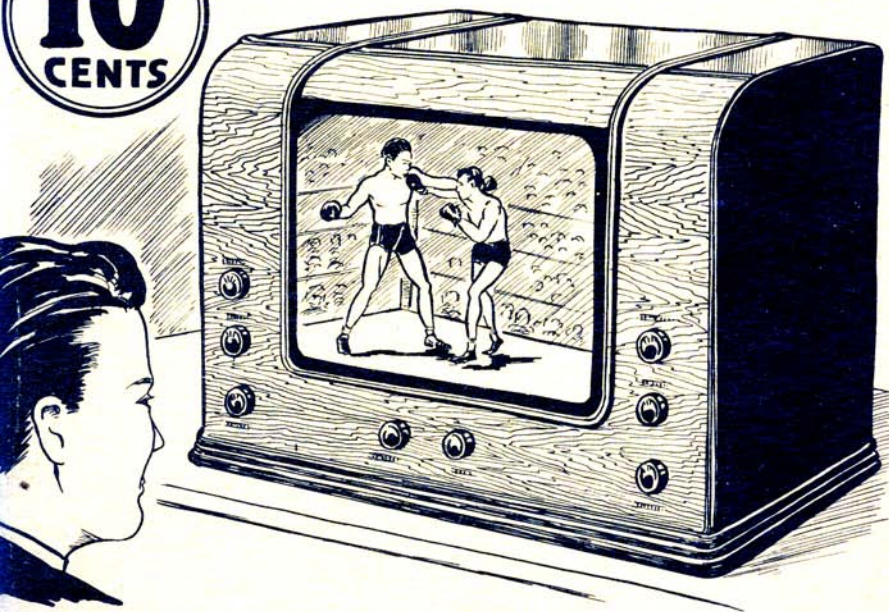


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TELEVISION

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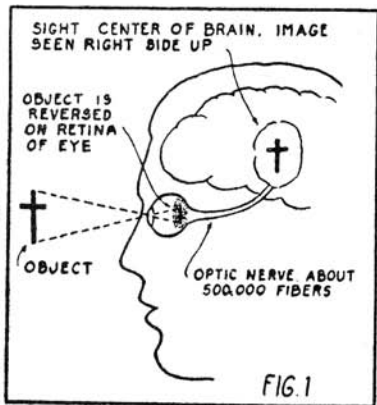
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A Primer of TELEVISION

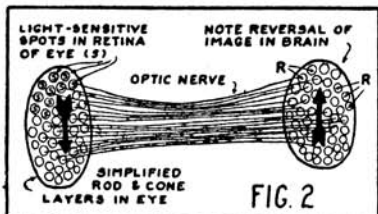
FOR THE STUDENT AND LAYMAN

TELEVISION, like our present-day motion picture, is dependent upon the little known fact that the human eye has a certain lag, and persists in retaining for the fraction of a second any image flashed upon the retina. Thus scientists found many years ago that, if a successive series of pictures of a man running, each picture showing a slight advance in the action, was flashed before the eyes, the illusion of motion was complete. In other words, by flashing say 16 progressive images on the eye, each a little more advanced, the viewer got the effect of a person running, each picture being stopped for the fraction of a second.

In *television* we have a similar situation — we build up a picture in front of the viewer, say 16 times or more per second and, if we do this with



The optical system connecting the eye with the brain is actually a television process



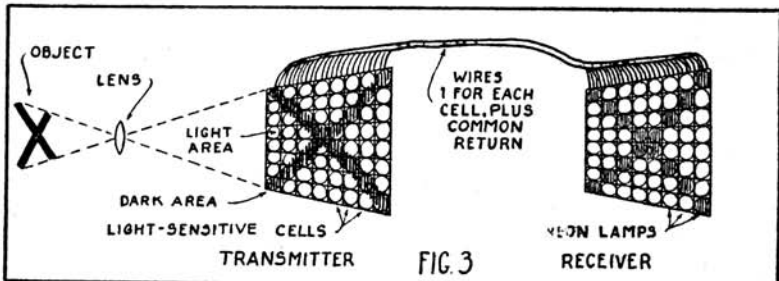
Even though the object as seen on the retina of the eye is upside-down, the brain sees it right side up

enough lines to give good detail, we provide as does the movie, a satisfactory representation of a person or object in motion.

The human eye is a very good example of television, so let us see how nature proceeds to transmit an image flashed on the retina at the rear of the eye up to the brain. The illustration (Fig. 1) shows how the optic nerve connects the eye to the sight-center in the brain; also note that, while the object is seen upside down on the retina, it is observed right side up in the brain. The light-sensitive layer at the rear of the eyeball is divided into thousands

of tiny segments, and it is believed that each of these segments transmits an electric (nerve) impulse to the sight-center in the brain, over 500,000 odd fibers making up the optic nerve. The optical system of the eye, in other words, acts like a modern telephone exchange; each wave or pulse representing a light or dark spot on the image is transmitted to the brain and here it is translated into the proper medium to give us the sensation of sight.

Easy, you may say — all you have to do is to duplicate that system and you will get television or the transmission of a moving image to a distance! Right you are, but the television experts thought of that too — and in fact the early television images were transmitted in just this fashion. A dozen light-sensitive cells (selenium — which was so slow in its action that it delayed television many years) were connected with wires to an equal number of light-reproducing devices, lamps for example. If the light falling on one of the selenium cells was weak, then the current passed over the circuit to that particular lamp was weak too, and the viewer at the receiving end saw



Simplest television system — a number of light-sensitive cells connected with a number of neon lamps

a weak light at that particular spot on the picture. If the next cell received a strong light, then a strong current was sent over that circuit to the corresponding lamp at the receiver, and a bright spot was seen in the reproduced image; all similar to the action occurring in the eye. But remember that the modern television image is made up of over 200,000 picture elements, and we would need that many cells at the transmitter, plus two hundred thousand wires, connected to that number of light-reproducing devices!

Fig. 2 shows how the light-sensitive spots in the eye are joined to the sight-center in the brain by the numerous fibers (corresponding to the wires in a telephone cable) of the optic nerve. Fig. 3 shows how the early television experimenters produced a crude image at the receiving apparatus, simply by connecting a selenium cell with a lamp or other device (a relay for example) as previously explained.

Nipkow, over forty years ago, devised the scanning disc, a circular piece of metal pierced with a spiral of holes. From a study of the construction of a picture, as exemplified by the modern halftone — with its dots of many sizes (3-a) representing light, dark and intermediate (half) tones, it becomes clear that, if we break down the image or picture into small elements, and transmit the light values of these elements progressively, at high speed, over an electric or radio circuit, we should be able to reconstruct the image at the receiving station.

This is what the *scanning disc* does — see Fig. 5. As No. 1 hole passes before the light-sensitive cell, it scans path No. 1 on the face for instance.

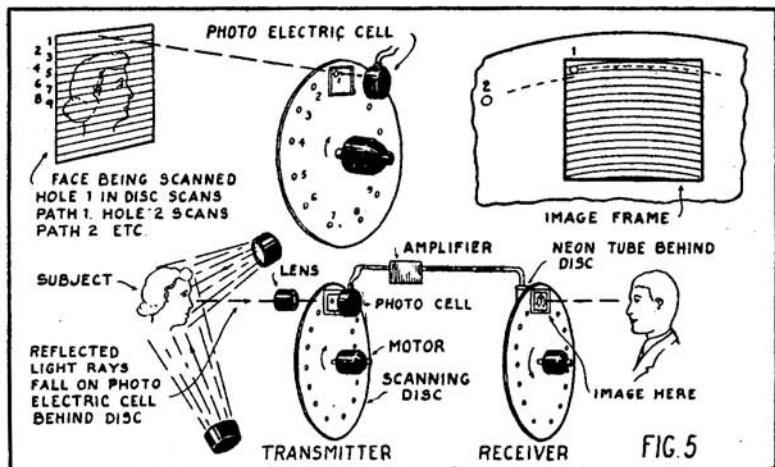


Half-tone images are made up of a series of dots

Hole No. 2 scans path 2 across the face, path 3 is scanned by hole No. 3, etc. When the last hole on the inner end of the spiral has scanned across the image, the whole picture has been scanned once: now revolve the disc fast enough to scan the image 15 times or



How image is scanned and how light varies along each scanning path



Scanning discs at both transmitter and receiver — the fluctuating neon tube light reproduces the lights and shadows of the image

more per second, in order to remove the effect of flicker, and you have *television* as we knew it a decade ago. But the holes did not pass enough light, the disc and its motor were crude mechanical devices after all, and it was not possible to obtain much better definition than 80 lines per image. Thinking in terms of 300 to 400 line definition, engineers bethought themselves of Braun's cathode ray oscillograph — here was a device that used a pencil of light having practically no inertia. So today we have the *electronic scanning* in a cathode ray tube, as perfected by Zworykin, Farnsworth and other scientists. But the principle of scanning the image line-by-line is still the "backbone" of modern television, so let us study this *scanning action* a little closer.

