MODERN TELEVISION

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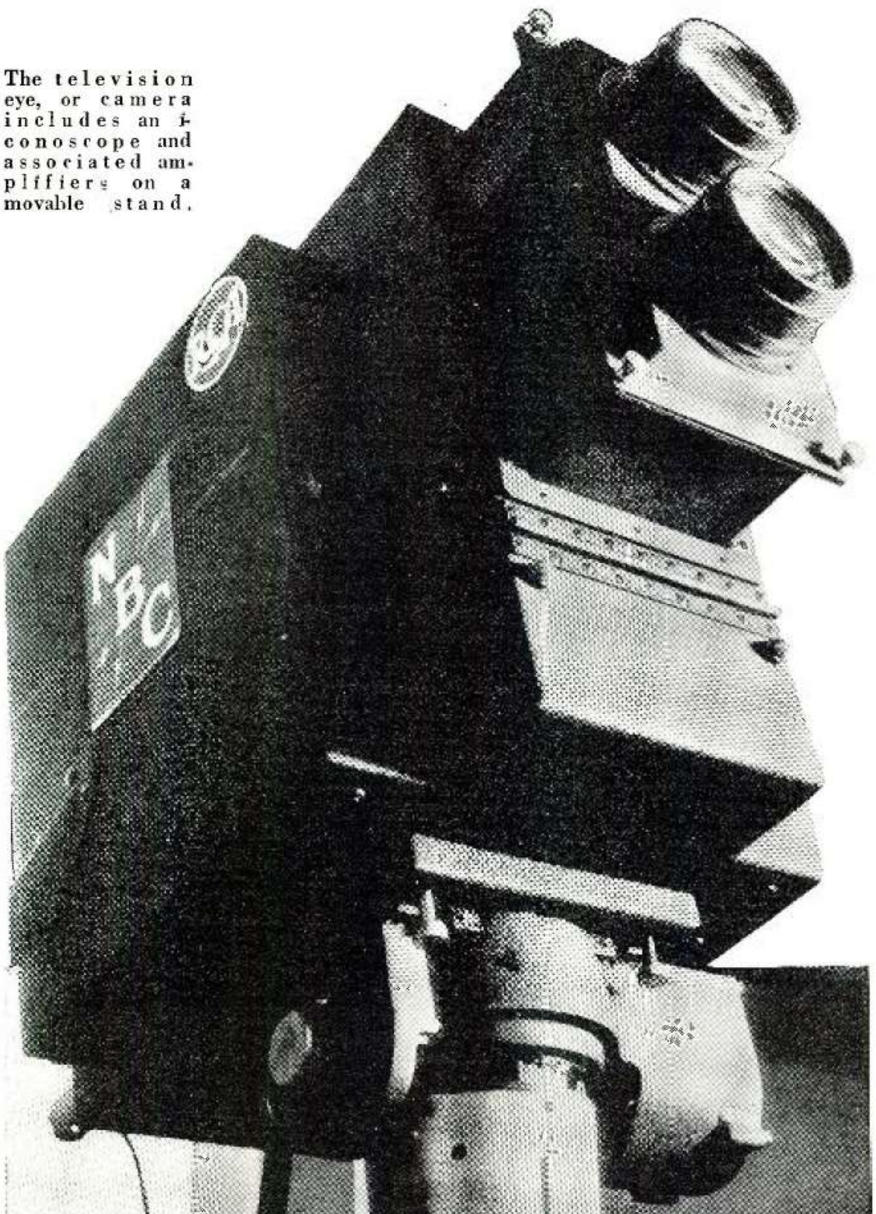
Here is your introductory course to television written so that all the difficulties are made understandable and very easy.

The television eye, or camera includes an iconoscope and associated amplifiers on a movable stand.



YOU gentlemen with more than the average broadcast listener's interest in radio, who intend getting acquainted with *Miss Television* during her "coming out" parties of the next few months, will find this fascinating newcomer speaks a new and strange language. Her sense of time is not that of seconds, minutes and hours, but is in terms of "H" and "V"—3H, 0.15H, 0.10V and 0.07V—in which "H" is 1/13230th-second and "V" is 220½ H's.

