WCFL
RADIO & TELEVISION
CONCISE CORRESPONDENCE COURSE
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Lesson Seven — Price—Free

Lesson 7—Television Theory and Progress

MAN, since time began, has wished to see what was taking place at a distance—at the same instant in the natural action and color. However, up to the present date television is not perfected to even half this ideal. It is true that we are able to transmit images to a distance but, at the time this lesson is being written, television is not at the stage where it may be used regularly as home entertainment.

Yes, several quite successful television outfits are on the market. We have just watched one of the first twenty-five of a make that will be on the market in the very near future. It is the best commercial outfit we have seen, and we saw it operated very close to the best television being broadcast today; in other words, under ideal conditions. Yet, it is only fair to say that this excellent televisor, and the really fine short-wave receiver with which it was used, do not constitute a family entertainment proposition.

To be entertainment for the family, television must be something we can turn on with the assurance of getting what we want. It must be clearly visible to the entire group of people in the vicinity of the set in our living room. It must continue as our present-day radio programs do—without interruption and without the necessity for continual adjustments. It must be accompanied by appropriate sound projection from the loud speaker, and, lastly, it must be of practical everyday usefulness at a reasonable price.

Television today is almost none of these things. The images are small, usually of a reddish color, poorly-illuminated; nearly always blurred and possessing little detail. The signals are of a nature that require careful tuning by an expert. Constant adjustment of the scanning motor speed is required if the image is to be seen at all, and even then anyone watching for the purpose of restful entertainment is sure to be disappointed. The only way we can project sound to accompany the image is by using a separate broadcast channel, meaning that you must have two receivers, one for the picture and the other for the sound.

While all of this sounds discouraging at the outset, we want to impress upon the minds of you who have come this far with us that this is by no means the case. The history of television probably will be like that of radio—the advance of an art due mostly to the work of the tinkerer

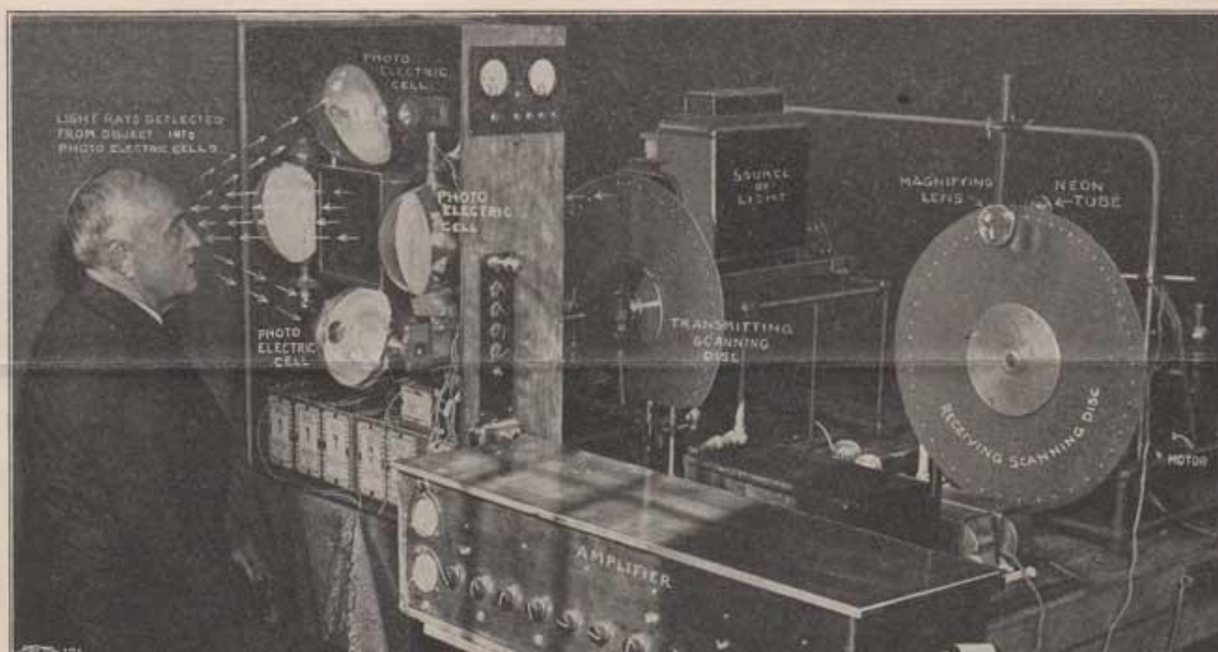


Figure 1—In the above picture of WCFL's second television installation the entire process of broadcasting and receiving images is graphically presented.

