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Television Receivers

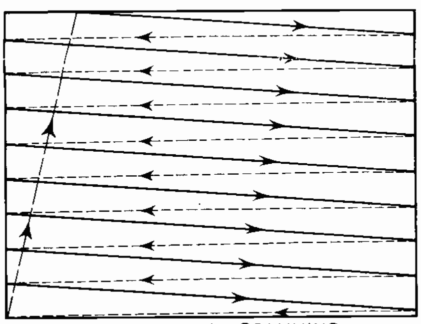
PART 1

By the Engineering Department, Aerovox Corporation

"TELEVISION" is the transmission of moving images either by wire or radio. Usually it is desirable to transmit sound along with the picture in order to make the entertainment complete. Hence, in the popular mind, a television receiver reproduces the images as well as the sound.

This series of articles aims to describe in the simplest possible way, the different parts of the television receiver, their function and adjustment, for the benefit of servicemen, home-builders, experimenters and others.

First examine the television system as a whole, including both the transmitting and receiving end. As in the case of sound transmission, picture transmission may be resolved into three parts: 1, The transformation of the moving image into a varying electrical current which represents the variations of brightness of the image; 2, the transmission and reception of these varying electrical currents by a radio transmitter and receiver; 3, the transformation of the varying electrical currents back into a moving image.



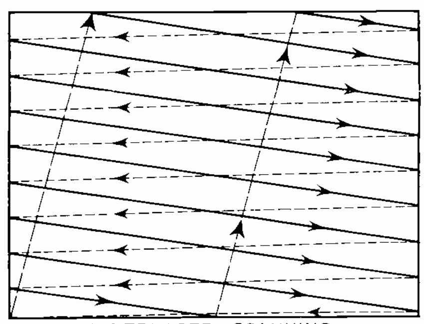
PROGRESSIVE SCANNING
Figure 1A

In the case of sound transmission, the microphone translates the sound waves into varying electrical currents. No matter how complex the sound wave, how many instruments, singers, or speakers there may be, one microphone can generate an electrical current which accurately represents the total of all of the sounds reaching it at all times. Similarly, the loudspeaker can reproduce this complex sound.

In television the problem is more complicated. A moving image may be thought of as an infinite number of very small points, each point having its own variations of brightness with time. The familiar radio system as used for sound could be employed to transmit the variations in brilliance of just one such point or the average of a small area by a neon light. A complete picture would then require a large number of separate radio transmitters and receivers.

Instead of this, the picture may be transmitted piece by piece, one small area at a time, depending on the persistence of vision to make the picture seem continuous. The image to be transmitted can be divided arbitrarily into a large number of small areas of definite size. Then the brightness of each small area may be transmitted in turn according to a definite order. At the receiving end, the signals must be translated back into light again and be fitted into the pattern so as to recreate the picture. Finally, the whole process must be repeated fast enough so as to make the picture seem continuous.

Step number one and three of the television transmission system can then be divided again and the complete process becomes as follows: (a) Scanning the image to be transmitted; (b) translating varying brightness into varying electrical currents; (c) generation of synchronizing signals to make the scanning at the receiver keep step with that at the transmitter; (d) transmission and reception of the composite signal by radio; (e) separating the synchronizing signals from the picture signal and making them control a scanning light beam; (f) modulating the light beam by the picture signal thus recreating the moving image.



INTERLACED SCANNING
Figure 1B

Tentative standards have been set up by the RMA to guide the industry.

These define the amount of detail, the number of scanning lines, the type of synchronizing signals, shape of picture, etc. so that all receivers may be able to receive signals from all transmitters. In this article these standards will be mentioned at various times with the description of the respective subjects.

SCANNING

The scanning process, both at the transmitting and receiving end, consists in making an electron beam travel across the picture area in a standard manner while it either picks up or recreates the picture. This electron beam is made to travel across the picture by two sweep circuits, one horizontal and the other vertical. The rate of travel along the vertical lines is very much slower. Thereby, the beam, having a definite width, covers the picture in a series of strips or lines as shown in Figure 1A. The number of strips or lines per picture determines the amount of detail that can be transmitted but note that the beam must not be much wider than the distance between two lines, else an increased number of lines will do no good. The frequency of the vertical sweep circuit is the frame-frequency and determines the number of pictures

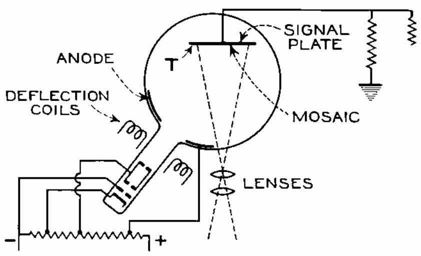


Figure 2

per second and the amount of flicker. The standards have gradually been increased from 60 lines and 24 frames back in 1931 to 441 lines and 30 pictures in 1939. The standard shape of the picture is the same as that of the motion picture screen, the height being three quarters of the width.