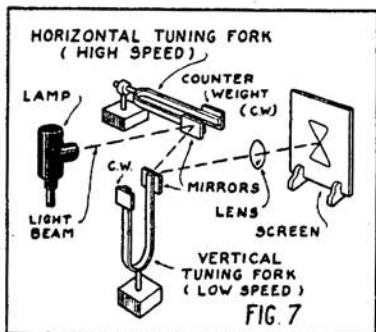
Fig. 4 shows how the illuminated object reflects varying strengths of light and shadow onto the scanning disc and a photo-electric (light-sensitive) cell; the variations in the photo-electric currents produced by the cell are amplified by several stages of resistance-coupled amplifiers, and if fed to a neon tube placed behind a second scanning disc at the receiver, one perceives the reconstructed image of the subject's face at the transmitter. Of course the two scanning discs must be driven at exactly the same speed and kept in step with each other at all times by the use of synchronous motors. Neon tubes or lamps proved useful for the earlier television; as they changed their brilliance very rapidly and could therefore follow the rapidly fluctuating pulsations of current in the circuit coming from the photo-

cells. The neon tubes used in the older mechanical scanning systems were often made with a large flat plate, 2 by 2 inches or larger, so as to cover the whole frame opening.

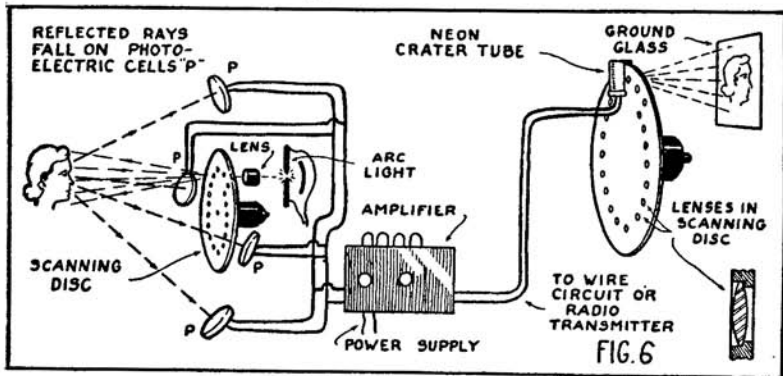
Fig. 6 illustrates a system used some years ago to obtain a larger image — here the object was lighted by a flying spot of light passed through a scanning disc from an arc light, and the reflected light rays fell on a series of large photo cells. The fluctuating current from the cells, corresponding to the lights and shadows of the subject, was fed into a neon crater tube, which gave a concentrated spot of rapidly varying light. This spot of light or crater was scanned by a lens disc rotated in front of it at exactly the same speed as the transmitting disc, and a bright image was projected by the whirling spiral of lenses on to a ground glass screen. Surprising as it may seem, an 8 by 10 inch image was obtained with fair brilliancy. Of course the detail was poor; for think what would happen to

the image of a face 1 inch in height, scanned by only half a dozen lines. Such is the way of invention and progress!

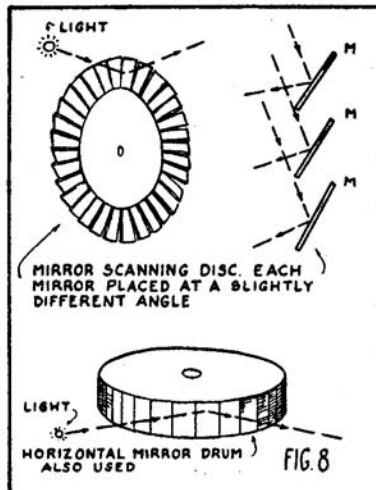
The diagrams show wire circuits connecting the transmitters and receivers, for the sake of clearness; but it is un-



A mechanical scanning system has been advocated by many inventors



Here a small pencil of light scans the object — the reflections are picked up by photo cells and transmitted to the receiver



Scanning has been done with flat discs and circular drums fitted with mirrors

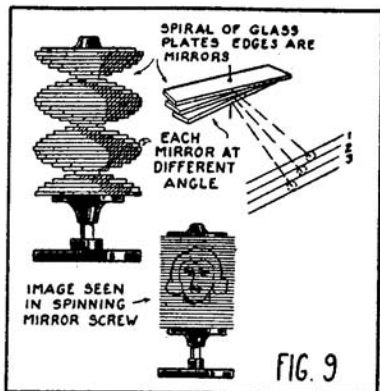
derstood that the television transmitter was often connected to a radio sending apparatus, and that the image signals were picked up on a suitable radio receiver, the wave-length used in those days being in the neighborhood of 80 to 180 meters. Today we are using waves only 6 to 7 meters long, because they furnish a much wider frequency spectrum.

William H. Pries and other inventors have frequently advocated vibrating mirrors to do the scanning — see Fig. 7. One scheme shown utilizes tuning forks for vibrating the mirrors, one in a *vertical* direction and the other in the *horizontal*. Pries has invented a clever device for vibrating a single mir-

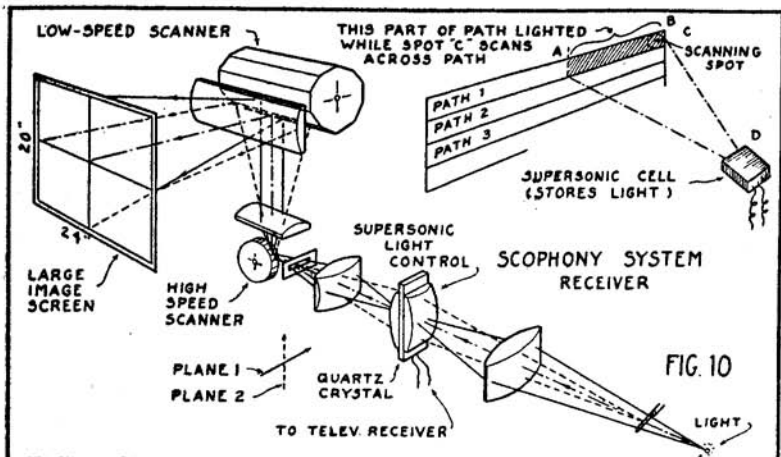
ror in *two directions simultaneously* — whether it can be used to scan a 441 (or higher) line image remains to be seen.

Mirror Scanning

Mirrors have been used widely for scanning in television. Fig. 8 shows a scanning disc made with a series of mirrors arranged around the edge of the disc, each mirror being tilted a fraction of a degree more than its neighbor, so that in one revolution of the disc the reflected rays from the mirrors will have completely scanned the image. In some cases the mirror drum design was employed, as below. The mirror screw (see Fig. 9) was devised in Europe, and the image was observed by looking directly at the rapidly revolving screw. Each mirror was set at a slightly different angle, so that in one



The mirror screw, used by some television investigators



In the Scopphony television receiver, a light-storage cell causes the scanning spot to persist for quite a period of time, giving a much brighter image

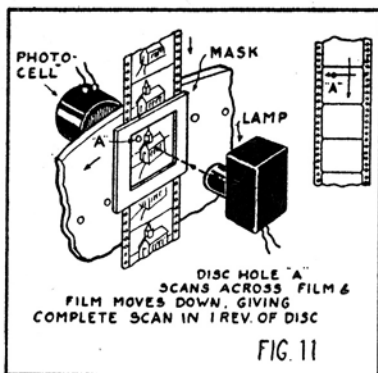
rotation of the screw, every path across the image had been scanned. If there were 60 mirrors then each mirror was set or ground to cover 1/60th of the vertical angle of the image. A special neon lamp with a long plate or heater was used to provide a narrow target of light equal to the height of the screw.

Scophony System

The Scopphony optical scanning system represents one of the most novel and radically different television systems thus far devised. In practically all other scanning systems, the only light obtained, at any given instant on the screen, is that yielded by the focussed spot of the cathode beam for example — a tiny spot less than one fiftieth of

an inch in diameter (on an image 8 inches high). Now suppose a plan was devised whereby over 200 times this amount of light was delivered at a given instant! This is what the Scopphony idea involves — and more than that, this English invention provides a picture 20 by 24 inches on a home type machine.

The two new features of the Scopphony system are the *split focus* and the *supersonic light-valve control*. The diagram (Fig. 10) shows also the mirror drum used as part of the scanning system. The split focus is an optical lineup of cylindrical lenses with their axes crossed, so that a beam of light is focussed in two separate planes. One advantage for optical scanners is that they can be of much smaller size or, with the same size of scanner, a far greater



In scanning motion picture film, the arrangement shown above has frequently been used

aperture of the optical system can be usefully employed.

With this improved scanning system any source of powerful light can be modulated by the supersonic light control, which consists of a container filled with a liquid, at one end of which is placed a quartz crystal. When the quartz crystal is actuated by a television signal, the mean carrier frequency of which is the same as that of the quartz, supersonic (super-audible) waves are set up at a speed corresponding to the velocity of the sound waves in that particular liquid. The lens system permits passing light through the container in a direction transverse to that of the supersonic waves; by means of scanners and suitable lenses an image, of the illuminated light-control itself, can be formed on the screen, the *width* being of one line of the picture, and the *length* determined by the length of the

light-control liquid column. A remarkable feature of the supersonic cell is the fact that light is stored up in it, and light from a powerful source is thus caused to illuminate the picture element being scanned at a given moment, while in addition many other elements in the train along a given scanning path will be illuminated too, possibly half of the scanning path, thus increasing the total controlled light of the image many times (200 times or more).

