulty may show up gradually, indicating such wide changes in circuit component values that the fine-tuning control is no longer able to compensate. Under these circumstances, it is possible that the oscillator can be adjusted to correct these troubles.

Oscillator Correction

Oscillators generally are tuned by varying the depth to which a brass or iron core is inserted in the hollow center of a coil. The coil in an oscillator section is shown in the photo on page 106.

Inserted in the coil is a threaded brass slug with a screwdriver slot at the outer end. When the channel strip is inserted in the tuner, this slotted end can be seen through the hole in the tuner marked "H." The oscillator is adjusted while the set is turned on and tuned to the defective channel.

Because of the frequencies involved in radio and television, tuning any section which operates at radio frequency must be done with a nonconducting screwdriver. These can easily be purchased for a small sum, or it is quite easy to make one from a slender piece of wood. With such a tool, turn the slug in the oscillator coil slowly and carefully. Watch the picture and listen to the sound with equal attention. There will be a point at which both picture and sound are at their best. If this point gives satisfactory results, no further adjustment is necessary.

If the results still are unsatisfactory, the oscillator tube should be changed and a new one tried. If the trouble lies in the oscillator section because of mistuning or a defective oscillator tube, this adjustment will clarify the picture and give good, synchronized sound.

In the turret-type tuner there is a separate oscillator adjustment for each channel. The process outlined should be performed only for those which may be defective. The procedure, however, varies somewhat in tuners which do not have separate strips for each channel.

As a general rule, the adjustment for the oscillator is found on the front end of the tuner. One type of tuner has only two oscillator adjustments, one for Channels 2 through 6 and the other for Channels 7 through 13. These are referred to as the "low-frequency oscillator" and the "high-frequency oscillator." Because of the variety of tuners used, it is inpractical to show details of every type. For the location of oscillator-tuning adjustments, it is necessary to refer to the service diagram of your particular set.

An example of a switch-type tuner is shown on page 110. Notice the two screwdriver adjustments for oscillator tuning. In making adjustments for the low-frequency channels, any station in that band is selected and tuned in as best possible. The oscillator is then adjusted for picture and sound. The channel selector is then turned to another station in the low-frequency band and the same procedure is followed, using the same oscillator-adjusting screw. Then return to the first channel. If the fine-tuning control cannot be adjusted to bring in the proper picture and sound, the oscillator slug should be retuned. Return to the second station and check. It may be necessary to repeat this procedure several times before settling on one position that satisfies the requirements of all the stations involved.

The steps to be followed in adjusting the oscillator for the high-frequency band are the same. Because of the higher frequencies, be more cautious in turning the slug.

Certain types of receiver employ a type of tuner which has replaceable channel strips other than those mentioned and illustrated. In these, it is frequently possible to purchase from the manufacturer a replacement part for an offending channel. This is necessary in those cases where there is no doubt that the strip itself is defective. Normally this is a task for a serviceman, but in localities where none is available the job can be done by a handyman.

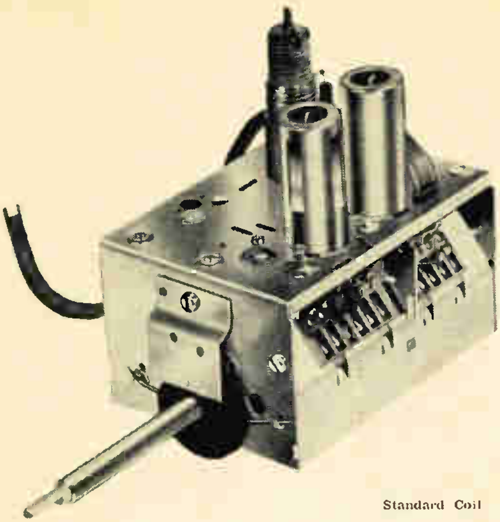
Audio-Amplifier Stages

The block diagram on page 99 shows the signal leaving the tuner assembly along two separate paths. One path is traveled by the video or picture energy; the second is used by the sound energy. The sound energy in the television-receiver diagram follows the same course as that in a conventional radio receiver. The i.f. amplifiers receive the energy and increase its strength.

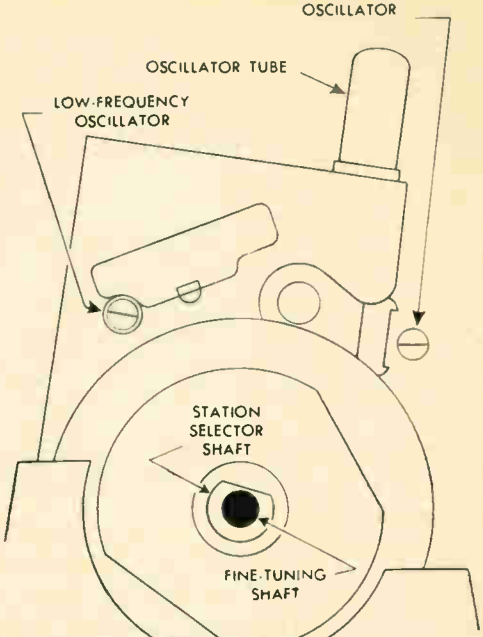
In some receivers this audio i.f. amplifier consists of only one tube, in others two tubes, and in some of the more elaborate receivers, three tubes—or stages—of i.f. amplification.

The strength of the radio-frequency energy carrying the sound intelligence has reached sizable proportions by now, and it is possible to separate the sound from the radio-frequency carriage which has brought it thus far. This is done by a circuit made up of one vacuum tube and associated parts. The circuit is called the "ratio-detector circuit," or "discriminator circuit." The ratio-detector circuit is the most commonly used because it has good sensitivity and the ability to reject AM signals. The discriminator-type circuit must be preceded by a limiter circuit —one that "cuts off" the unwanted amplitude modulation that is often impressed on a frequency-modulated signal. This involves the use of another vacuum tube and circuit which, of course, increases the cost of the receiver and adds another section to increase the possibility of trouble. Because a comparatively weak signal will cause a ratio detector to work, fewer stages of i.f. sound amplification are necessary, which further reduces costs.

At the audio detector, then, regardless of which type it is, the sound intelligence is removed from the radio-frequency carriage. This electrical sound energy still is too weak for prac-



The Standard Coil tuner, used by many manufacturers as original equipment, is also available as a replacement part for most television receivers. Adjustments are easy. The oscillator adjustment is made through a hole at the front end of the tuner. Right, switch-type tuner has two adjustments for the oscillator. For location of oscillator-tuning adjustments, it is necessary to check the service diagram of your set



FRONT VIEW OF TUNER

tical use. To strengthen it, two or more vacuum tubes are used. These are the audio-amplifier tubes, which, with their associated circuits, are called audio-amplifier stages.

Suppose a loudspeaker needs 100 units of energy to make it work. If the detector unit puts out only one unit, the signal must be increased. To do so in one step reduces the quality of the sound considerably. Therefore, it is done in stages. The one unit is delivered to the first audio-amplifier stage, which increases it in strength to 10 units. This signal is in turn delivered to the next, or final, stage, which in turn increases these units tenfold and delivers 100 units of electrical sound energy to the speaker.

The number of units used here for illustration is purely arbitrary. Many audio-amplifier stages increase the signal strength much more. The fidelity, or quality, of the sound which the television speaker delivers is largely dependent on the stages of amplification through which it passes—both the i.f. and the audio amplifications.

Without special test equipment, it is impossible to tell exactly how good this audio signal is. The only guide for the owner is his ear. Simply make your adjustments of the controls until the sound attains the most pleasing effect.

Video-Amplifier Stages

That part of the electrical radio-frequency energy which is carrying the picture intelligence is, meanwhile, following its own course. It, too, is amplified by i.f. stages. And, like the sound energy, it must be separated from the intermediate frequency, amplified to a usable degree and delivered to its final destination —the picture tube.

Separation from the i.f. carriage is performed by the video detector just as the audio detector separates the sound energy from its i.f. carriage. This resulting intelligence is further amplified by the video amplifiers and then sent on to the picture tube where it controls the intelligence delivered to the fluorescent screen of the picture tube by the electron scanning beam.

One more step is performed in this process. It will be recalled that the synchronizing pulses are impressed on that part of the radio-frequency carriage which carries the picture energy. These pulses must be separated from the picture intelligence and delivered to their proper circuits. This is done at either the video detector or at one of the video-amplifier stages. Which one is used can be determined by the service booklet for a particular model.

The Sweep Circuits

Once separated and ready for use, the pulses are amplified and sent to their respective circuits—the vertical pulse to the vertical-sweep circuit and the horizontal pulse to the horizontal-sweep circuit. These sweep circuits can be likened to columns of marching soldiers. Without some supervision they are apt to lose cadence and fail to keep in step. The pulse is the sergeant which calls the beat.

Because the beat comes from the same spot that controls the electron scanning beam in the camera at the television station, the sweep circuits in the receiver are thus kept in step with those which control the signal at the starting point. The controlling energy from the pulse circuits is then passed on to the deflection coil around the neck of the picture tube.

The vertical-sweep circuit operates at a rate of 60 cycles per second. In other words, its voltage rises to a maximum and drops off abruptly to zero at a 60-cycle rate. It is the current being passed through the vertical windings of the deflection yoke that causes the electron beam to be pulled down and released to return to the top of the picture tube at the same rate.

In the meantime, the horizontal-sweep circuit is performing its function at the rate of 15,750 cycles per second. By the time it has pulled the electron beam back and forth across all the odd lines in the 525-line picture, the vertical sweep has pulled the beam down from top to bottom of the picture tube.

Perhaps it would be clearer to compare this operation to a man painting the side of a house. Suppose there were 40 boards on the side of a house. The man starts at the top and paints the odd boards all the way down from one side to another. Thus far he has moved across the side of the house 20 times, but he has passed only once from top to bottom. Now he goes back and paints the even boards in the same manner. He has finished the side of the house, he has moved across from side to side 40 times and he has moved from top to bottom twice. If it took him an hour to do the job, his "horizontal frequency" is 40 strips per hour. The vertical frequency would be two per hour.

In television, each time the vertical sweep moves from top to bottom, one half the lines are scanned by the horizontal sweep. This is called a "field," and the field frequency is 60 per second. It takes two fields to cover all the lines—odd and even. Two fields are called a "frame," so the frame frequency is 30 per second. And, as the horizontal sweep causes a complete line to be painted each time it moves across, the line frequency is 15,750 times per second.

Reviewing the action of the sweep circuits, it can be stated that the vertical sweep circuit in a television receiver develops a control voltage 60 times per second and that the horizontal circuit develops another such control voltage 15,750 times per second. These voltages are told when to start by a pulse of energy from the broadcasting station. The pulse rides in the same "carriage" with the picture intelligence, and at a definite point in the receiver is taken from the carriage and ordered over to the sweep circuits to take charge. Once having been put in step, the sweep circuits are sent over to the deflection coil or yoke, there to move the electron scanning beam as a painter moves his brush.

Power-Supply Circuits

Two major circuits remain in a television receiver—the low-voltage power-supply circuit and the high-voltage power-supply circuit. Just as in any radio, a television receiver needs to have the filaments of the vacuum tube lighted and the proper voltage applied to the other elements in the tubes before they will operate and cause the correct functioning of their associated circuits. This is the job of the low-voltage power supply. This supply source is usually a transformer which takes the house current and changes it into higher and lower voltages as required.

The higher voltages are fed to a rectifier tube which has the ability to pass current in only one direction. When the voltage emerges from this tube it is no longer alternating current in the ordinary sense of the term but a type of direct current. It is made still "smoother" by means of coils of wire called "chokes" and by means of filter condensers. It is this voltage that is fed to the tubes in the receiver.

In discussing picture tubes we learned that voltage was passed through the turns of wire making up the focus coil in order to control the size of the electron scanning beam. This voltage also comes from the low-voltage power source.

We know that in order to cause the fluorescent screen of the picture tube to glow, the scanning-beam electrons must hit it with considerable force. Also, if a high voltage is applied to a substance which is attracting the electrons, the higher the voltage the greater the speed of the electrons. This high voltage in a picture tube is not applied directly to the fluorescent screen but to the second anode. The second anode speeds the electrons on their way and, after they have struck the screen, receives them and passes them back to the return circuit.

The voltage for the second anode is developed by a rather ingenious method. During the period that the horizontal-sweep circuit is allowing the electron beam to return to the start of a line, a strong pulse is generated. This pulse is fed to the high-voltage power-supply circuits, where it is amplified, fed to another transformer which steps up the voltage further, and then is rectified in the same way as the low-voltage rectifier tube converts its current to a type of d.c.

The resulting high voltage is between 8,000 and 13,000 volts, and is to be treated with a great deal of respect! It is applied to the second anode of the picture tube through a snap-on connection on the side of the cone. Because the original impulse voltage for such a power supply comes from the horizontal-sweep circuit at the time it is flying back from one side of the picture-tube screen to the other, it is called a "flyback" power supply. Not all receivers use this type of high-voltage power supply, but it is perhaps the most common. Such a unit is pictured on page 115.

Intercarrier-Sound Receivers

Before leaving the general discussion of receiver operation, one other type of television receiver—the intercarrier-sound type—should be discussed. A block diagram on page 105 shows the sound energy coming from a point following the video-detector circuit rather than directly from the tuner. This type is cheaper to manufacture and makes for simplicity of tuning adjustments. The sound-energy carrier is amplified by the video i.f. amplifiers, thus cutting out the need for separate sound i.f. amplifiers. Secondly, because the two carriers are amplified together, they keep step so that the picture and sound are well synchronized.

The video detector acts much as a mixer tube does, so that when the radio-frequency energy is fed to the audio detector, the difference frequency of 4.5 megacycles is used between the sound and picture carriers. In some models this energy is fed directly to the detector; in others one stage of i.f. sound amplification is used. In almost all instances a ratio-detector circuit is used because it is insensitive to amplitude modulation and thus no interference creeps through from the amplitude-modulated picture carrier.

Primary Controls

The primary controls of a television receiver are generally located at the front of the cabinet. These are the operating controls. They are:

Station or channel selector. By this means the station desired is selected. It controls the action of the tuner by putting into the circuit the proper r.f. amplifier circuit and oscillator circuit. As described previously in explaining the action of the tuner, the parts making up these circuits often change in value or adjustment. It is necessary to have some means of compensating for these changes. This is a function of the

Fine-tuning control. As a rule, the fine-tuning control and the channel selector are mounted on concentric shafts—that is, the shaft of the fine-tuning control is within that of the selector shaft. After the station desired is selected, it is brought into sharp detail by the fine-tuning control. This control is not found on continuous-type tuners.

Volume control. This performs the same function in a television receiver as the volume control of a radio—it controls the amplitude level of the sound.