From the "Source of Light" (near the center of the background) a powerful beam of light is projected through the spiral of holes in the "Transmitting Scanning Disc." This pencil of light first strikes above the head of the subject and continues flashing across the subject, each time a little lower down, until the whole surface to be televised is traversed. This beam of light is reflected from the subject into the "Photo-electric Cells," setting up an electric current which is fed into the "Amplifier" shown in the foreground. Whiter surfaces reflect more light than darker spots, thus variations are caused in the current flowing through the "Photo-electric Cells". From the "Amplifier" the current is fed to the "Neon Tube," the glow of which changes with each slight variation in current. The "Receiving Scanning Disc" revolves in front of the "Neon Tube" and must be synchronized with and in step with the "Transmitting Scanning Disc." The image of the subject being televised seems to appear on the "Receiving Scanning Disc" just under the "Magnifying Lens."

When the apparatus is in use a booth is placed about the subject and a heavy cloth hood is placed in front of the receiving apparatus. The signals are broadcast by being fed into the radio transmitter and can be picked up by any aerial within range of the station. In this installation 48-hole discs revolving at 900 r.p.m. were used, transmitting and receiving 15 complete images per second.

the scanning disc) are as much a result of good work on the part of the pick up system as they are of the audio amplifier upon which most of us have usually laid the blame for all our television troubles. All other things being equal, we now know that a truly first class television receiver requires.—

1 A high gain (high amplification) radio-frequency amplifier (Ideal is three stages of screen-grid radio-frequency.)

2 A power detector (No grid leaks or grid condenser.)

3 A resistance-coupled or resistance impedance-coupled first audio.

4 A push-pull 245 second audio.

Now let us analyze this a bit. We know that multi-stage radio-frequency amplifiers are not available for receiving the short waves under 100 meters. In fact they would not be practical because of insulation, capacity and other problems. Nor would we care to juggle from 12 to 15 plug-in coils. Lastly, we would not care to have a receiver with four tuning controls; yet a single control for these four circuits, with plug-in coils, is impractical.

However, a receiver covering the band from 100 to 200 meters, single dial control, no plug-in coils, is very practical indeed, and such a receiver has actually been prepared for commercial sale.

The reason for demanding high radio-frequency amplification is to supply the televisor with as powerful a signal as possible without requiring many stages of audio-frequency amplification. This is particularly desirable in an electric receiver where hum voltage results in the amplification of the harmonics of the 60-cycle alternating current and thus adds distortion to the signal. Also, a powerful radio-frequency amplifier supplies such a high signal voltage to the detector that we do not require four stages of audio amplification as we have usually believed necessary. This is a great advantage because it is much easier to construct a two-stage amplifier to respond to a wide range of frequencies than to try to construct a four-stage amplifier to cover the range.

In this lesson we show (Figure 5) the standard circuit of a resistance-coupled amplifier as used by so many television experimenters. The values are all given on the drawing. This may be used in conjunction with the tuner of the Federation Short-wave Four shown as Figure 2 of Lesson 6. In operation the loud speaker reports the presence of television signals by giving you a high-pitched purring noise. However, the main trick in adjusting the amplifier to proper operating condition is to change the C bias and plate voltages of the last tube until the neon lamp gives a constant dull red without flicker. This must be done with the set tuned in such a way that no signal is being received. When operating properly you may tune in a television signal, turn on your scanning disc motor, and get down to business.

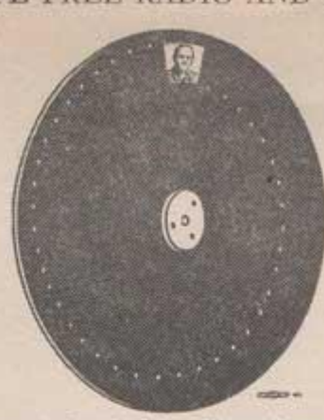


Figure 9—Scanning disc. Picture drawn near upper edge shows where image seems to appear, between the upper and lower range of the spiral of holes. That's why the image is so small.

Our recommendation is for you to use a 48-hole disc, but there are combination discs on the market that are excellent for the experimenter. A synchronous 1/15 horsepower motor is the best, but any "universal" (AC or DC) motor with a variable speed control will give you results. However, a synchronous motor saves you a great deal of the adjusting that makes television difficult for the beginner. In order to get your scanning disc in step, even with a synchronous motor, you may have to start and stop it several times.

We cannot show in detail just how you will mount your scanning disc, motor and speed control because we do not specify the make and type of these parts, due to the present experimental stage of the television art. However, the illustrations in the lesson are sufficient for any clever experimenter to follow. One of the main things is that you should be able to raise or lower the neon tube until you find the best location in relation to the holes in the disc. (See Figures 7 and 8.)