Other advantages of the Scophony apparatus are the small amount of radio frequency (television) signal required to modulate the quartz crystal on the light valve, and again — the simple type of receiver used — an 8-tube T.R.F. set for the *image* and a 6-tube set for *sound*.

Movies for Television

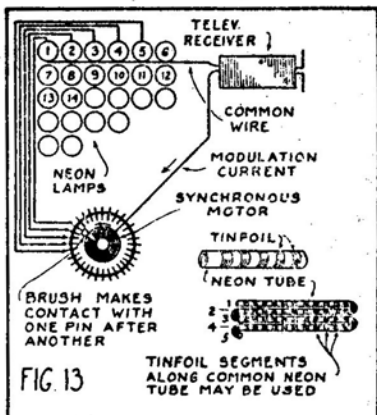
Fig. 11 shows how a motion picture film may be moved by the scanning disc (if a disc is used) in a *continuous* manner. It will be seen that the revolving disc provides the *horizontal* scan and the moving film the *vertical* scan. With the modern cathode-ray *electronic scanning*, the motion picture is flashed on to the photo-electric plate within the iconoscope; the tube then translates the variations in the light and dark parts of the picture into correspondingly varying photo-electric currents.

One of the schemes employed by several well-known television engineers to demonstrate *large image* television involves the use of the famous Kerr cell, which acts as a light valve when modulated by a television signal (See Fig. 12). Here we may again use any strong source of light and pass it through a diaphragm and a pair of Ni-

col polarizing prisms on to a whirling scanning disc. This disc is similar to those already discussed and is sometimes fitted with a spiral of lenses.

The Kerr cell is a small glass jar containing a grid made of brass or other metal and immersed in a nitrobenzol solution. (This is highly inflammable and should be carefully watched: also, if discolored, it should be redistilled or else replaced with fresh solution.) A projecting lens is used to throw the picture onto the screen. In setting up the apparatus one of the Nicol prisms is turned until no light passes through the optical train: then, when a television signal modulates the Kerr cell, a change in the polarizing effect takes place, which causes the light beam to be twisted so that light once more passes through on to the screen. The amount of light is in proportion to the strength of the modulating signal (this in turn is in proportion to the degree of light or shade on the particular spot being scanned at the moment).

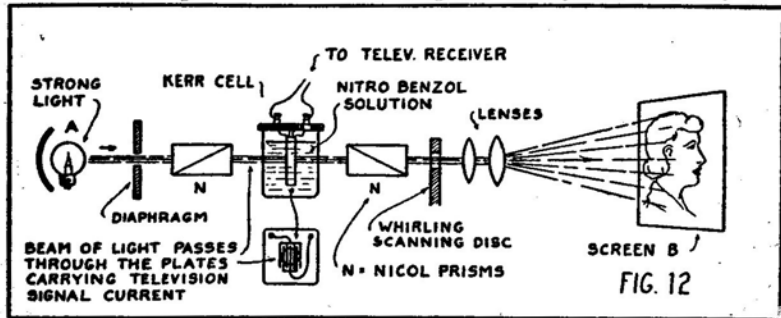
The efficiency of this system is quite low, and the scanning disc makes it unsuitable for modern 441-line definition (in previous demonstrations where



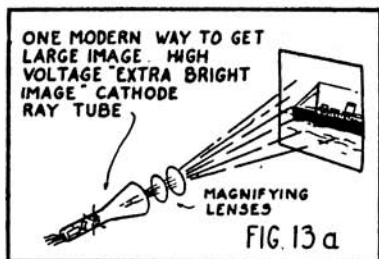
In this "big image" television reproducer, sections of a neon tube are progressively illuminated

this system was employed the scanning was done with 60 lines or thereabouts).

A plan for producing large television images — and actually demonstrated by the Bell Laboratories a decade ago — is that shown in Fig. 13. Here the scanning was accomplished in a very in-



A light valve using a chemical solution is shown above, in connection with a "large image" television apparatus



One of the more recent ideas for large television images employs magnifying lenses in front of a cathode ray tube

genious manner. Instead of using a scanning disc, a rapidly revolving commutator switch was employed at the receiver. As the switch blade made circuits with the successive contacts on the switch, successive tinfoil segments spaced along a neon tube were progressively excited. This had the same effect

as if light from the holes in a spiral in a scanning disc were being thrown onto a screen. Baird (in England) and others used a similar idea, but used a bank of small lamps which were progressively lit up as the scanning progressed. A scanning disc of the orthodox pattern was actually employed at the transmitter, and needless to say, the switch controlling the lamp bank was driven by a synchronous motor; so that each lamp (or section of the neon tube) was switched into action just as each respective hole of the disc at the transmitter was passing before the scanning lens aperture.

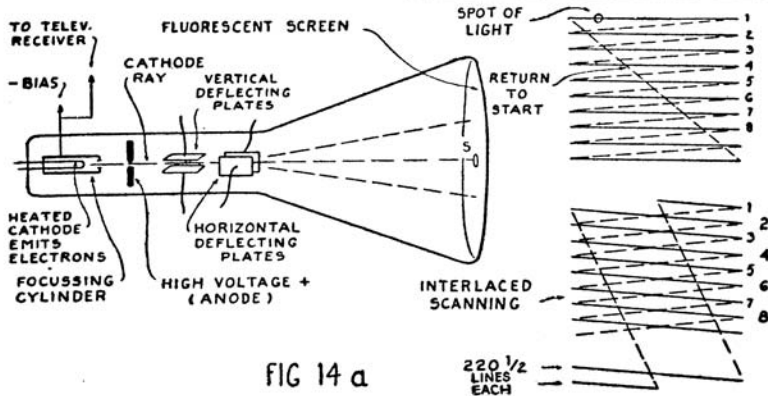
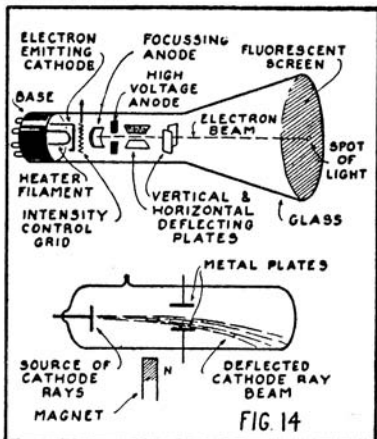
The high-power (20,000 to 30,000-volt) cathode ray tube seems to be the present hope of many television inventors for *big-image* presentation (Fig.13-A), but the apparatus is costly and some scheme like Scophony's seems to hold great promise for large theater-screen television.

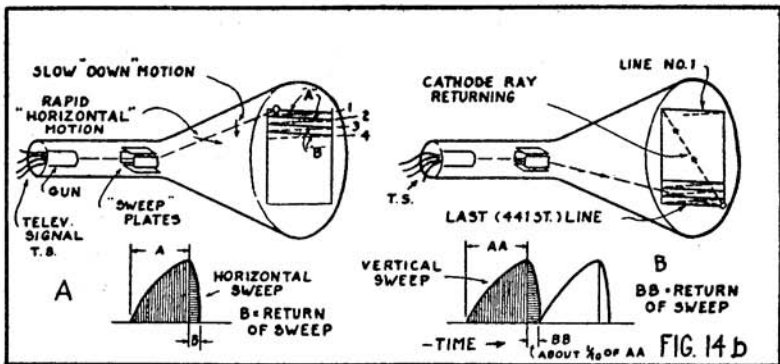


THE KINESCOPE OR CATHODE RAY TUBE FOR RECEIVING THE IMAGE

Science often works out a problem for which there seems to be no immediate application — such was the case with many of the vacuum tube experiments carried out late in the last century, by such men as Zender, Crookes, and others. The marvellous cathode-ray (C-R) tube, which is reproducing such fine television images today, is based on a discovery made years ago that, when a cathode ray was generated or projected in an evacuated tube, this ray could be deflected by a magnet held near the tube (See Fig. 14). It was also

The action of the cathode ray tube depends upon the fact that the electron beam produced inside the evacuated tube, may be deflected in any direction by a magnetic or an electrostatic field





The action taking place during the scanning of an image on a cathode ray tube is shown in the above diagram

The electrical control impulses in the beam are timed to give quick return of the beam after each scanning sweep

discovered that, if an electric charge was put on a metal plate arranged in the tube near the path of the cathode ray, it likewise would deflect the ray one way or the other, depending upon the polarity of the charge. (The same holds true for the magnets — a north pole having the opposite effect to a south pole on the ray.) It at once became apparent that, if we apply an alternating current to a pair of deflection plates within the C-R tube, we shall cause the cathode ray to oscillate back and forth in exact step with the alternations of the current. (See Fig. 14-A) This property you may have noticed if you have ever observed the C-R oscillograph now used by radio service men to align modern receivers.

