THE *Magic* OF

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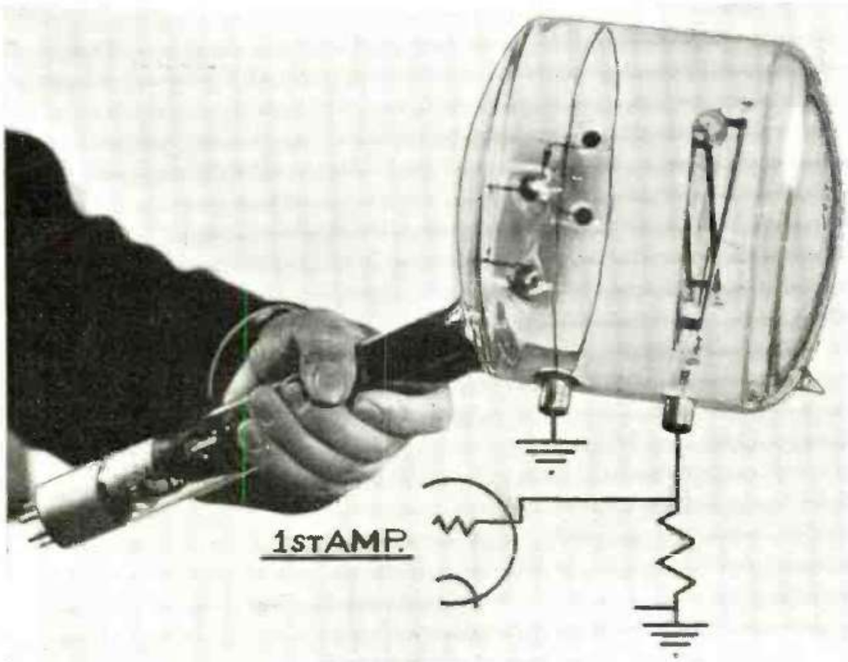
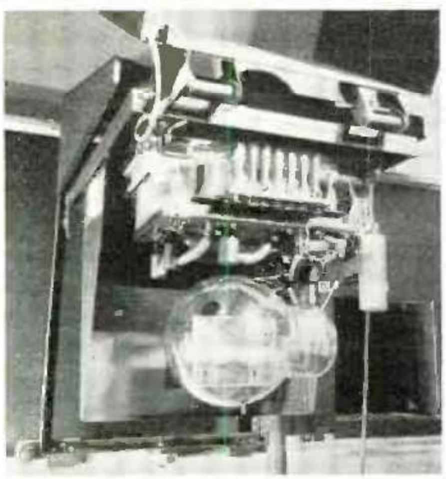


The Iconoscope and the connections to the first amplifier tube. ↑



The inside of the tele-camera with the iconoscope in its proper place.

The tele-camera is moved around by the cameraman by means of a dolly.

IN THE first article of this series, which appeared in the February issue, I presented a general, semi-technical view of modern television, as it stands on the threshold of its introduction to the public. Frequency channels for this new art were covered, the reader was introduced to "scanning," then the method of minimizing flicker and known as "interlacing" was explained, and synchronization was broken down into its blanking, pedestals, pulses and serrations. You are strongly urged, if you missed this first installment, to secure the February issue for the groundwork laid, upon which future discussions will be built.

Continuing the investigation of television, as it is unfolding today, it seems only fitting that the first unit considered should be the magical tube that most of us now call the Iconoscope. This name is the copyrighted term of RCA and it appears to have been developed from the Greek words "eikon" meaning image and "scopein" signifying observation. It is, of course, one form of cathode ray tube; to many it is known as Camera Tube, Mosaic Tube or Signal-Generating Tube. Farnsworth calls his pick-up tube the Image Dissector and its construction differs somewhat from the more generally-used Iconoscope.

In any parlor or schoolroom conversation on television, the question is asked "How do they get the picture into electrical currents?" The Iconoscope is an amazing satisfactory answer, open to improvement and development during the next few years, but, right now, a fascinating result of master research and laboratory work. Figure 3 of the first article gave the reader a very general idea of the construction of cathode ray tubes, but now, for the more detailed discussion, Figure 6 is presented.

