R·C·A INSTITUTES INC.
formerly
MARCONI INSTITUTE
Founded 1909

*Technical Lesson 66*

TELEVISION - PART II

The Electron in Television. When you first read about matter you learned that it was made up of atoms - particles so small that the most powerful microscope would not make visible. Atoms, themselves, are always the same, but matter differs depending upon the number of the atoms and the particular arrangement they assume.

A great deal of research was carried on by scientists who found that the atom consisted of two parts, the first of which they called a "Proton", and the other an "Electron". Now each atom of matter tends to remain in a normal state, that is, an unchanged state, and when this is the case the atom manifests no electrical characteristics. This means that when an atom contains an equal number of protons and electrons the atom is electrically neutral. If, however, for any reason the atom gives up one of its electrons it then becomes a positive charge and, conversely, if an electron attaches itself to a normal atom it then acts as a negative charge.

About the nucleus there is thought to be a number of electrons which revolve in regular orbits. One electron may move in a perfectly circular path close to the nucleus, another a little further away may not be confined to a single plane, while others may take an eliptical path in their sweeping motion about the nucleus, sometimes passing quite close to the nucleus, while further on in its flight it may follow a route which carries it in a wide swing far beyond the positive center. When an electron follows such a path, (that is, when at its fartherest point from the nucleus) it becomes an easy victim to some other positively charged force, which may be in close proximity, and it then can be easily influenced to leave its parent atom.

Thus, in the alkali metals such as caesium and others mentioned in the preceding lesson, we have an excellent material to be used as the basis for the photo-electric cell. First, because at least one of the electrons in each atom moves so far away from the nucleus that they are easily seperated and, second, because this particular form of matter is a light sensitive material which on being exposed to light rays will cause electrons to be separated from the atoms. When we expose the photoelectric cell to light, the freed electrons are sent whirling off into the vacuous space within the glass envelope of the cell and normally if nothing were done to prevent it they would all eventually return to the light sensitive element. It is our purpose, however, to use these liberated electrons, so in the center of the cell a piece of inactive metal which may be circular or rectangular in shape is placed and connected by means of a wire to the positive side of a battery; the negative terminal of the battery is then connected to the light sensitive material by a second wire.

When all these connections are complete, the electrons which up to this time have been roaming aimlessly about are suddenly brought into concerted action

and rush to the metal ring electrode made positive by the battery, pass through the connecting wire into the battery, through the battery, out of the negative terminal and return to the light sensitive element by means of the second connecting wire.

Now, an electron in motion constitutes an electric current, therefore, the light striking the cathode of the cell produces electricity by freeing the electrons and light energy is converted into electrical energy by the motion of the electrons through the circuit provided by the battery, measuring instruments, and connecting wires. The instant light is cut off, that is, prevented from reaching the photoelectric 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.

Having a device of this kind the science of television moved another step toward success. The early work in the field of television was conducted upon the principal 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 required.

Others continued to experiment along similar lines but finally it was decided to work out the problem by employing only one cell. This was quite a radical viewpoint to take of the subject at the time but it is because of this that the televisor of today operates.

The principal upon which any system of television must operate, in order that an image of an object or scene can be viewed at a properly designed receiver, is that the object must be exposed to light rays. The diffused reflection from each point of the object thus exposed is then picked up by a photoelectric cell, translated into an electrical current which varies according to the change in brightness of the object thus exposed, and then passes over what ever channel is available for the communication of this current.

The method used to carry out this idea is embodied in what is familiarly known as the "scanning process", a system of rapidly revolving parts. How well this system operates will depend upon the detail required, the sensitiveness of the photoelectric cell and the efficiency of that part of the system employed to amplify the minute currents generated by the light sensitive cell.

Since television is still in a purely experimental stage no attempt will be made to record hard and fast rules, for tomorrow may bring forth a complete revolution in the systems now undergoing research. Therefore the subject of our study will be the scanning system which is the fundamental principle upon

which television operates. The early attempts in this field were made by flooding the object to be televised by a powerful source of light, ranging into the thousands of candlepower. Because of the comparatively short distance between this intense illumination and the object no human being could be successfully televised without extreme discomfort due to the enormous heat generated by a light so powerful, hence inanimate subjects were used. Figure 1 shows in detail the principal just mentioned; the object at the right is placed under the powerful light. Lens 1 is placed between the object and the rotating scanning disc in such a position that the reflected light rays from the object pass through the lens and produce an image of the object on the rotating disc. How this image is produced was mentioned under "lenses" in the preceding lesson. To supplement that part of the lesson 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 2 illustrates how this experiment may be carried out.