INTERLACED SCANNING

It has been found that the amount of flicker can be reduced without increasing the total number of lines per second (lines per picture times pictures per second) by making the vertical sweep circuit have two or more cycles per picture. Practically, this means that the scanning beam covers every other line when scanning the picture and when it goes back for the second time it covers all the lines which were skipped the first time. Then the process is repeated, each picture requiring two vertical trips of the scanning beam. This type of scanning is illustrated in Figure 1B. It is of course possible to skip two or three lines each time and take three vertical sweeps to cover the picture, or perhaps four. This is advocated by some and is claimed to have some advantages.

There is now a distinction between picture frequency and frame-frequency or field frequency. The picture frequency is the number of times per second that a complete picture is being reproduced. The frame-frequency

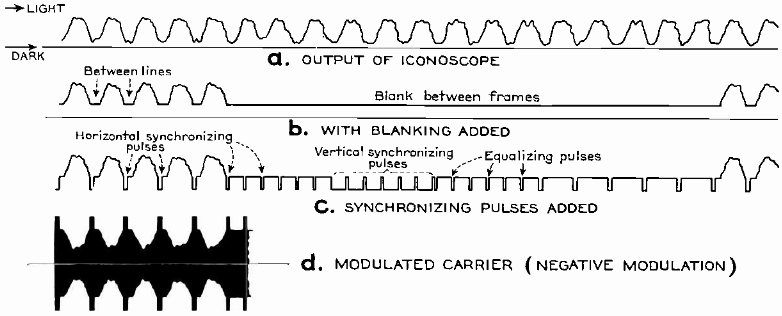


Figure 3

or field frequency is the frequency of the vertical sweep oscillator and may be two or more times the picture frequency. The RMA standard picture has 441 lines, a picture frequency of 30 and a field frequency of 60. This is interlaced scanning, taking every other line as in Figure 1B. The vertical sweep oscillator then has a frequency of 60 cycles per second, the horizontal one 30 x 441 = 13230 cycles per second.

THE CAMERA TUBE

The picture signal or "video" signal is generated at the transmitter by a camera tube which is a development of the cathode-ray tube. These tubes have different trade names. RCA calls it an "Iconoscope" and recently described an improved type, the "Orthicon". Farnsworth developed a camera tube which he calls an "Image Dissector". The Iconoscope works as follows (also see Figure 2). The picture to be transmitted is projected on the target, T, by means of lenses. The target consists of a piece of mica covered by a mosaic of a photo-sensitive material. The mosaic consists of tiny globules of a silver compound, each corresponding to a small photocell and insulated from its neighbors. At the back of the mica is a metal covering, the signal plate, which connects to the grid of the first amplifier tube and through a grid-leak to ground.

When the image is projected on the target, the photo-sensitive units will emit electrons in proportion to the light falling upon them. These electrons are attracted away by the anode and leave each globule charged positive. Together with the signal plate each small photocell or globule forms a condenser which is charged in proportion to the light falling upon it as well as the time during which the light fell on it.

The tube also contains an electron gun which projects a beam of electrons upon the target. This beam is made to scan according to the principles outlined above. When the electron beam passes over the charged "condensers" it discharges them, the discharge flowing through the grid-leak and constituting the signal. The discharge current at any time represents the amount of light which has fallen upon the respective photocell units since it was discharged last. This system is an improvement over the disc with holes because it saves up the charge due to all the light at each spot during the time the beam is busy covering the rest of the picture.

BLANKING AND SYNCHRONIZING SIGNALS

After each line and after each frame the electron beam travels back to its original position at greatly increased speed. It is not desirable to have this part of the beam's path represent a signal since it will cause a line on the picture. Therefore, at the end of each line and at the end of each frame a special generator erases the signal from the Iconoscope during the return trace and sends an impulse corresponding to black. Figure 3 illustrates the signal as it is formed at the transmitter. In Figure 3A the signal of the Iconoscope is shown, Figure 3B shows the same with the "blanking" periods indicated.