The Iconoscope's two main parts are, first, an electron gun contained in a long, thin tubular neck, the throat of which opens into a rounded square bulb, and, second, the mosaic which is a thin square plate within the bulb. The tube containing the electron gun is so placed that its axis is 30 degrees below a line drawn straight out from the center of the mosaic. This construction makes it possible to focus an image, through a lens, squarely on the mosaic. The coils from which four leads protrude, shown around the neck

THE ICONOSCOPE

By M. W. THOMPSON
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There is not anything as unusual as the method used to convert a picture into electrical impulses by the Iconoscope. It has been rightly termed, modern magic.

of the Iconoscope, are the deflecting yoke, by means of which the electron beam is made to scan the mosaic.

Figure 7 depicts the construction of the electron gun, that part of the cathode ray tube which handles the generation, concentration, control and focusing of the electron beam. At the left end is a heater of the usual type, contained within an electron-emitting, flat-topped cathode. In the center of the flat top is a spot of oxide preparation. While frequently termed a "grid" the control electrode takes the form of a short metal cylinder in which is a flat disc with a small opening at its center. This control element is kept at a negative potential relative to the cathode, which has the dual effect of limiting electron emission around the edges of the flat top of the cathode and tending to concentrate emitted electrons in the center.

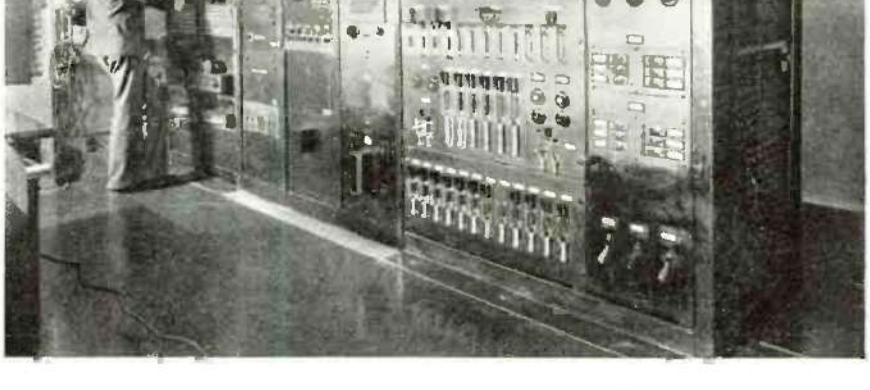
The longer cylinder, identified as the "Accelerating Electrode" (often termed the 1st Anode), is made very positive to both the cathode and grid. The first action of this element is that its electrostatic field "reaches into" the opening in the grid disc and draws the electrons into a beam. This electrode may, apparently, have either one, two or three discs; in the published papers of Messrs. Zworykin, Maloff and Epstein, all three types may be found. Its further action is to accelerate the motion of the electrons, narrow the diameter of the beam, and throw the stream (at its further end) into another electrostatic field.

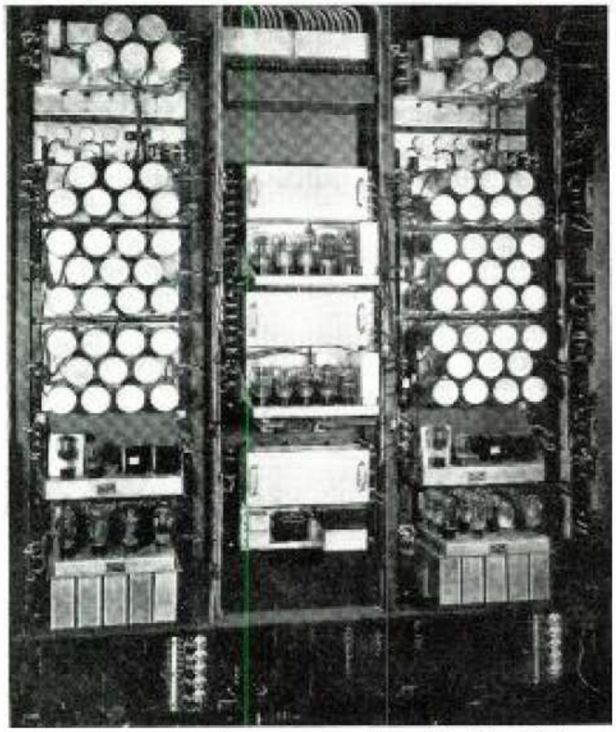
While the Accelerating Electrode and Focusing Electrode No. 2 are connected together, and are therefore at the same potential, it should be noted that Focusing Electrode No. 1 is interposed between them and is at a different potential. There thus will be an electrostatic field affecting the beam as it progresses from the Accelerating Electrode into Focusing Electrode No. 1, and another acting upon it as it passes from this latter electrode into the zone of influence of Focusing Electrode No. 2.