Brightness control. This governs the brilliance of the screen image. When the brightness control is varied, the difference in voltage between the grid and cathode of the picture tube is changed. Changing the voltage of the grid determines the number of electrons it permits to pass. If the voltage is permitting only a few, the amount of light on the screen will be small. If a large number of electrons are let by, the light on the picture tube will be great.

Contrast control. This governs the "volume" of the picture in much the same way as the volume control governs sound. In most sets the contrast control regulates the video amplifiers and occasionally it also controls the r.f. amplifier.

Horizontal hold. This is sometimes called the horizontal synchronizer, the synchrolock and the speed control. This allows the operator to keep his horizontal-sweep circuits operating at the required standard of 15,750 cycles per second. As tubes age and other parts change in value, the horizontal-sweep circuit oftentimes will generate a frequency that is not quite 15,750 cycles. The horizontal hold takes care of this variation. Because it is seldom necessary to use it, this control is often found at the rear of the receiver.

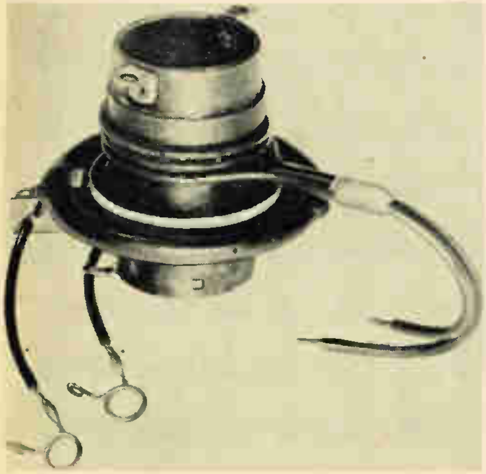
Vertical hold. Occasionally called the frame control or vertical-frequency control, the vertical hold keeps the vertical-sweep circuits operating at 60 cycles per second. The same comments that apply to the horizontal hold are true of the vertical hold. Often, the two controls are mounted concentrically. Like the horizontal hold, the vertical hold is sometimes mounted at the rear.

Secondary Controls

Secondary, or nonoperating controls, are those which seldom need adjustment. They are usually mounted at the rear of the set or under a plate on the front panel. A little understanding of what happens when these controls are adjusted often makes the difference between excellent and unsatisfactory results.

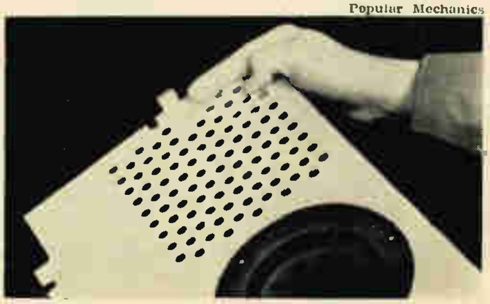
Focus. The focus control is a current-regulating device. Varying the current passing through the focus coil changes the focal

Merit



Below, safety interlock cuts off the power when the back of the television set is removed. Never remove this cover until you have learned where the high-voltage danger points are located and how to avoid them. Left, not all receivers use a "flyback" power supply, but it is fairly common. Flyback transformer controls high voltage to picture tube

Popular Mechanics



length of the electronic lens set up by the magnetic field. The focus control should be adjusted for the sharpest lines on the screen. This, like all image adjustments, should be done when the test pattern is being broadcast. One adjustment will satisfy focus requirements for all channels.

Width. This control is a coil or condenser which varies the operation of the secondary winding of the high-voltage transformer. Varying this control requires a screwdriver. Some require many turns before any effect can be noticed on the picture. Others can be turned only one revolution in all. The picture should fill the television screen from side to side. If it does not, the width-control adjustment is probably at fault. When such an adjustment is made, a readjustment also will be necessary for the

Horizontal linearity. This control makes sure that the voltage applied to the horizontal-deflection coil is smooth and even. If it is jerky, the picture will appear pulled in or pushed in on one side or the other. Like all secondary controls, adjustment is to be made slowly and carefully.

Vertical linearity. Similar in appearance and action to the horizontal-linearity control, the vertical-linearity control is used primarily to correct distortion in the top half of the picture. It acts on the vertical-sweep circuit and maintains its frequency at 60 cycles.

Height. Distortion of the lower half of the picture is corrected by the height control. It is almost always necessary to adjust the height and vertical-linearity controls together. Should it be necessary to adjust either one, only do so to fill the screen. Do not attempt to center the picture by these controls.

Horizontal drive. This control regulates the amplitude of the pulse fed to the horizontal-amplifier tube and thus affects the high voltage to some extent. Any adjustment of this control will also have an effect on the horizontal linearity, width and occasionally the horizontal hold, so that these adjustments may have to be "touched up" after changing the horizontal drive.

Horizontal and vertical centering. These controls vary the current flowing through the deflection coils. They are not found on all receivers. Those which do not have such controls center the picture by the positioning of the focus coil around the neck of the picture tube. This is adjusted by means of a shaft which protrudes through the perforated back cover of the receiver.

Mechanical Controls

The deflection yoke, focus coil and ion trap, all found around the neck of the picture tube, are called the mechanical controls. Their purpose and action has been described previously. How to adjust them is discussed in the following chapter.

TV-Circuit Tubes

Although many different tubes are used in the various makes of receivers, there are some which are commonly used in all types. It will be helpful in servicing your own set to have an idea of the tubes most commonly found in the various circuits. A survey has shown the following chief types:

Tuner—6J6, 6CB6, 6AG5, 6AK5, 6BC5, 6AB4
Sound i.f.—6BA6, 6AU6, 6SK7
Audio amplifier—6AU6, 6V6, 6K6, 6L6, 6SJ7, 6S8GT
Audio detector—6AL5
Video i.f.—6AU6, 6AG5, 6CB6, 6BA6
Video detector—6AL5
Video amplifiers—6AU6, 6AC7, 6SH7, 12AU7, 6AQ5, 6V6
Vertical sweep—6SN7, 12BH7, 12SN7, 6SL7, 6V6, 12SL7
Horizontal sweep—Same as vertical sweep, above
Synchronizing circuits—12AU7, 6SL7, 6SN7, 6AL5
Low-voltage power supply—5Y3, 5U4G, 5V4, 6X5
High-voltage power supply—1B3, 1X2, 2V3, 6BG6, 6BQ6, 6CD6

Danger Points

Now that the functions of the receiver have been explained and the common tubes listed, a study of those points which contain shock or mechanical danger can be made.

There is only one source of mechanical danger in a television receiver—the picture tube. The inside of the tube is maintained at a high vacuum. If it should break, air would rush in to cause an "implosion," and glass would fly all over the immediate area. How to handle it safely is explained in the following chapter.

There are real electrical hazards present in a television set. If the proper precautions are observed, however, there is no danger at all. The ones who get hurt are those who are careless or who didn't know the set was "loaded."

After a receiver has been turned on, a charge is built up in the many condensers which lingers long after the power is turned off. To prevent shocks during repair, this voltage should be discharged, or "bled." The metal chassis offers good discharge points. Among the following illustrations is one showing how the high-voltage lead to the second anode of the picture tube is discharged by touching it to the metal case which encloses the high-voltage power supply. If the picture is closely inspected it will be seen that there is a spark, or arc, at the point of contact. This is caused by the stored current jumping over the gap to the grounding point. When this arcing stops, the charge is fully dissipated and the metal contact of the lead is safe to touch.

Another picture shows how the high-voltage lead should be grasped—firmly by the rubber cap which surrounds the contact point. The tube itself, if of the glass-envelope type, has a coating on the outer surface. This coating often holds a charge which, though slight and not usually sufficient to give a harmful shock, should be discharged. If it is not, you might get enough of a jolt from it to drop the tube. Any piece of insulated wire will act as a medium for discharging this and the other storage points in the set.

How to Make a Shorting Tool

For the amateur repairman, an 18-inch length of ordinary lamp cord can be made into a satisfactory shorting, or discharging, device. Bare both ends of the wire and twist together the two conductors at each end. A half inch of bared wire is sufficient. If a soldering iron is available, it is wise to solder the bared ends to prevent fraying of the strands and to give the ends stiffness. Next, take two short pieces of wood, about 4 inches long, and tape them at each end of the rubber-covered section, leaving the bare wire protrude. This will provide a handle at each end.

To use this shorting tool, touch one end to the part that is to be discharged and the other end to the chassis (see photo 23, page 122). This provides a free path for the electricity to flow out. Sparking will result when this is done, but this is harmless and need not cause you concern.

Remember to keep your fingers well back of the bare ends of the shorting wires and do not permit any part of your body to touch the receiver. Amateurs are not likely to be careless when performing this operation the first few times. But the point to remember is that care must always be exercised even after you have become so adept at the shorting-out process that little thought is given to it. *Do not let familiarity breed contempt.*

How to "Bleed" a Set

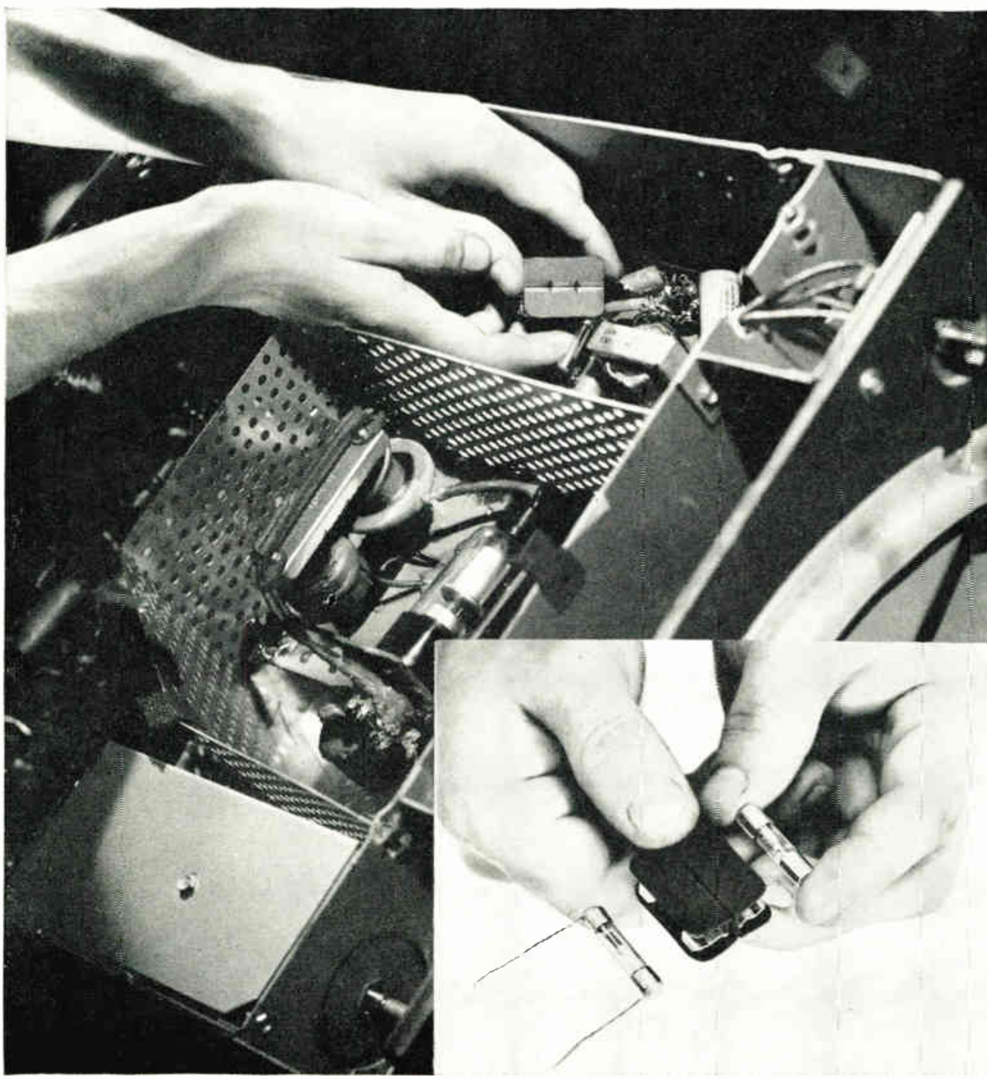
The danger points commonly found and the procedure to be followed in discharging them are as follows:

1. High-voltage lead from power supply to picture tube. Remove and short the metal tip against the chassis. An arc will result. Be careful to grasp the lead by the rubber cap

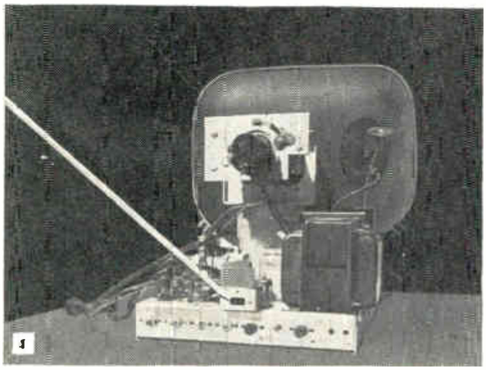
and do not let your free hand touch any part of the receiver. Follow the electrician's adage: "Keep your free hand in your hip pocket."

2. Short the cap connections to the high-voltage rectifiers and amplifier tubes to the chassis. This requires removing the cover of the high-voltage supply.
3. Short the outer coating of glass picture tubes to the chassis. Metal tubes are covered by a plastic insulating jacket. Stick an end of the shorting lead under this jacket, make contact with the tube envelope and short to the chassis.
4. If the underside of the chassis is going to be handled, it will be wise to short the positive leads of the filter condensers.

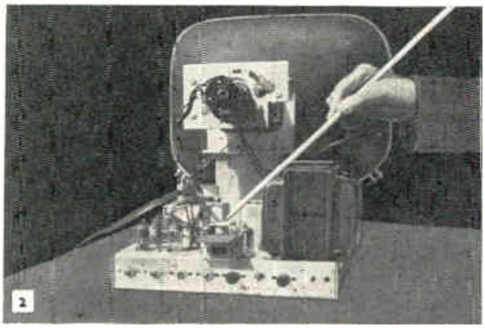
Snap-on fuse holder. Inset photo shows how easily fuse replacement is made



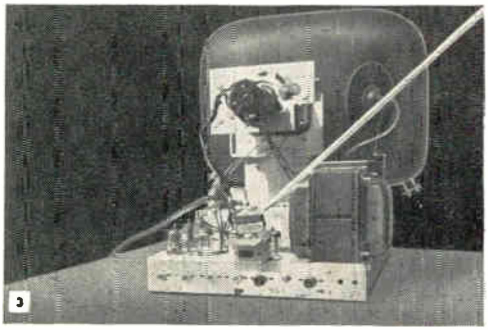
Danger points because of high-voltage buildups in your television set are illustrated on this and the following two pages. There will be no hazard, however, if you carefully "bleed" the current off these points by shorting them to the metal chassis of the receiver. Make a shorting tool like one shown in Fig. 22 on page 122. This picture series is excellent for familiarizing yourself with your TV set.



