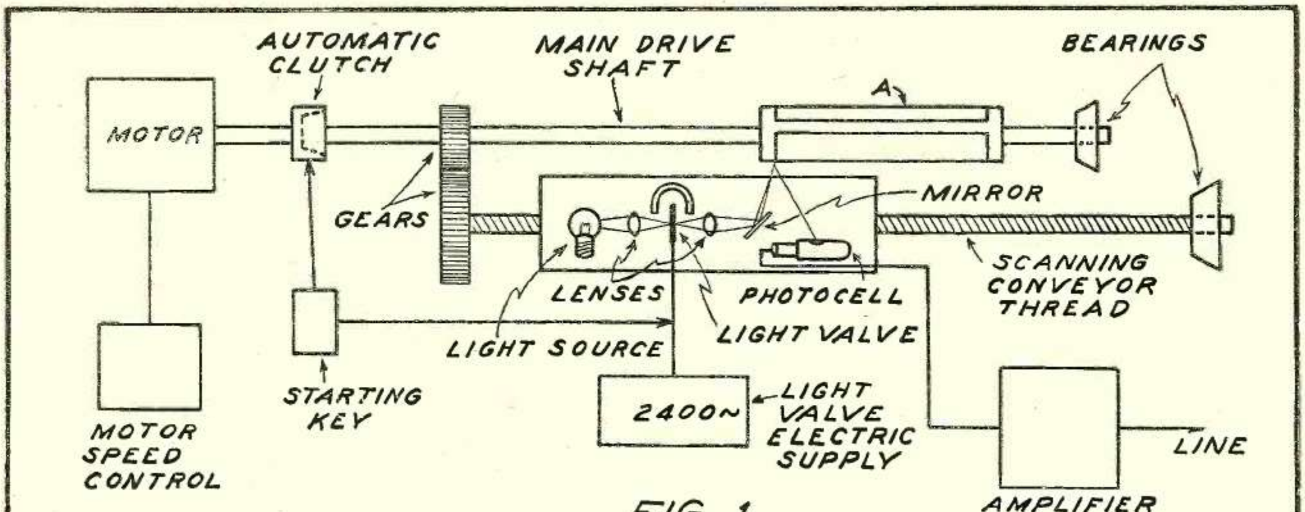

FIG. 1

# *Practical Lessons in*
# TELEVISION
## *(Lesson One: Sending a Picture)*

**Like all developments of present-day scientific marvels, television to the uninitiated seems to be too complicated for even a mediocre understanding. But such is not really the case if the layman is first presented with the fundamental ideas involved. Television has borrowed these ideas from so many different arts and its development has taken such an indirect course that its exact beginning may seem somewhat obscure. We can, however, trace its development from the various sources and present these ideas so that any interested person can grasp the principles without too much difficulty. This series begins with a description of picture transmission and elementary "scanning." If you are a radioman, it is important that during the next year you learn what television is and how it is accomplished. Start today and don't miss a single lesson.**

*By* **F. L. Sprayberry**

PERHAPS the most basic of all the ideas utilized in Television to the present day was brought forth even before the twentieth century by P. Nipkow, who was a Polish scientist. He had no thought of television in mind at the time, as this was in 1884, before the practical telephone or the practical use of the electric light bulb. Scarcely three years before this, Thomas A. Edison exhibited the first incandescent lamp in Paris, using the carbon of a small splint of bamboo as the filament. It hardly seems possible that television got its start almost with the incandescent lamp, but it had to await development of subsequent arts before these items could be borrowed and adapted for its use. To grasp the full significance of television in its present form, we must turn from electricity, to physics, to optics, to electronics and to chemistry as readily as a linguist may turn to one of many languages. Rather than a handicap to this study, we will find that this is really an advantage because of the similarity of each branch of science to others and the theories applying to one branch fitting another just as perfectly.

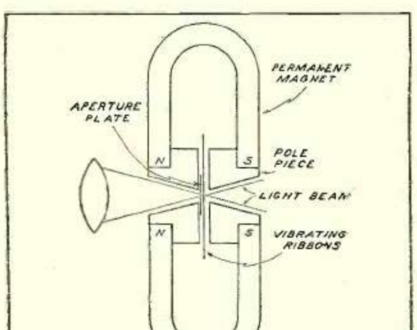

FIG. 2

### Picture Transmission

Were we studying moving pictures as employed in the theatre, we would naturally start with the projection of our picture and then simply show how the means were applied to project a number of slightly different pictures in rapid succession *to give the illusion of motion.* So it is with television, we start with the transmission of one picture and then show what means are required to perform the same basic operation many times per second *to also give the illusion of motion in the succession of slightly differing pictures.*

Only a small percentage of people realize today that a great number of pictures are sent by wire for newspapers and that the art of Wire Photography, also called Telephotography, has advanced to a highly refined stage. A picture may be taken with an ordinary camera in Seattle, Washington, for example, from which a negative may be made and sent to the location of the picture transmitting equipment. To the telephone