These electrostatic fields have been so developed that they focus the beam to a spot of the desired size on the mosaic. The lines of force of these static fields will force the electrons toward the axis, overcoming the natural tendency of electrons to repel each other. The action is very similar to

The Empire State Bldg. transmitter control panel is very complicated. ↓

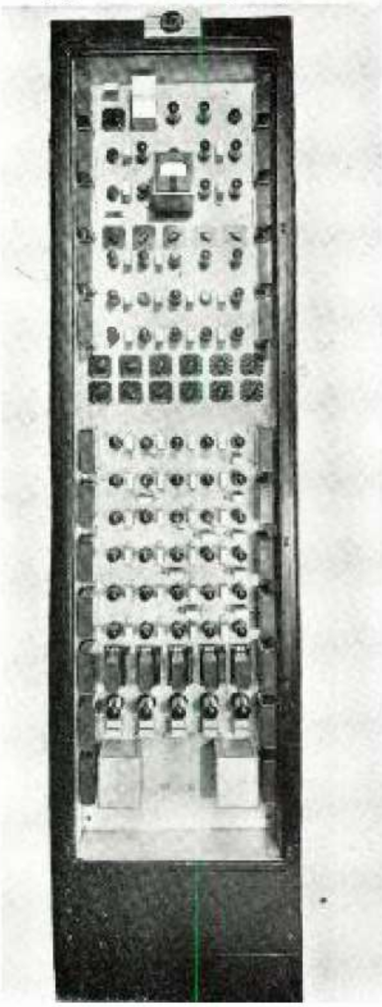
Pres. David Sarnoff (c) of RCA opens the 1939 N. Y. Television Programs. ↑





Early form of synchronizing panel used in New York.

Latest form of the same synchronizing generator developed by RCA.



the focusing of light rays with optical lenses. The beam can now be visualized as an extremely fine, high pressure stream, controllable as to direction, and with its negatively-charged particles moving with velocity of the order of 30,000 miles per second.

The mosaic upon which the image is directed by an optical lens, and over which the beam is moved in scanning, is to me one of the finest results of patient research and development to be found in either radio or television.

To analyze its construction, let us consider, first, a sheet of very thin mica, perhaps four inches square. On one side of this mica we deposit millions of little globules of silver, each one separate from the others, a unit in itself. Just how this is done at present its makers do not reveal, but comparatively recent models were made by evaporation of silver oxide in a vacuum, then heat-treating to remove the oxygen content.

The material which makes the tiny globules photo-sensitive is known as cesium. It is introduced into the operation either while removing the oxide or shortly thereafter. Each little bead now possesses the property of emitting electrons, the rate of emission varying *with the amount of light reaching it.* If now, on the reverse side of the sheet of mica, we place a conductive metallic film, we will have millions of little condensers existing between this sheet, known as the

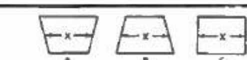


Fig. 9. Keystoning effect.

signal plate, and the multitude of globules forming the mosaic.

While our silver was deposited so finely that there will, very easily, be something like 67,500,000 minute dots of photosensitive material on the mosaic, we are going to consider these in groups of 300, and each 300 will be a picture spot, or unit. This number is arrived at because we are going to have 411 *active* lines vertically (of our 441-line scanning), and about 547 units

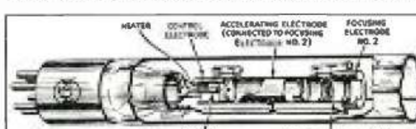


Fig. 7. Cutaway of an electron gun.

