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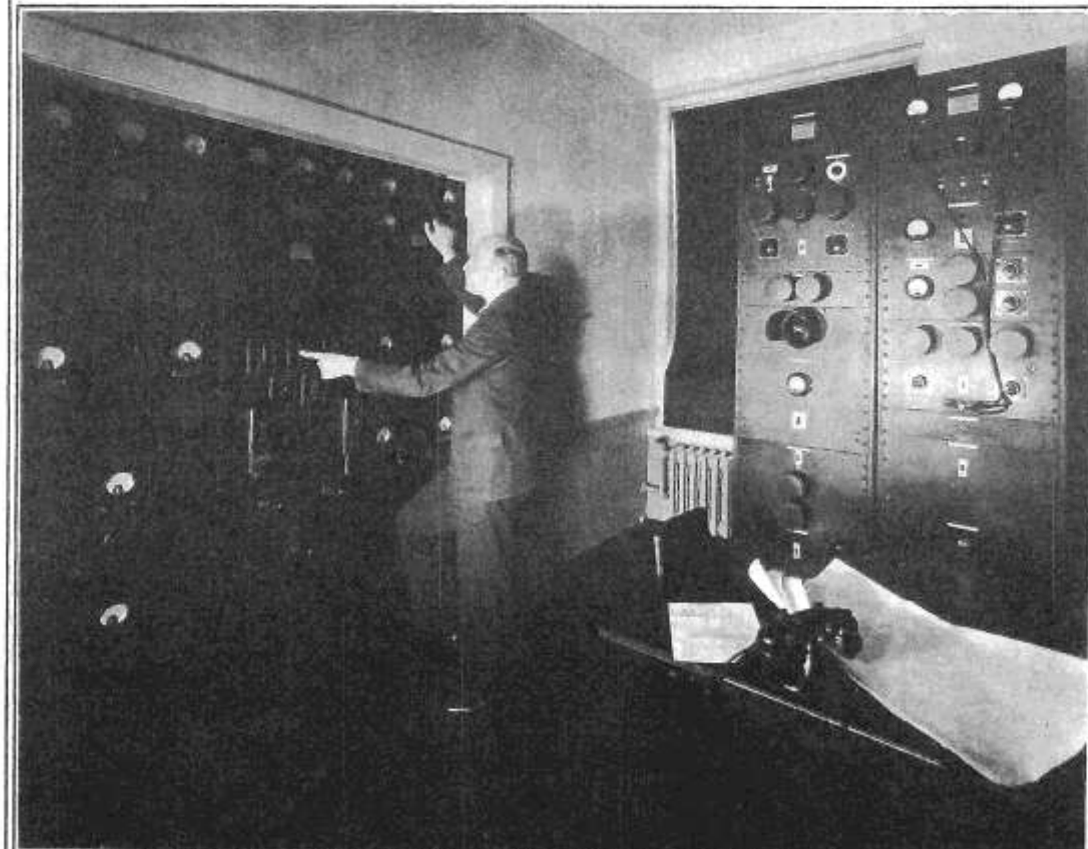

TUNING THE TRANSMITTER OF TELEVISION STATION W2XAB.
(COURTESY COLUMBIA BROADCASTING SYSTEM.)

— TELEVISION —

IMITATING THE HUMAN EYE

VOL. 59, No. 3

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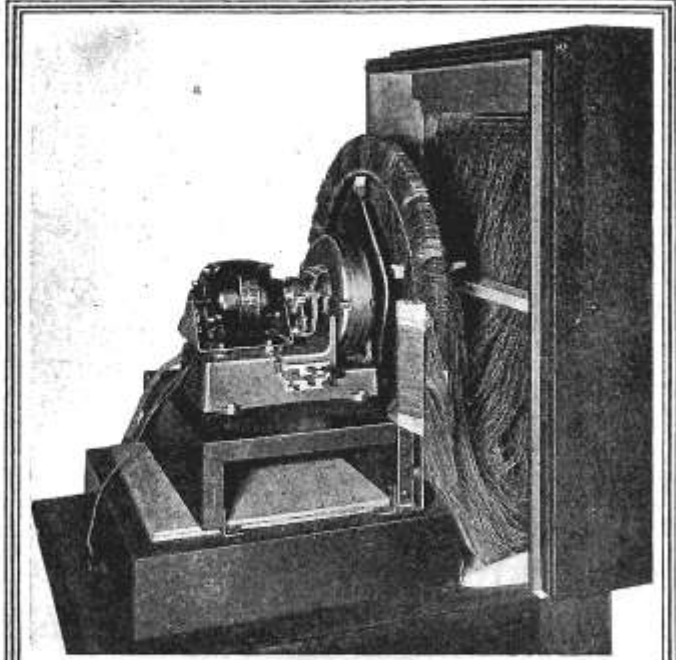

AN ELECTRICAL DISTRIBUTOR WITH 2500 CONTACT POINTS CONNECTED TO AN EQUAL NUMBER OF LAMP ELECTRODES, PROVIDING 2500 POINTS OF LIGHT ON A LARGE GRID. USED IN A DEMONSTRATION OF WIRE AND RADIO TELEVISION BY THE BELL LABORATORIES IN 1927. (COURTESY BELL TELEPHONE LABORATORIES.)