For this new miracle of the air waves is a matter of timing far finer than ever was achieved by Rockne's immortal *Four Horsemen,* the bat of the Yankee's *Babe* or a Bobby Jones iron shot. The successful maneuvers worked out for the triumph of the electrons, by coaches Zworykin, Maloff, Farnsworth, DuMont, Preisman, etc., are timed in micro-seconds, and consist of "blanking," "pulses," "interlace," "keystoning" and many others.

The long-debated matter of "when should television be released" was brought to a head and settled last June when the RMA Television Committee voted approval of a set of *Television Transmission Standards* for this country. As the RMA and the FCC have been in constant touch on this subject, it seems a certainty that the recommendations will be accepted by government authorities.

One thing should be made clear at this point. The system of television to which this series will give the greater space is most certainly not the only way in which this modern miracle can be accomplished; it is, however, the result of many months of work by the Television Committee of R.M.A. and represents the standards for transmission and reception that will, apparently, be general practice in this country.

There is much of merit in the developments of Marconi, Telefunken, Fernseh, Mihaly-Traub, Scophony, Dumont, Farnsworth and many others. While it apears that American practice will be developed around electron optical scanning systems, based on the cathode ray tube, equally good results have been achieved with mechanical optical systems. Research into the work done both here and abroad during the past ten years, brings to light an almost unbelievable number of combinations of lenses, apertures, prisms and mirrors mounted on drums, spirals and discs. As this is being written, announcement has been made by Scophony, Ltd. (British) that a $10,000,000 American affiliate will be formed to market receivers utilizing mechanical optical designs.

Allen Dumont has an excellent system of television which involves no sychronizing signals, has 4-to-1 instead of 2-to-1 interlace, and utilizes two carriers. Over in England they use "negative" modulation which means that highest amplitude is white rather than the sychronizing pulse level in blackest black, and the sync pulse level is zero radiated power where our standards of "positive" modulation result in white. Should one care to make a careful study of the work of many very brilliant minds and form his own opinion of the relative merit of each one's methods, it will be interesting, and definitely instructive; the fact will remain, however, that the electron optical systems are going to dominate commercial television just as gasoline motors outnumber diesels, there will be synchronizing signals transmitted, 441 will be the generally-used line frequency, and sync signals will be above blackest black.

In this first article, I will present briefly the many features, new to radio men, that are essential to commercially practical television, then in the second article explain with circuits and charts how they are accomplished, in both transmission and reception, then, with later articles, bring everyone up to the point where he can intelligently plan and construct his receiver. While few of us will attempt the construction of a television transmitter, it is essential to the building, altering or servicing of a receiver, that one know all the whys and wherefores of the complete system, as it is about to be handed to a more-than-expectant public.

First of all, television broadcasting is to be done in the ultra high frequency spectrum, and, to start, seven channels have been assigned for this service between 44 and 108 megacycles, and another twelve between 156 and 294 megacycles (see Figure 1). This is necessary as it was only in this division of the useful frequencies that enough frequencies were available to permit a few channels with the relatively wide sidebands required (a television channel is six megacycles in width). Here also, reflections from the "heaviside" layer occur but seldom. Reflections would be disastrous, as the difference in time between the arrival of the ground wave and that of the reflected wave would produce images in offset pairs or "ghosts."

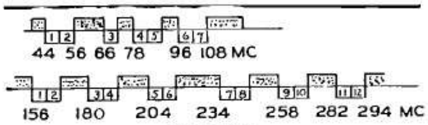


Figure 1.

Each channel is complete in itself, that is it will include both the video (picture) and the audio (sound) transmission, and these will, in every channel, be a definite distance apart. Thus they can be tuned-in simultaneously, heterodyned by one oscillator, and each diverted into its own intermediate amplifiers. How this works out is illustrated in Figure 2. For this example, the channel in use at the Empire State Building (N.B.C.) transmitter is chosen—the channel from 44 to 50 megacycles (mc.).