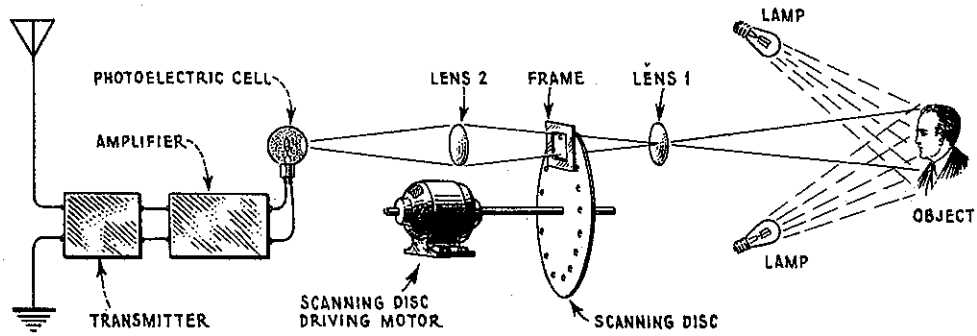


Figure 1

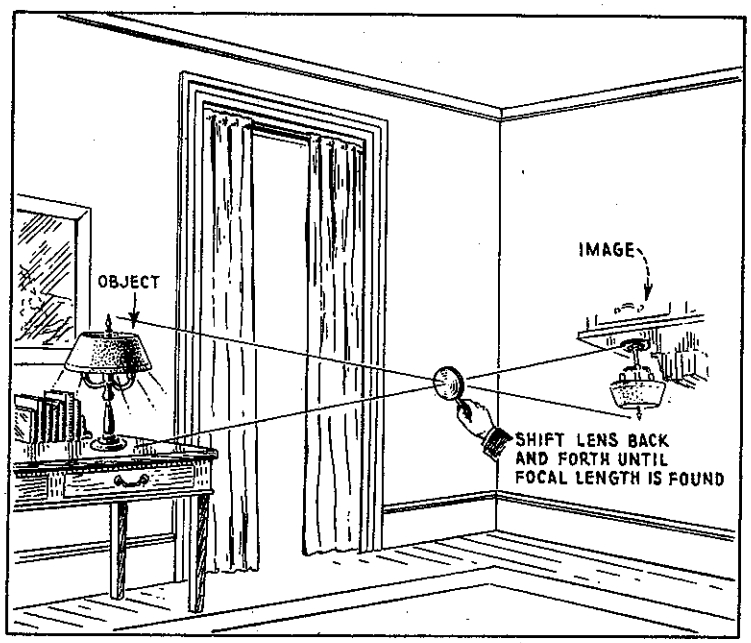


Figure 2

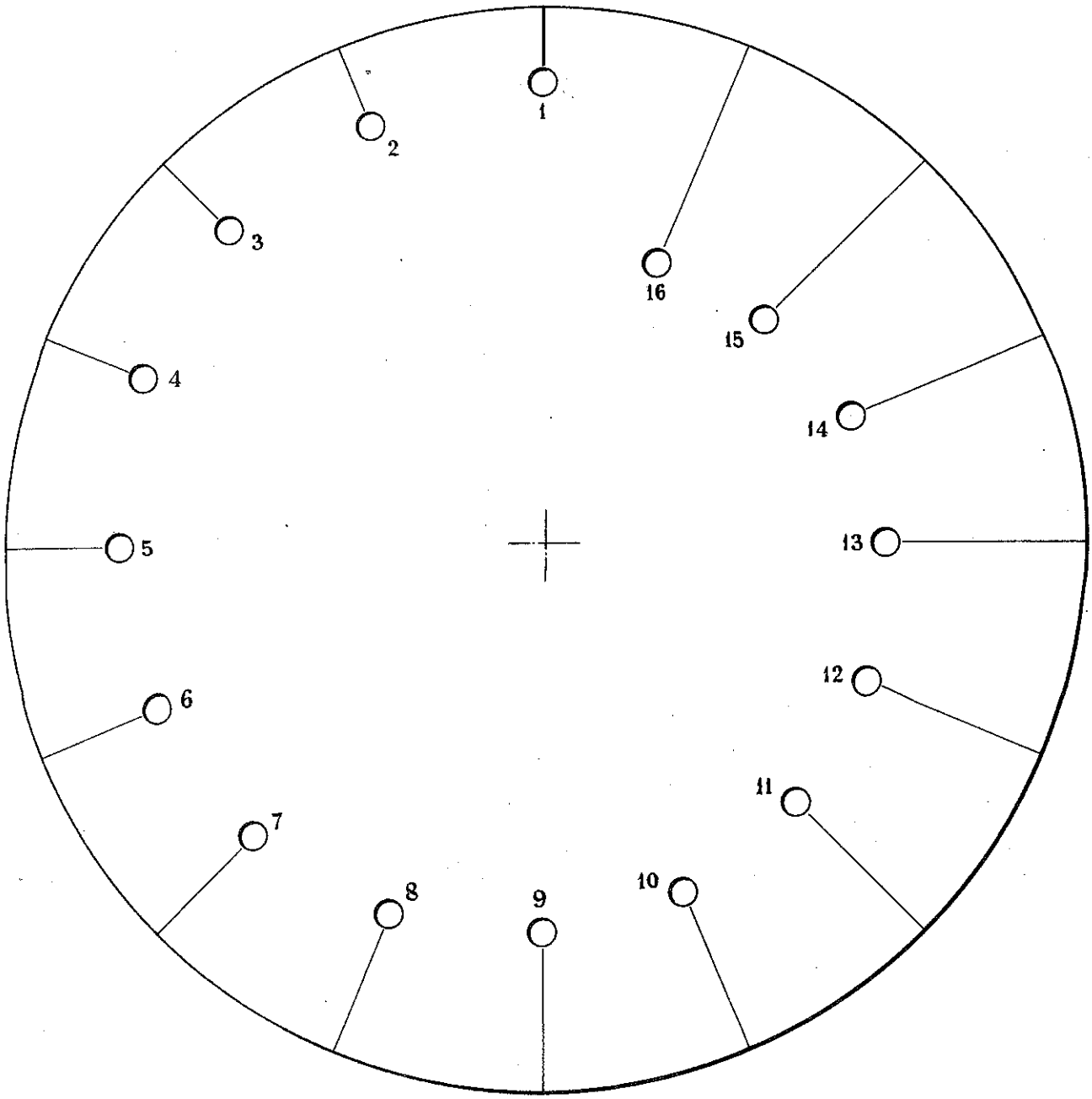


Figure 3

Let us return to Figure 1. About the disc in the form of a spiral is drilled a number of small holes, and as the disc rotates the small openings trace parallel lines across the image, one after the other in rapid succession. On the opposite side of the disc is a frame the opening of which is the same size as the formed image. This frame prevents more than a single opening being in the image at any one time. As each opening moves into the image, light passes through and is converged to a point by means of lens No. 2 into the photoelectric cell where it causes a current to pass through the cell. The amount of current that passes will be directly proportional to the brightness of each point in the image as it is traced out in parallel lines.

Before going further it will be necessary to go into detail concerning the scanning disc so that the tracing out of parallel lines of an image will be clearly understood. Figure 3 has been drawn for the purpose of studying this phase of the work; it is for illustration purposes only and not a model to be used in actual construction work, for the reason the size of the disc, the number of openings, and the form in which the apertures are arranged, assume different sizes and arrangements depending upon the idea of each individual experimenter.

With this clearly in mind use Figure 3 as a guide and redraw or trace out the figure on a sheet of paper, cutting out each opening accurately and taking care to follow all lines. Completing this, paste the traced copy on a piece of card board of sufficient weight to insure against curling. Next lay the finished disc on a white sheet of paper 8½ inches long by 7½ inches wide and place a pin through the center "O". Draw a short line "X" on the paper to coincide with line No. 1 on the disc. This is shown in Figure 4. With a sharp pointed pencil inscribe a small figure "1" on the white paper inside the opening No. 1. Slowly rotate the disc clockwise as shown by the arrow until opening No. 2 coincides with "X", and within the boundary of this opening inscribe a small figure "2" on the paper. Repeat this for all the openings, 16 in all.

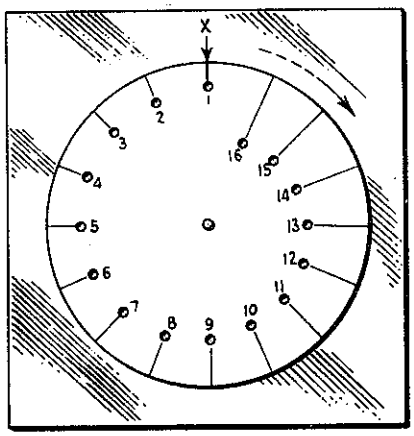


Figure 4

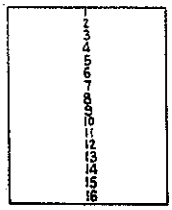


Figure 5

If this is carefully completed you will have drawn a row of figures on the paper as shown in Figure 5. If we enclose this row of figures by four lines we may then let it represent the image. Further we can let this series of figures represent a series of parallel lines. Now, by again rotating the disc clockwise, and at the same time peering through the openings as they come opposite point "X", the small figure "1" will be seen; this, we will let represent line one traced across the image, then figure 2 will represent line 2 and so on until the image has been completely explored from top to bottom by a series of parallel lines.