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TELEVISION ATTEMPTS BASED ON IMITATING THE HUMAN EYE

For years the world has produced men endowed with keen penetrating minds whose ambition it was to originate devices that would be of assistance to faculties already possessed by man. To successfully work along these lines and conduct intelligent research they have in many instances drawn upon the patterns laid out by nature.

The action of the telephone invented by Alexander Graham Bell, for instance, imitates the action of the human ear drum and because of the development of this invention the human ear is, figuratively speaking, capable of hearing sounds which originate at the ends of the world.

Before aviation progressed to its present state of development, hours upon hours were spent by engineers in observing the flight of birds, obviously a study of nature.

Greater and greater extension of sight beyond that possessed by the human eye has always been a goal of scientists. This was given an impetus by Galileo who developed a telescope with which he discovered the satellites of Jupiter, and from whose time modern physics may be said to have begun.

It does not require any great stretch of the imagination, therefore, to realize that scientists for years have directed their studies along a line of thought whereby existing models, both artificial and natural, have been drawn upon to furnish information leading to certain desired results.

So, in the study of television, we find that its progress has been slow. We also learn that contributions have come from many sources, which at their time were perhaps remote from the goal but, nevertheless, progressing toward a central point out of which the necessary information was obtained to construct apparatus that would allow the eye to see an image beyond the barriers of light waves. At the very start, therefore, we will begin our study by first becoming acquainted with nature's system of television provided by the human eye.

THE HUMAN EYE

Here, without question, is a part of nature's handiwork which everyone recognizes as a marvelous organism. We are able to account for certain functions of the human eye, but true to Nature's method of doing things she allows the puny mind of man to go just so far; there the curtain is drawn and we are left to conjectures.

The cornea is a bulging transparent tissue which forms a round window at the front of the eye ball admitting light to the lens. The amount of light thus admitted is controlled by the iris, in the center of which is an opening called the pupil. The iris is composed of muscle fibers capable of expanding and contracting thus changing tne size of the pupil. If the eye is directed toward a source of strong light these muscles act in a reflex manner to cause the iris to contract and in this way close the pupil aperture. When in a dim light the pupil is opened by these muscles so as to admit all the light possible. Immediately back of the pupil is the lens, the shape of which is changed by the action of a set of muscles in order that it may bring to a focus upon the retina the light rays proceeding from an object to which the eye may be directed, and thus form an image upon the retina or screen, as it may be called. The retina, a delicate membrane, is composed of an enormous number of minute cells each connected to the brain by nerve filaments over which the brain receives the impulse. Just how this impulse of the inverted image thrown upon the cells of the retina is generated is not known but from some scientific sources the action is conceded to be caused by the presence of a light sensitive fluid in the cells of the retina. This fluid, present in the millions of minute cells, is affected by the light rays impinged upon it and an extremely fine mosaic image of the object is built up in varying degrees of light and delicate shadings.

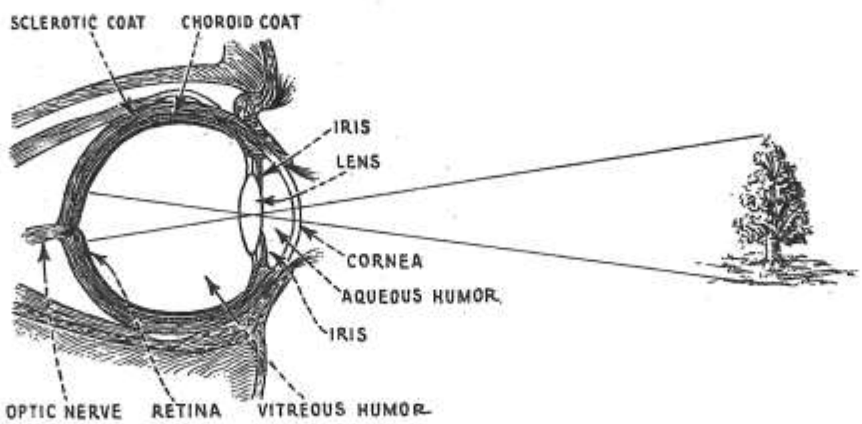


Fig.1 - THE HUMAN EYE — THE FIRST LENS SYSTEM.

The aqueous humor is a watery fluid while the vitreous humor is a fluid of jelly-like consistency. The two humors act to keep the eyeball distended and also act with the lens to form a real inverted image upon the retina. The choroid coat immediately back of the retina is intensely black and absorbs all the light rays reflected internally. The sclerotic coat (an opaque lining) covers the choroid coat in back of the eye ball and forms the cornea in front of the eye ball. When the eye lid is opened and objects before us are sufficiently illuminated, or the object is a self-luminous body, vision is the result.