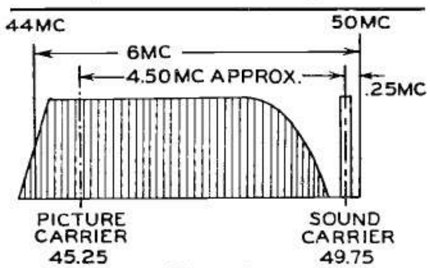
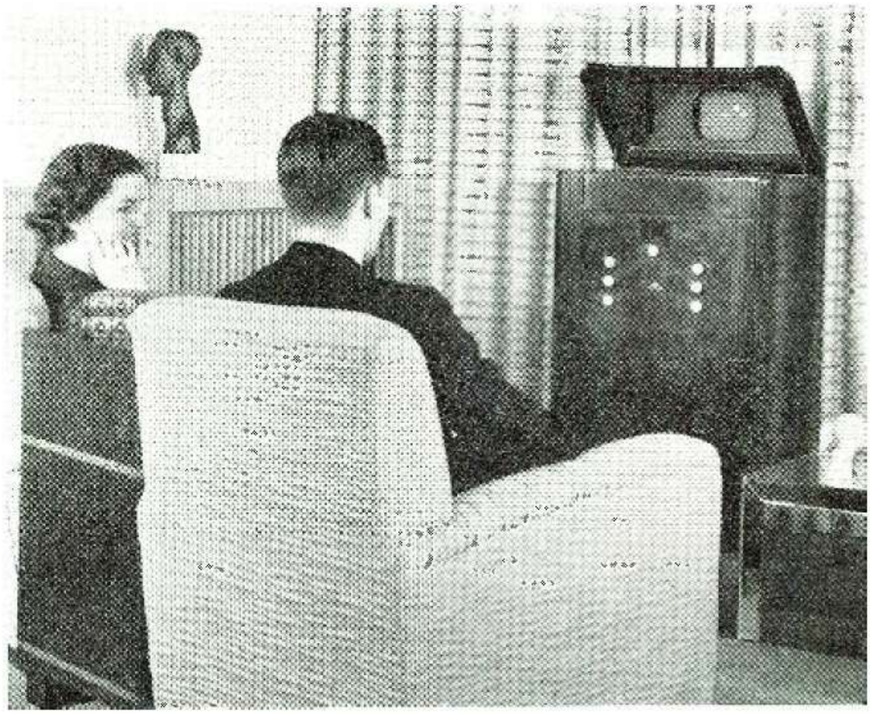


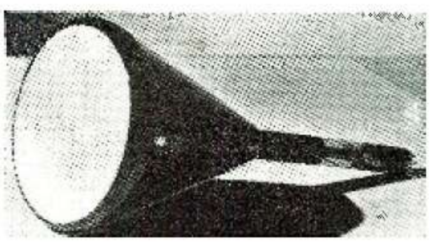
Figure 2.

It has been found that the wider the video sidebands, the better the detail and entertainment value, so, rather than transmit both sidebands (video) and have each be 2.5 mc. deep, it will be the practice to utilize but one sideband and have it, roughly, 4.0 mc. deep. The other will be suppressed. In Figure 2, the video carrier is shown as 45.25 mc. and placed 1.25 mc. from the 44 mc. (lower frequency) edge of the channel. Its sideband is about 4.0 mc. deep. The sound carrier is at 49.75 mc., placing it 4.5 megacycles above the video carrier and 0.25 mc. from the 50 mc. (higher frequency) edge of the band. This 4.5 mc. separation, and the 0.25 mc. placing of the sound carrier, are in the recommended standards.

If, at the receiver, we tune an oscillator to 58 mc., and have it heterodyne the 45.25 and 49.75 mc. carriers, we automatically secure the RMA standard sound intermediate fre-

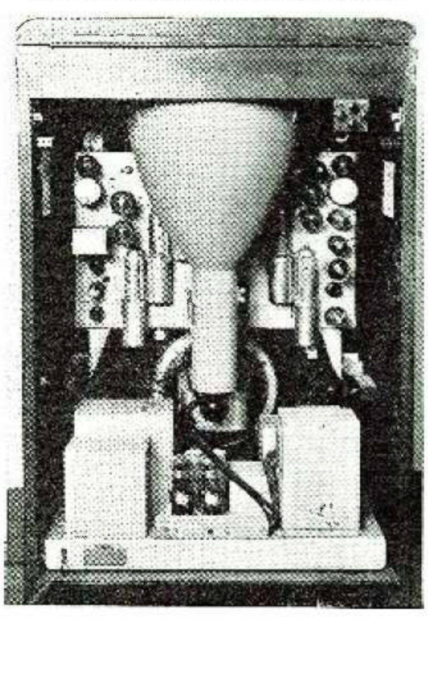


The newest television receiver will be so made that more than one person will be able to enjoy the broadcasts.