Because of the extreme inconvenience due to excessive heat and light, television carried out by the formation of an image on the disc was very soon discarded. This called for some other method of illuminating the object, therefore, instead of scanning the image of the object, the object itself is scanned by a rapidly moving pencil of light.

This does not change anything we have previously covered except the optical system which has been completely reversed as you will presently see by referring to Figure 6. This time the light first passes through the opening in the disc, then through the lens, finally striking the subject to be televised as a small spot of light.

We may again use Figure 3 to illustrate this new method by the application shown in Figure 7. Secure a small block of wood and on it erect two wooden standards, No. 1 and No. 2, the upper ends of which are rounded out as shown by the insert 7a. No. 1 accomodates a small wooden shaft "S" at point H and No. 2 is sufficiently long to hold a card board tube having a diameter large enough to allow a flash light to be slipped in one end. Provide bearings as illustrated in the Figure. Make sure that the disc D revolves true and the tube "T" is as close to the disc as possible without touching, thereby allowing a minimum amount of light to escape. When this arrangement is complete snap the flash light on and turn the disc so that opening No. 1 is in line with the light from the flash. A spot of light will appear on the screen and as the disc is slowly rotated a slender pencil of light will move across the screen from left to right. As opening No. 2 comes up the light shining through will trace a path lower down on the screen. No. 3 will be lower than No. 2 and so on until No. 16 is reached which will be the lowest path traversed by the spot of light. These two extreme positions of the light, No. 2 and No. 16, represent the height of the object. You may now draw a figure on the screen within these limits if you wish.

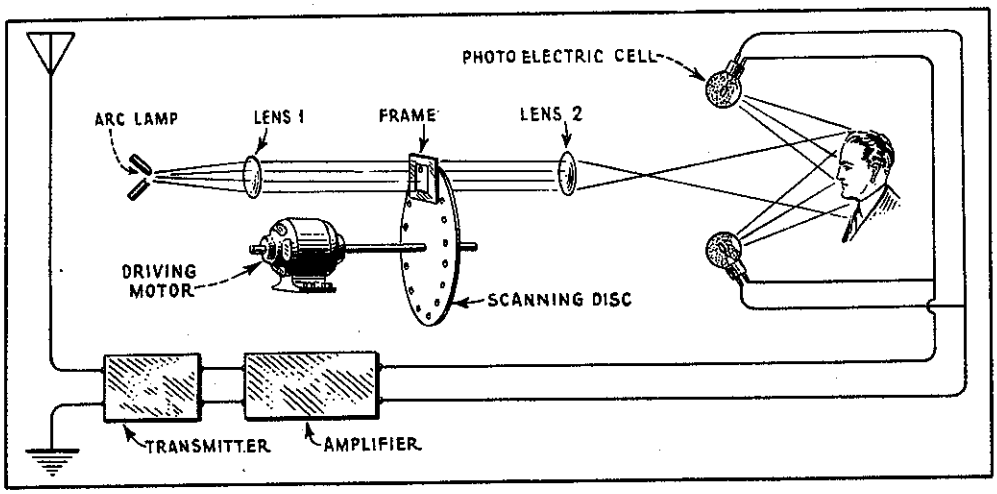


Figure 6

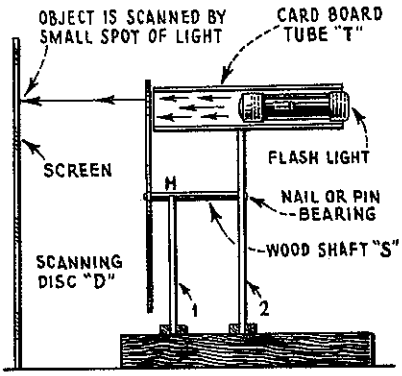


Figure 7

Figure 7a

Now spin the disc by twirling the shaft between the forefinger and thumb at the same time watching the screen. You will find that as opening No. 1 passes before the light a spot of light will sweep across the object in what we called path No. 1 as shown in Figure 8. Opening No. 2 will next pass between the light and screen, sweep across and illuminate the object along path No. 2, then path three, and so on, exploring the entire object in one revolution of the disc from top to bottom by parallel lines of light. The rate of speed at which you will be able to rotate the disc in this experiment will give you the impression of a number of spiral lines, each chasing the other about a central point. The

speed of the disc, however, in actual television equipment must make at least 16 revolutions each second because of a physiological characteristic of the human eye, without which either the so-called moving pictures, or television, could not be accomplished. This characteristic is called "Persistance of Vision"

No let us leave our object illuminated as explained in connection with Figure 8 for the time being and investigate this "Persistance 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 afterthe object ceases to reflect light to the eye. The three following experiments may be conducted to illustrate this phenomenon. First, swiftly swing a lighted lantern or fire brand 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 at the original position. The result is that we see a continuous circle of light. Second, make up a disc of any convenient size as shown in Figure 9. If this disc is rotated rapidly the black and white sections will no longer appear separated. The entire disc will appear grey in color because of the superimposing or merging of the black and white sections. Third, redraw Figures 10 and 11 on two separate pieces of white paper, each $2\frac{1}{2}$ inches long and $1\frac{1}{2}$ inches wide, and mount the finished drawing of Figure 10 on a piece of stiff card board of the same dimensions. Now, without allowing edge "X" to leave the table raise side "XX" and turn the card over by giving it a rotary motion away from you; edge "XX" will now be the top and "X" the bottom. Completing this, mount Figure 11 on the cardboard so that side "XX" is at the top of the card.

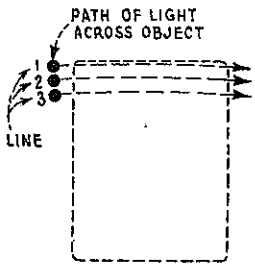

Figure 8

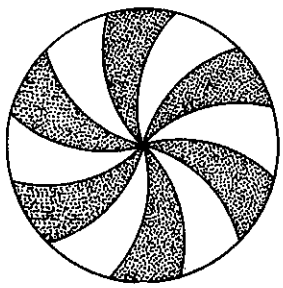
Figure 9

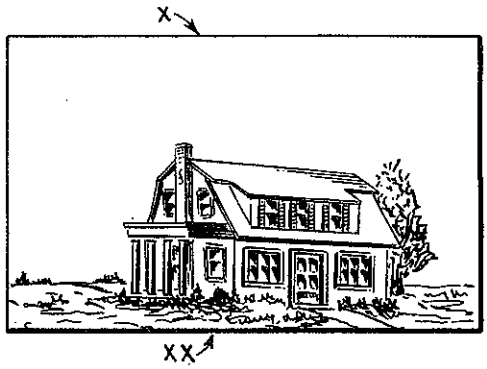

Figure 10

Next construct a support of any material handy so that when a pin is stuck in the ends of the finished card and mounted on the supports as shown in Figure 12 the card will be capable of rotating freely. With this completed and the house side of the card facing you slowly turn it until edge "XX" is facing you as shown in Figure 13 in which position neither view is visible. Continue to turn the card in the same direction and the view of Figure 14 is now seen. The purpose in rotating the card very slowly is to show that at this speed each view you have of the card is distinctly separate and different. Now, with the card in the position as shown in Figure 12, cause it to rotate rapidly; you will now see the house enveloped in flames. Before the image of the house fades from the