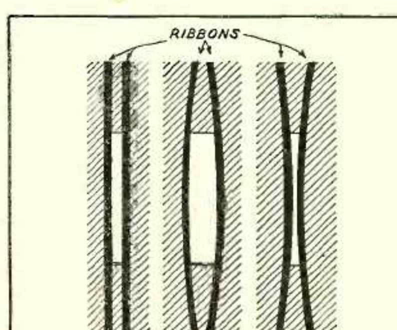

FIG. 3

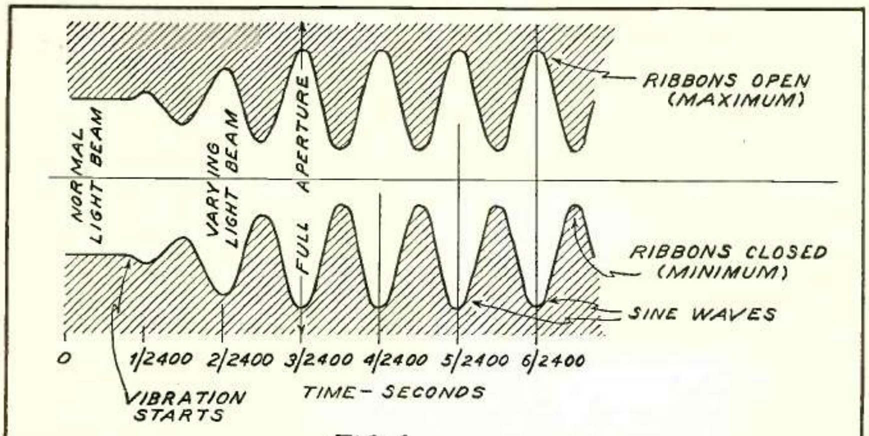

FIG. 4

HOW A LIGHT GATE WORKS
*Figure 4. Showing how the ribbons, upon opening and closing, modulate the light intensity.*

lines may be attached any number of picture receiving units and within a short time the picture may be showing on the news-stand in twenty-five or more cities all over the United States. This may be extended to foreign countries as well, through the use of a radio in place of a wire line.

Let us look into the details of this process as it will be a big step in the understanding of modern television. In Figure 1 is shown a diagram of a picture transmitting equipment. Any photograph up to 11 by 17 inches is placed on the cylinder "A" with its back toward the cylinder, usually with its longer dimension along the length of the cylinder. Means are provided for clamping the photograph onto the surface of the cylinder. The latter is approximately 3¾ inches in diameter or 12 inches in circumference, so that only a 1-inch space is left along the cylinder if an 11-inch picture is used. The cylinder is rotated by means of a speed-controlled d.c. motor through an automatic clutch on its shaft at exactly 100 revolutions-per-minute. A reduction gear mechanism on the cylinder shaft and an auxiliary shaft serves to drive a long threaded shaft beside the cylinder and parallel to it. On this shaft is mounted an assembly which it moves at the rate of 1 inch per minute in exactly the same manner that a cutting tool is carried along the "work" on a metal lathe. Of course, the gear ratio and the pitch of the thread on the second mentioned shaft is made to provide this speed of rotation and of movement of the assembly. In this assembly is housed the means for resolving the picture into a signal ("dissecting" or "scanning") for transmission. The light from an ordinary electric lamp, actually an automobile headlight lamp, is focused on a fixed mirror through a mechanical light valve. The mirror reflects the light beam onto a spot on the picture, one hundredth of an inch square which in turn reflects the remaining light back into the assembly and onto the cathode of a photoelectric cell.