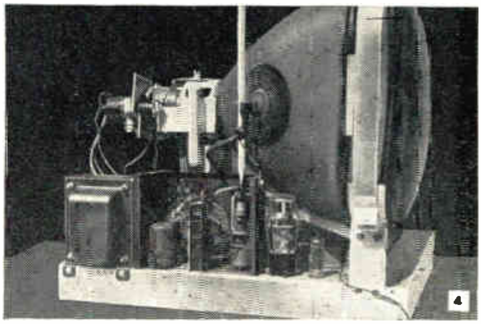
Power-input safety lock



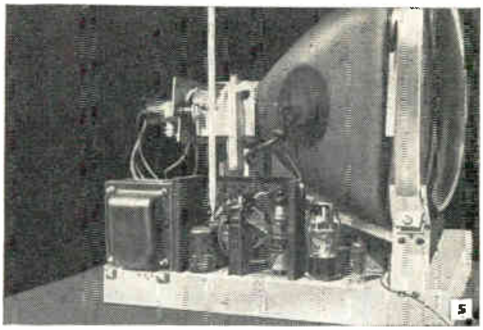
Exposed power fuse



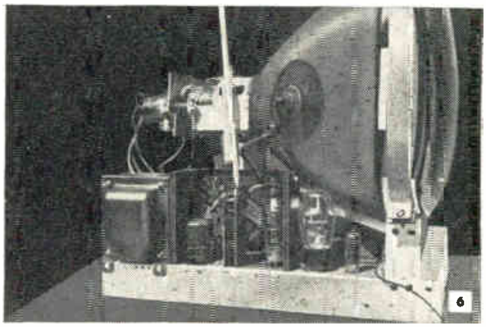
Snap-on fuse holder



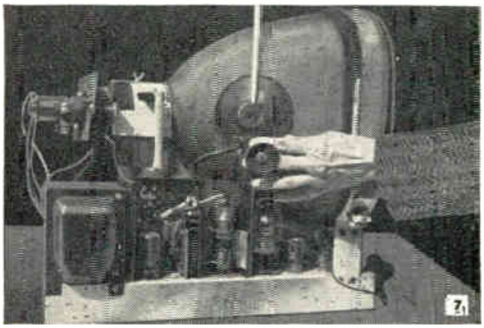
High-voltage rectifier tube



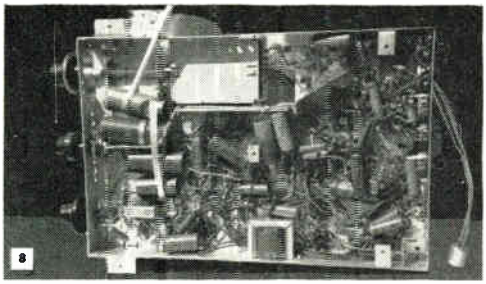
High-voltage amplifier tube



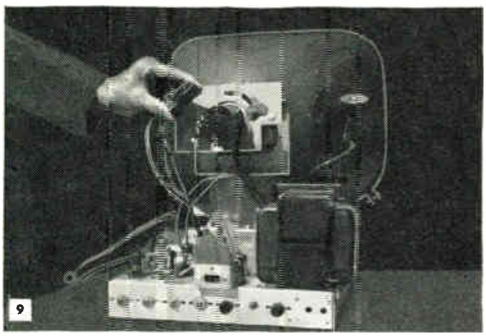
Flyback transformer unit



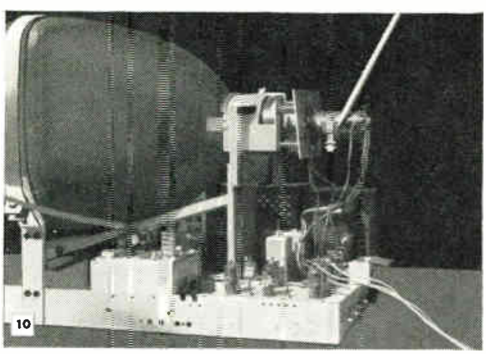
Second anode of picture tube



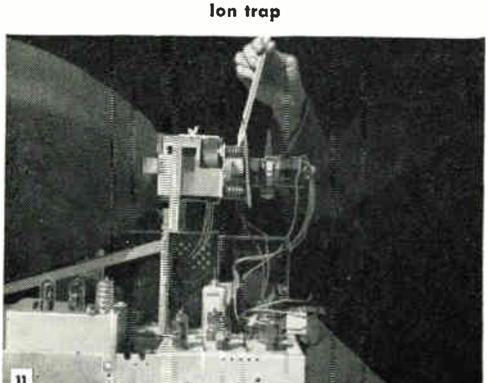
Filter condensers



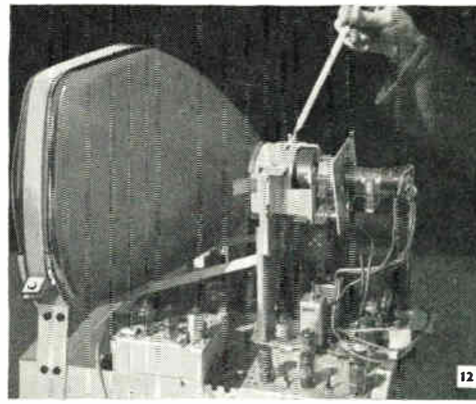
Picture-tube socket connection



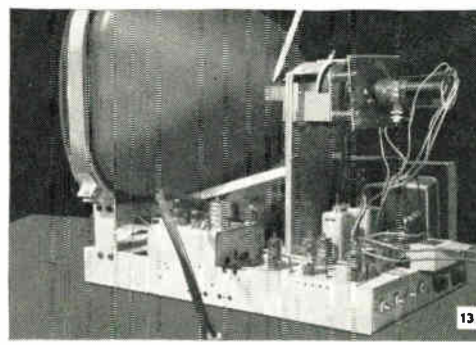
Ion trap



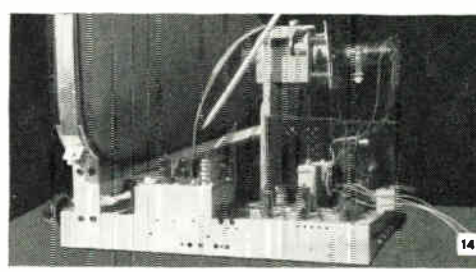
Focus coil



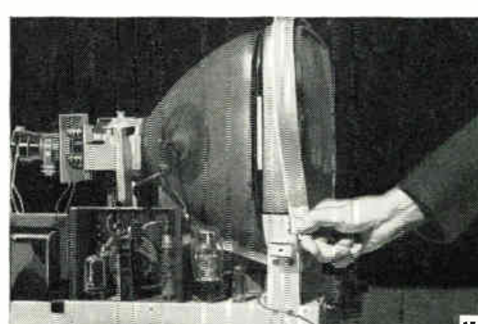
Deflection coil



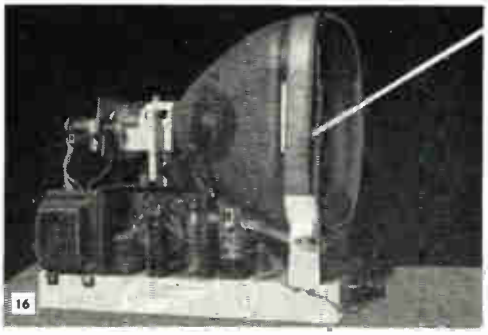
Metal short to picture tube



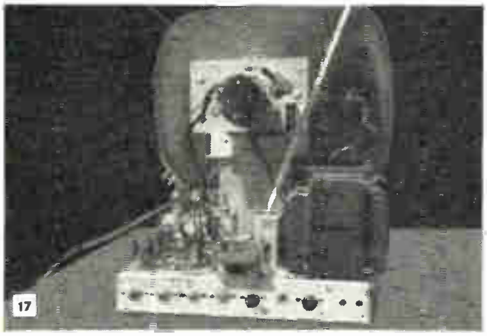
Chassis of tuner



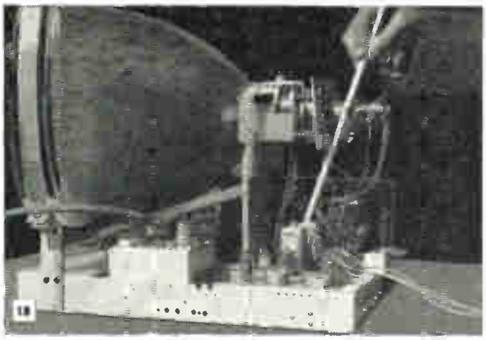
Metal band of picture tube



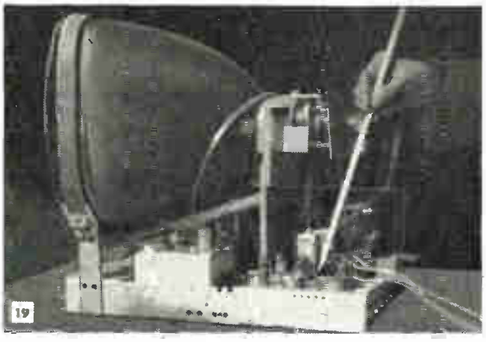
Rubber padding ring (safe point)



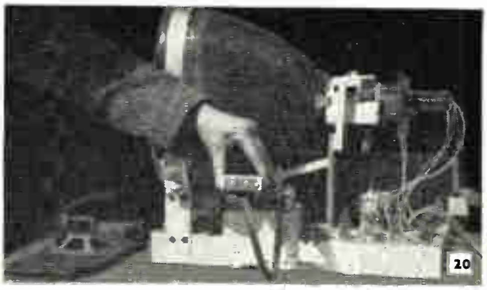
Horizontal-oscillator transformer



FM discriminator transformer



I.f. amplifier transformer



Antenna terminal strip

Speaker connection

Shorting cable

Shorting picture-tube coating to chassis

Chapter Seven

TV Troubles and Cures

TROUBLE THAT DEVELOPS in electronic equipment of any sort calls for the same approach as that used by a doctor. A boy's stomach becomes upset. The cause—eating green apples. The symptoms—nausea, stomach-ache and the like. The cure—pills, castor oil and no more green apples.

In television, the picture disappears, there is not a trace of light on the screen, but the sound is still good. The cause—a defective high-voltage tube, a defective horizontal-oscillator tube, etc. The cure—replacement of the defective part. Thus, every trouble makes itself known by symptoms. The problem is to know which causes can bring about the symptom.

Because television has two different circuits—sound and picture—and also because the signals which make up the sound and the picture follow a common path in certain sections of the receiver, there are three types of troubles which can arise: one, troubles which affect only the picture; two, troubles which affect only the sound and three, troubles which affect both. If one has become familiar with the basic course of the signals through a television receiver and the functions of the different circuits, he can, by elimination, reason that a certain symptom shows the difficulty must lie in a particular circuit or circuits and thus reduce hit-and-miss searching.

It is true that a number of causes can bring about identical results as far as visual or audible symptoms are concerned. But, for purposes of home servicing, these can be tabulated and the possibilities narrowed. In this section a fairly standard procedure for television servicing is followed; the symptom is given and the possible causes are listed. In some cases, causes are listed the repair of which are beyond the capabilities of many readers. This has been done for two reasons: one, to help those who have had experience in radio servicing and, two, to give an idea of the type of repairs a serviceman may have to make if it is necessary to call one.

It should be borne in mind that the majority of difficulties are brought about by failure of one of the small tubes and that very seldom do the secondary controls go out of adjustment by themselves. Therefore, when a receiver goes bad, do not start by twisting and turning all the available controls. To do so would be the most likely way to throw the whole unit out of adjustment.

For the television home repairs discussed in this chapter only a few basic tools are necessary. They are a screwdriver with a standard blade, a Phillips screwdriver, a pair of ordinary pliers and a supply of tubes for replacement. If any soldering is to be done, an 80-watt electric iron, some good rosin-core solder and a pair each of needle-nose and diagonal-cutting pliers are to be desired.

It is hardly worthwhile to purchase any sort of testing equipment if you only wish to do casual servicing on your own television receiver. But if you desire to make a hobby of electronics in any way, or have some other uses for such a device, you may purchase a reasonably priced multi-purpose meter at a radio-supply house. Such a meter will read resistance, voltage and current, and is usually quite satisfactory for the average man.

Small Tubes and Parts

The replacement of parts other than tubes can be simplified. Values of condensers and resistors are listed in the service bulletins. The major components in a receiver have distinguishing numbers which are not only listed in the service bulletins but usually stamped on the parts themselves. Replacements can be obtained directly from the manufacturer's service department or from his distributor in your own locality.

A wise precaution for the amateur to follow is to use a "direct" replacement for such a part. A direct replacement is one procured from the factory or made by some component part manufacturer so that it can be substituted for a defective part without any modification of the circuits in any way—electronically or physically. Many manufacturers have issued replacement guides to assist in the purchase of the proper component.

In replacing tubes, have on hand a supply of tubes which have been thoroughly tested. It is disconcerting to look for a defective tube in a receiver and not find it because the tube one is using for replacement is bad also. The best test is to try the replacement tubes in an operating receiver as they are purchased to make sure they are good. Even a tube tester is not infallible.

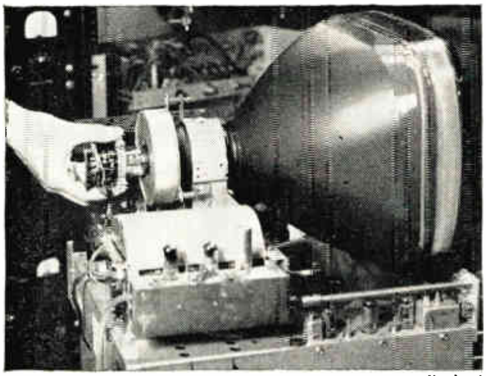
With a supply of replacement tubes on hand which are known to be good, a suspected tube in the receiver is removed and a good one put in. The receiver should always be turned off before doing this. Then turn the receiver back on and see if the trouble is cured. If not, leave the replacement tube in and go on to the next one. Continue this until the trouble is located. Then start at the first tube and put in the one which had originally been in the receiver. If the set still operates well, the replacement tube need not be substituted. Check the other tubes replaced in the same manner. This step is necessary inasmuch as more than one tube may be bad at one time. By replacing tubes singly and then reinserting the original it is not possible to cure the trouble in such a case.

The same principle holds true throughout any servicing. That is, bear in mind that more than one component may be defective. Usually a burned resistor will indicate a shorted by-pass condenser or a shorted tube, for example. In such a case it is not only necessary to replace the resistor but to locate the other defective part and replace it also.