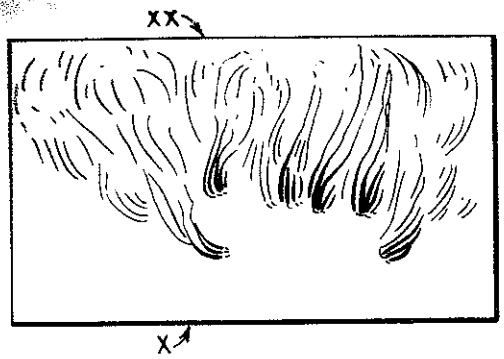


Figure 11

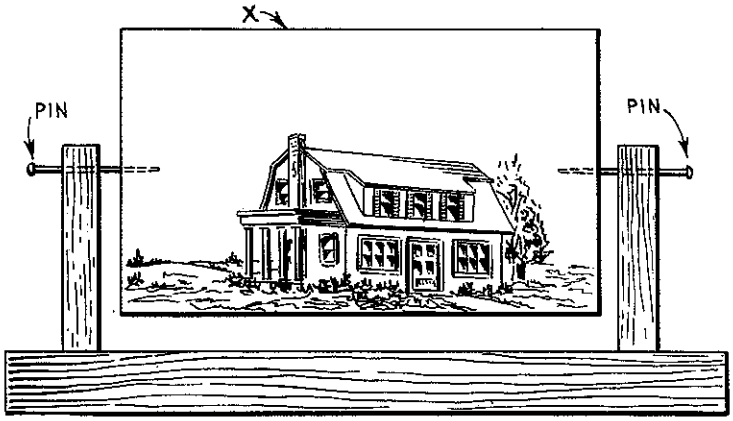


Figure 12

retina of your eye the flames have been superimposed upon it and as a result the house appears to be burning. This is why the disc on a television transmitter is rotated at a speed so rapid that the last part of the object is explored by a sweeping spot of light before the image of the first part fades from the retina.

A more apparent reason for this phenomenon will be made clear later on when we deal with the receiving scanner. We now have the object being traced by rapidly moving spots of light, so let us see what becomes of this light. By referring to Figure 6 we shall find that some of the light, upon striking the object, is obsorbed, and part will be reflected. Some of this reflected light passes into the photoelectric cells conveniently placed before the object being televised and generates an electric current within the cells. The amount of light reflected into the photoelectric cells will depend upon the subject being scanned. For example, suppose a man is seated before the scanning disc. As the spot of light passes across his hair, which we will assume is dark, considerable of the light will be absorbed and little reflected. As the light passes across the face more light will be reflected, therefore, since the output current of the photoelectric cells are proportional to the light they receive, this current will accurately follow the brightness of the various individual areas of the man's features as he is explored or scanned by the spot of light.

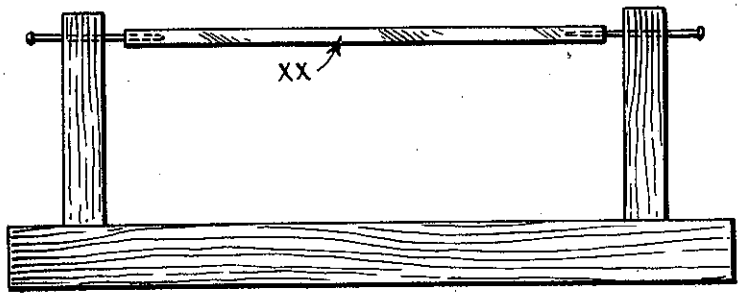


Figure 13

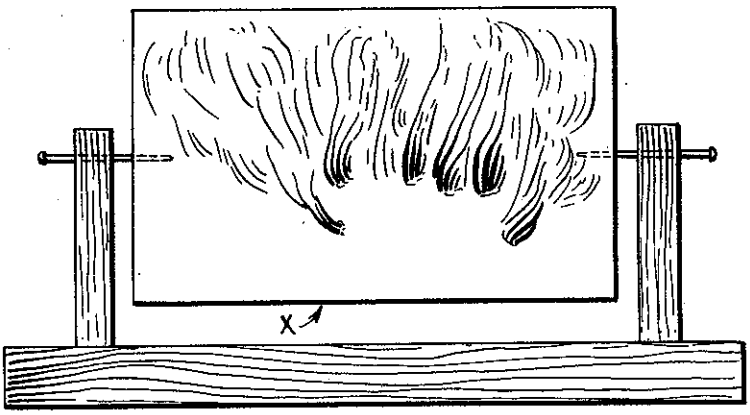


Figure 14

the current output of the photoelectric cell, or cells as the case might be, is very small (only a small fraction of a watt). It is then fed into several stages of resistance coupled amplification where it is amplified to a sufficient value to modulate the carrier wave of the transmitter from whence it is broadcast in the usual manner. We now have a modulated signal impulse which is following the brightness of the elemental areas of the subject being televised and it remains for us to intercept this signal and reconvert it to light.

The Television Receiver. In the transmission of sound the microphone translates the sound waves into varying electric currents. At the other end the receiver accepts these varying electric currents and converts them back into sound. In the transmission of images we deal primarily with light waves which are translated into varying currents closely following the light and dark elemental areas of the subject being scanned. The receiver of this system picks up this signal and converts the varying currents into light. From what we have studied we know that this receiver must give forth light, and further the intensity, that is, brightness of this light, must be directly proportional to the current received, for to have an image reproduced the light recreated at the receiver must follow faithfully all the delicate variations as picked up by the photoelectric cells at the transmitter.

The device we employ in the receiver to convert the varying currents must operate without a time lag, that is, it must be instantaneous with the passing of current, therefore, a special type of applicance called a "neon" tube will have to be employed. Here, then, is something new to us - new in the sense to which it is to be used, but old as the principal upon which it operates. In the lesson on "Interference Elimination" mention was made of a phenomenon called the Aurora Borealis. Explanations were offered there relative to the production of light caused by this phenomenon. The major condition under which this glow resulted was based upon a condition of rarefied atmosphere. Now the neon tube glows under identically the same conditions but we are going one more step and call upon nature to give us an analogy which will better suit our purpose; namely, lightning.

Lightning takes place because nature, posing as a ring master in a circus, snaps her whip and demands a readjustment of the electrons which she controls. If there is anything contrary to the wishes of nature it is an unbalanced condition of her molecular forces. So, when the sky, during a hot summer's day, becomes overcast with thick clouds and a thunder storm is impending this is what takes place: A terrific agitation is going on in the electronic world of the atmosphere; electrons are rushing here and there endeavoring to find an atom with which to associate themselves and once more settle down. There are, however, forces at work which keeps them on the move. The clouds and earth are at such a time building up charges of opposite sign and in the intervening space billions upon billions of air molecules are making up the atmosphere. Between the space separating these molecules are to be found a few happy carefree electrons skipping aimlessly about to be captured perhaps by a molecule which needs an electron to balance things up. Others may be compelled, due to contrary forces, to join up with a normal or uncharged molecule which immediately becomes negatively charged because of the preponderence of negative charges it is forced to carry. The negatively charged ions are now attracted to any positively charged body that might be present. Off rush the negatively charged

ions and electrons toward either the cloud or earth, depending upon which happens to be positively charged at the instant. Some of the neutral molecules, in their wanderings, get in the path of these rushing negative charges and a wreck results. The neutral molecule has an electron knocked from it, leaving it a positive ion. The freed electron joins the speeding negative stream and the positive ion rushes off in the opposite direction.