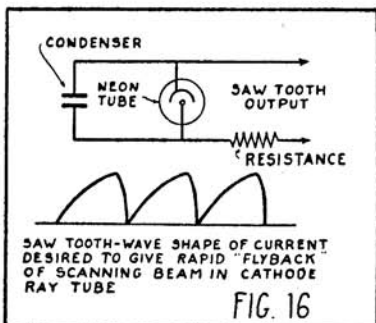
Not only does the cathode ray have no inertia (practically none), enabling it to respond to almost infinite frequencies, but scientists have found that, if a metal sleeve of the right shape and carrying the correct electric charge, is

interposed in the path of the cathode ray, the electrons composing the ray may be focussed similar to light rays. Fig. 15 shows this focussing effect and also an early experimental C-R tube, in which the cathode ray was caused to project an image of a metal cross on the end of the tube. In the modern cathode ray tube as used for television reception, the end of the tube has a coat of certain chemicals deposited over its inner surface, so that wherever the cathode ray impinges on this coating, it causes a fluorescent spot to appear. The higher the voltage applied to the anode in the tube, the brighter the spot on the screen. In some cases, a series of anodes are placed progressively along the tube and by connecting these with higher and higher voltages (D.C.) the velocity of the electrons is tremendously increased.

Fig. 14 shows the principal elements of the cathode ray tube. The heated cathode generates the cathode ray: the

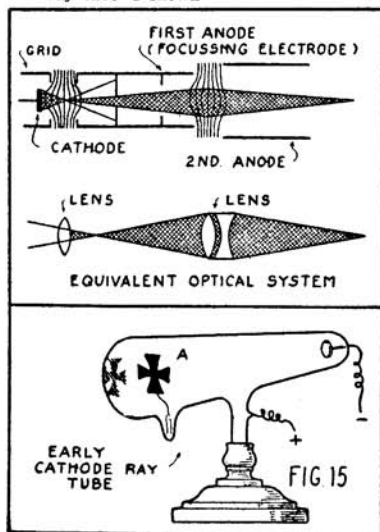
focussing cylinder does what its name implies, the amount of focussing being dependent upon the degree of negative bias applied to the cylinder. Note that the varying modulation current from the television receiver is applied to this focussing cylinder also (or else to a grid member), for the purpose of changing the strength of the ray in accordance with the light and dark portions of the image being scanned.

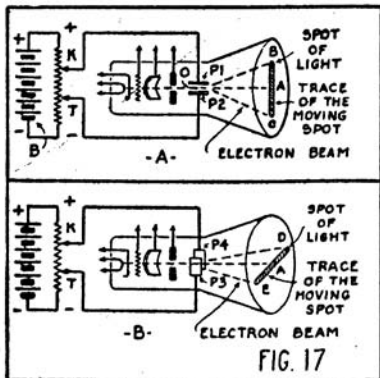
For television purposes a *sawtooth* (named from the shape of the wave) form of scanning wave or current is applied to the respective pairs of vertical and horizontal plates for this purpose. The purpose of the sawtooth wave for scanning is to give a slow progressive sweep of the cathode ray across the screen and a quick return of the ray to its starting point. For instance, the ray moves across the screen on scanning path No. 1 (Fig. 14-B) as it reaches the end of this line the condenser in the neon tube circuit discharges, and the ray suddenly flies back, to begin the scan along path (line) No. 2. But in the meantime a second force has acted on the ray—that of the *vertical* scanning oscillator and the second scan begins, a fraction of an inch lower down on the screen. Eventually the whole screen is scanned in a progressive line-by-line manner and this action—when repeated 16 to 24 times per second—results in a *moving image* being flashed on the fluorescent screen at the big end of the tube. The color of the image can be changed by using different chemicals; the present tubes favor a bluish-black, but many C-R tubes show a greenish image. The black-and-white image seems to be the most popular now.



Above — The wave form of the current produced by a neon tube oscillator is here shown

Below — The principle of the electron lens for electron focussing in a cathode ray tube is shown





Further explanation of the movements of the cathode ray beam in making the horizontal and vertical movements across the end of the tube

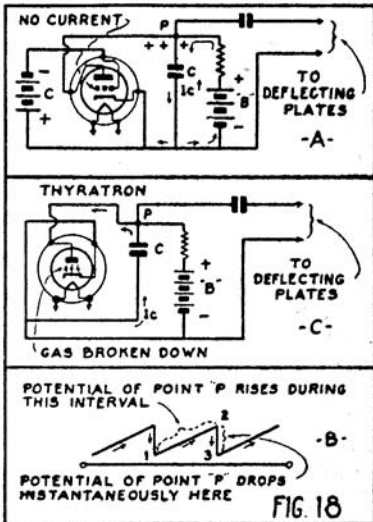
The neon tube sweep oscillator, Fig. 16, was one of the first, but a more constant type of oscillator is now favored, using new type radio tubes of the gaseous type. Fig. 17 shows the respective scanning action of the *vertical* and *horizontal* traces or sweeps. Fig. 18 shows the action of the modern thyatron tube oscillator at A, and how the condenser action repeatedly breaks down the gas in the tube and then starts the cycle all over again at C. The saw-tooth form of the wave or current is seen at B.

For the larger cathode-ray tubes (above 5 inch diameter) the *magnetic scanning* method is preferred, and the arrangement of the vertical and horizontal magnetic sweeps is shown in Fig. 19; also an end-view of the magnets. These are sometimes made with a split iron yoke, so that they can be opened for the insertion of the neck of the glass C-R tube.

It is interesting to note that the size of the spot on the target or screen of the tube remains constant in size, but varies in brilliance as it is modulated by the television signal. Another point overlooked by many students is that the cathode ray itself does not pass beyond the glass tube, or at least the effective part we are concerned with; and it reacts on the chemical screen deposited on the *inner* surface of the tube. If the image is projected beyond the end of the tube, we really see a shadow picture projected on to the screen, and not a cathode ray picture.

Synchronizing

A *synchronizing signal* is transmitted after scanning each line, as Fig. 20

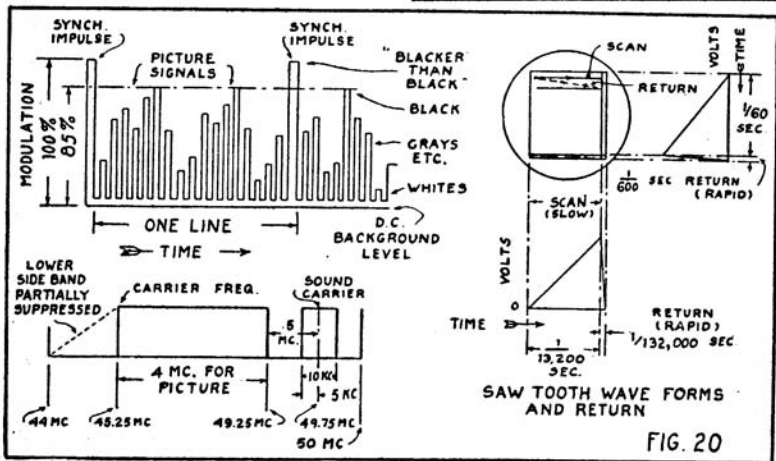
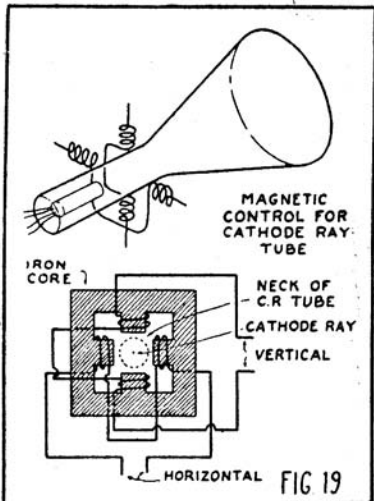


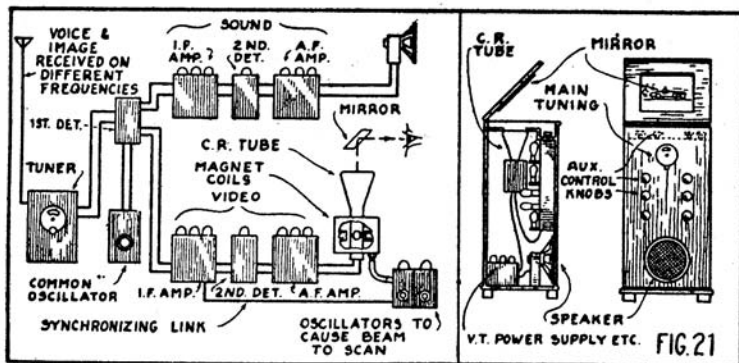
The wave form of the current and also the circuit connections for modern type sweep oscillators

shows, and in this way the scanner at the receiver is kept constantly *in step* with the scanner at the transmitter. Note how the current fluctuates up and down as the scanning beam moves across the object being viewed, in accordance with the lights and shadows on the image. At the start of each line, a stronger impulse comes through from the transmitter, and by means of a synchronizing filtering circuit this signal is impressed on the two sweep oscillators and holds them in perfect step. Fig. 20 shows the frequency relation between the image carrier frequency and the sound carrier.