The Kinescope which makes the reception of television signals possible.

The modern television receiver is a bit more complicated than the BC set.



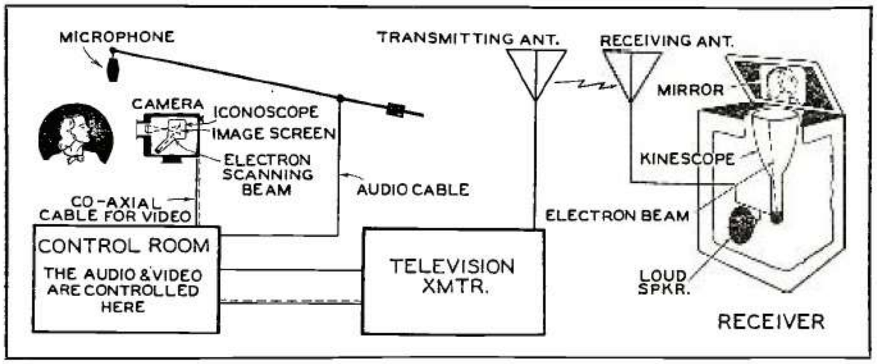
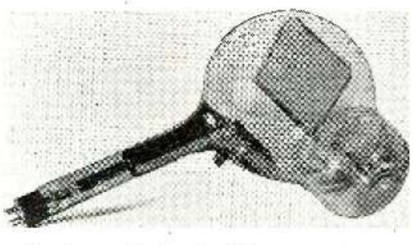


Diagram showing the various stages of the television and audio broadcast.



The heart of the television transmitter.

quency of 8.25 mc. and the video intermediate frequency of 12.74 mc. Whether one tunes to the 44-50, the 50-56 or the 78-84 mc. channel, the two carriers will tune correctly and heterodyne to their proper i.f. passbands.

Probably the easiest way to visualize the "pickup" and re-creation of television transmission of a scene is to imagine that you have before you, as a photoprint, the scene to be transmitted, as it would be at any given 1/30th-second. You have a current-generating pencil, from which a wire leads to the transmitter—you draw a straight line across the top edge of the picture, and, as you go over a black spot the current generated increases, while a gray spot produces less current, and a white area would result in no current flowing. Obviously, using a photograph, the current would constantly be changing.

Now you draw another line as close to the first as possible, so that a total of 441 lines will cover the picture completely. When you have finished, every point of the picture will have been represented by a current, either strong or medium or weak, flowing from your pencil. In television, a tiny stream (or beam) of electrons is caused to travel, just as you did it, over the image picked up by a lens and a complex variety of cathode-ray tube called an *Iconoscope*. This is called "scanning" and it results in a constantly-varying current, modulated onto a high frequency carrier, which, when received, can be re-created into an identical picture by another beam on the end of another type of cathode-ray tube termed a *Kinescope*.

While cathode-ray tubes, as used in television, will be analyzed and explained in detail in the next article, I present in Figure 3 a simplified sketch of the *Iconoscope* and *Kinescope*, to make the current discussion more readily understandable. The pickup of a scene is, in principle, not difficult to understand when an illustration is available. The left wall of the *Iconoscope*, as shown in Figure 3, is of exceptionally clear, highly-polished glass, with a lens of the order of f2.8 or f3.5 mounted at correct focal distance so the scene to be transmitted is reduced to proper size on the *Signal Plate* within the tube. As the electron beam

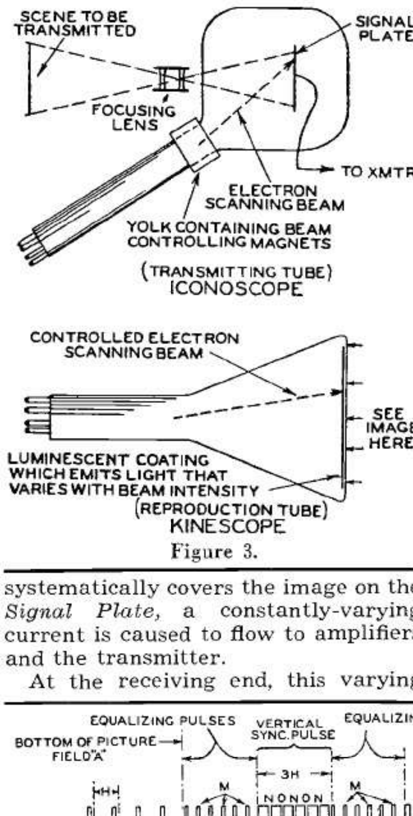
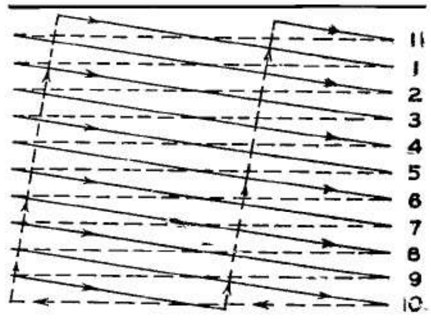