All the senses with which man is endowed are important but the two which stand out in our studies are the sense of "hearing" and the sense of "sight." If we were allowed to retain only one of the two we would no doubt choose sight because, with sight, material objects take on a concrete form. Impressions conveyed to the mind by the eyes make lasting records, and perhaps to a greater degree on our conscious mind than writing or the sounds of a language. Furthermore, our eyes permit us to take in scenes and actions at a mere glance which could not be described in the spoken or written word in nearly as short a time nor with the same degree of satisfaction that comes from actually seeing the events.

For ages man has toiled and studied in an effort to improve the means given him by nature to better see objects, and most especially objects beyond normal range of vision (the unseen). It is unnecessary to say that any attempt to change the human eye to produce greater vision is a dangerous undertaking and would be sure to fail, therefore, the only thing that seemed possible was to copy nature and produce an artificial device that would extend the range of vision. The study of how this was accomplished is interesting for it brings to us first hand the contributions of science which have been applied to television, and also the various divisions of scientific thought called upon to solve the problem, such as light, optics, chemistry, mechanics and electricity. Close attention will be required in this study to enable the student to recognize the closing of the links in the chain of discoveries, some of which were, perhaps, remote from the subject of television at the time, but eventually doing their share in the development.

It seems fairly well established that magnifying glasses were unknown to the ancients. Pliny, a Roman, in his historical writings tells us of the use of crystal globes filled with water which were employed as cauterizing agents by bringing the rays of the sun to a focus on the wound to be cauterized. Also, from Roman history we learn that letters seen through a glass filled with water appear enlarged but indistinct. No attempt, however, was made to explain this phenomenon at the time.

Perhaps the earliest known record relating to the invention of lenses used as spectacles is that appearing in a manuscript from Florence, dated 1299. The year 1285 is considered by some writers to be the date when spectacle lenses were first known and it was later discovered that a Florentine, Salvino Armati, was the inventor. Something of the science of optics, therefore, must have been known at this early date. Our first knowledge of lenses came from these people and since the use of lenses and light are both important in television we, too, must know something of the behavior of light rays when passed through mediums of optical density.

OPTICS — A STUDY OF LIGHT

What is the meaning of the word "light?" According to our present theory it is a form of radiation, that is, a vibrational movement in space which affects the human eye. The eye is sensitive to the relative amplitudes of the vibrational movement. From this we can say that light is the external cause of the sensation of sight. This would lead us to believe that light is necessary to enable us to see. This is a correct belief as we shall soon learn.

There are luminous and non-luminous bodies. Under the first heading we have the sun, electric lamps, arc lamps, candles, the heated filaments of your vacuum tubes, and so on. Under non-luminous bodies we have the moon, wood and iron as common examples. A luminous body, then, is one which throws out light, while a non-luminous body becomes visible only after it has received light from a luminous body and reflects this light to the eye.

When you go into a room at night and snap on the electric switch controlling the current supply to an electric lamp the objects in the room receive light, part of which is absorbed and part reflected. From this we obtain our definition of the term "illumination" because the filament of the electric lamp, normally a non-luminous body, has been transformed to a condition of incandescence by an electric current and changed into a luminous body which emits light, and in turn illuminates the objects about the room. The light thus created follows certain laws; for example, a substance such as air or clear glass will allow light to pass through it, and we say that such substances are transparent. Ground glass, thin sheets of paper and oiled paper are substances which do not provide a perfect passage for light waves; they are termed translucent substances. Under the opaque classification we find many substances such as iron, wood, sheets of cardboard, and so on, which will not allow light to pass. This brings us to the study of how light travels — an important phase of the work because it has a great significance in television.

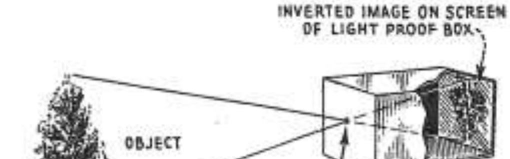


Fig. 2 - A PIN-HOLE CAMERA PROVIDES AN IMAGE WITHOUT THE USE OF A LENS.

Light travels in straight lines through any medium that is transparent and of uniform density. This fact is evident because of common phenomena which is familiar to everyone. Sunlight streaming through a crack or knot hole in a barn, or any building that is otherwise dark, illuminates the particles of dust floating in the air and forms straight lines of light.

Another illustration is the "pin-hole camera" shown in Figure 2. This consists of a light-proof box having a minute opening in one of its sides. Any light reaching the hole from an illuminated object will pass through the hole and continue in a straight line. The result is the formation of an image of the object on the side of the box opposite to the opening. When a sheet of sensitized photographic paper is placed against the inner surface of that side, and exposed sufficiently long, an excellent picture will result after proper development.