Right — The arrangement of sweep control or deflecting magnet, placed about the neck of the the cathode ray tube

Below — We see the relation between the image and sound carrier frequencies used in modern television





The general arrangement of the sound and image receiver components are here illustrated

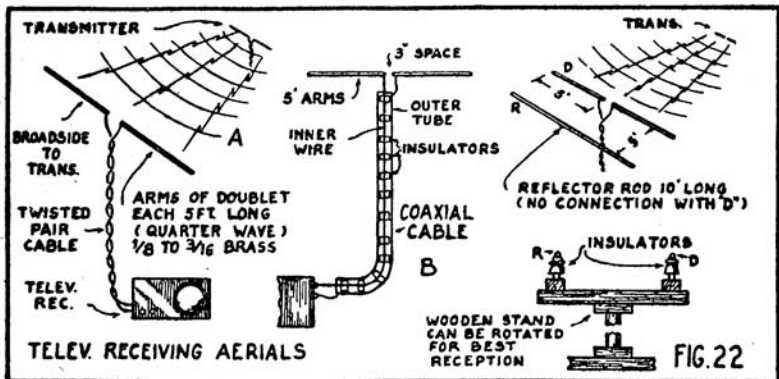
A typical television receiver circuit is shown in Fig. 21. As the spacing between the picture and the sound carriers is set definitely by the R.M.A.

standards, it is possible to use a common single oscillator for both the image and the sound receivers, as the diagram indicates.



TELEVISION

Receiver Antennas

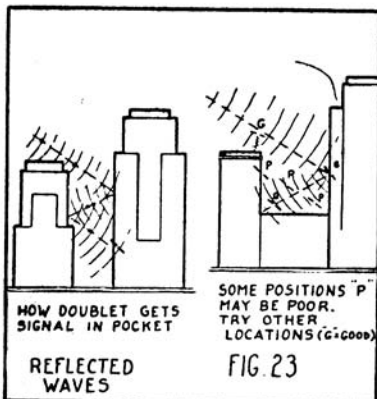


The picture shows how the television receiving doublet is arranged "broadside" to the television transmitting station. How the signal can be intensified by the use of a reflector rod is indicated at the right of the picture.

The accompanying sketches (Fig. 22) show several designs of television receiving antennas—the simplest is the doublet having two horizontal arms, each about 5 feet long. The doublet is placed broadside toward the transmitter, and should be moved about until the clearest and brightest image is obtained. In some locations, due to

reflection from other buildings, there may be several waves received at a given point (multiple path). Thus, if a *ghost (double) image* is seen on the screen, then the aerial should be shifted about until the *ghost image* disappears.

A twisted pair of rubber-covered wires may be used to connect the



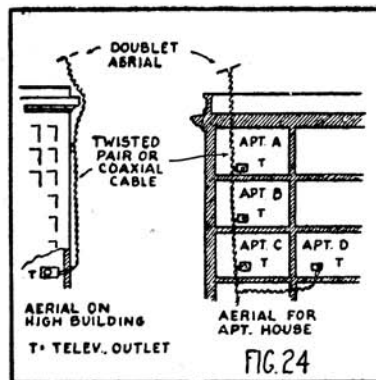
The ultra short waves used in television transmission are reflected between tall buildings as shown, and the best location for the antenna is found by experiment

doublet to the receiver; but, for distances of over 75 feet, it is preferable to use coaxial cable. (See Fig. 22-B.) The aerial may be placed at quite a distance if coaxial cable is employed. If interference from automobile ignition is experienced with the aerial at the front of the house, put it at the rear of the building. It is best to get the aerial as high as possible to minimize pickup of interference from man-made static, electric light wires, etc., and also because of the line-of-sight transmission properties of the ultra-short waves used for television. Where the signal is weak, it may be intensified by placing a reflector rod a quarterwave length (about 5 feet) behind the aerial as the sketch shows. The metal rods of copper, brass or aluminum can be mounted on porcelain or glass insulators and all connections should be sol-

dered. Don't forget to slowly rotate the aerial, to ascertain the best position for strongest reception.

Fig. 23 shows how a reflected wave may account for the reception of a television signal in a location hemmed in by high buildings. The multiple reflections of these waves often produce the difference between failure and success. The *strongest* signal may not always be the *best* signal: move the aerial around—sometimes a few feet will make all the difference imaginable, due to multiple reflections. The aerial may have to be raised up a few feet to get the best signal. Also try putting the doublet on an angle, as shifts in the polarization of the wave may demand this. If you live on a lower floor of a high building, try to get the aerial on the roof and run the lead-in down the side of the building, as Fig. 24 shows. Apartment houses will eventually have a common doublet or other type of television receiving aerial mounted on the roof, with coaxial cable feeding the signal down through the floors to the various apartments. Of course, you can try using the aerial doublet inside the apartment—a number of experimenters have had surprising success with indoor antennas.

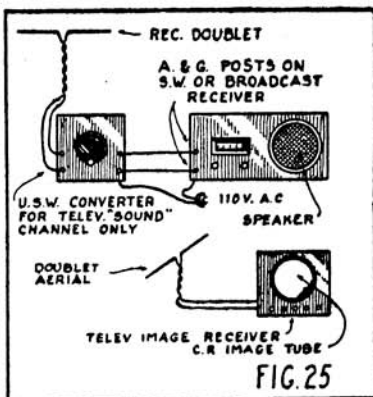
Many people have asked the question—"Can I obtain a converter to pick up the television image signal on my present broadcast or all-wave receiver?" The answer, in general, is emphatically NO! The reason is that the image receiver requires extremely broad amplifier stages to pass the image signals, and this requires special intermediate frequency transformers, etc., all of which cannot be done in a simple converter. However, the television sound channel can be picked up on a



For apartment houses the receiving antenna is best placed high above the roof

converter, and one may be built from plans given in the television magazines or else purchased on the market. (See Fig. 25).

The television sound channel can also be picked up on a regular *short-wave* receiver, capable of tuning to the proper frequency. Some of the modern all wave receivers tune down low enough to intercept the television sound channel, and in this case the acquirement of a television image receiver is all that you require, in order to enjoy the complete television program. Many of the small Ham type receivers will tune in the sound channel too. However, the broad frequency bands allotted to sound in television broadcasting, give excellent quality to the sound picked up on vision programs, and if you wish to



An ultra short wave converter may be used for the reception of television "sound"

fully enjoy this superior sound quality, it will pay you to, obtain the best quality receiver possible. Otherwise the beautiful high-fidelity feature of the television sound channel will be lost, to a great extent, if poorly designed receiving circuits and a low-quality loud-speaker are employed.

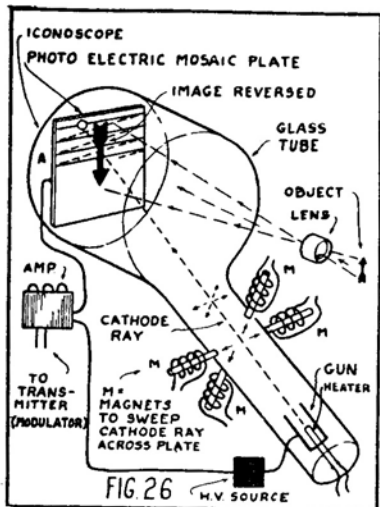
One of the latest innovations in the realm of television receiving aerials, is a *loop* aerial. This is still in the research stage but the experimenter will want to try it out. The two halves of the loop are connected together through a high resistance of about 900 ohms. By placing the aerial in different positions, the best one for a given location is readily determined. The dimensions of the loop vary somewhat for different frequencies.

HOW TELEVISION PROGRAMS ARE BROADCAST

A few years ago, the subject to be televised was "viewed" by a scanning disc with a strong beam of light sweeping over his face; today the subject merely stands before the television camera and he hears no sound of whirl-

ing discs or motors. Strong lights illuminate the actors and the image is picked up by a lens the same as in a camera; only in the *Iconoscope* (as the television camera is called) the image falls on a special mosaic plate. This mosaic plate is made up of thousands of tiny photoelectric cells and, every time a spot of light strikes a spot on the mosaic plate in the evacuated tube, an electric current proportional in strength to the light is developed by the iconoscope tube. See diagram (Fig. 26 and 26-A).

The image is thrown on the mosaic plate upside down, as in a camera; next, we find that the scene is scanned with 441 lines by magnet coils placed about the neck of the iconoscope tube. One set of coils causes the cathode ray inside the tube to sweep across the screen *horizontally*, while the second set of coils acts on the ray to sweep it up and down *vertically* thirty times a second. At the end of each horizontal line sweep, a synchronizing signal is sent over the radio transmitter; and the reception of this signal at the receiver serves to hold the sweep oscillators in step or synchronism with the transmitter.



