Radio Vision Demonstrated in America

By H. Winfield Secor

For the past several years radio news has been describing various television systems, all more or less in an in-complete state. That described by Mr. Secor, however, is a real development, by means of which clear and recognizable images are received. We are sure all our readers will be interested in reading the details of its operation.—EDITOR.

April 7, 1927, will always be a memorable day in the annals of science, for on that day before a group of invited guests, the experts of the Bell Telephone Laboratories demonstrated in New York the first, practically perfect reproductions of the living image of Mr. Herbert Hoover and others speaking at the Washington end of a telephone circuit; and secondly, similar images transmitted by radio from Whippany, N. J., thirty miles away.

To make the subject more interesting, it is well to state at the outset that at the transmitting end of the circuit the image of the moving object was reproduced in two forms. In the smaller receiving instrument the size of the image is about 2 1/2 x 2 inches, and here the likeness was very perfect; Mr. Hoover’s face appearing in a photographic reproduction against a rose-pink background. This color is due to the use of neon gas in the glow-tube, which is placed behind a revolving disk in the small machine. The larger reproduction apparatus, used to show the built-up image before the assembled guests, had a screen approximately 24 inches wide by 36 high. Here also the general color of the background was pink, due to a grid of evacuated glass tubing containing neon gas, which formed a surface on which the picture was built up by means of 45,000 light-flashes sweeping over the screen every second.

How Image Is Transmitted

Referring to the diagram (Fig. 1, A, B and C), we shall first consider here a contracted light-beam from an arc lamp is caused to sweep across the object, a human face for example, in a series of small spots and at a rate of 900 light-flashes per second. The light from the arc is concentrated through a condensing lens upon the back of the rotating perforated disk shown in the figure. There are 30 small holes drilled through this disk, these being laid out in a spiral, it rotates eighteen times per second, or 1080 revolutions per minute. As the three stages of the process, (Figs. 1A, B and C), demonstrate, and thanks to the slit or diaphragm placed behind the disk, one hole only through and sweeps across the image in the second lower position. Look at Fig. 1C, and it becomes evident that when No. 2 hole has reached the vertical position, and the third pencil of the beam sweeps across the image in the third position from the top of the face or other object at the transmitter.

This action is repeated, as becomes clear, so that when the 50th or innermost hole of the spiral on this disk comes into position before the diaphragm, a pencil of light passes through, sweeping the bottom of the image. This is clear on inspection of Fig. 2.

It is well known that the motion picture of today is possible only because of the retention of vision by the human eye. That is, sixteen slightly different pictures are jerked one after another, in front of the lens and flashed on the theatre screen every second. Due to the "lag" of the human eye, the individual pictures overlap and give the illusion of a perfect moving image. The same thing occurs in this television system; but instead of flashing each line of the picture sixteen times per second, the engineers who developed this system of television in the Bell Telephone Laboratories cause the light-beam to travel across the image at the rate of eighteen times per second. As there are fifty light-beams, due to the fifty perforations in the rotating disk at the transmitter, there are 18 times 50, or 900 light-targets traveling across the image every second.

It might be thought that such speed would cause discomfort or haze, for instance, would prove unbearable; but such is not the case. The effect when looking through the opening in the transmitting machine is like looking into a camera lens with a fairly strong light behind it. The light beams change places so fast that the result is a slightly flickering bluish light, which seems to bathe the face or other object at the transmitter.

The next very important point to note is that, as the light-beam (at Fig. 1A for instance), moves across the top of the man’s face, a ray of light with a constantly-changing angle of incidence is reflected from the face and impinges on some part of the three large photo-electric cells used in this perfected system of television.

Looking at Fig. 2 we see how the three large photo-electric cells of new design are arranged in front of the image. In the pictures you will note that these three photo-electric cells, each of which measures about
The image at the receiving instrument, give a very faithful reproduction of the image at the transmitter.