REFLECTORS

It was previously stated that an object to be seen must first be illuminated· also that light travels in straight lines. Therefore, when viewing an object through a mirror there must be no obstruction between the eye and the mirror. Although we can see around corners or view events taking place behind us by means of mirrors, this does not alter the law that light travels in straight lines for remember that between the object and the mirror, there must be no obstruction for the light ray, and neither can there be a barrier between the mirror and the eye. When you look into a mirror it appears that objects you see are located at some distance behind the mirror when actually they are not, and it seems as though you see these objects through some sort of an opening in the wall. The eye sees only an image of the objects because the light from the objects is reflected light rays striking the eye from the direction of the mirror, and since the eye sends an impulse to the brain only of the direction from which light enters it, the object appears to be in that direction. If the frame of a mirror could not be seen and the reflecting surfaces were not detected the eye would not be able to distinguish the difference between the real object and its image in the mirror.

A mirror of spherical shape is sometimes employed in television work. A mirror of this type, shown in Figure 3, is called a con-

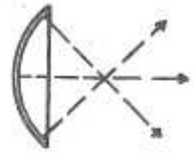


Fig. 3 - A SPHERICAL MIRROR.

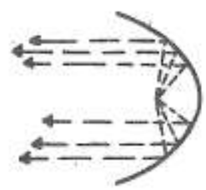


Fig. 4 - A PARABOLICAL MIRROR.

cave mirror. The parabolic mirror shown in Figure 4 is a familiar type, and is used often when a broad beam of light is required from a small or point source.

When light rays strike a polished surface, the regular reflection permits seeing a good image of the object providing the light. When the rays impinge on a rough or unpolished surface such as paper, ground glass, etc., the reflection is diffused, and no image results from the direct light falling on the surface. An image may be formed on the rough surface by means of a lens, but this is a separate effect.

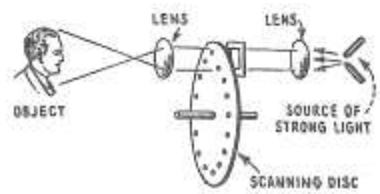


Fig. 5 - GENERAL FEATURES OF A MECHANICAL SCANNER.

Figure 5 shows, fundamentally, some parts of a system utilized for scanning a subject. The object illuminated reflects the light by irregular or diffuse reflection. If light sensitive cells are placed in the path of this reflected light they will function in such a manner as to cause a current to flow through a circuit. Before going into further detail, however, we must pause long enough to become acquainted with what is known as the optical system of this group, namely the lenses, and to find out what effect they have upon the passage of light rays. This phenomenon will be readily understood after reviewing the meaning of certain terms given in the paragraphs immediately following.

REFRACTORS.

"Refraction" is a term used to describe the bending, that is, the change in direction taken by a light ray in passing through mediums of different optical density.

In the study of optics we note that air, water, glass, liquid or solid bodies that are sufficiently transparent to allow light to pass, may be termed optical mediums.

Fig. 6 - A DOUBLE-CONVEX LENS.

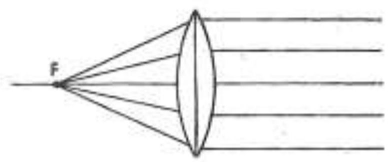


Fig. 7 - FOCUSING ACTION OF A LENS.

By density is meant the compactness of the substance which makes up the medium; thus, air is less dense than water and water is less dense than glass. "Lens" is the name given to a solid of glass

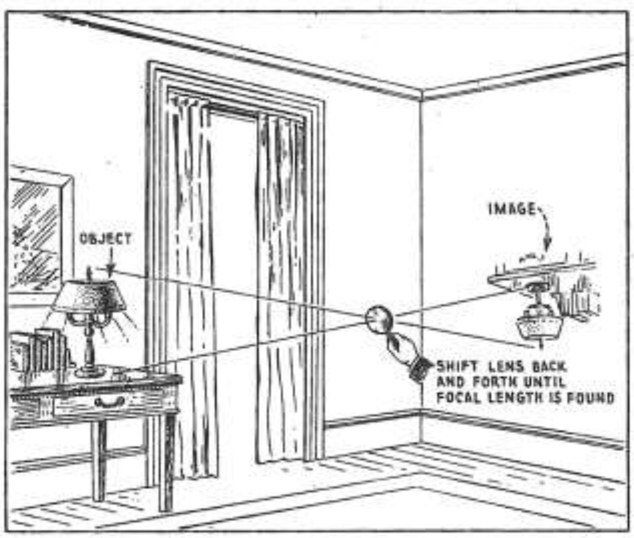


Fig. 8 - AN IMAGE MAY BE FORMED ON A WALL OR OTHER FLAT SURFACE.

which is a transparent medium capable of diverging or converging rays of light that pass through it due to the curvature of its surfaces.

Another type of lens we are interested in because of its use in television is called the "double convex lens" shown in perspective in Figure 6. As a child, how many times have you used this type of glass to burn holes in leaves, paper, and so on, by focusing the sun's rays, that is, bending them toward a single point as shown at F in Figure 7?

The pin hole camera previously mentioned will reproduce the image of an object regardless of its distance from the aperture and with great clearness of outline, but if we attempt to increase the opening the image becomes indistinct. Now, this opening may be enlarged to obtain a greater increase in brightness, that is, allow more light to strike the screen, if we place in the aperture a double convex lens, such as we have been discussing. Distinctness of outline will not be sacrificed if the screen and the object are at the conjugate focuses of the lens. That is why, when you take pictures with certain cameras you move the lens back and forth until the light rays striking the lens from the object are focused clearly upon the screen. In the camera the screen is the sensitized film or plate, as the case may be.