The replacement of defective parts is relatively simple. Anyone should be capable of disconnecting leads and resoldering leads from a new component in the same manner as the old ones. The real trick is to know which part is defective. A logical approach and an ohmmeter will help considerably. Remember a good service technician is paid not so much for the labor involved but for his knowledge.

Replacing a Picture Tube

The replacement of a picture tube is a comparatively simple operation. There are no connections which must be unsoldered and remade. The widespread use of the rectangular tube has made it easy to mount. Careful attention to safety factors and care in making sure the new tube is installed in the same position as the old one are necessary. With the exception of the early 7-inch receivers, it is almost always necessary to remove the entire receiver from the cabinet in order to replace the picture tube. Some few models have removable front panels so that the replacement can be made by merely removing the panel and the



Rauland

Above, ion trap can be adjusted easily. Photo shows that only a portion of tube glows when ion trap is misadjusted. Right, picture tube should be left in original carton until it is to be installed

back cover. Still others have the picture tube mounted on a separate framework which can be removed, tube and all, by disconnecting the various cable leads to the focus coil, deflection yoke, the high-voltage lead and the tube socket. Whatever method is used, the procedure is the same.

Taking Out the Old Tube

When access to the picture tube is gained, disconnect the high-voltage lead to the second anode and discharge it to the chassis of the receiver. Secondly, discharge the coating on the tube itself. This removes any latent energy that can give you a shock which, if not harmful in itself, may cause the tube to be dropped with disastrous results from flying glass. Make a note of the position of the connection to the second anode on the tube in order that the replacement may be installed in the same position.

Next, pull off the socket at the base of the tube. There is a "key" on the socket which matches the one on the tube so that it cannot be put back on incorrectly. Note the position of the tube socket to aid in positioning the new tube. Next observe the position of the ion-trap magnet before removing it from the neck of the tube. Some ion traps are clamped around the neck of the tube with screw clamps, while others are held in place by means of spring clips. Whatever the method, they are all slid off the tube by pulling them over the tube base.

The picture tube itself can now be removed, since the focus coil and deflection yoke are held in position by their own mountings. The picture tube is held in place by mounting straps which encircle it at its strongest point—just in back of the face—and which are fastened in varying ways by different manufacturers.

Loosen the mounting straps and grasp the picture tube firmly at the front end. Never grasp this tube by the neck, which is very fragile and apt to snap off. Pull it forward and through the focus coil and deflection yoke.

Put the old tube carefully aside where it cannot be knocked or bumped in such a way as to break it. The very high vacuum inside the tube will cause a tremendous implosive action if the tube is broken, and if this occurs shattered glass can do material damage to anyone in the vicinity. For this reason you are advised to wear leather gloves and safety goggles when handling the picture tube. The gloves have another advantage when handling the new replacement: perspiration from the hands can cause internal arcing in the tube if allowed to dampen the coating on the outside of the tube "bell."

Putting in the New Tube

You are now ready to install the new tube, which should be kept in its carton until needed. This is an advisable precaution not only to prevent its being accidentally broken but also to prevent the face from being scratched and thus marring the picture.

Remove the new tube from the carton, handling it by the front end. Slip the neck of the tube from front to back through the deflection yoke and the focus coil. Do not force the tube through if it tends to bind. This may be caused by the fact that the focus coil has been tilted or twisted to obtain good focus on the old tube. Instead, loosen the focus coil and position it so the tube base slips through easily. The deflection yoke generally fits snugly, but not so tight that it binds. Push the tube well back against the yoke so that the metal clips that protrude from the yoke are making good contact with the bell of the tube.

If the new tube is a round one, make sure at this time that it is positioned the same as the old one by observing the markings you have made with respect to the second-anode connection. If it is rectangular, there is only one way to install it—with the second-anode connection on the same side of the chassis as that on the old tube. Put the holding straps in place and tighten them.

Some receivers have a ring of foam rubber around the tube at the front end. It is there to keep dust from gathering on the face of the tube and on the inside of the safety glass. If this rubber is held in place by the mounting straps, it should be placed around the tube and tightened after the tube is positioned. In some cases the rubber is held in place by glue. Procure a tube of rubber cement at a hardware or dime store to fasten it on the old tube. Other glue is perfectly all right, but the rubber cement will hold it firmly as soon as it is applied, whereas airplane glue and other adhesives take some time to set and must be held for awhile.

With the tube mounted, slip on the ion trap. If the trap has an arrow marking on it, the arrow points toward the face of the tube when properly installed. If it has two magnets, one large and one small, the smaller magnet should be closest to the screen. Having installed the magnet, connect the socket to the base of the tube. This is a keyed device which will go on only in one way. Now connect the high-voltage lead to the second anode.

While the tube is out of the cabinet the opportunity should be seized to clean off the inside of the safety-glass window. Also, make sure the face of the tube is clean and free from dust, fingerprints and the like before installing the receiver in the cabinet. A big thumbprint in the center of the screen is not nearly as pretty a view as some that are seen on television.

Having completed these steps, install the receiver in the cabinet and turn on the power. It is entirely possible that no light will appear on the face of the tube. This indicates misadjustment of the ion trap.

Adjustments

In positioning the ion trap, bear in mind that there are three types of picture tubes on the market. Tube one has no internal markings to show where the ion trap should be placed. In such cases, the ion trap should be moved back and forth along the neck of the tube while rotating it around the neck in all directions until the light appears. Continue to position the trap until the four corners of the raster appear. Then carefully move it back and forth until all segments of the picture are clear and well focused.

Tube two has two small metal flanges welded on the electron gun in the neck of the tube and visible through the glass. The ion trap should be placed over these flanges to start with and then carefully moved into the best position.

Tube three is a development of the Rauland Corporation which makes the adjustment of the ion trap quite a simple matter. As the illustration on page 126 shows, a portion of the internal structure has a glow when the ion trap is in an incorrect position. This operates in the following manner: the aperture of the first anode is coated with a fluorescent material. When the ion trap is misadjusted, the electron beam is incorrectly aligned and some of the electrons strike the fluorescent substance, causing a glow. If the trap is correctly adjusted, the beam does not strike the anode and there is no glow. Thus, in this type of tube, simply adjust the ion trap until the glow completely disappears or is at an absolute minimum. With the other two tube types it is necessary to watch the results of moving the ion trap by observing the picture as it is reflected in a mirror while one is working at the rear.

With the tube lighted and the ion trap adjusted for even focus, the next step is to check the picture for centering and tilt. If the picture is tilted, rotate the deflection yoke until the sides of the picture are parallel with the sides of the window and the top and bottom of the picture are parallel with the top and bottom of the window. Next, put the vertical and horizontal-centering controls at the center of their positions. If the picture is not properly centered, adjust the deflection yoke by twisting it slightly until the picture is centered. The object of putting the two centering controls in the center of their positions is to allow leeway on each side should the centering of the picture need adjustment again. With the picture tube properly adjusted for tilt and centering, tighten the deflection yoke in position.

The final step is adjustment of the focus by means of the focus coil. Again center the control involved—this time the focus control—and adjust the focus coil for perfect focus on all parts of the picture. Some focus coils are adjusted by a shaft which protrudes through the back cover. Other receivers vary the position of the focus coil by means of setscrews. Remember that the focus coil affects the electron beam, and can be so misadjusted that there are shadows which blot out the picture on various corners. With the neck components properly adjusted, wait for a period when a test pattern is available and check the linearity, width and height of the picture.

The remainder of this chapter is devoted to common television troubles, their causes and their cures.

Horizontal bars across screen (signaling loss of horizontal synchronization)

Causes—Misadjusted horizontal-hold control, misadjusted horizontal-oscillator transformer, defective horizontal-oscillator transformer, defective horizontal sync-circuit tubes, defective resistors or condensers in the circuits.

Cures—Readjust the horizontal-hold control.

Check tubes by substitution. The tubes which may be involved here are: the horizontal-oscillator tube, horizontal-sync clipper, horizontal-sync separator, horizontal discriminator, horizontal discharge or the AFC tube. Most receivers do not have all these tubes. The most common ones are: 6SN7, 12AU7, 6SL7, 6AL5, 12SN7, 12SL7.

Readjust the horizontal-oscillator transformer. This unit is on the main chassis of the receiver and can be located by reference to the service bulletin and sometimes by referring to the component-layout chart on the inside of the cabinet. This is the device by means of which the horizonal-sweep-circuit frequency is put in step with the pulses from the transmitter. It is generally "slug" tuned. Fig. 17 on page 122 locates the common type of horizontal-oscillator transformer. Notice that the threaded shaft which protrudes has a small screwdriver slot at the end. Turn this shaft slowly until the horizontal lines straighten out and the picture appears clear. This should be done with the horizontal-hold control centered, so that after the adjustment has been made on the transformer there is play on either side of the hold control. This is a primary control, and the play is needed for making small adjustments from time to time as the values of other parts undergo changes.

Replacement of resistors or condensers will require an ohmmeter for testing.

Horizontal overlapping (the picture folds over on itself from the sides)

Causes—Defect either in the horizontal-sweep circuits, damping circuits or possibly the sawtooth generator circuits. Slight change in values of components which may be compensated for by adjusting secondary controls.

Cures—Adjust horizontal-hold control. Adjust width or linearity controls. Make these adjustments very carefully as it is not too likely that they will cure this trouble. If they do not, return the controls to their original positions and go on to the next step.

Replace the damper tube. Commonly used damper tubes are the 5V4, 6W4 and 6AS7. A weak damper tube is the most common cause of horizontal overlapping.

If an ohmmeter is available, check the resistors and condensers in the damping circuit.

If the foldover is quite pronounced—both sides of the picture lapping over the center—check the tubes in the horizontal-sweep circuits. Most likely offenders are the horizontal discharge, horizontal output, horizontal-amplifier tubes. 12AU7, 6BD5, 6BQ6, 6BG6 are commonly used types.

Wrinkled edge on picture

Causes—Defective damping tube, defective deflection yoke or components in the deflection circuits.

Cures—Although it is very seldom that a defective damping tube will cause wrinkles, it should be tried first. Common types are 5V4, 6W4 and 6AS7.

The deflection yoke has a number of small components—resistors and condensers—mounted on it. Some of these may be at fault in this case and should be replaced.

The deflection yoke itself will sometimes cause wrinkles. Because there is small likelihood of these yokes going bad, it is not worth while to keep one on hand to check the old one by the substitution method. If an ohmmeter or other test instruments are readily available, resistances and voltages can be checked. The man handy with a soldering iron can replace the small components attached to the deflection yoke at small cost. For component values, refer to the service bulletin.

The amateur repairman can quite successfully replace components if he labels the wires so that they can be reconnected to the proper terminals and if he makes sure that all solder joints are firm and properly made. All power should be turned off and condensers and other danger spots discharged, of course, before proceeding with work of this sort.

Vertical line on screen

Causes—Failure in the horizontal-sweep circuits. (NOTE—This trouble occurs only on receivers whose horizontal-sweep circuits and high-voltage circuits operate independently.)

Cures—Check tubes in the horizontal-sweep circuits. Most likely offenders are the horizontal-oscillator and the horizontal-output or amplifier tubes (12AU7, 6SN7, 12SN7, 6BD5, 6BG6, 6BQ6).

Occasionally a receiver has a small fuse on the order of ¼-ampere in this circuit. If that opens, the result will be a vertical line. If the horizontal-deflection coil in the deflection yoke opens, there will be no horizontal control applied to the electron scanning beam. If an ohmmeter is available, this can be checked.

Narrow picture; cannot be widened to fill screen

Causes—Defect in the horizontal-sweep circuits or in the low-voltage power supply.

Cures—Although the apparently logical first step is to check the tubes in the horizontal circuits, this is one defect which does not quite conform to the logical way of servicing. The most common cause of a long, narrow picture is weakening of the low-voltage power-supply rectifier tube. As a general rule, the narrowing comes about rather gradually. The first step, then, is to substitute in the low-voltage power supply. The most common tube in this circuit is a 5U4G. 5V4G tubes are occasionally used, as well as two or more 5Y3 tubes.

If, after trying the low voltage rectifier tube, the picture still is too narrow and cannot be widened with the width control, substitute the horizontal-oscillator and amplifier tubes. The horizontal-output or amplifier tube is, incidentally, the most expensive one in the receiver excepting the picture tube. In replacing any of the tubes in the horizontal-sweep circuits, it should be borne in mind that it is almost always necessary to make a readjustment of the horizontal secondary controls—width, speed, frequency, hold and the like. These adjustments should not be made, of course, until the trouble has been cured. Generally speaking, the horizontal-oscillator transformer is that which will require the adjustment so that it can bring the horizontal-sweep frequency in step properly by taking into consideration the changed characteristics of a new tube.

Failure of certain other components will also cause a long, narrow picture. A shorted horizontal-deflection coil, shorted output transformer, and defective condensers and resistors are possible causes.

Scalloped edges on picture

Causes—Defective filtering in the sweep circuits.

Cures—This is a rather difficult trouble to cure without an ohmmeter. It usually occurs in the vertical circuit and indicates that a ripple from the 60-cycle components is getting through due to failure or leakage of a filter or by-pass condenser in the sweep circuits. Check the by-passes in the centering circuits and the filtering condensers in both sweep circuits. The same effect can be caused by defective filter condensers in the power supply.

Picture rolls vertically (loss of vertical sync)

Causes—Poorly adjusted vertical-hold control, defective tubes in vertical-sweep circuits, defective small components in vertical circuits.

Cures—Adjust vertical-hold control. This is best done by rotating the control until the picture moves downward very slowly. Then reverse the rotation to the point where the picture snaps back into a steady position.

Replace tubes in the vertical-sweep section. These include the vertical-synchronization tubes, both clippers and separators. Types used are 12AX7, 12AU7, 6SN7, 12SN7 and 6J5 tubes.

Failure to correct this defect either by adjustment of the hold control or substitution of tubes in these circuits is evidence of the failure of a condenser or resistor component.

Picture is split by vertical black line, with part of picture on each side

Causes—Defective horizontal discriminator or sweep circuits.

Cures—Adjust discriminator or oscillator transformers in horizontal-sweep circuits. As previously mentioned, these transformers are usually the slug-tuned type with a threaded screw for control.

This trouble may also be caused by a defective discriminator tube (6AL5).

Picture either too large or too small vertically

Causes — Vertical-sweep circuits, vertical-linearity and height controls, voltages to vertical circuits not proper.

Cures—Adjust height and vertical-linearity controls.

Replace vertical oscillator and/or amplifier tubes.

Check small components in this circuit.

Check voltages applied to vertical-oscillator and amplifier tubes to see if they meet the standards set by the manufacturer in his service bulletin. If not, the supply voltage should be traced back to the source to see where the trouble lies.

Horizontal line in center of screen (no vertical sweep)

Causes — Vertical-sweep circuits have developed failure.

Cures—Replace vertical-oscillator or amplifier tubes. The common ones used are 6AQ5, 6SN7, 12BH7, 12SL7, 12SN7, 6V6, 7C5.