Simplified arrangement of the image pick-up tube, used at the transmitting station

New light-weight television pick-up units have been perfected by RCA and others, so that all of the amplifiers, cameras, etc., can be packed into several bags or portable cases, and carried about by a small crew of men. In many cases the mobile television pickup unit is plugged into the nearest specially compensated telephone or other circuit. In one demonstration the television image was sent over a telephone circuit about one-half mile in length, the circuit having been carefully balanced as to its capacity and inductance before hand. There is a far greater loss of signal strength of course on such telephone circuit transmissions of television images, compared to the special coaxial cable designed by the Bell Telephone Laboratories. In the television transmission between New York and Philadelphia the images are sent over the coaxial cable installed between the two cities by the Bell Laboratories.

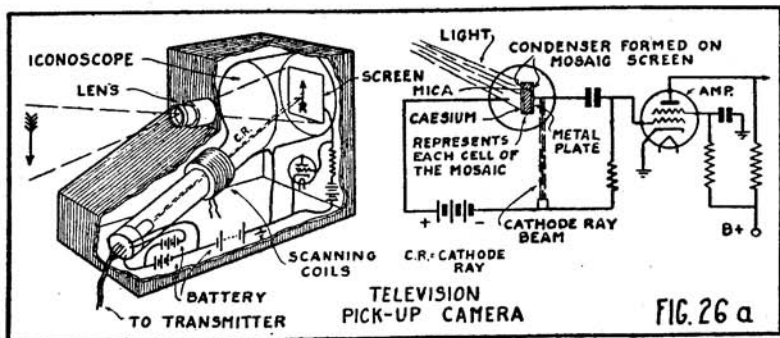
Television relay apparatus so compact and self-contained that it can be mounted on poles located 25 to 30 miles apart, has been perfected by the RCA. This relay system will eventually use frequency modulation (F-M) and in fact in some of the test demonstrations F-M was used. This will obviate the effect of static and other undesirable factors, which show up in the television image at the receiver in the form of white splotches or streaks.

Eventually, all of our large cities will be linked by ultra short wave relay transmitters. The relay station has a receiver tuned to pick up the image as broadcast, and the amplified vision signal is fed right back into a transmitter and sent on its way again, usually on a different frequency so as not to interfere

with the original transmission. Each time the signal is retransmitted the frequency is slightly changed, for the reason aforementioned. The relay apparatus, or at least its antennas, are placed on steel or wood masts as high as possible, to give the maximum range. The higher the antennas the greater the range. A recent demonstration of television pickup by an airplane in flight, showed what the future of television in warfare (as well as peace) may be like. The airplane carries a television camera and a small compact transmitter, with which it sends out the image signals to a special pick-up station; this station relays the image signals to the television broadcasting station, from which the image and sound is telecast to the receivers located in your home and mine.

Where desired the plane can have a vision receiver aboard and pick up the image as broadcast from the television station. Images of the enemy terrain, gun emplacements, etc., can be transmitted back instantly in war-time, and can also be transmitted to other planes if necessary. In fact, by means of television, it becomes possible to send out robot bombing planes (with no one aboard); the directing officers behind the lines send out radio impulses which cause the plane to rise or fall as desired, and at the crucial moment release its load of bombs! The effect of the bombing can be seen at once—thanks to television.

The staging of television plays and the handling of speakers, etc., is quite different than the technique followed in regular stage and radio broadcasting. The television studio is as *quiet as a graveyard* when a play is ready to go *on the air*. The play director speaks his



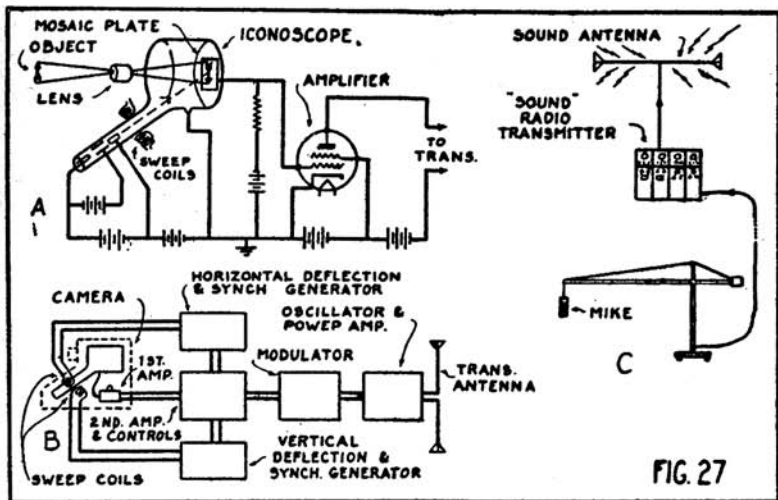
Another view of the television pickup tube and first amplifier stage

"cues" into a microphone in a closed room provided with a glass window, through which he watches the actors. The stage manager down on the studio floor hears his cues and other correction orders in a pair of phones worn on the head. As the play progresses, we see the camera men (or rather their assistants) pushing the rubber-tired camera dollies in and out, in order to catch close-ups, long-shots, etc., as the director orders. These actions are rehearsed in the same way that stage plays are rehearsed. At present the actors are viewed in small groups, but as the optical range of the camera and iconoscopes improves, the groups of actors viewed at one time will grow larger and larger.

In picking up the image of football and baseball games, a great deal of improvement in technique is still to be worked out. One camera is not enough and a second or third camera is required, so that close-ups of the action at certain spots can be focussed on and

transmitted to the waiting television audience. If a baseball player slides to a base during an exciting play, the television camera should be there to catch it, and place it on your television receiver screen! The technique of televising such sports is now being greatly improved by the engineers, and the sports telecasts are rapidly becoming more popular with those owning television receivers.

In producing plays and special "news events" in the studio, some very interesting devices are resorted to in order to give continuity to the action being portrayed. For example, if a naval battle is to be shown, it is impossible to show the actual battle, so the television experts resorted to an old movie trick — they used miniature models of war ships. When skillfully handled, with smoke pouring from their funnels and guns blazing, you — the viewer, sitting before your receiver, can not tell but what it is the real thing! The houses and other figures are cleverly built by



At the transmitting station the image and sound pickup units are lined up in this manner

artists and painted so faithfully, that when you see the whole ensemble — ships moving about, etc., you are completely fooled — and, let it be said to their credit — completely entertained.

Another trick of television broadcasting is the method of rapidly flashing from one scene to another. A closeup of a box of matches mysteriously opening itself can be staged easily; also such weird effects as candles that snuff out themselves, glasses that empty themselves, thanks to a glass tube fitted through the bottom of the glass, but which you can't see on the television screen of your receiver, etc., etc.

One of the most ingenious machines

imaginable produces dissolving titles and all sorts of fancy designs to serve as entertainment between scenes.

One of the diagrams (Fig. 27) shows the simplified line-up of the oscillators, the amplifier, modulator and finally, the transmitting oscillator and power amplifier.

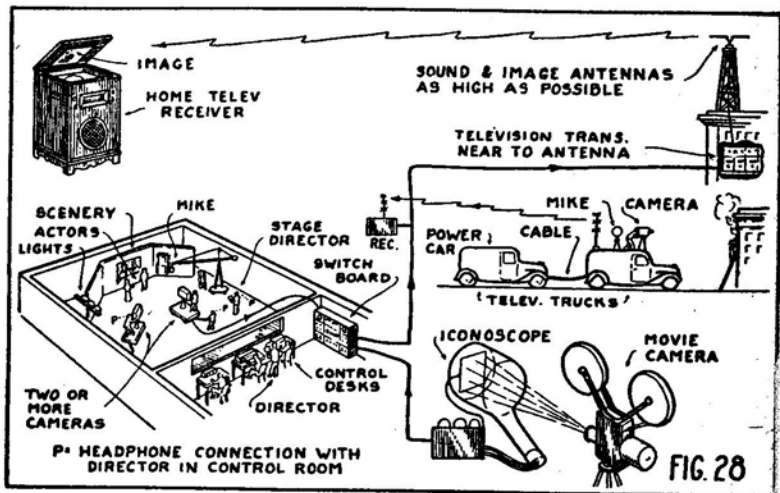
The sound is picked up by a microphone, supported above the actors on a boom, and the sound currents are amplified in the usual manner; then they are passed into a modulator and radio transmitter, finally being led to the aerial and broadcast on a slightly different wavelength than the image. The

R. M. A. television standards committee has fixed the ratio between the sound and image frequencies, so that one tuning control can be used at the receiver to tune in both the image and the sound. Furthermore, a single oscillator can be used for both the image and the sound sections of the receiver.