A special vacuum-tube amplifier of several stages serves to magnify the very minute fluctuating currents coming from the photo-electric cells five thousand, thousand, million (5,000,000,000,000) times. It is interesting to note that this vacuum-tube amplifier had to be designed to amplify all frequencies from ten up to twenty thousand cycles. The image-currents then enter a
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5-kilowatt standard radio transmitter of the vacuum-tube type, and a 200-meter gap between the two antennas, is maintained practically uniform at all times. Note particularly how the 2,000-cycle alternating current supply is connected in parallel to the 60-cycle A.C. supply circuit. Suitable filters made up of inductances, resistances, and condensers, are placed in each pair to prevent the supply from reaching the A.C. line directly to the telephone circuits, which is simple in design and relatively inexpensive. A radio transmission, the insertion of a standard transmitter of the vacuum-tube type is necessary to transmit the synchronizing signals to the receiving instrument. In the demonstration recently conducted, these synchronizing signals were transmitted to the receiving station by a single-kilowatt transmitter, on a wavelength of 1,000 meters. It should be noted at this point that no such high power is necessary, and all of the units were operated at considerably less than normal capacity. The reason that these particular transmitters were used is that they happened to be available and handy at the experimental station. In radio transmission of the television image, the synchronizing signals were picked up on a standard receiving set fitted with suitable inductances and condensers for tuning at 1,000 meters; and the amplified synchronizing signals were then fed into the circuit supplying the 600-cycle and 2,000-cycle A.C. to the two synchronous motors driving the revolving disk in the receiving instrument.

HOW VOLUME WAS TRANSMITTED

Referring to Fig. 3, we see that the voice of the subject of the broadcast reception was transmitted to a standard radiophone receiver (40-kw), set, which was here used at greatly reduced power, from whence it was amplified by a standard microphone, fed into the circuit supplying the 600-cycle and 2,000-cycle A.C. to the two synchronous motors driving the revolving disk in the receiving instrument. The radio waves carrying the voice were picked up on a thin and independent antenna amplified by means of a standard receiving set, and then passed into a loud speaker placed alongside of the picture-reproduction mechanism.

REPRODUCTION OF IMAGE

Sufficient has been said to give an insight as to how the image is reconstructed or built up by light pulses, rapidly following one another at the receiving instrument.

Reverting to Fig. 3 once more, we note that the neon glow-tube, placed behind the revolving perforated disk, is about the size of a 75-watt electric light bulb; it contains two flat metal plates a short distance apart. The detail sketch in the upper right-hand corner of Fig. 3 shows the relative positions of the eye, the perforated disk, and the neon glow-tube when viewed from the top. Usually a curtain is drawn around the person looking through the aperture. The remarkable thing is that no screen of any kind is here used, and we might say that the person at the receiving instrument sees the brightness of the person at the transmitter actually reconstructed in the air.

The image at the receiving instrument is built up by reproducing the same number of light pulses per second, as those flashed across the face or object at the transmitting station. This is the effect of the perforated disk which carries the proper tone of some part of the image. The revolving perforated disk at the receiver rotates at the same speed as that at the transmitter and, like it has all fifty perforations. One of the wonderful things accomplished at this juncture is the perfection of the synchronization between the two revolving disks. Another very important contribution to the science of television is of course the special photo-electric cells used at the transmitting instrument.

Simplified Radio Transmission

Where the picture is transmitted and received over telephone circuits, four circuits would ordinarily be required; but, thanks to the ingenuity of the scientists who worked on this problem in the Bell Telephone Laboratories, this has been reduced to three circuits by combining the 600-cycle and 2,000-cycle.

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cycle alternating current circuits feeding the synchronous motors. Where regular wire circuits are to be used, there can be a still further reduction to one full-metallic circuit of two wires; as it is perfectly feasible now to transmit the three-signal currents for the image, for synchronism, and for the voice, by utilizing three carrier-frequencies. These must have a value above an audible frequency, in order not to interfere with the voice transmission. With voice transmission over special telephone circuits, the engineers have for several years been able to transmit six telephone currents over one circuit simultaneously, by using carrier-currents of different frequencies; in the case of multiplex telegraphy and telephony, transmitting ten different signals over two wires circuit simultaneously by the use of suitably graduated carrier-currents.