Check the vertical-linearity and height controls by moving them slightly while observing the picture. These are usually carbon potentiometers, and over a period of time arcing can occur which will burn a small spot at the point of contact and break the circuit. If this does happen, it is sometimes possible to clean the offending component by pouring into it some carbon tetrachloride. At other times, slightly moving the control contact off the bad spot will bring back the vertical sweep with a slight sacrifice to height or linearity.

The best cure, of course, is to replace the control that has gone bad.

If tube replacement does not cure the trouble and the height and vertical-linearity controls are good, continuity should be checked with an ohmmeter on the vertical-blocking transformer, the vertical-oscillator transformer and the vertical-deflection coils in the deflection yoke. Open resistors and shorted condensers in the vertical-amplifier circuits can be at fault.

Picture split vertically

Causes—Improperly set vertical-hold control, or a defective component in circuit are the most common causes of this trouble.

Cures—Readjust the vertical-hold control.

Look for a defective tube in the vertical-sweep and sync circuits by substitution. It is unlikely that any of these will cause the difficulty, but it is possible and should be attempted as it's one of the easier things to do. Possible defective components are: vertical-oscillator transformer, resistors and condensers in the oscillator and amplifier circuits.

Picture jumps vertically, either up or down

Causes—Vertical-hold control set too critically, vertical-sync circuits not operating properly, poor filtering, interference entering through antenna.

Cures—Reset vertical-hold control. Picture should snap in position with a good, positive action. If not, trouble lies elsewhere.

PICTURE JUMPS VERTICALLY

Replace vertical-sync-circuit tubes—sync clipper, sync separator, etc. Checking the filtering usually incurs a fair amount of signal tracing to find where alternating current may be entering the circuit.

If the trouble is caused by interference which enters through the antenna system, as would be the case where ignition noises and other electrical interference is the cause, only two real cures are available—reorienting the antenna for minimum interference and replacing the lead-in with a coaxial or shielded type.

Occasionally, microphonic tubes will cause the picture to be jumpy. Tap the tubes in the vertical circuits lightly while watching the picture on the screen. If it jumps when any one tube is tapped, this is the trouble.

No picture, no sound; picture tube not lighted

Causes—Receiver not plugged into electrical outlet, power cord defective, safety-interlock switch not properly connected, fuse in receiver blown, power-transformer primary open, defective on-off switch, defective low-voltage-rectifier tube, open tube filament in a.c.-d.c. sets, short in set, etc. There are other causes possible for this trouble. Some can be very obscure.

Cures—Remove the receiver plug from the electrical outlet and test the outlet by plugging in a lamp to make sure none of the house fuses has gone bad.

Check the power cord for an obvious break. If an ohmmeter is available, check continuity by connecting it to the prongs on the power-cord plug. The line should read open—infinite resistance—with the power switch in the "off" position. In the "on" position, there should be a reading of some sort. Lack of a reading with the power switch turned to the "on" position indicates an open power cord, poor contacts or a defective safety-interlock switch, a defective "on-off" switch, an open primary in the power transformer or, possibly, some other open circuit among the most common of which would be the fuse. All possible troubles which can be checked without completely removing the chassis from the cabinet should be investigated. The interlock, the power cord and usually the fuse can be checked merely by removing the back of the set. Replace defective wire or switches.

Caution should be exercised if the fuse is found to be defective. Often a fuse will open because of age, a small surge in the power supply or for some other very temporary reason. However, it must be borne in mind that a fuse is a protective device and that the usual reason for its failure is that some circuit in the receiver has developed a short, thus drawing excessive current. If the fuse does not open but permits this condition to go on, it is quite possible that the continued operation of the receiver will cause one or more components to burn out, wires to burn and a great deal of damage to follow. Therefore, whenever a fuse has gone bad, do *not* short it out by wrapping tinfoil around it or jumping the contacts with a piece of wire. Replace it with a fuse of the same value. This is a simple matter. Fuses are most commonly of the "pigtail" type, that is, a small glass tube, metal-capped at each end and with a wire lead soldered to the metal cap. Small "snap-on" devices are available on the market which can be snapped on the fuse in the circuit and another good fuse snapped on the back of the device. The photos on page 119 show how this is done. Whenever a new fuse is needed, it is a simple matter to snap it into the snap-on fuse holder.

A less commonly used method of connecting a fuse into a circuit is by use of the "fuse-extractor post." This is more expensive for the manufacturer, entailing an additional component besides the labor of installing it. However, some receivers do have such posts, generally at the rear of a chassis. Replacement of a fuse in this case is done by simply unscrewing the cap, removing the fuse and inserting a new one. As always, care should be exercised to replace with the proper-sized fuse.

"Slo-Blow" fuses are often found. A "Slo-Blow" fuse is one which will not open immediately with a slight current surge or build-up such as occurs in filter condensers, but opens only after the rating has been exceeded for a short period of time. Thus the nuisance of changing fuses constantly because of small surges is alleviated and the temptation to insert fuses of higher value to reduce the number of blowouts is removed.

The procedure to follow in replacement of a defective fuse is simple but should be adhered to rigidly. Insert the fuse of the proper value. Turn on the receiver and watch very closely for any sign of arcing, smoke, smell of burning, odd streaks on the screen of the tube or other indications of trouble. If these do occur, turn the power off immediately. The indications given show that the fuse went out in its capacity as a safety device and not because of some trouble within itself.

Perhaps the most common cause of a dead receiver is failure of the low-voltage rectifier tube. If inspection shows the filaments of the tubes to be lighted but there is no sound, picture or raster, the first culprit to suspect is the low-voltage rectifier. This supplies B-plus voltage in almost all receivers except a very few with a special power supply. Check this tube then by inserting a known good one. Rectifiers are 5U4G, 5V4G, 6X5, 5Y3, 7X6, 25Z5, etc. Note that the letter following the first digit in rectifier tubes is usually one from the last part of the alphabet. Remember that some receivers use more than one low-voltage rectifier tube, in particular those with 5Y3 tubes.

In some types of a.c.-d.c. television receivers, where the tube filaments are in series, failure of the filament of one tube will cause the whole receiver to become inoperative just as failure of one light in the old-fashioned Christmas-tree series circuits would cause a whole string to go out. If the pins on the tube base to which the filament leads are connected are known, each tube can be tested for this defect with an ohmmeter. Otherwise, find the difficulty by substitution or by removing the tubes and having them tested.

Replacement of a defective on-off switch, a defective power transformer, an open circuit in the receiver or similar troubles is too difficult for the average person to undertake unless he is positive where the trouble is. Open transformers and defective switches are best found by checking continuity. They should be replaced with a manufacturer's replacement or by a standard type. In some cases, a transformer which is proper for the job cannot be mounted without drilling new mounting holes in the chassis. If tools are available, this is not difficult to do and often quite feasible in that it enables a "stronger" unit to be used in replacement than was originally installed.

Vertical overlap

Causes—Defective vertical-deflection yoke, defective vertical-oscillator, vertical-amplifier or output tubes. Misadjusted height or vertical linearity.

Cures—Substitute—one by one—for the tubes mentioned as possible causes.

Check the adjustment of the vertical-linearity and height controls. Trouble of this sort is often caused by an attempt on the part of juvenile members of the family to "fix the television set."

Deflection yokes have several small components—resistors and condensers—mounted inside the cardboard casing. If the foregoing cures are ineffective, it is advisable to remove the yoke and check these components with an ohmmeter. It may not be possible for the amateur to identify which is the horizontal and which the vertical section by tracing the leads. To find out quickly, disconnect the yoke and measure the coil resistances, which are given in the service bulletin. If the resistance measurements of the wire that compose the coils match those given in the bulletin, the coil itself is all right. To check the small components themselves, one end of each should be disconnected, otherwise the readings may be inexact.

Top and bottom of picture out of proportion

Causes—Linearity and height controls misadjusted, defective vertical-amplifier tube, defective components in the vertical-oscillator and vertical-amplifier circuits.

Cures—Readjust the vertical-linearity and height controls. Replace the vertical-amplifier tube—6SN7, 6AQ5, 6J5, 12AT7. Check small components with an ohmmeter.

TOP AND BOTTOM OF PICTURE OUT OF PROPORTION

No picture, no sound; picture tube is lighted

Causes—Reasoning will show that in this case the high voltage is operating, the receiver is getting power and the trouble must lie in some section which carries or in some way controls both the audio and picture signals. The fault could be in the antenna or its lead-in, the tuner, or, in receivers using the intercarrier system, the intermediate-frequency amplifier circuits.

Cures—Check the antenna system for a break in any of the connections either at the antenna itself or along the lead-in or at the point at which it is connected to the receiver. If a folded-dipole antenna is used, the lead-in and antenna can be checked by connecting an ohmmeter across the conductors at the receiver end without going on the roof. If continuity shows, the trouble lies elsewhere. Indoor antennas are highly suspect as they are handled so much that leads are more often broken.

Check the tubes in the tuner by substitution. The most likely offender is the oscillator tube. Tubes used in tuners are 6J6, 6AG5, 6AK5, 6BC5 and 6BC6. It is possible in some types of tuners that the switch mechanism has become defective and no contact is being made when the knob is turned. This is rare, however. Repairs on tuners are quite critical, and a new one is recommended.

Check the tubes in the intermediate-frequency amplifiers. This applies to the intercarrier-type receivers where the sound and picture signals follow along the same path to the detector tube. Common tubes are 6AU6, 6BA6, 6AC7 and 6CB6.

Open resistors, open coils, open or shorted condensers and the like can cause this trouble. Simple tube failure or a break in the antenna lead is the cause in almost all cases, however.

Sound but no picture; tube lights

Causes—The trouble must lie in a circuit which affects only the video signal. This could be the video i.f. circuits, the video detector or the video output. One further cause is possible. Occasionally, a "screwdriver" mechanic will attempt to better his picture by adjusting i.f. transformers or some tuner components. If the picture is lost because of this there is no recourse but to call the serviceman and let him take the receiver to his shop for a complete realignment.

Cures—Replace the tubes in the video i.f. circuits. These are 6AU6, 6BA6, 6AQ5, 6AC7, 6AL5, 6AG5.

Replace the video-detector tube—6AL5, 12AU7.

Replace video-output tubes—12AU7, 12SN7, 25L6, 6AC7, 6AL6, 6V6.

Open coils, resistors, etc., are found by using test instruments.

Sound but no picture; tube does not light

Causes—The failure must lie in a circuit which lights the picture tubes or controls the electron beam or video output. Therefore, the possibilities are the picture tube itself, the high-voltage power supply, the horizontal-sweep circuits and the vertical-sweep circuits or the video-output circuits.

Cures—Check the picture tube and make sure the filament is lighted. This is seen by looking inside the neck of the tube after removing the back cover. If the filaments are not lighted, either the transformer which supplies the voltage has become defective, a socket or connector between that source of power and the picture tube has lost contact or the tube itself is bad. If a voltmeter is available, the output of the kinescope filament transformer can be checked. If the transformer is defective, replacement should be made in the usual manner. Sockets and connectors are easily checked to make sure they are not loose or that a lead is not broken. In some picture tubes, it has been found that the filament wires are not properly connected to the pins on the tube base. If this is the case, the tube is defective and should be repaired or replaced by the dealer, distributor or manufacturer under the terms of the warranty. If the sockets, connectors, transformers, etc., are good, and the filaments do not light, the inference to be made is that the picture tube is defective and should be replaced.

If the high-voltage power supply is defective, there will be no light on the picture tube. Perhaps this is the most common failure in television receivers and in the majority of cases it is due to a simple tube failure. The presence of sound indicates that the low-voltage power supply is functioning properly. Therefore, only those tubes directly affecting the high voltage need be tested. As most receivers use the flyback or kickback high-voltage system, the failure of the horizontal-oscillator tube which provides the triggering impulses will cause the high voltage to go out. Check by substitution. The common tubes are 6SN7, 6SL7, 6AL5, 12SN7, 12BH7, 12AU7. Next, substitute the horizontal output or amplifier tubes—6BG6, 6BQ6, 6CD6—and the high-voltage rectifier tubes—1X2, 1B3, 2X2, 2V3. Occasionally, high-voltage power supplies are independent of the other portions of the receiver in which case all tubes in the supply are potential offenders.

Caution! In making substitutions in the high-voltage supply, be sure the power cord is disconnected and all discharge precautions are carefully observed. Replacement of other components in the high-voltage power supply are made in the usual manner.

Check the tubes in the video-output circuit.

Check the ion trap. There are times when a receiver is jarred so badly that the ion trap becomes misadjusted. This can be determined by adjusting it in the manner described previously under the heading, "Replacing a Picture Tube."

Adjust the brightness and contrast controls. If these are defective they can cause the trouble cited. However, such a cause is most uncommon. More common, oddly enough, is the fact that some people fail to turn up their brightness controls and call a serviceman to repair a nonexistent defect.

Picture but no sound

Causes—Defect must lie in those circuits which carry only the audio signal. These are the audio i.f., audio detector or discriminator, audio amplifiers and speaker.

Cures—Check the speaker cable and plug to make sure that contact has not become broken. This sometimes happens during a housecleaning period when a mop or broom is pushed under a console television receiver.

Check the audio-output tubes first—6V6, 6K6, 6F6, 6L6, 25L6, 7C5—then the audio-amplifier tubes, which can be the same types plus 6SQ7, 6SJ7, 12SQ7, 12AT6, and then the detector or discriminator tube. Audio-detector tubes are many and varied, but the 6AL5 is the most popular in the TV sound system.

If the defect is not uncovered at this point, the next step is to try the audio i.f. tubes. Receivers using the intercarrier method of sound detection and amplification will as a rule have only one i.f. tube in the audio system—a 6AU6, 6BA6, 6SK7, 6SJ7, etc. Those in which the sound and video signals follow separate paths have more.

If the replacement of tubes has no curative effect, the speaker can be checked. This is a most unusual difficulty and shows up generally in a gradual manner. Because of the necessity of matching impedances and the fact that some receivers use permanent magnets whereas others are the dynamic type, it is not too practical to check by substituting the speaker from another receiver—radio or TV. The simplest check is to apply an ohmmeter to the voice-coil leads of the speaker. If there is continuity or the speaker diaphragm or cone moves with a slight click as the leads are applied, then the speaker itself is not the cause of the trouble. If an ohmmeter is not available, applying an ordinary 1½-volt flashlight battery to the leads also will cause it to click and move. The leads can be identified easily in most cases. Many sets have only the two leads going directly to the voice coil from the chassis. Others may have several, some of which go to a transformer or a choke mounted on the speaker casing. The voice-coil leads can be identified by observing which are attached to the cone of the speaker itself.