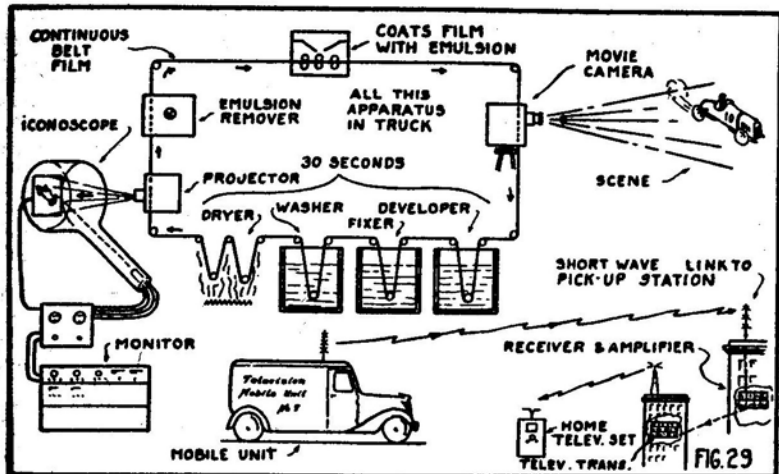
A typical television broadcasting station set-up is portrayed in Fig. 28. In the studio the actors are brightly illuminated; the control room is placed to one side and higher up than the studio floor. The director usually sits in the control room, and all orders are given to the stage manager and the camera men on the studio floor by telephone lines connecting with

headphones worn by these men. Several television monitors are arranged before the sound-and-image control experts in the control room and the director can cooperate with these men to produce the best possible show.

"Spot news" may be picked up by a mobile camera unit as shown, and the image as well as the sound signals is picked up by a suitable receiver and then fed into the coaxial line leading to the transmitter. The television transmitter is placed as high as possible, in order to reduce losses and to get it as close as possible to the antenna. In the case of the N. B. C. installation the antenna is placed on top of the 1250-foot Empire State building, and the transmitter on the 85th floor of



"Spot news" is often picked up by a mobile television unit, connected to the transmitting station by an ultra short wave "link"



In this "spot news" system images are photographed on a film, rapidly developed and dried, then transmitted via radio

the building. The studio is in the R. C. A. building over half a mile distant. The mobile truck can transmit the spot news or other programs picked up by its cameras for a distance of several miles if need be.

These mobile units are, in the case of N. B. C., arranged in two sections — one is the power supply unit, and the other truck houses the radio transmitters for sight and sound. The trucks can be joined together by quick coupling cables and they can hasten to the scene of a disaster or other event with fire truck speed. The crew erects the special antenna mast and gets out the parabolic mike reflectors and the iconoscope camera in a few minutes.

For studio movie pickups, the motion picture is flashed onto the iconoscope

camera and the sound taken off separately and sent through its respective amplifier to the sound transmitter.

The Intermittent Film System has been used in Europe for reporting "spot news" and is quite interesting as the film can be developed, washed and fixed — all in 30 seconds or less. Fig. 29 shows this system: in one method the film is a continuous link loop, as fast as the picture is flashed on the television pickup, it keeps moving along until it reaches the emulsion remover; then it goes to a device which puts another coat of emulsion on it and the film is ready to pass through the standard movie camera and register the next scene. In other systems, the film is rolled off a stock spool and is not recoated in the mobile truck.

COLOR TELEVISION

BY SCOPHONY USES

THREE SPECIAL TUBES

● **LARGE** screen projected television pictures have been made possible by the Skiatron, a new development of the Scophony system, described in *Electronics and Television & Short-Wave World*, London. The process is different from the more usual method in that the subtractive method of color separation is employed. The accompanying illustration shows the path of the light beam from the source of illumination to the screen. Three complementary color screens on each of which a momentary color deposit is produced are utilized.

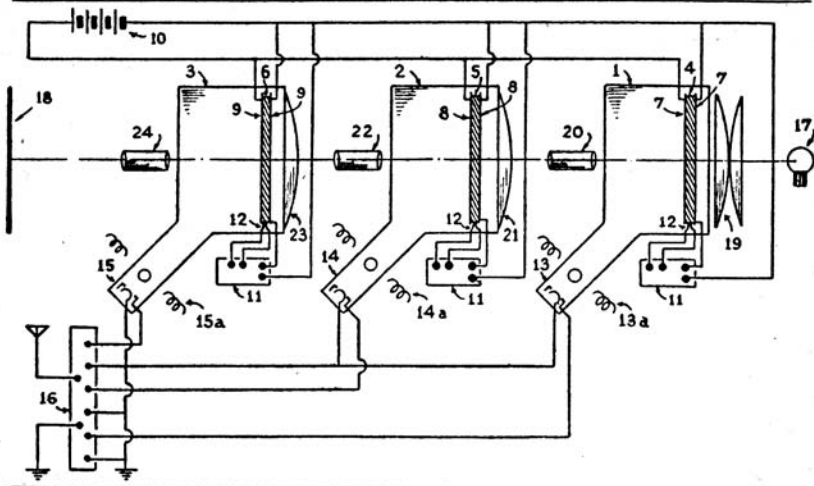
A complete description of the system follows as taken from the British publication.

Three cathode-ray tubes 1, 2 and 3 are provided, each comprising a transparent image screen indicated at 4, 5 and 6, respectively. Each screen is situated in an electric field provided by pairs of transparent electrodes 7, 8 and 9, across which is maintained a potential difference by means of a source of potential 10. The screens can also be maintained at a suitable temperature by means of a thermostatic control of suitable form, which in the example

shown consists of a source of current 11 for each tube which passes a current through one of the electrodes 7, 8 and 9 of each screen, the amount of the current and hence the temperature for each screen being controlled by a thermo-couple 12 in each screen. Means indicated at 13, 14, 15 are associated with the tubes for producing a scanning cathode-ray beam and the amplifying arrangement 16 is fed by signals representative of each of the primary colors of the object being transmitted.

The sense of the modulations applied to the beam is such that the density of the deposit produced is inversely proportional to the intensity of the corresponding primary color. The three beams are caused to traverse the three screens 4, 5 and 6 in synchronism by means of scanning coils 13a, 14a and 15a.

The material and/or temperature of the screens are chosen so that the colored deposits produced therein have the required complementary colors. White light from a suitable source 17 is projected successively through the screens 4, 5 and 6 in such a way that



Three color filters operate from incoming signals in new system

the screen images are *superimposed* in register on a reproduction surface 18. This can be done by fully illuminating the first screen with a condenser system 19 which also forms an image of the light source 17 on a first projection lens 20 situated between the first two screens 4 and 5. This projection lens forms an image of the first screen 4 on the second screen 5 in register, and the light is focused by means of a field lens 21 on to a second projection lens 22 which forms an image of the second screen 5 on the third screen 6 in register. A field lens 23 focuses the light

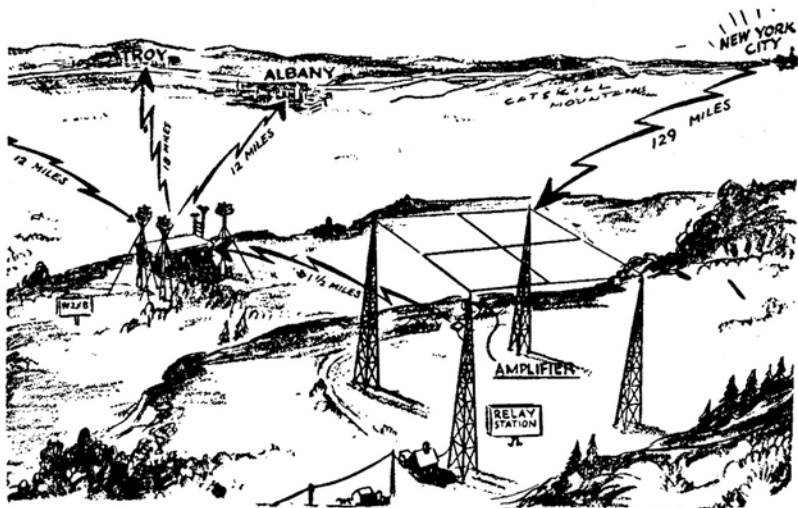
passing through the screen 6 into a final projection lens 24 which forms an image of the third screen 6 on the reproductive surface 18, forming thereon the final color picture.

It will be noted that with the inverting optical system shown, the image on the screen 4 must be inverted, that on screen 5 upright and that on screen 6 inverted, so that the projection lens 24 forms an upright image on the screen 18. This can be arranged by applying the deflecting currents to the coils 13a, 14a and 15a in a suitable sense or direction.

Network Television

● NETWORK television, necessary to give vision to the radio sets of America, was successfully demonstrated at Schenectady, N. Y., in Jan. 1940. The program, which originated in NBC's New York studios, was picked up in Schenectady homes, 142 airline miles away, thanks to the General Electric's relay station, working in conjunction with its main transmitter atop the Helderberg Mountains.

Although telecast programs had been received at the Helderberg relay station before in tests, it was the first time (Jan. 1940) that such programs were rebroadcast for the entertainment of persons in the area served by the local station. Both image and voice were excellent, in fact, equally as good as programs originating in the Schenectady studio, thus proving that network television is practical. The 1940 New



Artist's sketch, showing how programs from New York are relayed by General Electric's television transmitter, as well as being fed to the transmitter from the main studio in Schenectady. Left—12 miles to Schenectady.

York-Schenectady test and demonstration marked the first time a television program was actually rebroadcast over any such distance and from a point more than a mile below the line of sight.

By the use of the new relaying equipment, located 1.2 miles from the main transmitter atop the Helderberg Mountains, 12 miles from Schenectady, television broadcasts from New York are made available to Capital District residents within the range of the company's station W2XB.