Looking at Fig. 4, we see how it is possible to simplify the radio transmission of picture images by this or any other system, and where three different wavelengths have to be transmitted simultaneously for the image, synchronism and voice transmission. As pointed out in an interview with one of the scientists of the Bell Telephone Laboratory, who is familiar with this remarkable achievement by their engineers, it is possible, it occasion required, to connect the three separate radio transmitters shown in Fig. 3 to a single antenna as shown in Fig. 4. This can be accomplished by connecting special, high-voltage transformers, using independently operated transmitters, condensers and resistances, in series with the respective radio transmitters and the common aerial and ground. In the recent demonstration and tests leading to it, it was found much cheaper and more convenient to use three separate transmission antennas and to introduce three separate aerial receiving antennas. These special filters required where three radio transmitters are to be connected to our antennas, are quite expensive. Probably even today it does not cost too much.

There are several ways in which the three wavelengths being transmitted simultaneously can be picked up and passed into the three independent circuits, for the image, synchronism and voice circuits. One of the simplest ways of picking up and sharply tuning the three desired wave-lengths is shown in diagram at A. Here an aperiodic primary winding on a special coil performs the function of transforming the aerial current to three or more independently tuned secondary windings. All the operator has to do is to tune the respective secondary circuits to the desired wavelengths. This is the system used for reception of transatlantic radio telephone messages. The more elaborate system of Dr. A. Hoyt Taylor of the Navy (see page 1421) can be used; as well as numerous others which have been patented and described in the technical press.

**DETAILS OF LARGE-IMAGE SCREEN**

These details have probably made fairly comprehensible how at last it has become possible for a person at a long distance from the telephone or radio circuit, to actually see the moving image of the person at the other end, but the mind fairly staggers at the results obtained in reproducing the larger television image on a screen measuring two by three feet, such as that demonstrated before the public which preceded the introduction of this system of television.

Imagine for a moment what a problem the engineers had to solve, when it became
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evident that to properly build up the image of a face for example, on a screen as large as two by three feet, that not less than 45,000 light impulses per second must occur! This meant, for one thing, that the synchronization between the two rotating elements at the transmitter and receiver must not be out of step by more than one ninety-thousandth of a second. As one of the scientists working on this problem pointed out to the writer, if either one of the revolving elements slipped out of synchronism by one-half a cycle, it would result in a negative image being received instead of a positive one from another words, you would see a white man with a black face and white hair. This problem, therefore, was one of the hardest ever placed before electrical engineers.

Other phases of the research problem were encountered in the development, by Dr. U. Gray, of the large tube used for the projection of an image large enough to be viewed by a considerable audience. The development and use of such a tube, with its present total of 500 external electrodes, required the construction of a current-distributing system from which 2,500 compactly-arranged metal segments, cemented along the back walls of the 500 revolutions of the neon tube. These are correctly and progressively energized. Note that the image is formed by passing light from a single glow-tube into a single glow-tube, as in the simple apparatus for the small image, are now amplified to a sufficiently high potential to cause the neon gas in the large tube to glow at the spot corresponding to any one of the 2,500 tips of the tube.

The man who built the commutator needed lots of patience, a good hard-wearing tinfoil, and also plenty of time. He had to connect the 2,500 insulated wires running from as many tinfoil segments on the back of the neon tube in exact order to their respective segments around the stationary commutator frame. When he had connected 50 wires from the 50 tinfoil segments on the back of the neon tube, the device was ready for the 50 wires to be connected to the 50 tinfoil segments on the second leg of the neon tube. Then the action, taking place in the magnified image on this large exhibition screen is made a little clearer perhaps by looking at the mechanically analogous diagram in Fig. 6.

Referring to Fig. 6 for the moment, let us note that at one of the fifty points of light at the transmission screen crosses the face for example, if, by analogy, causes a mechanical arm, corresponding to the commutator brush, to sweep across the fifty metal segments and has therefore caused fifty spots of light of varying intensity or tone to sweep across this top leg of the glass tube screen. As the commutator has 2,500 segments, it will be seen that, while the fifty light beams passing through the transmitter tube cause 900 spots of light to traverse the face of the picture each second, the number of light pulses, all properly graduated reproduced on the large glass tube screen will be 45,000. In other words, 2,500 light pulses, 8 times every second on the 2 x 3-foot exhibition screen; this is sufficient to give a satisfactory image, owing to the retention of vision by the human eye, as described in the first part of this article.

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