Figure 3.

systematically covers the image on the *Signal Plate*, a constantly-varying current is caused to flow to amplifiers and the transmitter.

At the receiving end, this varying current, which is stronger as the picture is darker and weaker as the picture tends toward white, varies the intensity of the electron stream in the *Kinescope* as the beam scans the inner surface of the glass end of the tube. As this inner wall of the tube is coated with a preparation (may be either a



VISUALIZATION OF INTERLACING
Figure 4.

sulfide or a silicate of zinc) which is highly luminescent, the original scene is re-created in approximately 225,000 pin points of light with surprising fidelity. The negatively-charged particles that compose the beam are moving with velocities of the order of 30,000 miles per second.

Thus, what one will really see is a rapid sequence of pictures as "scanned" by a lightning-fast electron pencil. To avoid flicker, it was known that 24 complete pictures (movie standards) or better, would have to be created per second on the end of the *Kinescope*. The number 30 was chosen, because, being a multiple of the 60-cycle supply frequency, hum difficulties could more readily be avoided. Hum would, in this case, show itself as a dim pattern moving across the picture.

Further to eliminate flicker, it was decided to "scan" the image in a manner known as "interlacing" (see Figure 4). This means that, instead of picking up our lines in regular 1, 2, 3, 4, 5 order, we pick them up as 1, 3, 5, etc., until we have 220½ lines and then jump back and get 2, 4, 6, etc., through another 220½ lines—each complete operation taking not more than 1/60th-second. The full set of 441 lines is known as a "frame" while each half is a "field."

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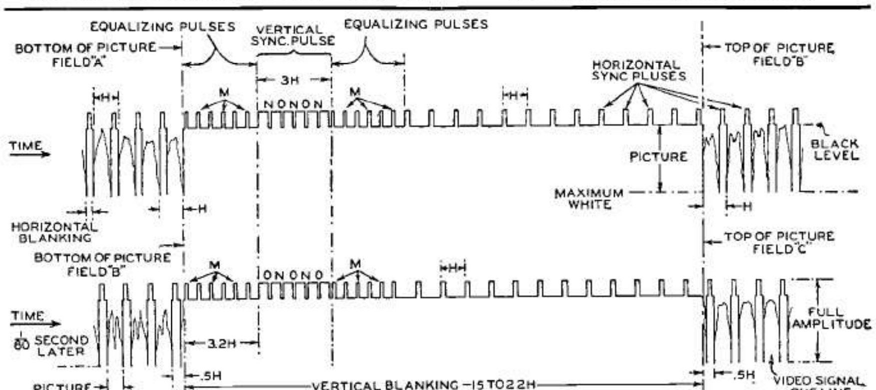
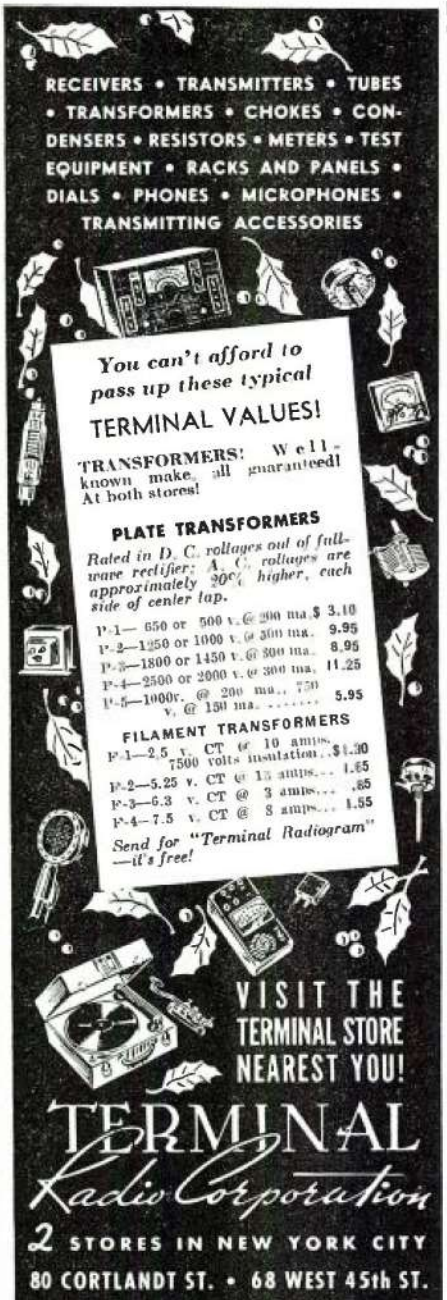