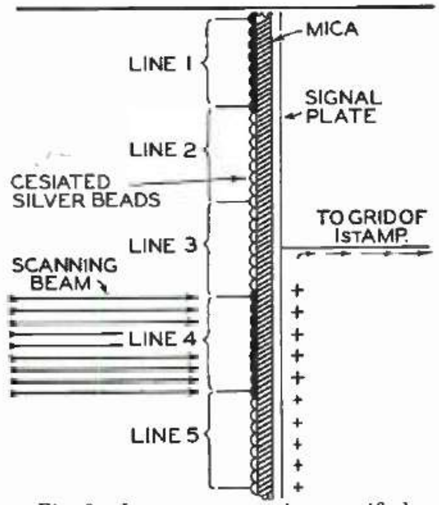


Fig. 8. Iconoscope mosaic, magnified.

horizontally in each line, which means that our mosaic is to be considered as 225,000 scanning spots. If 67,500,000 be divided by 225,000 we have about 300 silver dots per unit.

The mosaic is now placed in the evacuated glass bulb of the Iconoscope, so that it is at right angles to the light striking it from the lens through which the image is secured. The sensitized surface faces the image to be televised; on the reverse side of the mica sheet a connection is made to the metallic surface and brought out through the glass bulb. Figure 8 is a cross section of a mosaic and signal plate,

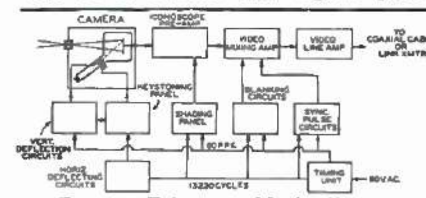


Fig. 1. Telecaster block diagram.

highly magnified, and including a height sufficient for five scanning lines. As drawn, only seven or eight silver beads are shown per horizontal line, although this would actually be 17 or 18 for a 300-beads-per-unit mosaic.

While a long and very detailed technical treatise could be written on the subject of cesiated silver under bombardment, and the secondary emission of electrons, it should be sufficient, for a semi-popular outline on television, to sum up the activity on the mosaic as follows: The scanning beam from the

(Televise further on page 64)

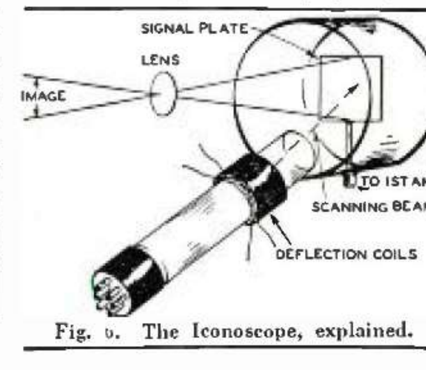


Fig. 6. The Iconoscope, explained.

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Television Course

(*Continued from page 8*)

electron gun is, at the moment, on a scanning spot in line 4. It is presumed that the image being scanned is dark on lines 1 and 4 (for that reason I have made the beads black in those lines) and light on lines 2, 3, and 5.

Due to the photosensitive characteristics of our cesiated beads, the charge on the beads in lines 1 and 4 will be greater than on those in lines 2, 3 and 5.

As the beam strikes each scanning spot, the 300 little condensers contained in the spot release their charge into the conductive signal plate and thence to the grid of the first amplifier. As the beam moves over the image on the mosaic, there is generated at the signal plate a voltage whose magnitude, at any instant, depends on the image brightness at the point where the beam is at that instant. Very dark spots provide a stronger current, grays produce a medium current, and whites hardly any, comparatively. These currents are all in the neighborhood of only a few tenths of a microampere.

And that, my readers, is how a visible scene is converted into 225,000 little impulses chasing each other along a wire so fast that they are all out of the way in 1/30-second, and our scanning beam is ready to do it all over again.