The sound section of a TV receiver is very much like a regular radio receiver. The major difference lies in the fact that certain circuits of a television receiver—notably the tuner—carry both sound and picture signals. Besides the possible causes listed as trouble sources, defective transformers, coils, condensers, resistors and controls also can result in loss of sound. Trouble shooting in the audio is, therefore, to be carried on as it would be in a radio, always bearing in mind that when the set is turned on there is high voltage in the video circuits which should be avoided with care. Anyone with a knowledge of radio repair should have no difficulty servicing the sound section of a TV receiver.

Sound is distorted

Causes—Defective tubes, defective components, improper alignment, rubbing voice coil in speaker, torn speaker cone, misaligned detector transformer.

Cures—The same cures as those tried for lack of sound should be tried in this case. Tube replacement is less likely to correct the trouble but should be attempted. Inspect the speaker for a torn cone. If the cone is torn, it frequently can be repaired by patching it with stiff paper similar to construction paper and cementing the patch with airplane glue. This, of course, is possible only if the tear is relatively small. A rubbing voice coil indicates complete replacement or having a professional put in a new cone. Rubbing can be checked by removing the speaker and gently pushing the cone in and out with the finger tips, taking care not to tear or punch the cone. The cone should move freely with no apparent friction.

Alignment of any sort should not be attempted without proper test equipment such as a signal generator, output meter, oscilloscope, etc., as well as a knowledge of just what one is doing.

Shorted or leaky condensers, defective resistors and the like are found with test instruments.

Hum; otherwise sound and picture are good

Causes — Noisy tube, misalignment, sound traps misadjusted.

Cures—Except for checking the tubes, there is little the layman may do in this case. Misalignment is only to be corrected with proper equipment. Faulty settings of sound traps are, generally speaking, jobs for the serviceman. And, as is usual, the trouble can be caused by a faulty by-pass or filter condenser which will require test instruments to find.

Sound is weak

Causes — Same as in "Sound is distorted." Open condensers, changed value resistors and weak tubes are the most common causes of weak sound.

Cures—Same as for distorted sound. It is also possible that the low voltage being supplied to the audio circuits is deficient. If the picture is excellent but sound is weak and the cause is poor voltage, the circuit must be traced out to locate the seat of the trouble.

Poor alignment can be determined by adjusting the position of the fine-tuning control. If good clear sound can be obtained at any point regardless of the picture quality, then misalignment is indicated. The indicated procedure is to call a serviceman, but in some receivers an adjustment of the oscillator "slug" in the tuner will rectify the trouble. Such cases are rare and are most often found when the oscillator tube has been replaced. To adjust, gain access to the oscillator adjustments on the tuner either through the front panel as provided for in some receivers or by removing the receiver from the chassis. Make all adjustments with an insulated alignment tool since the metal in an ordinary screwdriver affects the circuit.

Picture is "smeared"

Causes—Fault lies generally in the video-i.f. or video-amplifier circuits. It is necessary to amplify all portions of a video signal equally and, in order to do so, circuits composed of certain small

PICTURE IS SMEARED

components are designed. Any defective part in these integrating and compensating networks can cause smearing. Occasionally, one of the video tubes will become slightly defective and give the same results.

Cures—Check by substitution the video tubes.

Further attempts to correct this trouble should be made only by qualified service people.

Part of picture in shadow or is cut off entirely

Cause—Misadjustment of the focus coil or the ion trap.

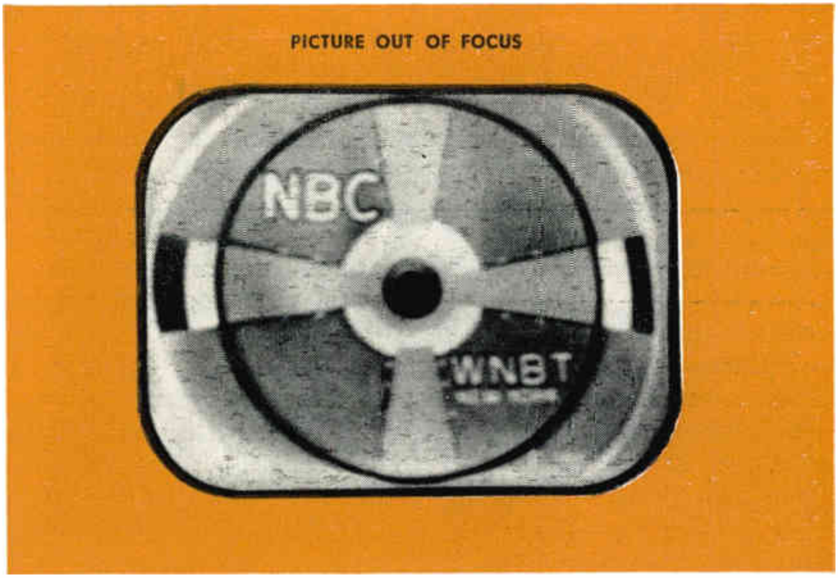
Cure—Readjust the focus coil and ion trap. Remember that the focus coil is an electronic lens. If it is not focused properly the electron beam will not be swept across the face of the screen in the proper manner but will be emphasized on some spots and not on others. Thus, a shadow or shadows will result. It may be necessary not only to move the focus coil back and forth but also to tilt it up and down or sideways. The ion trap is a likely offender.

Picture is tilted

Cause—Misadjusted deflection yoke.

Cure—Adjust deflection yoke as described under "Picture not centered." Be careful to tighten the holding screws after the adjustments are made to prevent the yoke from slipping again should the receiver be jarred. Some accident like this caused the trouble in the first place.

PICTURE IS TILTED



Picture out of focus

Causes—Focus control misadjusted, focus coil misadjusted, focus control or focus coil completely or partially shorted, ion trap misadjusted.

Cures—Readjust focus control. Occasionally, it will seem that the focus control adjustment will almost—but not quite—focus the picture. If that is the case, the focus control should be set at the center point of its rotation. Then, readjust the focus coil, which is located around the neck of the picture tube. To adjust the focus coil, it will generally be necessary to loosen the set screws which hold it in position. Carefully move it back and forth or tilt it as seems necessary to (1) focus the picture all across the screen and, (2) make sure there are no dark shadows on the screen. Some receivers have no variable focus control at the rear of the chassis or on the front panel. This type requires that all focusing be done by the focus coil, either by manipulating it manually with the back off or by means of a shaft which protrudes through the back cover.

If adjustment of the focus control has no effect, the implication is that the control itself is shorted and should be replaced. Also, resistors shunted across the control may be shorted. A shorted—either partially or complete—focus coil is best determined by using an ohmmeter. In testing the resistance of the coil, disconnect one of the leads so that the resistance of the coil only is being read.

A slight misadjustment of the ion trap will often defocus a picture. Move it in the prescribed manner to determine if this is the cause.

Occasionally, a defective picture tube is indicated by the inability to focus the picture. This is decidedly the exception rather than the rule.

Picture not centered either horizontally or vertically

Causes—Centering controls misadjusted, deflection yoke misadjusted, centering controls shorted, ion trap misadjusted.

Cures—Adjust centering controls. If they fail to bring the picture to center, but do have an effect on the positioning of the picture, the control itself is not defective but a misadjustment of the deflection yoke is indicated. To adjust the deflection yoke, loosen the holding screws that hold it in the bracket and move it slightly until the picture is centered. Be careful to keep the yoke well forward and pushed against the bell of the picture tube.

If adjustments made with the centering controls fail to move the picture at all, the control itself quite probably is shorted or the associated components in the centering circuit are defective —generally a shorted condenser will be to blame.

Misadjustment of the ion trap occasionally results in improper centering.

Insufficient brightness

Causes—Ion trap not set properly, picture tube defective, defective brightness control, wrong voltages supplied from power supplies.

Cures—First rotate the brightness control with the contrast turned down low. If there is no apparent change in brightness the indication is that the brightness control is defective and should be replaced.

Readjust the ion trap. This may be necessary particularly after a set has been jarred or moved.

Replace the high-voltage rectifier tube—1X2, 2X2, 1B3 or 2V2. Replace the horizontal-amplifier or output tube—6BG6, 6BQ6, 6CD6. Replace the horizontal-oscillator tube—6SN7, 6SL7, 6AL5, 12AU7, 12SN7, etc. These tubes are all part of the high-voltage supply. Obviously, a picture not bright enough can mean that insufficient high voltage is being provided, and a weak tube in the high-voltage power supply can bring about that result. Replacement of the horizontal-oscillator tube often means a readjustment of the horizontal-oscillator transformer will be necessary.

If the rectifier tube—5U4, 5V4, 5Y3, 25Z6, etc.—is weak, it is possible to have good sound and still not have a bright picture as this tube supplies voltages to the horizontal oscillator. It likewise should be checked.

Replacement of the high-voltage, or flyback, transformer is sometimes necessary.

Because of the expense involved, the picture tube is usually the last item to be checked. Unless the picture has been growing dimmer gradually, there is not too much reason to suspect the picture tube itself as being the seat of trouble. The only satisfactory check to be made for a defective picture tube is direct substitution, and a picture tube is a rather expensive item to keep on hand or to purchase should the kinescope be suspected. Having picture tubes on hand for substitution checks is an advantage the professional serviceman has over the amateur.

Picture is weak, contrast values are poor

Causes—Antenna system partially shorted or connections broken, weak r.f. tube, defective video i.f. or video-amplifier tubes, defective video-detector tube, misalignment of the i.f. or video-amplifier circuits, poor signal from station.

Cures—Make certain the trouble applies to all stations by tuning each one in. If all but one are good, the inference is that the poor station has had its signal affected temporarily.

PICTURE IS WEAK, CONTRAST VALUES ARE POOR

Replace the r.f. tube—6J6, 6AK5, 6AG5, 6BC5, 6BC6.

Replace video i.f. tubes—6AU6, 6BA6, 6CB6.

Replace video-amplifier tubes—6SJ7, 12AU7, 6AG5, 6V6, 6SN7.

Replace video-detector tube—6AL5, 12AU7, 6SN7, 12SN7.

Check the antenna system from the antenna down to the connections at the receiver. Often, antennas which are mounted on chimneys gather a tremendous amount of soot and oil waste which is very detrimental to efficiency. This should be cleaned off.

Uneven shading on picture

Causes— Most common one is man-made, that is, a misadjustment of the contrast control. A d.c. restorer tube or circuit may be defective.

Cures—Adjust the contrast control when a test pattern is available to make sure the shading of the concentric rings is even and regularly graduated.

If contrast-control adjustments are ineffective, replace the d.c. restorer tube—6AL5, 12AU7—or check the last video-amplifier tube.

Picture appears "snowy"

Causes—Receiver location in a fringe area where signal is weak, antenna system not sensitive enough or not properly connected, weak amplifier tubes, particularly r.f. amplifier tube in tuner, poor alignment.

Cures—Check the antenna system. First make sure that all the leads are properly connected and that the lead-in is held in position away from gutters, etc., by stand-off insulators. Check the orientation of the antenna to make sure it is aimed at the point from which the greatest signal strength comes. Also, if the receiver is in the fringe area, be sure that the antenna used is the one which has the maximum pickup for the frequencies on which the desired stations are operating. An efficient antenna is a must in the fringe area, but even one coupled with a booster will not entirely rid the picture of snow.

Check the amplifying tubes. Just as there are various degrees of strength among healthy people, so will tubes of the same types vary in amplifying ability although all check good. When purchasing a supply of tubes to keep on hand, it is worth while asking the dealer to test several and choose those which have the highest amplification factor for the video i.f. amplifier circuits. You will probably have to pay for this service—and rightly so—but it is worth it to fringe-area dwellers.

If stronger tubes, good antennas and proper orientation do not correct a snowy picture and receivers of the same make and model in the same locality do have good pictures, take the receiver to a serviceman and have him completely realign it and check it thoroughly for good solid connections.

Poor deail; picture not clear and sharp

Causes—Poor alignment, misadjusted fine-tuning control, occasionally, but seldom, defective components.

Cures—First make sure that the cause is not misadjustment of the fine-tuning control by tuning in a station with the test pattern on. If unable to adjust the fine-tuning control so that the lines in the vertical wedges are sharp, clear and not merged until they reach the center of the pattern, then the assumption is poor alignment. This is a job for the serviceman.

Picture "blooms," or appears too large

Causes — Defective high-voltage power supply, defective picture tube.

Cures—Check the tubes in the high-voltage power supply, particularly the rectifier—1B3, 1X2, 2V3.

Defective small components in the high-voltage power supply. To be checked with instruments.

Defective picture tube. Check by substitution.

Negative picture (black shows as white and vice-versa)

Causes—Defective picture tube, defective video circuits, overloaded power circuit.

Cures—Check the picture tube. This is often an indication of a defective picture tube.

Check the video amplifier and video i.f. tubes—6AU6, 6BA6, 6AG5, 6CB6, 6SJ7, 6SN7.

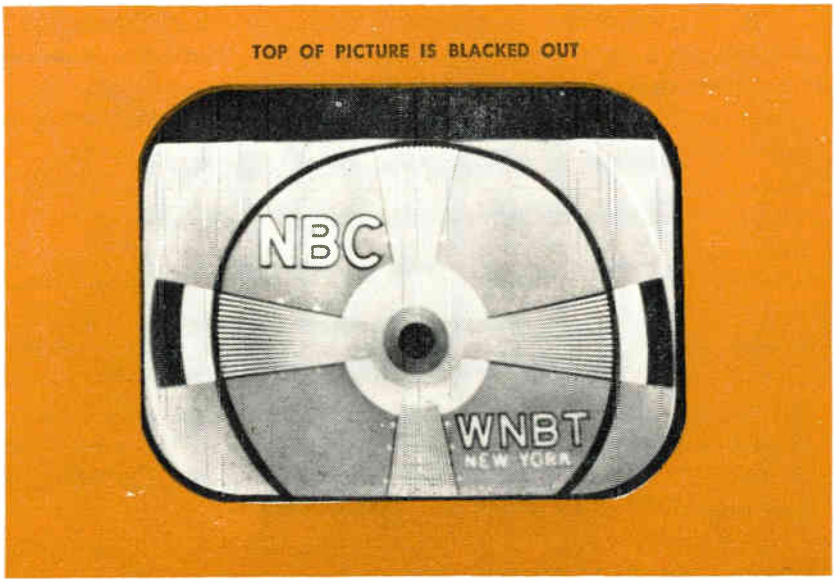
Check the video-detector tube—6AL5, 12AU7, 6H6, 6SN7.

Components in any of the video circuits can be suspected in this trouble. Usually, however, the difficulty may lie in a phase-shifting network, crystal diode or some hard-to-find component.

Ghost images on picture

Causes—Reflections from external surfaces to antenna or mismatched impedances in the transmission line.

Cures—See the chapter, "Erecting the Antenna." This gives a careful discussion of all the factors which can lead to "ghosts" on the picture.