You may perform a simple experiment in your own room by placing an ordinary magnifying glass between some illuminated object and a screen. The screen may be the opposite wall of the room. When the proper focal length is found an exact image will appear on the screen. Figure 8 illustrates how this experiment may be carried out

We see, therefore, that lenses are not only useful for refracting light but are also capable of producing images.

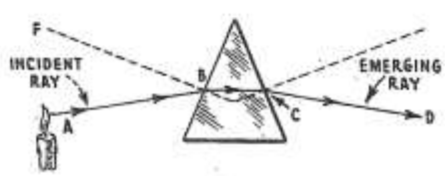


Fig. 9 - A PRISM REFRACTS A LIGHT RAY.

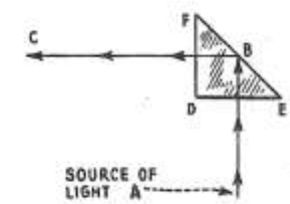


Fig. 10 - A PRISM MAY BECOME A REFLECTOR.

A second form of refractor is the prism, which is shown in Figure 9. This is used in television where the direction of a light ray or beam is to be changed slightly, but no focusing is desired. On passing from the medium of air to the denser medium of glass, the ray is bent in direction, and again on emerging from the glass into the air a further change of direction is caused.

When a prism is used as in Figure 10, it becomes a total reflector, instead of a refractor.

Let us sum up the work we have been over. First we found that nature produced the first televisor, the eye, which generates an impulse resulting in vision. Next we discovered light to be absolutely necessary before vision was possible. History tells us that for years scientists have been constantly working to improve apparatus that would assist vision. First came the pin hole camera. Then later it was found that glass worked into the proper shape would cause light rays to converge forming an image of objects appearing before it, and from this knowledge was born the microscope and telescope.

The electrical era arrived and work was begun on apparatus that would enable one to talk with friends miles away by wire telephony. Next came the wireless telephone, and in its footsteps followed radio broadcasting of voice and music, resulting in the reception of sounds from London as distinct as listening to your own voice. Then finally we come to the ambition to couple all of this with an electric eye (Television) which would enable one to see with whom he was speaking.

Before attempting to grasp all ow the ideas of a television system suppose we draw analogies to make comparisons along lines with which most of us are more or less familiar.

Speech, music and other audible sounds produce sound waves which, in striking your ear drum, cause it to vibrate. The inner ear receives these vibrations and generates an impulse which is carried to the brain and the brain interprets this impulse.

Because speech and music can be heard for only a comparatively short distance we place a telephone transmitter, or you may call it an electrical ear in a location where it can pick up these sounds. You speak into this device, and immediately a rise and fall of electric currents take place corresponding to the sound waves that were created when you spoke or when music was played. At the other end of the wire connected to the transmitter is the telephone receiver, or electrical mouthpiece which converts the varying electrical currents back into sound waves forming the spoken words or music picked up by the transmitter.

In television our purpose is to transmit an image instead of sound, therefore, we shall have to change our terminal apparatus from an electrical "ear" and "mouth" to an electrical eye, and provide some device which will duplicate in light what the electrical eye observes.

To obtain an electric eye was one of the difficulties encountered by scientists in their effort to place television on a successful experimental basis. Chemistry, however, came to the assistance of the early investigators along this line of endeavor in the development of a non-metallic element called "Selenium." This element was discovered in 1817 in the deposits of sulphuric acid chambers. In its native state selenium has an extremely high resistance (many times that of copper), but on being prepared by a heating process and then allowed to gradually cool, it forms into a crystalline state changing in color from a blue to a dull slate.

The prepared selenium, it was found, possessed the property of varying in electrical resistance directly in proportion to the intensity of light waves to which it was exposed, the resistance decreasing as the light increased and increasing as the light decreased. In this element, therefore, the scientists placed high hopes, since the essentials were there for a device which would operate in such a manner that varying intensities of light could be made to cause a corresponding flow of electric current.

Selenium cells were made by placing a film of the prepared selenium over two german silver or platinum wires of No. 20 to No. 30 gauge wound on a small 2 by 1 inch mica form. The windings were spaced about one thirty-second of an inch apart as shown in Figure 11 and then placed in a box provided with a window to admit light, somewhat as suggested in Figure 12.

The selenium cell found many uses, perhaps the most important, commercially, was in marine buoys and isolated lighthouses along the coast where it was employed to control switching mechanism to turn on the light when darkness set in and to turn it off at daylight, the light of the sun furnishing the requisite energy.

For television work, however, science was again disappointed because of the property of inertia inherent in the element. The change in its conductance lagged so far behind the instantaneous values of light to which it was exposed that a considerable time exposure was required before a proportional current would flow for a given intensity of light. Selenium, therefore, had to be abandoned as an electric eye for television.