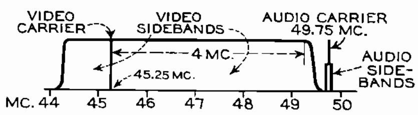


Figure 4A

Synchronizing signals for keeping the scanning oscillators in step with the transmitter have to be sent along with the signal. The only period that leaves time for this is the blanking period. Synchronizing signals at the end of each line and at the end of each frame are super-imposed upon the signal. They are in such a direction as to represent blacker than black and do not interfere with the action of the Kinescope since they simply cut off the beam a little more during a period that it is required to be dark.

The horizontal pulses consist of rectangular shaped waves at the end of each line. At the end of each frame these pulses last longer, the longer pulses together (six of them) constitute the vertical synchronizing signal.

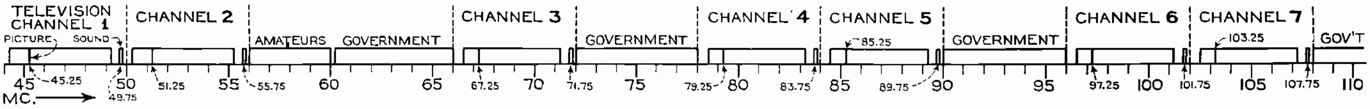


Figure 4B

Interlaced scanning requires the beam to start its vertical trace at the end of a line after one frame and at the middle of a line the next frame. This causes a little complication in the synchronization signals. The matter is simplified by the "equalizing pulses". During the vertical synchronizing pulse, and three lines before it and after it, there is a horizontal synchronizing pulse twice per line. This extra pulse at the half line does no harm to the horizontal sweep oscillator but it permits the vertical syncronizing pulse to start with a half line as required.

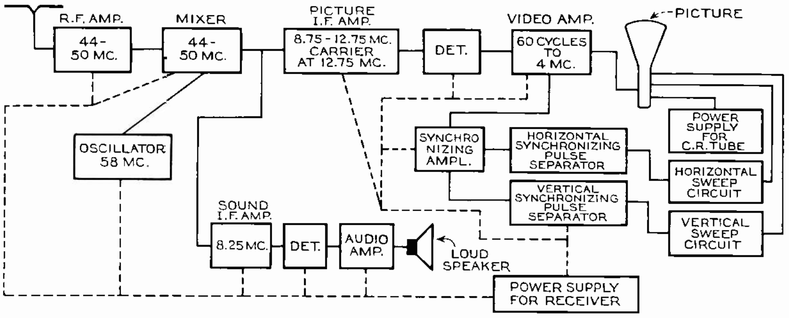


Figure 5

At the receiving end the synchronizing pulses are filtered from the signal or, rather, the signal is filtered from it and the horizontal and vertical synchronizing pulses are separated by circuits which discriminate against waveshape. They are then applied to the respective oscillators. This will be further explained in later articles. Figure 3C shows the signal after the addition of the synchronizing pulses.

The signal must now be modulated on to a carrier. There are two possible systems of modulation: positive or negative. Negative modulation is now the standard; this means that maximum carrier represents dark parts of the picture and minimum carrier represents light parts. Figure 3D is an illustration of the modulated carrier.

The negative modulation must be kept in mind and the receiver designed accordingly else the picture appears similarly to a photographic negative. The picture can be reversed by the addition of one video stage or the change to another type of detector.

At the receiver the signal passes through a superheterodyne tuner, is rectified and again amplified and applied to the grid of the picture tube. At the same time the synchronizing signals are utilized as described.

SINGLE-SIDEBAND TRANSMISSION

So far, the radio transmission and reception has been take for granted but a little arithmetic shows that a very special kind of transmitter and receiver is required.

Assuming a picture of 441 lines and considering a horizontal detail of the same grade as the vertical detail, one might divide the picture into small squares with the side equal to the width of a line. There are 4/3 x 441 x 441 such squares. The greatest possible detail of such an arrangement would be when the squares are alternately light and dark. Two such squares would represent a cycle; thus there would be 2/3 x 441 x 441 cycles per picture and 2/3 x 441 x 441 x 30 = 3,889,620 cycles per second. The video amplifier must then reproduce frequencies from 60 cycles to about 4 megacycles. But that is not all; employing the usual system of modulation, the sidebands would extend 4 mc. at each side of the carrier, requiring an 8 mc. or 8000 kc. width for just one station. Furthermore, the r.f. and i.f. amplifiers must be wide enough to pass such a band.