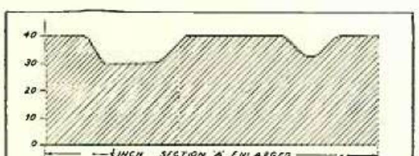

FIG 7A

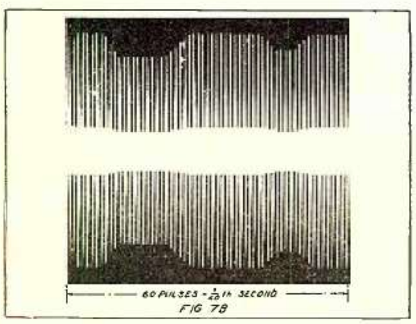

FIG 7B

## How It Works

Suppose we now turn to a study of how these pieces of apparatus are capable of producing a signal by which a picture may be rebuilt. The light is of constant intensity and by means of the lens between it and the light valve, is focused almost to a point at the light valve. The light valve consists of two ribbons connected at one end forming a hairpin loop suspended in a powerful magnetic field. As seen in Figure 2, this field is constructed somewhat like a dynamic speaker field except that the air gap between the two magnet poles is flat and rectangular instead of cylindrical and permanent magnets are used. A hole in the center of the magnet is provided and it is fitted with a metal plate with a slit about ¼ inch long and .01 inch wide. In passing through this slit or aperture the light next comes to the two ribbons as in Figure 2. An alternating current of 2400 cycles is impressed on the two open ends of the two ribbons and they vibrate at 2400 cycles because of the action of the main permanent magnetic field on the 2400 cycle field. The action of the two fields, one due to the permanent magnets and one due to the 2400 cycle current moves the ribbons "laterally" across the permanent magnetic field. When in their normal positions they partially conceal the total light "gate" or aperture as in Figure 3. When the ribbons separate, more light may pass through the gate, but when together very little light may pass. As current is flowing down one ribbon, it flows up the other one, thus they move in opposite directions.

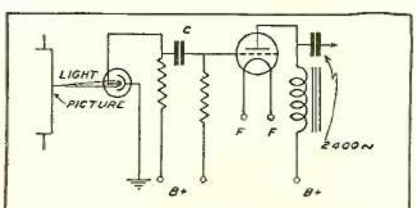

FIG 8

## What the Graph Shows

At high speed these ribbons move in a wave-like manner, like a violin string or a pendulum. Therefore, if we make a graph of a few complete cycles of motion showing the relative size of the cross section of light passing through the gate as in Figure 4, we will have a good idea of the light fluctuation reaching the mirror. It will increase and decrease in a sine-wave manner as shown.

## Beam Modulating

From the mirror this light is projected onto the rotating cylinder carrying the picture to be transmitted. The light reaches the picture when focused to a point .01 inch square and is reflected from the picture back into the moving assembly and into a photocell (photo-cell to be explained later). The picture will reflect various amounts of light depending on whether it is black or white at that point or in proportion to any graduation between black and white as it passes under the light beam. Practically no light will be reflected from a black area while a large percentage of light will be reflected from a white area. In other words, shading in photographs will modulate the clear beam of light from the light source. In addition to this the amount of light will be proportional to the tone or grade between

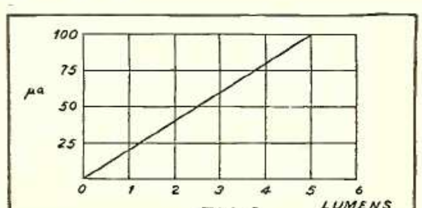

FIG. 9

FIGURE 5

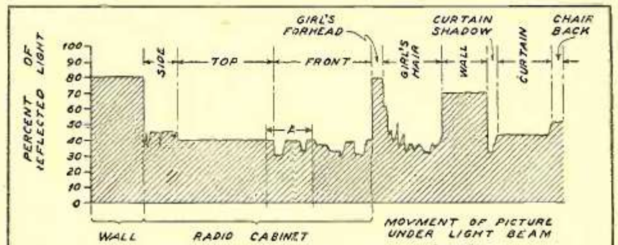


FIG. 6

WHAT A "SCANNING" LINE REALLY MEANS

*The photograph above, Figure 5, shows a scene being televised, the white line across the picture representing a scanning line. The diagram in Figure 6 shows how this line of light reflected from the scene will produce a varying electric current in accordance with light and dark portions of the scene.*

black and white of the picture. As the cylinder rotates the light traces a "helical" path on the picture as the unit carrying the light source and apparatus just described moves at the rate of .01 inch per revolution of the cylinder. The area traced by the light is much like the thread groove on the end of a pipe, one groove being directly adjacent to the next one.

### How Scanning Works

A study of the photograph in Figure 5 will show how this works. Note particularly the line through the photograph. This represents one tracing across the photograph. This one tracing or single beam of light as shown in Figure 5 (this beam of light would be reflected from the drum A in Figure 1) strikes the cathode of the photo-cell shown in Figure 1. The photo-cell changes the shadings of light intensities into electrical pulses which correspond exactly to the light intensities which strike the photo-cell. Thus intensities of light are changed into electrical pulses—and remember these represent reflections of one narrow strip of light from the photograph of Figure 5, which we are imagining is placed on drum A of Figure 1.

### Light Fluctuations

You are, no doubt, interested in the nature of the electrical pulses which represent the one narrow strip across the photograph of Figure 5. A graph of these pulses is shown in Figure 6.

Referring now to the photograph of Figure 5, from left to right, we first come to the wall in the picture which is quite light and may reflect about 80% of the light back onto the photo-cell. The modulated light fluctuates a trifle responding to the "grain" of the wall as seen. Then the picture turns with the side of the radio cabinet under the light. This is much darker and suddenly the percentage of reflected light reduces to below 40%. See the electrical equivalent in Figure 6.