A new development eventually appeared, the photoelectronic cell, or phototube, which found immediate acceptance because this was the first device produced that would follow with true fidelity the rapid varia-

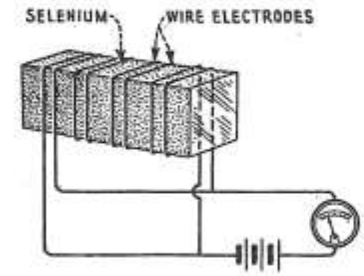


Fig. 11 - TYPICAL CONSTRUCTION OF A SELENIUM CELL.

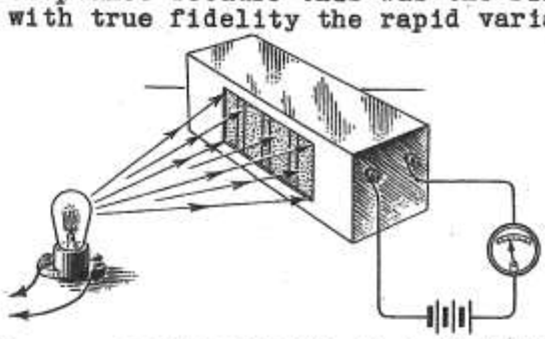


Fig. 12 - LIGHT FALLING ON A SELENIUM CELL RELEASES A FLOW OF CURRENT.

tions of light and shade necessary to form an image and produce an instantaneous current in proportion to the various delicate shading that forms a picture. The photoelectronic cell is a vacuum tube depending for its action upon an electron-emitting cathode and an electron-attracting anode.

Figure 13 shows one general design of the cell. Figure 14 shows the cell connected in a simple circuit and when light is allowed to enter the window a deflection of the galvanometer will be noticed, thus indicating that a current is passing through the cell.

The instant light is cut off, that is, prevented from reaching the light sensitive element, the current through the cell ceases. On the other hand, by increasing the intensity of light the electron emission is increased and a greater current flow will be indicated by the current-indicating instrument connected in the circuit. By repeated experiments it was found that the current passing through the photoelectric cell was directly proportional to the amount of light striking the cell. If the light varies in intensity the current instantly conforms to the change in light, so when the light increases the current rises in proportion and, conversely, when the light is decreased the flow of current decreases in proportion to the decrease in light.

What takes place is explained as follows: Light waves, passing through the circular opening or window of the glass envelope, strike the potassium hydride coating on the inside of the bulb. The potassium, having the property of emitting electrons when exposed to light waves and especially those predominating in blue violet light, emits clouds of electrons which are attracted at once to the positive electrode. This electrode is a loop or rectangle of wire made of some photoelectrically inactive material such as nickel or platinum. The electrons are considered to constitute an electric current which flows through the cell and the circuit connected to the cell in which the source of electromotive force maintains the anode at positive potential.

It has been mentioned that the potassium type of cell is particularly sensitive to blue-violet light. On the other hand a cell using a thallium-sulphur compound in the cathode surface shows a great sensitivity at the red end of the color spectrum. This color-sensitivity quality brings several unique features into the field of television.

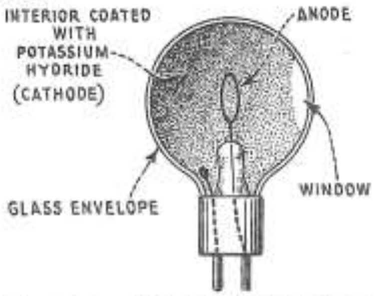


Fig. 13 - CONSTRUCTION OF A TYPICAL PHOTOELECTRONIC CELL.

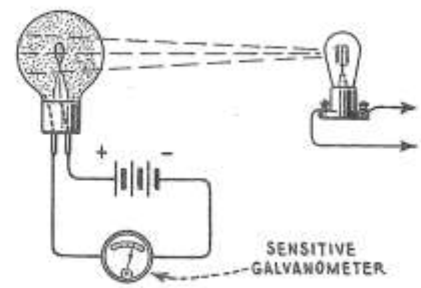


Fig. 14 - EFFECT OF LIGHT ON THE PHOTOTUBE.

When using the potassium cell it is possible to televise with an intense blue light without the discomfort to the players that comes from using a white light which includes all the heat-producing rays at the red end of the spectrum. When using the thallium-sulphur cell, invisible infra-red light can be used to televise an object or scene, providing distant visibility of things that are in darkness to the human eyes present at the scene.

Let us return to the time when the epochal invention of the selenium cell was made. Having a device of this kind the science of television moved another step toward success.

PHOTOELECTRIC SCRUTINY OF COMPLETE IMAGE

The early work in the field of television was conducted upon the principle of constructing an imitation of the human eye. This manufactured eye employed a great many selenium cells and attempted to build up a mosaic pattern of the object or scene to be televised. The effort failed; first, because of the inherent time lag in selenium and, second, because of the prohibitive cost of the great number of selenium cells and wire circuits required.