Top or bottom of picture is blacked out

Causes—Defective low-voltage power supply, horizontal-sync circuits defective, clipper circuits defective. (Usually accompanied by a wavy action of the picture.) Defective vertical-sync circuits.

Cures—Replace tubes in horizontal-sync circuits—6SN7, 6AL5, 12AU7, 12SN7.

Replace tubes in vertical-sync circuits—same as above.

Check sync-separator tubes—12AU7, 12SN7, 6SN7, 6AL5.

Check tubes in vertical-sync circuits, particularly if the picture is blanked out in the top half and the flyback-retrace lines are visible. In almost all cases when part of the picture is blacked out the fault lies in either the sync or clipper circuits and is specifically a defective tube.

Occasionally a defective filter condenser which will allow an alternating current ripple to pass will have the same effect. Therefore, if tubes are not to blame, filter condensers that apply particularly to the sync and video circuits should be suspected.

Picture very dark and dull; brightness control operating

Causes — Defective high-voltage power supply, misadjustment of the ion trap, defect in the d.c. restorer circuit, defective picture tube.

Cures—Adjust the ion trap for best position.

Check the tubes in the high-voltage power supply.

Check the d.c. restorer tube, if any.

Check the picture tube by substitution.

The most common causes of this trouble are a maladjusted ion trap and/or a defective picture tube. As it is unlikely that the ion trap will become misadjusted unless the receiver is jarred, the picture tube itself must be held up as the probable cause.

White lines appear on picture

Causes — Brightness control turned too high, d.c. restorer circuit defective, low-voltage-to-picture-tube components improper, defective condenser in video-amplifier section, defective video-amplifier tube, vertical deflection critically set.

Cures—Readjust the brightness control. Too much brightness will make the retrace lines visible. Back it off till the lines are blanked out.

Check the d.c. restorer tube by substitution. If no tube is used in this circuit, then the various components must be checked with test instruments.

Check the setting of the vertical-hold control. Occasionally, if these controls are set just at the point where the "rolling action" stops, the retrace lines will appear. Rotate the control until the picture is firmly locked in position.

Check the video-amplifier tubes by substitution. There is a possibility that a defective tube in these circuits may be causing the trouble. A leaky condenser in these circuits can also be the cause.

Check the components in the video-amplifier section.

If the picture is weak and the sound not too good, replace the low-voltage rectifier tube—5U4, 5V4, etc. This should bring up both the sound and picture and erase the lines. If it does not, suspect some other component in the low-voltage power supply.

Black bar of varying width across center of picture

Cause—This indicates the "60-cycle hum" is present in the video circuits. The usual 60-cycle alternating current which supplies power to the receiver is rectified and filtered. This keeps a varying voltage from being applied to the wrong places. Therefore, if it appears on the picture, some filtering component is defective.

Cures—Check the filter condensers in the high and low-voltage power supplies. If the sound is free from hum at the same time that the bar appears on the screen, the indication is that the low-voltage power supply is functioning properly and the trouble is most likely in the high-voltage power supply.

Check the filter condensers and the high-voltage condensers in the sweep circuits.

Check the filter condensers in the video amplifiers.

Picture fades in and out

Causes—Virtually all receivers have an automatic gain-control circuit, called AGC, whose purpose is to compensate for slight variations in signal strength and thus maintain an even picture. If the picture fades in and out, therefore, either this circuit is defective or the variations in signal strength are too great for the AGC to compensate. Causes, therefore, could be a defective AGC tube, a defective component in the AGC circuit, a loose antenna which sways in the wind, airplanes that interfere with or reflect the signal, or a defective video-detector tube, which often provides the AGC voltage.

Cures—Check the antenna system. Make sure that the mast is firm and steady. See that guy wires are taut. Inspect the lead-in to make certain that it is not loose and flapping. Check the lead-in for frayed spots and good connections at the antenna.

Substitute the AGC tube, if any—6AU6, 6AG5.

Check the video-detector tube—6H6, 6AL5, 12AU7.

Check for loose connections in the video circuits, particularly at the antenna input, the r.f. amplifiers and the tuner.

A defective filter condenser in the AGC circuit will cause this trouble also.

Purple or brown spots

Cause—Defective picture tube. It is on the way to a complete failure.

Cure—Replacing the picture tube is the only remedy for this condition. Complete instructions for making a picture-tube replacement yourself have been given earlier in this chapter. Follow them step-by-step for a safe and satisfactory replacement.

Intermittent performance of either sound or picture

Causes—An "intermittent," in the professional repairman's vocabulary, is a defect which occurs only occasionally—sometimes lasting for a few seconds—and is caused by loose elements in a tube, loose wires, defects in condensers, resistors or coils and the like. This trouble is often very difficult to find.

Cures—To locate a suspected intermittent tube, tap each one lightly with a rubber mallet or the eraser end of a pencil. Tap other suspected components with the end of an insulated screwdriver or some similar light object. Be careful not to use conducting metal when the set is turned on, as it must be when trying to locate an intermittent. Also, be careful not to place a screwdriver shaft or any conducting material across leads in such a manner that they are shorted together. Do not ground any lead to the chassis unless you know what you are doing.

Carefully inspect solder connections. Occasionally a joint is not soldered at all in the manufacturing process. "Rosin" joints are suspect. This are connections where the soldering job has been done improperly so that only a coating of rosin is present instead of a firm joint of solder. These can be determined by turning off the receiver, grasping leads firmly with a pair of long-nosed pliers and gently wiggling them. Care must be exercised so as not to break the lead or the lug to which it is connected.

Another cause of intermittent operation—the defective condenser, resistor, etc.—is more difficult to cure. To find a component that acts properly some of the time and improperly the rest of the time is extremely difficult. Trouble of this sort is the type that makes it necessary for your serviceman to keep your receiver for a long period of time. He cannot cure a trouble that doesn't show up long enough for him to find it any more than you can. It should be realized that the intermittent trouble is one which may be extremely simple to find or extremely difficult. If vibrations of any sort, such as those brought about by walking across a room, will cause the receiver to act intermittently, it is likely that something in the receiver is loose or a tube has a defect. This type of trouble can usually be located readily. If, however, the trouble is one which comes and goes as the set is or isn't warmed up, or appears and disappears for no reason at all, the trouble is more obscure and may require treatment in a service shop.

Noisy volume control

Causes—Dirt or worn spots.

Cures—Wash the control by pouring carbon tetrachloride on it from an oil can or with a medicine dropper as it is being rotated. This will wash most of the dirt out.

If washing the control still does not correct the trouble, and particularly if the sound is distorted or dead at one setting of the control, it should be replaced. This is done in the usual manner by ordering the direct replacement part. In making the replacement, the receiver must be removed from the cabinet. Unscrew the nut which holds the control in place, label the wires or draw a picture showing which color lead goes to the various solder points, disconnect the old volume control and install the new one. This is a simple job, easily performed. The control will cost from $1.25 to $1.75, approximately, whereas paying a serviceman to do the work will cost from $5.00 to $10.00.

Electronic interference

Causes—Diathermy, automobile ignitions, electrical equipment, other television receivers, amateur radio operators, internal—such as misaligned sound traps.

Cures—Interference cures can best be discussed generally. Interference shows up in various forms—noise in the sound system, horizontal bars from FM interference, loss of vertical synchronization, a curlycued band across the screen caused by diathermy, flashes of light from ignition, flutter by airplanes, moving black dots across the screen, herringbone lines from other television receivers and the like. Internally, if the sound traps are not properly aligned within the receiver, the energy of the sound signal will "leak" through to the picture circuits. This trouble is easily identified, since the interference form will appear in synchronization with the sound as it is spoken or played. The cure for this is a realignment by a serviceman.

If FM interference is suspected, try to tune in the FM station by adjusting the fine tuning control. If the FM station is heard when the volume control is turned up, the simplest cure is to adjust the FM trap on the tuner. This trap is usually a combination of condensers and coils at the antenna input to the receiver and can be located by following the antenna lead to the point where it connects with the receiver. Some service bulletins definitely locate the trap and make it easy to find. The interference is eliminated by adjusting the screw shaft on the coil until the FM sound and interference disappear. This is an adjustment that must be carefully made while watching the picture to make sure that its tuning is not disturbed. It will not be possible to locate an FM trap on many tuners; in that case call the serviceman.

Interference from other television receivers is best cured by relocating and reorienting the antenna. It is caused by radiated signals from the oscillator of a nearby receiver, by reradiated signals from a neighboring antenna, radiation from nearby objects and the like. The best cure is to make sure the antenna installed is equipped with a reflector and director to sharpen the directivity of its "aim" and to locate it as high as possible.

ELECTRONIC INTERFERENCE

Interference from ignitions is best cured by locating the antenna as far away from the street as possible and not running the lead-in in such a way that it will pick up the noise. Should this not be sufficient to cure the trouble, use a shielded lead-in for the antenna. Shielded lead-in consists of the conventional two conductors enclosed in a metal shield. The shield is connected to the chassis of the receiver while the two conductors are connected in the usual way to the antenna terminals. The shield is best connected to the chassis through a .01-mfd. condenser and can also be connected to a good ground. The final effort to be made in reducing ignition interference is to install a filter specifically made for the purpose. If the interference is caused by electrical equipment, the first step is to clean the unit to minimize arcing. If there is no condenser connected across the brushes on a motor, one should be installed. This again is a .01-mfd. condenser. Installing a filter in the power-line input to the television receiver will often cure the trouble. These are obtained at radio-supply houses, where they are known as "power-line filters."

Filtering of the power line and reorienting or relocating the antenna are the only possible cures for correcting diathermy interference. If neither remedy does the job, the only hope is to be patient and await the day when the offending physician finds it necessary to discard his old diathermy machine and purchase a new one which is properly isolated and shielded to prevent radiation and power noise.

Interference from a radio-amateur's station may be very hard to cure and at the same time can be one of the easiest. It may entail shielding part of the television receiver and it may entail shielding the whole cabinet. The easy part of the cure lies in the fact that radio amateurs as a group are well-informed on the subject of radio and interference and are generally more concerned by the fact that they may be interfering with your TV picture than you are. These amateurs do fine work, perform national services and are to be encouraged rather than castigated. If amateur interference is noticed, therefore, locate an amateur in your neighborhood, call him up and tell him your troubles. In practically all cases he will help you locate the offending transmitter and see that steps are taken to correct the trouble. If the offender is not a radio amateur but one of the many government and commercial transmitters, the "ham" will help to identify the frequency of the signal and advise you on the type of filter to install. Treat him well; he can be a good friend to you in your TV problems.

Offending electrical devices in the home can be easily located by noting whether the refrigerator, sewing machine, furnace, or the like causes interference when it goes on. Correct it by making sure each motor has been properly cleaned and that the contacts at the brushes are not arcing.

Arcing in the receiver, evidenced by crackle or buzz

Causes—Short in a high-voltage lead, loose connection, improper shielding of high-voltage points.

Cures—Watch the high-voltage section of the receiver while it is in operation. If the room is dark, careful inspection—without touching the receiver—should reveal a visible spot which will locate the source of arcing. Turn off the receiver and discharge the condensers in the usual way by shorting out the danger points to the chassis. If the arcing has been caused by a high-voltage lead running too close to the metal chassis or shield cage of the high-voltage supply, move it far enough away to prevent the arcing. If the spark seems to be jumping from the cap of one of the tubes to another lead or surface, or if it is located at any solder point or contact point, two courses are indicated. The first step is to brush off all dust on the offending source. Then purchase a jar of anticorona fluid at a radio-supply house and coat the surfaces of the joints or tube caps thoroughly and completely with it.

If the high-voltage lead to the picture tube seems to be the offending item, wrap it with a good polyethylene tape and coat it with anticorona fluid. Ordinary friction tape is not an insulator worth mentioning for the radio-frequency, high-voltage arcing of this sort.

Arcing occasionally will occur at the point where the high-voltage lead snaps onto the picture tube. Inspect this to make sure that it is properly seated and that no dust is present which might provide a path for the current to travel over.

Above all, in searching for high-voltage arcing, be extremely careful not to touch the receiver or push your nose in too far. The high voltage can jump a considerable distance and a nose or finger is as good a place to jump to as any.

Receiver noisy when jarred or subjected to vibration

Causes – Microphonic or noisy tube in the sound system. Loose connection in cable from chassis and sound output to speaker. Defective tube socket in sound circuits. Worn volume-control contacts.

Cures—Tap tubes to determine which is the offender. It will almost always be one of the sound amplifier tubes.

If tapping the tubes definitely locates the trouble in one spot but replacement of the tube by a known good one does not cure the difficulty, the socket or the connections of the leads to it should be suspected. To check this it will be necessary to remove the receiver from the cabinet and inspect the socket at the underside. Using an ohmmeter to check from the lugs at the bottom of the socket to the points at the top through which the tube pins are inserted will show up a broken socket lug.

Check the cable connecting the speaker to the receiver. The connectors may have worked loose. Occasionally leads are stripped too far or are frayed in such a manner that they rub against the chassis or another lead. Tape the frayed spot or move it away from the point of contact. Rotate and tap the volume control to locate noise at that point.

Chapter Eight

Ultra-High Frequency

STANDARD television bands are divided into two sections. The low band covers the range from 54 to 88 megacycles and includes Channels 2, 3, 4, 5 and 6. The high band ranges from 174 to 216 megacycles and is filled by Channels 7, 8, 9, 10, 11, 12 and 13. These are the very high frequencies (v.h.f.).

Because adjacent channels operating in the same city or locality will interfere with each other, the FCC licenses a city's television stations only on alternate channels. Thus, a city cannot have two stations, one operating on Channel 2 and the other on Channel 3. Channels 4 and 5, separated by four megacycles, are the only exceptions. Obviously, two stations cannot operate on the same channel in the same locality. This not only limits the number of stations that can operate in one place but also places a limit on the number that can operate within a certain radius. For example, Channel 9 is assigned to WGN-TV in Chicago. If a station in Waukegan, Ill., 40 miles away, were to be assigned either Channel 8 or Channel 10, the two would interfere with each other.

With only 12 channels available, a large number of population centers would be banned from having their own television station or stations lest they interfere with already existing assignments. For that reason, another portion of the radio-frequency spectrum has been set aside by the FCC for television use. This band covers the range from 470 to 890 megacycles and is called ultra-high-frequency (u.h.f.) band. This band makes available 70 additional 6-megacycle channels, beginning with Channel 14 and ending with Channel 83. The FCC has also summarized the requirements for co-channel and adjacent-channel separation as follows:

Minimum Separation—City to City—Channels 2-13	
Co-channel station separation	180 miles
Adjacent-channel separation	70 miles
Minimum Separation—City to City—Channels 14-83	
Co-channel separation	165 miles
Adjacent-channel separation	65 miles

Special-Purpose Channels

These distance separations are based on the results of experiments performed by the FCC engineers and those of the television industry. The industry accomplished engineering advances which made this spacing closer than was first thought possible, so that more station assignments could be made.