Obviously, the ultra-high-frequency region is the only one where there is enough "space" for such a television signal. Even so it has been found desirable to use "single-sideband transmission". The lower sideband has been partially suppressed at the transmitter and the receiver employs tuned circuits which are 4 mc. wide.

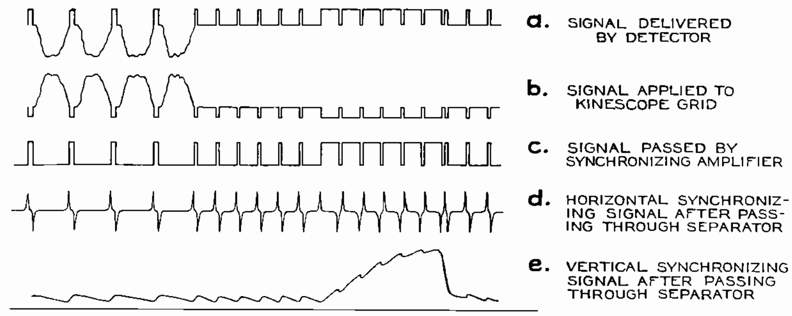


Figure 6

The audio signal is transmitted on a separate carrier which is always 4.5 mc. higher than the picture carrier. This permits of an easy method to tune in both the sight and the sound by a single dial. Such a procedure is of advantage, for the looker-in can then tune in by sound knowing that both sections will be in tune at a time. The broadness of the picture channel would make the tuning difficult without the guidance of the sound.

The Federal Communications Commission has assigned special wave bands for experimental television service. Each channel is 6 mc. wide and the picture carrier and sidebands and the audio are located in it according to the standard manner shown in Figure 4A. Figure 4B shows the complete spectrum of the television channels up to 110 mc.

RECEIVERS

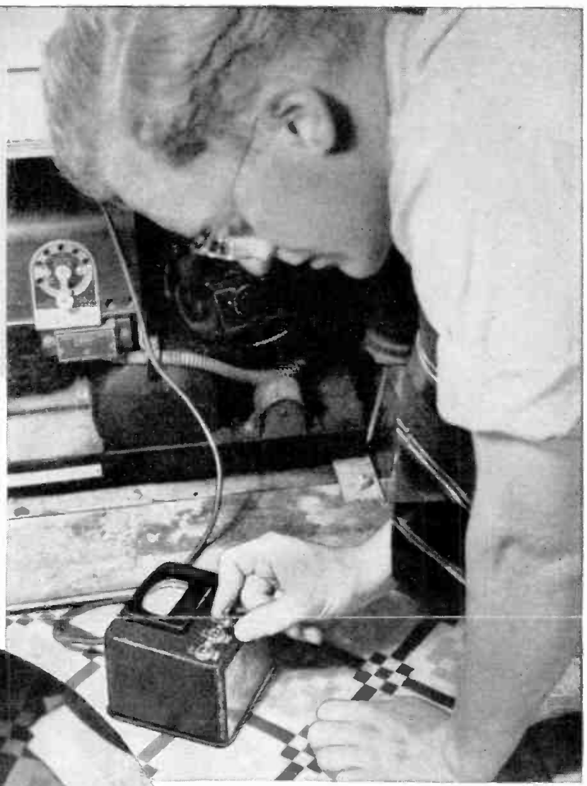
Present day receivers generally consist of sight and sound receivers with different size pictures from 5-inch to 14-inch. There are also some "attachments" which utilize the regular all-wave set as a part of the sound receiver. Such an attachment consists of a complete picture receiver and a converter for the sound part. So far there seems to be one receiver which includes an all-wave set in addition to television.

The different parts are shown in block diagram form in Figure 5. The 44-50 mc. channel has been assumed in order to describe the changes occurring in the frequency. A single r.f. and oscillator-mixer section handles both the picture and the sound signal. This single oscillator causes the picture carrier and the sound carrier to be 4.5 mc. apart. The separation is done in the converter plate circuit. The picture i.f. is generally 12.75 mc. with the single-sideband extending to 8.75 mc. The sound i.f. is then at 8.25 mc. Other parts of the receiver have been named above. Figure 6 shows what happens to the signal in different parts of the receiver.

In future installments the television receiver will be described section by section.

First Aid

for servicing refrigerator MOTOR STARTING Capacitors



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