This can be better understood by comparison with Figures 1 and 2. A light-tight box was built similar to a camera but much larger. Instead of a photographic plate, the back surface of the box was covered with scores of selenium cells placed in regular rows like a tile wall. This corresponds to the retina of the human eye, and the image of the scene was focused on this photoelectric wall, whose function was to "analyze" the image, or break it up into its component parts. Corresponding to the optic nerves which connect the retina and the brain, there were a multitude of wires leading from the selenium-tiled wall, each cell using a pair of wires. These wires were made part of battery circuits connected with the distant point.

Here an upright frame was used to support a sort of honeycombed box, in which were installed a bank of lamps equal in number to the selenium cells at the transmitter. The function of this lamp bank was to "synthesize" (meaning "put together") a light pattern resembling the original image. In front of each lamp was a shutter, magnetically operated by the current coming to it through the pair of wires connected to the selenium cell placed at the same relative point in the transmitter frame. Whenever a selenium cell was acted upon by a light-element of the image, the corresponding lamp-and-shutter combination provided a light-element at that point of the receiver frame.

When an object moved in front of the transmitter box, its image moved correspondingly across the photoelectric wall inside the box. The values of light falling on the various cells at any instant determined the open or closed condition of the corresponding light shutters at the receiver. The pattern formed by these many light sources in the honeycomb structure gave an approximate image of the object televised.

It is to be noted that this form of television equipment, while cumbersome and costly, transmitted the entire picture-effect at once. The analyzer and synthesizer were continuously connected, each wire channel having to carry only one element of the image. Others continued to experiment along similar lines but finally the development turned toward working out the problem by employing only one wire channel between the two places. With this limitation of equipment, it is not possible to analyze the image in one operation, nor is it possible to synthesize the light pattern completely at once.

There will be required the progressive examination of the light values of small sections of the image, and to this process we apply the term "scanning."

Retaining the effect of a selenium-tiled wall of many cells, but now using only one circuit, there must be some way to shift this lone circuit from one selenium cell to the other in rapid succession. Likewise, there must be some way to shift the opposite end of the circuit from one lamp to another in succession. At the instant when any particular cell is connected to the transmitter end of the wires, the other end must be connected to the particular lamp which is placed in the corresponding location on the receiver screen.

This mechanism required two rotary switches, each having as many contact points as there were cells or lamps. The switches sometimes took the form of commutators as used in motors, etc. These switches were required to rotate in synchronism. This means that not only did isochronism (same revolutions per second) have to be maintained, but also the proper relation (phase) between the switch-positions at each end. This was necessary in order that each selenium cell in turn might get the "right party" among the distant lamps.

In order to comprehend the necessity for speedy rotation of these switches we must have a clear understanding of a certain faculty of the human eye, which is explained on the next page under the topic "Persistence of Vision."

PERSISTENCE OF VISION

When light strikes the retina of the eye, the impression caused by the light will remain, that is, it will persist, for an appreciable time after the source of light has been cut off. Because of this peculiarity we continue to see brightly illuminated objects for a short time after the object ceases to transmit or reflect light to the eye. The following two experiments may be performed to illustrate this phenomenon.

Fig. 15 - DRAWING OF A HOUSE. (SEE FIG. 17.)

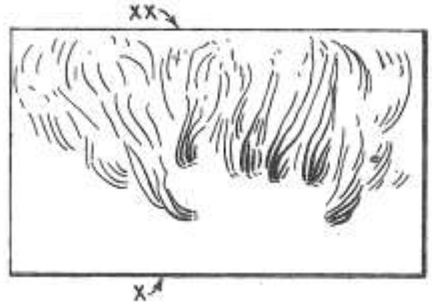


Fig. 16 - ILLUSTRATING FLAMES. (SEE FIG. 18

First, swiftly swing a flashlight in a circle. The image recorded by the retina in any one position of the swinging light will persist until it is again renewed on the retina by the light arriving in the original position. The result is that we see a continuous circle of light.

Second, use the pictures shown in Figures 15 and 16 to construct the model described in the following paragraph. This demonstration explains why the path-changer of a television transmitter is rotated at a certain speed so that the last part of the object is examined before the light representing the first part fades from the retina.

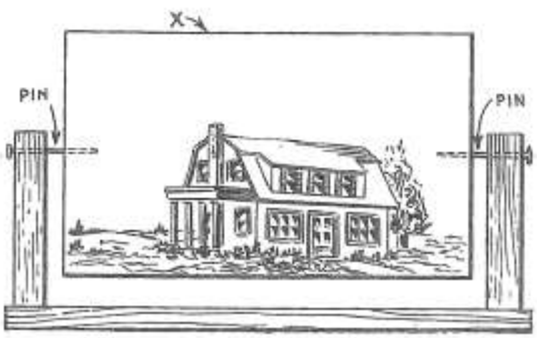


Fig. 17 - VIEW OF HOUSE MOUNTED ON ONE SIDE OF CARD.