Figure 5. A diagrammatic breakdown of a television signal.



Television Course

(Continued from page 8)

Quite a few factors entered into the choice of 441 as the correct number of scanning lines; any less than this did not give satisfactory detail from a complex scene, while more than this created serious problems. Important, however, as will be shown later, the number has simple factors and can be had by multiplying odd numbers—3x3x7x7. This enters into the generation of synchronizing signals at the transmitter.

Which brings me to the all-important matter of synchronization. Most of the devices, and many of the practices, essential to successful transmission of images were developed many months, and even years, ago. Video transmission is very similar to sound transmission insofar as modulation, envelope, detection and amplification are concerned — the *Iconoscope* and *Kinescope* tubes have been in laboratories quite awhile — but until RMA pooled the ideas and plans of the various experts, and set standards, everyone had his own favorite ideas for synchronizing—and receivers could not be built with any assurance that their synchronizing systems would match those of a nearby transmitter.

At first thought, it would seem that the speed of the scanning beam in a receiver's *Kinescope* could readily be set to the speed of the scanning beam in the transmitter's *Iconoscope*, and one could sit back and forget them. Unfortunately, this does not work out in actual practice. So accurately must these two electron beams function together that it is necessary to inject a synchronizing "pulse" into the signal not only at the end of every 1/60th-second field, but also at the end of every 1-13230th-second scanning line, and then make provision for the separation of these pulses from the video signals in the receiver.

To use the language of the RMA *Recommended Television Standards Report*, I will, hereafter, refer to the length of time required from the start of one line to the start of the next line in a field as "H," and the time required from the start of one field to the start of the next as "V." These times are, of course, 1/13230th-second and 1/60th-second respectively.

To see how they are used, I now refer to Figure 5. The upper half illustrates the television signal covering the bottom edge of the picture in one scanning field ("A") and the top edge of the following field ("B"); the lower half of Figure 5. portrays the signal during transmission of the bottom edge of the second field ("B") and the top three lines of what would be a third field ("C"). This is necessary to show the differences in pulse arrangement, which explain how interlacing is accomplished.

As in voice transmission, the carrier provided for video transmission has a definite amplitude (voltage maximum) which it maintains evenly until modulated, whereupon the voltage rise in each sideband varies with the impressed signals. In the television transmitters and receivers, it is so arranged that full black (of the picture) will be at 75 to 80% of maximum amplitude. The remaining 25 or 20% is to be used for synchronizing pulses. Thus, all variations in the image transmitted are taken care of by variations in carrier voltage from zero to 75 or 80% of maximum amplitude.

Since we have full black at 75% amplitude, anything that may be done with the other 25% would not be visible on our *Kinescope*, and it is here that we put the synchronizing pulses. At the left end of the upper half of Figure 5 we come into the middle of the fifth line from the bottom of the picture of one field. As illustrated, it is going from dark to light (sloping down). The narrow upright pedestal shown represents the last 15% of this line, at the right edge of our transmitted picture. What is called a "blanking pulse" is injected which immediately jumps the carrier to full black. In other words, we do not "see" the last 0.15H on each swing of the *Kinescope* beam.