There is trouble now; more collisions result and more molecules are smashed; the rushing negative stream becomes greater in one direction, while the positive ionic stream sweeps past in the opposite direction augumented at every molecular smash-up. The atmosphere soon breakes down, a tremendous flash occurs and great forces of electrical energy pass in both directions between the earth and clouds. This is lightning - nature simply causing a readjustment of electrons. With the rush of current at the break down of the atmospheric pressure the flash becomes visible instantaneously. It is just this sort of flash that we must produce in a neon tube before television is possible.

Since the voltage which is required to break down atmospheric pressure to produce a flash is enormous, it can be readily appreciated that a voltage of this magnitude could not be employed in a small vacuum tube. Suppose, then, we rarify the atmosphere in which we wish the flash to take place. In this case we may use comparitively low voltages because electrons may, at a low voltage, attain tremendous smashing velocities in an atmosphere that is rarefied to the proper extent.

We arrive then at the door of the neon tube in which miniature lightning flashes are caused to occur by repeated collision between charged particles.. The tube itself is a glass envelope from which the air has been exhausted. Two flat plates form the electrodes, one of which we can compare with a cloud bank and the other with the earth. A rarified atmosphere of gas is introduced into the envelope called "neon", a chemical inert gas which was found to be the first gas coming off when liquid argon was allowed to evaporate. In the television receiver this tube is so connected that sufficient voltage is continually applied to the electrodes to cause collisions among the particles to the extent that a constant steady glow is produced. If, however, an additional voltage is applied the intensity of the glow varies with the increased voltage. It is in this connection that it has its importance in television, that is, once it is connected to a local source of potential sufficent to cause the miniature lightning flashes to steadily occur between the flat electrodes so that a constant glow is produced, any additions to this locally applied source of voltage will increase the intensity of the glow. Therefore the neon tube will follow exactly those additions that are sent to its electrodes by the photoelectric cell of the transmitter.

<u>The Receiver</u>. Any good short wave receiver may be used to intercept the signals of television providing it is capable of being tuned to the frequency at which the transmitter is operating. However, there are improvements which the experimenter may incorporate in this receiver which will materially assist him in obtaining a more marked success; namely, one stage of screen grid radio-frequency amplification and a change from transformer to resistance coupled audio-frequency amplification.

The radio-frequency stage improves the sensitivity and over-all working efficiency of the receiver, while the resistance coupled audio-frequency amplifier allows a wider band of frequencies to pass, thus insuring greater detail.

Figure 15 is a schematic diagram presented by "Radio Engineering" in which a special amplifier is built up about a "National" screen grid short wave receiving unit. The signal is intercepted by the antenna and passes to an untuned impedance coupled stage of radio-frequency, thus energizing the grid of the r.f. screen grid UX-222 amplifier. L1 inductively energizes the secondary coil of the tuner L2 which is tuned by the condenser C5. The signal is detected by the UX 112-A and regeneration is accomplished by coil L3. A resistance coupled amplifier is coupled to the receiver which is of higher frequency range than found in the ordinary broadcast receiver. This amplifier is used to provide better detail.

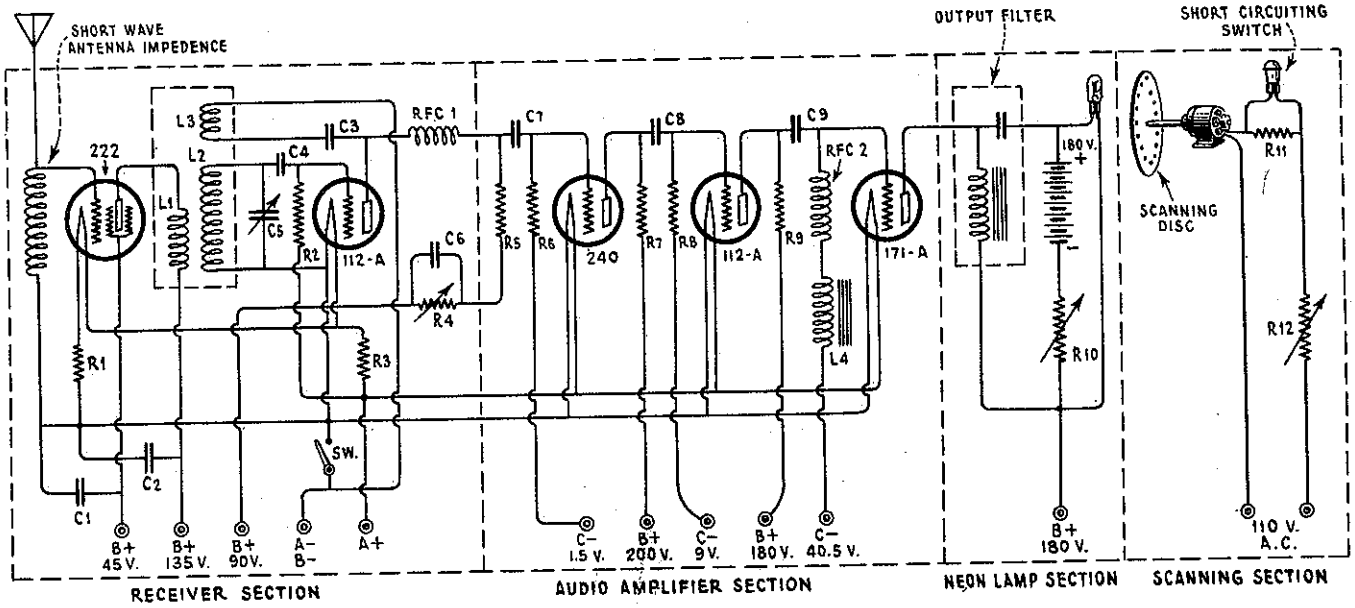


Figure 15

The output of the UX-171-A leads into an output circuit and then to the neon tube which is maintained at a constant glow by the 180 volt battery connected across the glow tube. The entire circuit must be constructed in such a manner that absolute ridigity of coils and other parts is insured, care also being taken to guard against vibration of the unit as a whole.