Because of the importance of the part that can be played by noncommercial, educational TV stations, certain frequency assignments have been made to noncommercial television use. Many of those frequencies remain available in various localities.

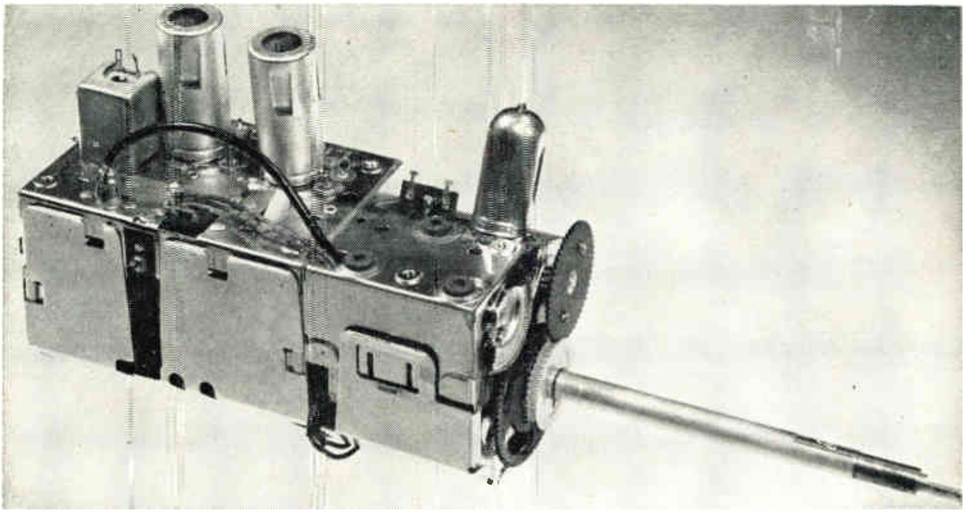
Converting Your Set to U.H.F.

With the construction and operation of u.h.f. television stations, the industry was faced with two more problems (1), the development of tuners which would enable the receiver to pick up the desired signals and (2), the development of satisfactory u.h.f. antennas.

In certain areas, both u.h.f. and v.h.f. stations were on the air. In order to receive signals from stations on either band, the receiver had to be equipped with a converter or an all-channel tuner.

Basically, a converter is a device which is to the tuner of a receiver as the tuner is to its own i.f. amplifiers. The converter has its own controls, vacuum tubes, antenna input, power supply and the like. Its function is to pick up the signal from a u.h.f. station, amplify it, alter it to a frequency which can be detected by the tuner on the TV receiver and feed that signal into the v.h.f. tuner on the receiver.

Generally speaking, most converters are the continuous-tuned type. However, work has been done on some which require switching or strip replacement to cover different portions of the u.h.f. spectrum. Also speaking generally, most converters



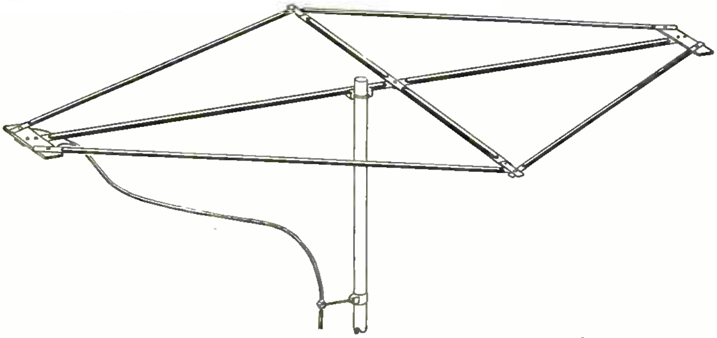
Standard Coil photo

Converter on Standard Coil TV-5100 tuner. See page 4 for an exploded diagram of this unit

emit a frequency equal to one of the existing v.h.f. channel frequencies, although some work has been done on converters which put out the intermediate frequency (i.f.) of the TV receiver and therefore feed directly into the i.f. amplifier section.

Let us cite an example of typical converter use. A city which has stations operating on v.h.f. channels 3 and 7 has been awarded Channel 38 in the u.h.f. band. In order to make use of the existing TV receiver and yet receive Channel 38, a converter is connected to the TV receiver and a u.h.f. antenna is used to feed it a signal. The converter is tuned to Channel 38. The signal is amplified and mixed with another signal generated within the converter. The result is a signal which is the equivalent of Channel 6—an arbitrarily chosen frequency which is unused in that city. The v.h.f. receiver is tuned to Channel 6 and treats the signal from the converter just as if it were receiving it over the air.

The tuners which provide complete coverage of both v.h.f. and u.h.f. stations are either (1) the turret type or (2) the two-unit type in which two ganged tuners are used, one for v.h.f. and one for u.h.f. coverage. The turret tuner will be found in many TV receivers originally intended for only v.h.f. channel coverage. In some of these, quite satisfactory u.h.f. reception is obtained when an existing "dead strip" on an unused channel is replaced by a tuning strip for the u.h.f. channel desired. Some difficulties may arise from improper i.f. frequencies and other problems.



American Phenolic Corp. photos

Above, u.h.f. rhombic antenna. Right, corner reflector antenna with broad band receives all u.h.f. channels

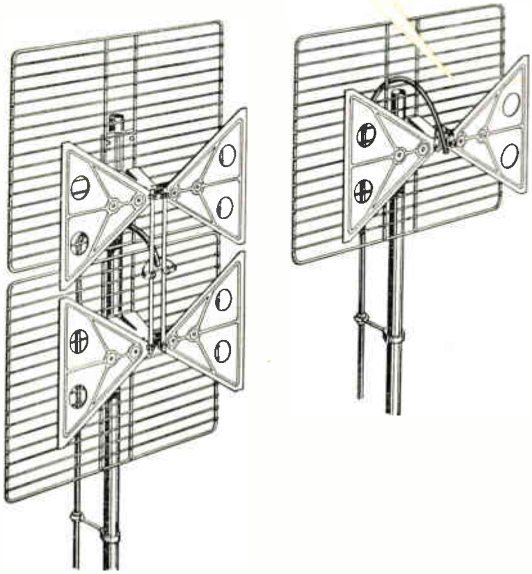
The turret tuner intended for u.h.f. conversion is basically the same as that described above except that it has been specifically designed to allow tuning-strip changes to be made with efficient results on desired channels. Electronically they are so superior to the old-type tuner that complete tuner replacement is desirable in a locality covered by both u.h.f. and v.h.f.

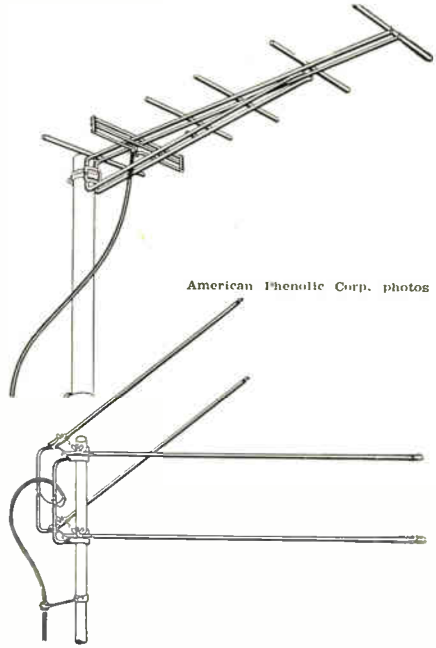
An example of the two-unit tuner is the Standard Coil TV-5100 Tuner pictured. In effect, it consists of two tuners, the one at the rear a conventional tuner of the turret type for v.h.f. tuning and the front tuner the continuously rotary or continuous-tuning type for u.h.f. Tuning is accomplished by means of three concentric shafts. The inner shaft tunes the u.h.f. channels. The middle shaft tunes the v.h.f. channels in a switching action and the outer shaft provides the control for fine tuning. In addition to selecting the v.h.f. channels, the middle shaft has a position which disables the v.h.f. tuner and throws the u.h.f. tuner into the circuit. One added feature of this tuner is an excellent matching network which permits the use of only one antenna lead-in.

U.H.F. Antennas

New names confront the TV viewer as he investigates antennas suitable for u.h.f. installations—bow-tie, collinear, corner-reflector, rhombics and the like. Despite this confusion of names, the same principles apply to u.h.f. antennas as were explained in Chapter Five on v.h.f. Wavelength is measured in exactly the same way, the gain of an antenna is still measured in decibels, the pattern is still shown in terms of lobes on a circular diagram.

This does not mean that u.h.f. television antennas can be exactly the same as v.h.f. antennas. It will be recalled that transmitted signals tended to bend around a solid object. This phenomenon, called diffraction, becomes virtually nonexistent in





American Phenolic Corp. photos

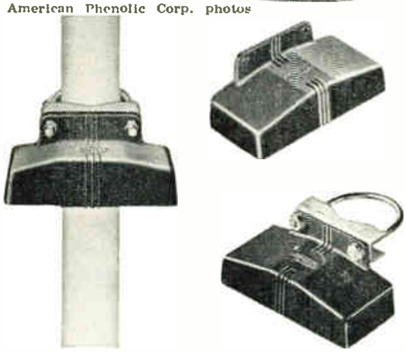
Above, single bow-tie and stacked bow-tie antenna for fringe-area operation. Top right, Yagi antenna designed for u.h.f. Lower right, multipurpose stacked-V antenna

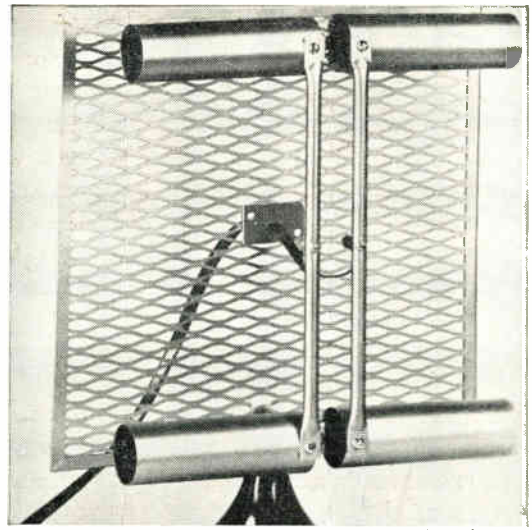
the u.h.f. band. Therefore, one cannot expect to get excellent TV reception if a large object—hill, mountain, building, etc.—lies immediately between his receiving antenna and the station. In the same way, it was mentioned that the transmitted signal tended to follow the curvature of the earth so that distant receiving antennas could, quite often, receive presentable pictures. Because this characteristic becomes less true as the frequency is increased, the u.h.f. "fringe area" is closer to the transmitting station than the v.h.f. "fringe area." The signal, in other words, is becoming more and more "line of sight." Therefore, the u.h.f. antenna will have to be higher in the air than a v.h.f. antenna used at the same point.

Another characteristic of transmitted radio energy is that the higher the frequency, the more the wave loses its strength. Ground objects, the atmosphere, trees, etc., will all tend to bring about this attenuation more rapidly at u.h.f. than with a v.h.f. signal. So, where an indoor or attic antenna might work in a certain location for v.h.f., an outdoor antenna will be necessary for u.h.f. Or, where a simple dipole was satisfactory for v.h.f., a u.h.f. receiver may require a multi-element stacked array to produce equal results. A u.h.f. antenna erected in winter might produce good results, but in summer might become almost ineffective because of the absorption of energy by tree leaves.

The shorter the wavelength the more an object will reflect radio energy. And, of course, the shorter the wavelength, the

American Phenolic Corp. photos





Tricraft photo

Above, indoor u.h.f. antenna. Top left, flat twin-lead for v.h.f. and tubular twin-lead for u.h.f. and v.h.f. Coupler (left) ties both antennas to a single lead-in

smaller an object needs be to provide a reflecting surface. For city dwellers, this means more possible "ghosting" on u.h.f. than on v.h.f.

As the ability of an antenna to receive weak signals is increased by adding more elements or changing its design, it tends to become not only more directional but also develops a character which permits it to receive a signal with greater efficiency on a particular frequency. Here it becomes like a man putting money in his right-hand pocket from his left-hand pocket. The more he puts in his right-hand pocket the less the left pocket contains. So, if one increased the ability of an antenna to receive Channel 63, at 764 to 770 mc., he would reduce its efficiency on Channel 39, at 620-626 mc. Therefore, if there is a choice between two or more stations and each is weak, the only alternative is to erect antennas for each one or settle for good pictures on one station and inferior reception on others. This holds most true, of course, in fringe areas.

An excellent antenna of this type is the Amphenol "Stacked-V2" pictured on these pages. More often seen is a single mast bearing two antennas, one for u.h.f. reception and one for v.h.f. reception. This gives rise to the problem of the transmission line; what does one do? Run down two lines or one? The answer to that depends on the receiver. If a u.h.f. converter is being used, it may be necessary to run one line from the u.h.f. antenna to the converter and another from the v.h.f. antenna to the receiver. Some converters have switching arrangements which permit both lead-ins to be connected directly to the converter. Other converters, and many v.h.f./u.h.f. tuners built into receivers, have a built-in network which enables the set owner to join the transmission lines and run only one to the receiving device. Here the signals are automatically separated as needed. Usually, however, it is necessary to use a matching network at the point where the two transmission lines are joined. This is usually at the base of the antenna mast, under an eave or some other convenient spot.

Because of the shorter wavelength of u.h.f., minor factors tend to rob the signal of more of its strength than is the case in v.h.f. reception. Many people have already experienced weakening signals on v.h.f. as their antenna and its connections acquired thicker and thicker layers of dirt and soot. In u.h.f., the effect of this is still greater. Corroded connections, loose transmission lines, improper impedance matching, poorly constructed lightning arresters, poor material or incorrect transmission line itself all have more serious ill effects on u.h.f. television. For these reasons, certain precautions must be doubled. Well-soldered connections are important. Connections wrapped tightly in a layer of good vinyl or polyethylene tape or sprayed with a good low-loss plastic will remain effective over a long period of time. Carefully chosen networks and lightning arresters are a necessity; consult your dealer or parts house for recommendations. The flat-tape lead-in wire used on v.h.f. antenna installations is unsatisfactory for use with u.h.f. Air-core tubular twin lead-in is recommended. This type will often have beneficial results in the lower v.h.f. bands as well.

The orientation of the u.h.f. antenna is extremely important. Fortunately, it is not as bulky and cumbersome as a v.h.f. antenna and is, therefore, more easily handled. Remembering that the wavelength at these high frequencies is extremely short, one can understand how easily a small movement can affect the ability of the antenna to pick up the signal. The antenna should be moved slowly, not only up and down and to and from the station, but rotated as well. Once the best position has been determined, fix the antenna firmly in place to the mast. The mast should be as rigid as possible and guyed if necessary to prevent movement.

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