The narrower extension on the top of the pedestal is the "horizontal synchronizing pulse," whose job it is to swing the traveling *Kinescope* beam back to the left for the start of the next line (4th from bottom) while a condition of full black exists. This horizontal synchronizing pulse starts 0.01H after the front edge of the blanking (full black) pedestal pulse. It lasts but 0.08H in time, then the voltage drops back to the blanking pulse level for 0.06H more, and, at its end, we are starting the 4th from the bottom line of the picture. This cycle continues through the last line of picture.

You will note a vertical broken line identified as "Bottom of Picture—Field A." This is the bottom edge of that which is visible; our electron beam will continue swinging but the final 15 to 22 lines of the field will be blanked out or black. The recommended standards say this period, known as "vertical blanking" shall be 0.07 to 0.10 of the time of one field (1/60th-second) which is, roughly, 15 to 22 lines of our 220½ per field.

With the *Kinescope* held black, six narrow pulses, termed "equalizing pulses" are introduced. They are 0.04H wide and spaced at 0.5H intervals, beginning 0.01H after vertical blanking began. Three of these are, in effect, horizontal synchronizing impulses to keep the beam horizontally synchronized; the three marked "M" are necessary to assure proper interlace in the receiver, and their action will be described in article three.

The vertical synchronizing pulse, which comes next, requires the time 3H. It is composed, as shown, of six 0.46H pulses and six serrations or slots which are 0.04H each. It should be noted that the front edge of the vertical synchronizing pulse and two of these serrations (O) correspond in their timing with the horizontal synchronizing pulses. The other three (N) are necessary to make identical the vertical synchronizing pulses of odd and even fields (see the vertical synchronizing pulse directly below in the following field).

While these slots are shown with vertical sides, because they are so small in the illustration, the sides are really sloping, so there is a slanting fall on one side of each slot equal to 0.005H in time, and a slanting rise on the other side of 0.005H in time. That is only 5/1000th of 1/13230th of a second, but these slopes are necessary that a wave of the proper form be supplied to the deflecting circuits of the receiver's *Kinescope*.

While the vertical synchronizing pulse has now thrown the *Kinescope* beam back to the top of the picture for the start of another field, there remain six more equalizing pulses, which must be present for the same reason as was the first group. A series of horizontal pulses then follows before the vertical blanking is removed, and the picture is resumed. The number of such pulses at this point may vary from approximately six to thirteen and this will not affect reception, except that it shortens the height of the picture by an infinitesimal amount if more are used. At the point marked "Top of Picture—Field B" the vertical blanking ends and slightly over four lines of the next field are shown.

The lower half of Figure 5 is similar in its cycle of pulses to that of the previous field, but certain features should be stressed. Note that the last line of Field B (odd field) is not complete when the vertical blanking begins at the bottom of Field B's picture. These are (presuming 30 lines of blanking per frame) lines 407, 409 and 411, and their timing must be ½H "off" in relation to those above in Field A (even field) which are 406, 408 and 410. At the right end of the lower illustration, a half video line is indicated following the finish of vertical blanking, whereas above it, a full video line is shown. In the upper drawing, these top-of-field (B) video lines are 1, 3, 5, 7, etc., while below, these first lines are 2, 4, 6, 8, etc., of an even field (C).

When the fact that "an aspect ratio of 4:3 is recommended to conform with existing motion picture practice" is added, we have concluded our review of the more important introductory features of television. This quoted sentence simply means that the height of the picture shall be ¾ the width, regardless of size of *Kinescope* used.

For Additional Reading

ELECTRON OPTICS IN TELEVISION
I. G. Maloff and D. W. Epstein
McGraw-Hill Book Company

ELECTRONIC TELEVISION
George H. Eckhardt
The Goodheart-Willcox Co., Inc.

TELEVISION WITH CATHODE RAYS
Arthur H. Halloran
Pacific Radio Publ. Co.

TELEVISION RECEPTION TECHNIQUE
P. D. Tyers
Sir I. Pitman & Sons, Ltd.

THEORY & PERFORMANCE OF THE ICONOSCOPE
V. K. Zworykin, G. A. Morton & L. E. Flory
Institution E. E. Journal—Jan. '38—May '38.

TELEVISION INTERMEDIATE FREQUENCY AMPLIFIERS
E. W. Engstrom and R. S. Holmes
Electronics Magazine—June 1938

A LABORATORY TELEVISION RECEIVER
Donald G. Fink
Electronics Magazine—Sept. and Oct. 1938.

[Next month the author continues with Part 2 of this interesting course.—Ed.]

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