The scanning disc motor and its associated circuit are mounted entirely separate so that vibration is not transmitted to the receiver. The values of the receiver parts are as follows: The impedance used in the antenna circuit is a No. 10 National impedance. R1 is a 15 ohm filament resistance; C1 and C2 are 0.5 mfd. bypass condensers; L1, L2 and L3 are short wave plug-in coils covering the frequency range from 15 to 100 meters; C5 is a 0.000125 mfd. variable condenser; C4 is a 0.00024 mfd. grid condenser; C3 is a small 0.001 fixed condenser and R2 is a 6 megohm grid leak. The coil RFC 1 is a 90 millihenry radio-frequency choke coil; C5 is a 1.0 mfd. bypass condenser, while the variable resistance connected across this condenser has a value of 0 to 500,000 ohms. R3

is a 3 ohm resistance for controlling the filament of the detector tube and C5, C8 and C9 are 0.5 mfd. coupling condensers. R5 is a 50,000 ohm resistance and R6 a grid resistance of 500,000 ohms. R7 is a plate resistance of 300,000 ohms; R8 is a grid resistance of 500,000 ohms and R9 is a plate resistance of 25,000 ohms. When the 171-A tube is used the grid resistance of the amplifier of this stage is omitted and in its place is connected a radio-frequency coil, RFC 2, having a value of 500 millihenrys and, in series with this coil, is an audio-frequency grid impedance L4.

In the output circuit a regular output filter is provided with a 180 volt battery connected across the neon tube in series with a variable 0 to 10,000 ohm resistance R10.

In the scanning disc motor circuit we have a variable resistance, R12, of 0 to 100 ohms having a 75 watt rating. It is employed to control the speed of the motor. R11 is a fixed resistance of 5 to 10 ohms of 40 watt rating to assist in better control of the motor speed. It may be cut out by the short circuiting switch when desired. The battery terminals and voltage for each part are clearly shown in the Figure.

The Scanning Disc. In addition to the receiver and amplifier the receiving scanning disc and motor must be considered. All the other parts of the system may function perfectly but if this last unit is incapable of doing its work efficiently we have made no headway in the creation of an image. The scanning disc of the receiver is operated by a suitable motor the speed of which must be so regulated that the disc of the receiver, which is an exact duplicate of the one employed at the transmitter, will revolve at identically the same speed.

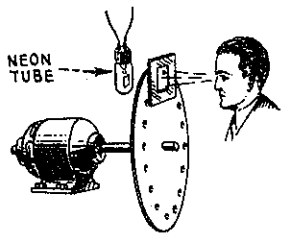


Figure 16

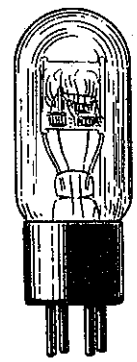

Figure 17

When opening No. 1 of the transmitting scanning disc is exploring the top of the object, opening No. 1 of the receiving scanner must be moving across the top of the neon tube plate. For example, suppose a minature of the burning house which you used in one of the experiments was being scanned at the transmitter; by adjusting the speed of the receiver disc to exact synchronization, the image seen when looking through the receiving scanner as shown in Figure 16 would be that of Figure 17, built up upon the glowing plate of the neon tube by various degrees of brightness. The receiver then merely reconverts, into light, the image as seen by the photoelectric cell at the transmitter.

Figure 18

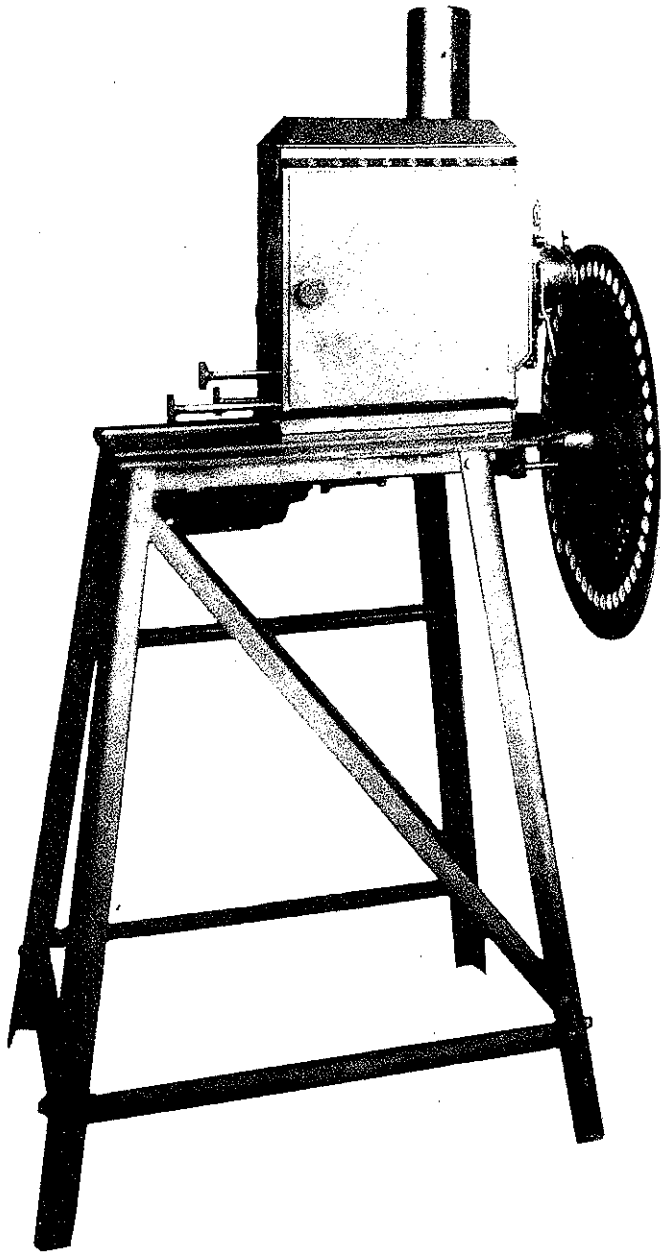

Figure 19

The ambitious experimenter may spend some profitable hours with television but he must not be led to believe that he is going to be able to gaze upon excellent reproductions as would be, for example, the case when viewing a motion picture production. Television has not advanced to that stage. Considerable work, however, is being carried on to overcome many of the difficulties, expecially in the development of more sensitive photoelectric cells and the ability to transmit over long distances instead of short labaratory circuits. Also, research work in an attempt to obtain a more brilliant source of light for the projector and a more positive means of synchronizing, and many other problems.

One of the peculiar problems is the phemonenon of "Mirage" which at times makes itself known by the reproduction of several images at the receiver instead of one, resulting in a hopeless distortion of the whole picture. This condition fortunately does not regularly appear, but it is one of the troubles facing the engineers.

Figure 18 shows the extent to which skilled engineers are going to in an endeavor to learn more about Television. The "Kings Messenger", a play written 30 years ago, is being televised at WGY. Three portable electric eyes are used, one for each character's face and the third for the props and the hands of the actors. Only the hands and faces of the actors can be shown which is another limitation to be overcome. Figure 19 shows experimental television projection apparatus. In this picture a view of a scanning disc is shown.