It might, perhaps, be appropriate, at this point, to go into the circuits and tubes that are used to deflect the beam of electrons from top to bottom and left to right (or vice versa, as is sometimes necessary) for scanning. The subject is, however, so important, complex and essential to construction of a receiver that I believe it better to handle it, fully and in detail, in another article. There are several types of oscillators used for this purpose, such as "blocking" and "relaxation"; there are gas discharge tubes and high vacuum tube discharge circuits; impulse wave forms and saw-tooth wave forms; and amplifiers new and unique both as to characteristics and purpose. For the time being, take it for granted that our mosaic can be scanned, as described, and let the "how" wait.

While we are on the subject of the mosaic and its scanning, let me point out some interesting effects that television camera operators will be able to obtain, once they become familiar with the device and its operation. Let us say the camera is televising a scene in a room in which a group of three are talking at one side of the room and a couple are standing at the other side. At first, the image of the whole room will be covered as the electron beam scans the entire mosaic.

By decreasing the amount of swing (amplitude) of the beam, both vertically and horizontally, and shifting the centering current (thus scanning but an off-center part of the mosaic) the effect will be of moving the camera "in" for a close-up on the group of three, although *the camera itself is* *not moved.* Shifting the position of this "reduced area" scanning pattern on the mosaic, the effect will be that of turning the camera around for a close-up of the couple; then, by increasing the amplitude of swing of the beam to include the entire mosaic, it will appear (to those with receivers) that the Iconoscope was moved away to again take in the entire room, yet the camera itself need not be shifted.

I am quite sure that, long before this, quite a number of discerning readers have said, in effect, "Wait a minute here, Thompson. If that electron beam scans the mosaic from a 30-degree angle, it is not going to scan a rectangular shape. The scanning pattern will be a keystone-shaped area (see Figure 9a) because of the greater distance from the deflecting point to the top of the mosaic." Which is absolutely right, and brings up the matter of "keystoning."

What is actually done to correct this is to so deflect the beam, by the scanning action, that, if it were scanning a plate at right angles to the axis of the electron gun, the result would be a trapezoidal pattern such as is shown by Figure 9b. The swing of the electron beam is made slightly shorter toward the top of the mosaic, gradually increasing in length as it moves down. Thus, the result, at the receiver, is exactly as it would be if both the axis of our optical lens and the axis of our electron gun were squarely perpendicular to the mosaic (see Figure 9c).

A block diagram of the more important units necessary to a commercial television transmitter is presented in Figure 10. Because of the feebleness of the initial currents from the Iconoscope it is practically essential that the unit termed "Iconoscope Pre-amplifier" be included in the camera.

This unit may consist of five stages of amplification, using the comparatively new type 1851 tubes, which will permit the signal voltage to be raised to a level of about one-half volt (peak to peak video signal). By doing this immediately following the Iconoscope, and before subsequent mixing, clipping and transmission operations, the signal will be well above any "noise" or hum introduced while in transmission lines or by control circuits. The difficulties to be overcome in developing such an amplifier can well be imagined when one considers that equal response is desired over a band width of 60 cycles to 5 megacycles.

The unit identified as "Shading Panel" may cause some lifting of eyebrows. An Iconoscope has the inherent characteristic of having appear in its output a variety of undesirable spurious signals along with the video currents. What is known as "dark spot signal" appears (if not corrected) in the received picture as shading over portions of the picture. This can be almost completely eliminated by the introduction of "shading" signals at the grid of the first tube in the Preamplifier. Because this "dark spot signal" varies for different operating conditions, and for different Iconoscopes, it is useful to have available, from the shading panel, saw-tooth, sine and parabolic waves at both horizontal (13,230) and vertical (60) frequencies.

Following the Pre-amplifier in Figure 10, it will be seen that the signals now go into the "Video Mixing Amplifier." The formation of a complete set of television transmission signals, such as were shown in the first article, requires that the video signals be combined with suitable blanking (blackest black) voltages, and that synchronizing pulses be superimposed upon the blanking signals.