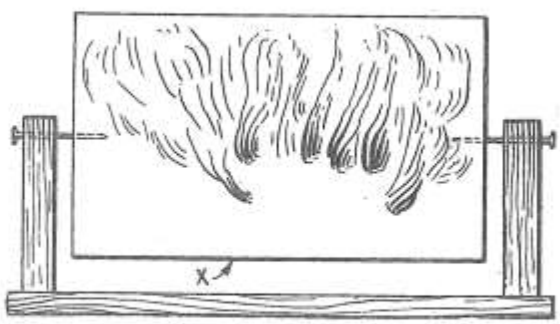


Fig. 18 - DRAWING OF FLAMES MOUNTED ON OPPOSITE SIDE OF CARD.

Redraw Figures 15 and 16 on two separate pieces of white paper of the same size, or cut them out of the text, as desired. Mount the finished drawing of Figure 15 on a piece of stiff cardboard of the same dimensions. Now, without allowing edge "X" to leave the table, raise edge "XX" and turn the card over by giving it a rotary motion away from you; edge "XX" will now be at the top and "X" at the bottom. Completing this, mount Figure 16 on the cardboard so that side "XX" is at the top of the card. Next construct a support using some suitable material which is handy, so that when a pin is stuck in each end of the finished card and mounted on the supports as shown in Figure 17, or held by both hands, the card can be rotated freely. With this completed and the "house side" of the card facing you, slowly turn it until edge "XX" is facing you, in which position neither view is visible. Continue to turn the card in the same direction and the view in Figure 18 is now seen. The purpose in rotating the card very slowly at first is to show that at this speed each view you have of the house and the flames is distinctly separate and independent.

Now, with the card in the position as shown in Figure 17, cause it to rotate rapidly and you will see the house enveloped in flames. The house appears to be burning because as soon as the image of the house fades from the retina of your eye the flames are superimposed upon it.

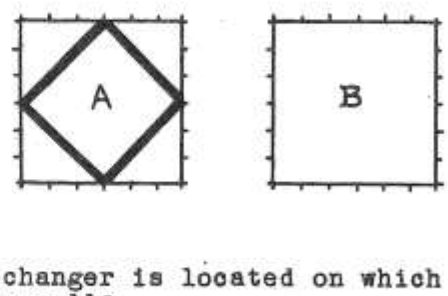
CONCLUSION

You have advanced now to where you should have a good understanding of the growth of television up to and including the systems which employ:

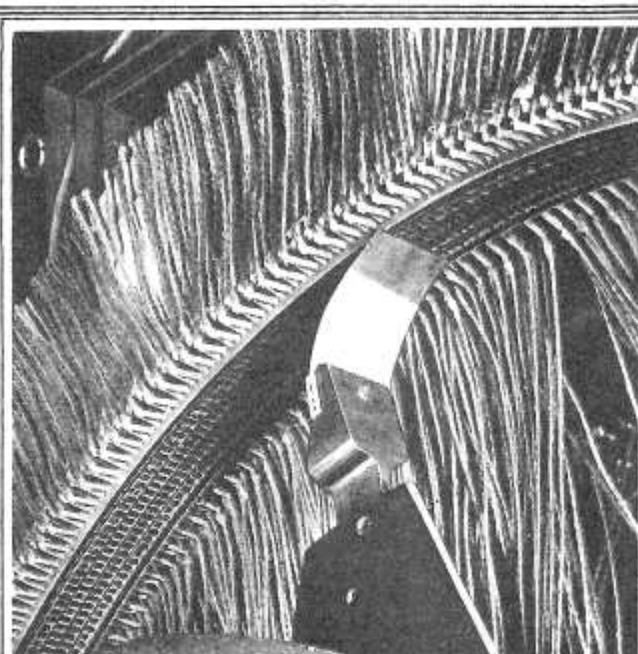
(a) Analysis by multi-cell arrangement.
(b) Synthesis by multi-lamp arrangement.
(c) A single channel for television signals.
(d) A path-changer on the electric side of the photoelectric cells.
(e) A path-changer on the electric side of the television lamps.

EXAMINATION QUESTIONS

1. What fundamental principle of optics is used in the pin-hole camera?
2. Why was a lens added to the pin-hole camera?
3. Is selenium suitable for television? Why?
4. Compare the telephone and television.
5. Explain the construction and operation of the electronic type of photoelectric cell.
6. Why is television scanning sometimes done with a blue light?
7. What is the difference in principle between photoelectric scrutiny and modern scanning?
8. In an electrical scanning and distributing system, what would be the picture-effect at the receiver if its commutator switch were travelling at the same speed as the transmitter switch, but exactly one-third of a revolution behind the transmitter? Using sketch A as the transmitted design, fill in the blank square in sketch B with your answer and copy the latter on your answer sheet.



9. What is the function of the bank of lamps used at the receiver?
10. (a) In the scanning system described last, the scanning path-changer is located on which side of the photoelectric pickup cell?
    (b) The distributing path-changer at the receiver is on which side of the photoelectric reproducer (lamps)?



DETAILS OF THE DISTRIBUTOR. THE SLIDING BRUSH BEARING THE TELEVISION SIGNAL VOLTAGE IS A STRIP OF THIN SHEET METAL.

(Courtesy, BELL TELEPHONE LABORATORIES.)