The principal elements of a system of television, therefore, is made up of first a source of strong light, then an exploring disc, a photoelectric cell and amplifier at the transmitting end. At the receiver we have the receiver and amplifier, the neon tube, and a synchronized duplicate exploring disc. When the photoelectric cell is exposed to light the neon tubes varies in its intensity and any increase in light intensity at the transmitter causes a proportional increase in brilliancy of the neon tube. With such a system properly functioning, the instant the photoelectric cell is exposed to a change in light intensity a corresponding change in voltage is impressed upon the neon tube resulting in a variation in the glow.

<u>The Jenkins Television Receiver</u>. The intensity of illumination varies with the intensity of the sources of light and as the distance is increased between the source of light and the objects on which the light rays fall. In fact there is a definite law of physics which clearly states; "That the intensity of illumination upon a surface varies inversely as the square of the distance from the source". This simply means that if a surface "X" placed "Y" distance from a source of light which receives all the light emenating from that source it will spread over an area four times the area of "X" at a distance "2Y" from the source. At a distance "3Y" the light will spread over an area nine times the area of "X", hence the intensity at distance "2Y" will be only one fourth that resulting at the distance "Y" and only one ninth as great at distance "3Y". There is then a loss of intensity as the surface to be illuminated is moved away from the source of light. This is known as the "loss of light" due to the inverse square law. To correct a loss of this nature is one of the features of the Jenkins system of television reception. The scanning disc first explained was used by Nipkow as early as 1884 and is still employed by experimenters.

As a further analysis of this disc let us use the same number of openings as was originally used by Nipkow; namely 48. The object will then be scanned in a series of 48 parallel lines and the transmission of the picture would take place as if it were rapidly being assembled, that is, made up of 2,304 small elementary areas. Because of the spiral form taken by the openings, or apertures, each one of the holes will be on its own particular radius and since there are 48 openings there will be as many different radii with each succeeding opening. Therefore, its associated radius becomes shorter, i.e., nearer to the axis about which it rotates by approximately the diameter of the apertures.

With this explanation and those which have preceded it is clear that when the disc is placed in rotation the locus, that is, the area of each of the openings, will produce a linear exploration of the entire area of the picture. Because each one of the small openings limits the amount of light that can pass through and flood the object with a spot of light, a powerful source is required in order to obtain a sufficient illumination of the object.

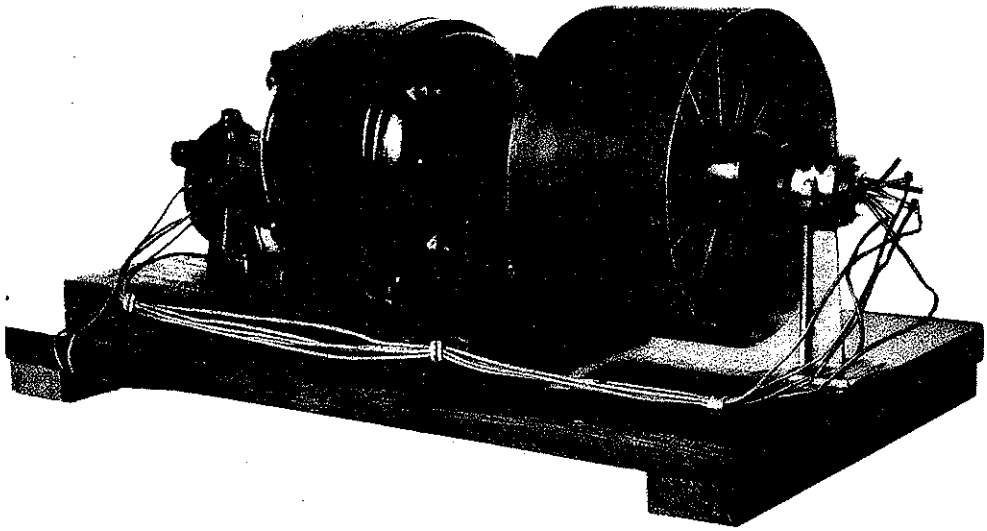

Figure 20

The necessity of such a powerful light source was overcome by placing a lens over each opening of the disc. The necessary elementary area was then obtained by focusing the light to a small point on the object to be scanned. With this arrangement only a small source of light was necessary, such as might be obtained from an automobile head light. This type of disc was employed by Jenkins with a fair degree of success but in any scanning disc there are physical limitations which are drawbacks to its development. For example, the minimum separation of the openings determine the width of the picture and since the picture is nearly square the separation of the openings will also determine the offset at the end of the spiral. For a two inch picture a thirty six inch scanning disc would be required, and if a four inch picture is to be produced a six foot scanning disc is necessary. It is realized, therefore, that apparatus of this kind is not the most practical for home entertainment.

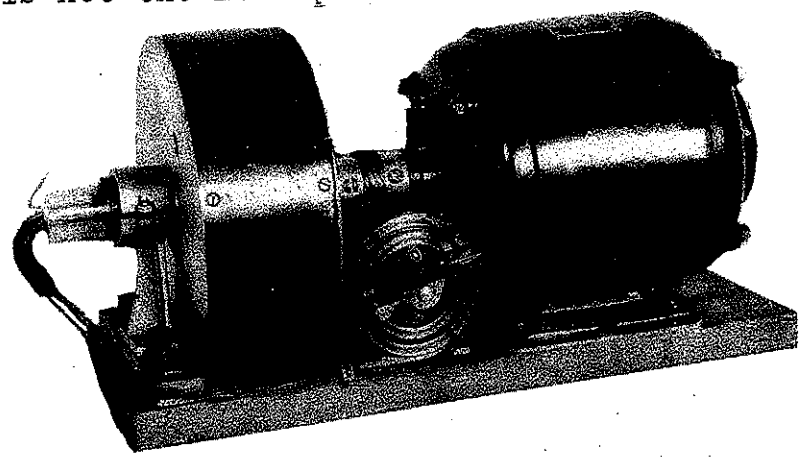

Figure 21

With such limitations as these, Jenkins has developed television along somewhat different lines by employing what is termed the "drum method". In order to obtain a better mental picture of this drum, a view of which appear in Figure 20, consider a cylinder approximately seven inches in diameter, three inches long, and having a thickness of one sixteenth of an inch. The hub of the cylinder is hollow for the entire length of the drum and has an inside diameter of one and one-half inches with an extension extending outside the drum and made to fit a one-half inch shaft of a small motor. In the periphery of the drum 48 small openings are drilled, each having an elementary area of about one twenty-fourth of an inch and arranged in four helical turns spaced two inche apart around the circumference of the drum, each turn being separated by one-half inch.