### Picture Analyzing

Due to the "beading" and other decorative designs on the radio cabinet, this light as reflected varies some 10% in the region entering the cabinet side from the wall to the left and at other places. The "grain" of the cabinet top forms slight variations in the reflected light and so on.

In further pursuit of what happens in this instrument, let us take a small section (A of Figure 6) representing a length along the "scanning" or dissecting direction and give it further study. Let us say that the distance "A" is ½ inch long, and that the picture is moving under the light at the rate of 20 inches per second. To move distance "A" (½ inch) then only requires 1/40th of a second and in this time the modulated light sends 60 "pulses" of light to the picture. If it produces 2400 pulses (cycles) in 1 second, in 1/40th of a second it must send 2400/40 or 60 pulses of light to the picture to be reflected. These 60 pulses of reflected light on an enlarged scale would look graphically like Figure 7B. In Figure 7A we have duplicated section "A" on a much enlarged scale so that we can examine it more closely.

Figure 7B represents the actual amount of light falling on the photo-cell. We now must consider what this photo-cell is and what use it makes of those light pulses. The photo-cell used here is a type of vacuum tube having an anode element in the form of a circular ring and a cathode in the form of a circular disc. Of course, the construction of various types of photo-cells differ widely and some use a rod anode instead of the ring and a cylindrical cathode instead of a circular disc. Some even use a coating of metal condensed on the inner surface of the glass envelope as a cathode.

### How the Photo Cell Works

A d. c. voltage is impressed between the anode and cathode with, of course, cathode negative and anode positive and the reflected light from the picture is impressed on the cathode of the photo-cell. The cathode has been chemically prepared in such a way that it will discharge electrons when exposed to light and there will, of course, result a current of electrons to the anode.

Now the number of electrons liberated from the cathode depends very closely on the amount of light reaching it and since all liberated electrons are attracted by the anode having but one positive voltage value, the electron current depends on the light striking the cathode. Moreover the current is proportional to the amount of light reflected into the photo-cell.

The current flowing through the photo-cell circuit would, therefore, have 2400 pulses per second (if we employ the system of Figure 1) and the amplitude of the successive pulses would be modulated by the tone value of the original picture.

The photo-cell circuit is wired exactly as the plate circuit of an amplifying tube would be wired as in Figure 8. The effect of the light on the cathode is almost precisely like that of a control grid in a triode although the anode current here follows the light changes more accurately proportional than the plate current changes in a triode follow the grid voltage changes. What is equivalent to the Eg-Ip curve in a triode, is the light—anode current. For a given anode voltage, 60 to 250 volts, depending on the cell, Figure 9 shows the perfectly linear relationship between the light intensity and the anode current.

### The Light Unit

To get a good idea of the size or magnitude of a "lumen" of light, one standard candle power requires very roughly 1 watt of power. Of course, if the power is used for lighting a filament type lamp, a good portion is converted into (*Turn to page 423*)

## Lessons in Television

(*Continued from page 396*)

heat. One watt can, therefore, produce only from 8 to 12 lumens of light. If a standard candle lamp is placed in the center of a sphere with a radius of 1 ft. (diameter 2 ft.), the light will produce $4\pi$ or 12.57 lumens on the inner surface of the sphere or I lumen every square foot of inside surface area—there being 12.57 sq. ft. in all. Since this would light 1 sq. ft. of surface at 1 ft. distance, it might be called a foot-candle (which is I lumen) the most common unit of light intensity measurement. Since the total light value is the product of the light source intensity, and the area on which it falls, we see immediately that for a small area the light density must be increased to preserve the same total or product.

Coming back to Figure 8, we have an audio amplifier which may be tuned as desired to 2400 cycles. A band-pass filter is used to cut off all frequencies below 1200 cycles and above 2600 cycles.

Here for the first time, we can see the necessity of the vibrating light modulator. It permits the amplification of a definite audio frequency whereas if we attempted to amplify only the wave produced by the graduations in tone of the picture the amplifier would not be as effective at some points on the picture as others. For example, if the tone of the picture changed only gradually from light to dark or vice-versa, each grid in the amplifying system would change just as gradually and the corresponding frequency would not be sufficient to pass through the coupling condensers. The 2400 cycle tone, however, will be amplified the same amount throughout the system and the system will handle this energy with any rate of modulation desired. Just as we found it necessary to use a high-frequency carrier to transmit voice currents through space, we may use a "carrier" (2400 cycles) to transmit what we will call the "picture component" through a wire and amplifier circuit.

### For Stronger Signals

Rochester, N. Y.—Mr. E. A. Hanover, Vice-President of the Stromberg-Carlson Telephone Mfg. Company, recently announced that station WHAM, NBC Blue Network affiliate, has under construction a self-supporting vertical antenna that will tower 450 feet into the air. The vertical radiator will be a 4-sided steel angle structure 25 feet at the base and tapering to a square 21 inches on a side.