The programs transmitted from New York City are received at the relay station on the 44-50 megacycle band by means of a rhombic antenna that resembles two diamonds placed end to end and supported by four 128-foot towers. The programs then pass through an amplifier, a part of the antenna structure, that increases the signal strength about 20 times before entering a wire line leading to the relay receiving station located beneath the antenna. Here the radio signals from New York are changed to sound and picture signals.

By means of a low-power 10-watt transmitter the picture part of the pro-

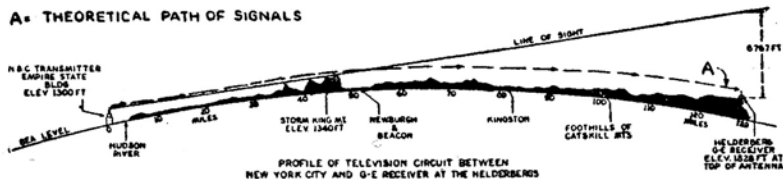
grams is then relayed on a carrier wave of 156-162 megacycles from a small transmitting antenna to the main Helderberg station. This transmitter is similar to the diamond-shaped one used to pick up the programs from New York but is only 10 feet across as compared with the 400 feet of the receiving antenna.

At the main transmitter a dipole antenna picks up the picture part of the relayed program and feeds it to the transmitter where the frequency is converted to the 66-72 megacycle level and amplified to 10 kilowatts.

The sound part of the program is relayed from the receiving station to the main transmitter by wire line. There it modulates a standard 10-kilowatt ultra-high frequency transmitter, and the programs are then broadcast from two antennas above the transmitter to listeners in the Capital (Albany) District.

The relay station is located 129 air line miles from New York City and stands 1,700 feet above sea level, with the rhombic antenna 128 feet above. The main transmitter is at an altitude of 1,502 feet with 60-foot antennas above.

A. THEORETICAL PATH OF SIGNALS



Sketch, showing curvature of the earth between New York and Schenectady and how the relay receiver, although mounted atop a mountain, 1800 feet above sea level, is still more than a mile below the line of sight from New York and 129 miles distant

EFFECT OF ANTENNA HEIGHT ON TELEVISION DISTANCE

● THE accompanying chart provides an approximate method of quickly determining what the height of the transmitting and receiving aerials should be to cover a given distance in miles. Ultra short wave transmission, in general, obeys the laws of light and while freak distances are covered from time to time on the five and six meter bands, the average range of an ultra short wave

(transmitter height) to the vertical line corresponding to the height of the receiving aerial. The nearest diagonal line is the normal limiting distance for that particular station.

That the ultra short waves proceed in a fairly straight line and form a tangent with the curve of the earth's surface, was proven in one television test conducted above the city of Washington, D. C., by the RCA engineers. No television reception from the transmitter in New York City was possible at Washington, a distance of nearly 300 miles, but when an airplane carrying a television receiver went aloft to an elevation of several thousand feet, the images were picked up at once. By the same token, if we place a television aerial high enough, all sorts of long distance reception becomes possible. During 1938 the RCA television receiving station located on Long Island picked up the image being broadcast by the British Broadcasting Station in London, England. This was a freak performance, made possible by certain atmospheric conditions and shifting of the reflecting layers of the upper atmosphere.

The reception of the New York transmitter's television image signals in Chicago by RCA engineers, is another example of freak transmission. The image in this case was only held for about 20 minutes; the engineers concluded that it was received because of a sporadic ionized layer at a certain critical height in the upper atmosphere.

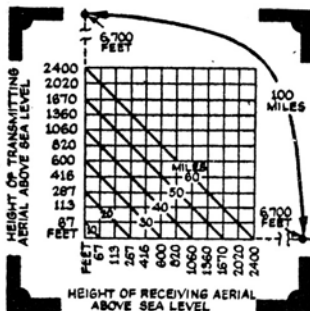


Chart giving "line-of-sight" transmission distances

transmitter is 40 to 60 miles, when the antenna is placed at fairly high elevation.

Here is a chart that can be used in calculating distances in miles when the height of both the transmitting and receiving antennas are known. As an example: find the height of the transmitting antenna and your receiving antenna. Follow over from the left margin

TELEVISION TERMS

- AMPLIFIER** — In radio parlance usually considered as comprising one or more stages of vacuum tube amplification, in which the voltage or current (or both) is amplified.
- ANODE** — The positively charged electrode in the cathode ray tube, also the positive terminal of a battery.
- ARC** — The effect produced when two electrodes such as carbons, connected to an electric supply circuit are separated, producing an arc or flame discharge between the separated electrodes.
- AUDIO FREQUENCY** — A frequency range falling within the range of audibility of the human ear and usually considered to cover 25 to 16,000 cycles per second. Some people can hear sounds of much higher frequency.
- BEAM ANTENNA** — An antenna which can be swung around so as to pick up the maximum amount of energy from the advancing wave.
- BRAUN TUBE** — The first cathode ray tubes were demonstrated at the turn of the century by Dr. Ferdinand Braun, famous German scientist. It was the first device capable of showing graphically on a screen at the end of the tube just what was going on in high frequency circuits.
- CARRIER** — The oscillatory wave which carries the television or sound signal and which is modulated by the signal.
- CATHODE RAY** — In the cathode ray tube a heated cathode produces a stream of electrons, known as the cathode ray, and its great value to television lies particularly in the fact that this ray can be moved back and forth in any direction very rapidly without any appreciable lag. The ray may be acted upon by an electromagnetic field or an electrostatic one.
- COAXIAL CABLE** — This cable was developed by engineers of the Bell Telephone Labs. for carrying several hundred telephone conversations simultaneously, or for carrying television image signals. The cable comprises a hollow tube, usually of copper, with a lead sheath and a small wire is placed at the center of the tube, supported in that position by a series of small circular insulators placed every few inches.
- ELECTROMAGNETIC FOCUSING** — The method of focusing a stream of electrons, such as the cathode ray, by causing the ray to pass through the field of a powerful magnet.
- ELECTROSTATIC FOCUSING** — A great many cathode ray tubes now used for television image reproduction employ electrostatic focusing — i.e., the cathode ray stream is concentrated or otherwise changed by a high voltage electric charge placed on an electrode within the tube.
- KINEOSCOPE** — The name given to the cathode ray tube when used for reproducing television images at the receiver.
- ELECTROSTATIC DEFLECTION** — Many cathode ray tubes used for television reception use electrostatic deflection in contradistinction to those using the *electromagnetic* reflection. A series of four plates, arranged in two pairs — placed at right angles to each other, are fitted within the neck of the tube and by causing alternating charges to be applied to

these two pairs of plates, the cathode ray is rapidly deflected back and forth across the screen and thus "paints" the image on the screen at the end of the tube.

FLUORESCENT SCREEN — The chemically prepared coating on the inside of the large end of a cathode ray tube. When the cathode ray impinges on this chemical screen, it causes a fluorescent spot to appear, the color of which depends upon the chemicals used. Green is a common color seen on such tubes, while some of the later tubes produce a black and white image.

ICONOSCOPE — The special vacuum tube somewhat resembling a cathode ray tube, and which is used in the television camera to pick up the image at the transmitter. It was invented by Dr. V. K. Zworykin.

INTERLACED SCANNING — A method of scanning which helps to eliminate flicker and in which the picture is scanned not in progressive paths, such as 1, 2, 3, 4, but 1, 3, 5, etc., on the first scan, and 2, 4, 6, etc., on the second scan.

KERR CELL — A light modulation valve using a special solution, such as nitro-benzol, and having two or more thin metal plates separated a slight distance and between which the beam of light to be modulated is passed. The incoming television signal is connected to the metal plates in the cell and thus modulates the beam of light passing through the cell by electrostatic reaction on the light beam.

MAGNETIC DEFLECTION — See Electrostatic deflection.

MICRO WAVES — Very short radio waves, usually considered as those

having a wavelength shorter than one meter.

MIRROR DRUM OR DISC — Previously used by television experimenters for the purpose of scanning.

OPTICAL LINE-OF-SIGHT — Refers to the fact that a person on a high building can only see to the horizon, not beyond; the ultra short waves, in general, follow this law of optics and thus the range of a television transmitter is limited by this phenomenon.

PHOTO-ELECTRIC CELL — Usually an evacuated glass tube containing two or more electrodes, one of which is coated with a chemical sensitive to changes in light. Fluctuating light impressed upon such a cell causes corresponding fluctuations in the electric current, controlled or generated by the cell.

REFLECTING LAYERS — Refers to the various ionized layers in the upper atmosphere which reflect radio waves, the angle and degree of deflection depending upon the frequency of the wave.

SCANNING — The process of breaking up the image into paths or strips whereby the cathode ray, for example, scans the image — path by path — in a progressive manner, until the whole image has been completely scanned. The whole process is repeated many times per second, similar to a motion picture, at a speed which obviates any flicker.

SYNCHRONIZING — The method whereby the scanning of the image at the receiver is kept in perfect step with the scanning of the object at the transmitter, usually effected by transmission of regular synchronizing impulses.

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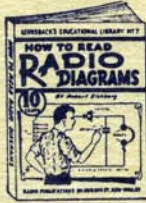
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