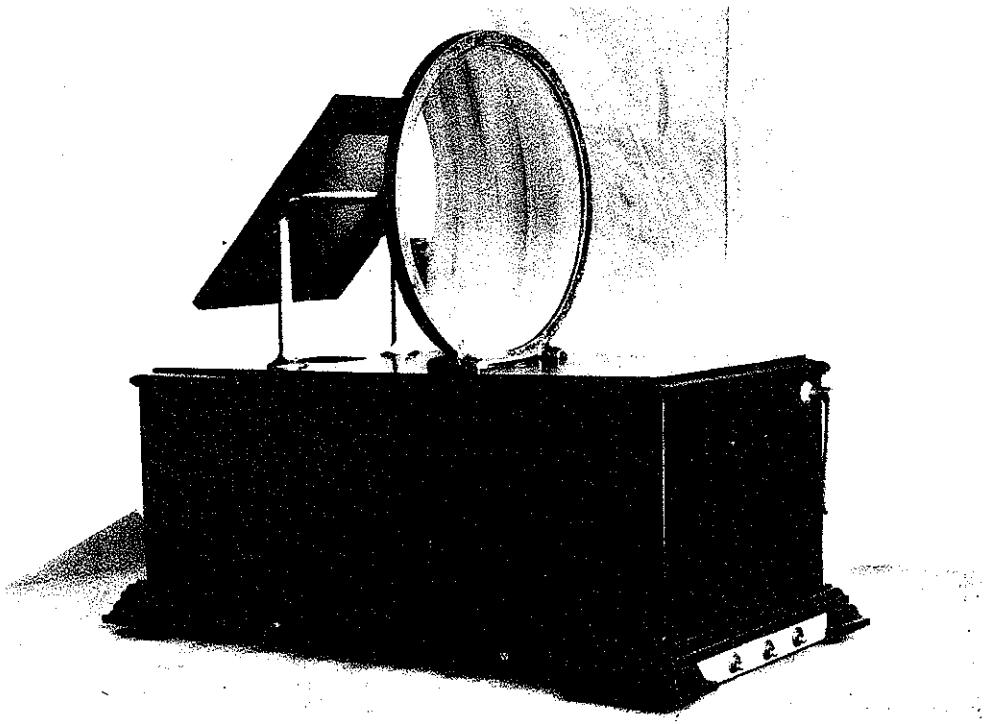

Figure 22

In the center of the hub a special neon lamp is placed having four small plates; this particular tube is called a "four target cathode glow neon tube" and is held in place by a clamp mounted on the motor base. One end of this lamp clampe in place may be seen in Figure 21. Between the lamp and the periphery of the drum a number of small quartz rods are mounted, each ending under its particular minute opening in the drum surface.

It is in this feature that the Jenkins television receiver differs from the disc type and it is in connection with these quartz rods that the inverse square law was previously mentioned.

A quartz rod will conduct light from one end to the other without any loss in intensity. The plates, i.e., targets, of the neon glow tube are placed in the hollow hub under each of the rows of quartz rods. The plates (targets)

are then lighted in succession through a four segment commutator by current from the plate of the last audio-frequency tube of the receiver. Since the movement of the inner ends of the quartz rods is short the neon glow targets are required to be only one eighth by three-sixteenth of an inch in size or, at the most, no larger than three-sixteenth by one-quarter of an inch. Therefore only a small amount of current is required to cause them to glow, light modulation being accomplished as easily as in a larger plate.

As the small targets glow, light passes up the quartz rods as these rods, in turn, pass over the target and the light arrives at the spirally formed opening about the periphery of the drum without any loss in intensity.

This apparatus is installed in a cabinet as shown in Figure 22. The openings of the drum, as they pass by the small square hole shown in the top of the cabinet, directs light against the mirror inclined at an angle. The mirror reflects the light to the lens where it is magnified resulting in a picture about six inches square.

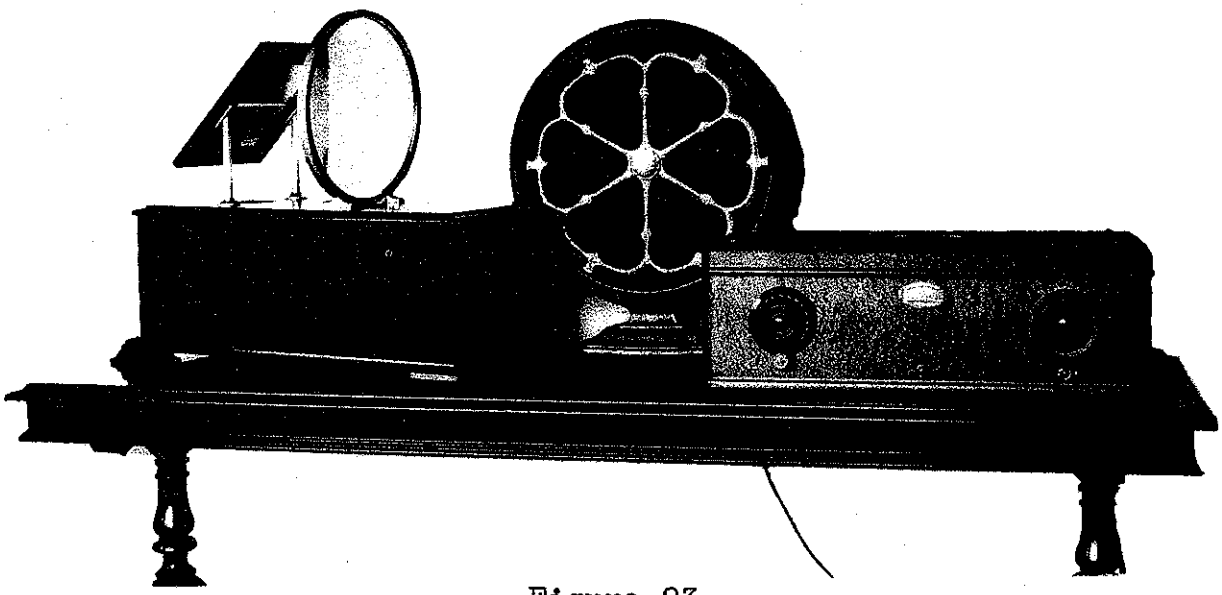

Figure 23

Figure 23 shows the Jenkins television receiver together with a modern radio receiver. Only two connections are necessary to set this device in operation; one connection goes to the house lighting circuit to supply current to the motor; the other connection fitted with a phone-jack, is connected to the output of the radio receiver amplifier.

Provision is made for adjusting the speed control of the motor as one watches the picture. When the signal has been picked up by the receiver and is in approximate synchronism with the transmitter, a little closer adjustment makes the picture stationary providing, of course, a picture has actually been seen. When no picture is seen at all the adjustment is entirely out and the adjustment screw must be turned until a picture appears in frame.

You can see readily that this is an attempt to solve the problem from a different angle with measurable success. Others improvements are sure to follow but when and with what degree of success, no one can really tell.

As stated in the first part of this lesson, television is still a baby; it must grow, and to grow requires time.

## EXAMINATION - LESSON 66

1. Is the photo electric-cell an important part of television equipment? Why?
2. Of what importance is light in connection with television?
3. What is the purpose of the scanning disc?
4. What is meant by the term "Persistance of Vision"?
5. Where is the neon tube used?
6. Is it permissible for the scanning disc of the transmitter to revolve at a different speed than the scanning disc of the receiver?
7. Upon what principal does a system of television operate?
8. Explain the methods used to illuminate the object to be televised,
9. What is the inverse square law as applied to light?
10. How does the Jenkins system of television overcome the loss of light?