The mixing unit wherein this is done may very properly consist of seven tubes, the first two of which are straight amplifiers. Into the plate circuit of the second, however, a third tube (acting as an amplifier only) injects blanking signals supplied to it from the unit called "Blanking Circuits." The fourth and fifth tubes merely amplify the combination of video and blanking signals. An operation known as "clipping" is performed by the sixth tube. As used here, it is (for the benefit of advanced amateurs) a plate current cut-off type circuit, the linearity of which has been improved by degeneration, introduced by cathode loading.

Clipping removes transients and spurious peaks caused by both the Iconoscope return trace and the shading signals. It is necessary also, first, so that the top of the blanking period pulse will be perfectly flat; second, that the height of the blanking period pedestal be set at a definite level, as it is this height which ultimately determines "blackest black"; third, it prevents high peaks of the video signal from extending up above the black level where they might interfere with the synchronizing operation.

Having now so arranged our continuous stream of signal that we have a flat-topped pedestal inserted 13,230 times per second, between which there are periods of video signal, we can now, in the plate circuit of the sixth tube, superimpose synchronizing signals upon the pedestals (see Figure 5, first article). Our seventh tube (used as amplifier only) is connected with its plate in parallel with that of tube six, its grid being fed with properly-timed synchronizing pulses from the unit termed "Synchronizing Pulse Circuits" in Figure 10. The output of the mixing unit is then amplified in a Video Line Amplifier properly designed to pass our 60-cycle to 5-megacycle video band width.

It is far beyond the scope of these articles to go into the circuits of the Synchronizing and Blanking Impulse Generator. It is an awsome array of tubes and the necessary coupling and control adjuncts, which includes all three units in my block diagram labelled "Blanking Circuits," "Synchronizing Pulse Circuits" and "Timing Unit." An illustration of such a panel, as used in one of RCA's transmitters, is shown. Sixty-two may be seen, of which about one-fourth are for timing and three-fourths for blanking and sync impulse generation. One begins to understand why the investment in a commercial television transmitter runs into box-car figures.

The timing part of a transmitter is interesting in many ways. There is, of course, an oscillator (6A8) which starts everything going, this being tunable and adjusted for 13,230 cycles. A lead from this oscillator can be taken out at this point for horizontal timing. The tetrode section of the 6A8, acting as a frequency doubler, then raises the frequency to 26,460; the next tube is a 6F8 multi-vibrator, synchronized with the frequency which is one-seventh of 26,460, or 3,780. Again, the frequency is divided by seven, reducing it to 540; the next two stages each divide by three, bringing it down to 180 and, finally, 60. Here a tap is taken off to provide our field (vertical) frequency; another lead takes part of the 60 pulse-per-second output into a unique arrangement whereby the whole array is locked into synchronization with the 60-cycle city power lines.

One may wonder why all this seemingly unnecessary doubling and dividing. It is a condition imposed by 441-line interlacing that the horizontal frequency of 13,230 p.p.s. contain no *even* harmonic of the field frequency of 60 p.p.s. The field frequency is obtained by dividing the second harmonic of 13,230 (26,460) in steps of 7, 7, 3 and 3. These four numbers, multiplied, equal 441, the lines per frame.

The amplified video current, complete with blanking and synchronizing pulses, may now be used to modulate an r.f. output created by any of the usual combinations of r.f. exciter, power amplifiers and output stage. So much for pick-up, amplification and transmission; having high-spotted some of the more interesting phases of these operations, we can now, in future issues, get into receiver essentials and design.

Reference Reading

Iconoscopes and Kinescopes in Television
By V. K. Zworykin
RCA Review, July 1936.

The Brightness of Outdoor Scenes and Its Relation to Television Transmission
By Iams, Janes & Hickok
Proc. I.R.E., August, 1937.

Some Notes on Video Amplifier Design
By A. Preisman
RCA Review, April, 1938.

Theory and Performance of the Iconoscope
By V. K. Zworykin, G. A. Morton & L. E. Flory
Proc. I.R.E., August, 1937.

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[Next month the author continues this revealing, interesting television course by laying the groundwork for a discussion of the television receiver.—ED.]

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