Strange as it may seem, in spite of the fact that an ideal television amplifier should respond equally to all frequencies from 15 to 18,000, yet we have seen some very fine pictures with only a good grade of audio transformer used. The point is that this outfit was very well designed. In order to get a well illuminated image you must have a terrific signal output!

QUESTIONS ON LESSON SEVEN

IF you desire Lesson Eight of this interesting course, it will be necessary for you to submit written answers to the questions on Lesson Seven listed below.

1 What is the purpose of the scanning disc?

2 How many impulses do we transmit at one time in modern television?

3 What does the photo-electric cell do?

4 How can we hear the voice of a singer at the same time we see her picture?

5 In lesson 8 we tell you many practical things about constructing electric receivers. Are you interested in making a set or just the theory?

6 Do you expect to experiment with television?

7 Does the light from the projector directly affect the photo-electric cell?

8 Can you hear a television signal? What does it sound like?

9 What makes the neon lamp useful in television?

10 Why must the receiving scanning disc have a speed control?

Here are the schematics for the most modern type of television receiver and amplifier. While we are not suggesting any particular brand of parts, the stock list gives the necessary values, so that any who wish to experiment can build a set from this data.

Shield the radio-frequency stages from each other. They can all be tuned by a single control but the efficiency of the set will suffer, particularly if you do not carefully match your coils and condensers. The high voltages recommended for the amplifier are necessary if you expect to get results: You will need a high-voltage power pack but, since the plate current drain is reasonable, one 281 rectifier tube is sufficient.

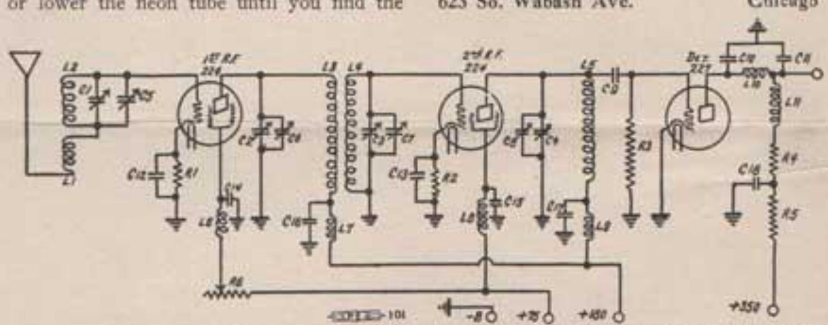


FIG. 11—SCHEMATIC OF TELEVISOR WITH LIST OF PARTS.

L1—24 turns No. 32 d. c. c. wire on 1-inch core.
L2—48 turns No. 32 d. c. c. wire on 1-inch core. (Ends of L1 and L2 are placed together.)
L3, L4 and L5—48 turns No. 32 d. c. c. wire on 1-inch core.
L6, L7, L8, L9 and L10—Radio frequency choke.
L11—Choke, 20 to 100 millihenry.
C1, C2, C3 and C4—4-gang .00015 condenser, shielded.
C5, C6, C7 and C8—Compensators on 4-gang condensers, 30-mmf. range.
C9—Grid condenser, .0001.
C10 and C11—R. f. by-pass condensers, .001, detector plate.
C12 and C13—R. f. by-pass condensers, .01, r. f. cathodes.
C14 and C15—R. f. by-pass condensers, .01, r. f. screen-grids.
C16 and C17—R. f. by-pass condensers, .01, r. f. plates.
C18—Audio by-pass condenser, 1 mf., detector plate.
R1 and R2—500 ohm resistors, r. f. cathodes.
R3—2-megohm grid-leak, detector.
R4—30,000-ohm resistor, detector plate.
R5—20,000-ohm resistor, detector plate.
R6—Variable resistor, 0 to 200,000 ohms, volume control

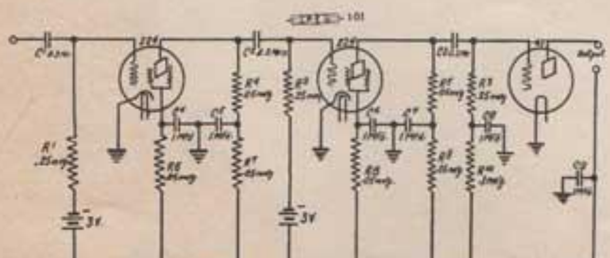


FIGURE 10—SCHEMATIC OF A. C. TELEVISION AMPLIFIER.

who cluttered up the dining-room table with his "junk" and fussed with all the latest "dope" at his workbench.

So we are here giving you the cream of the television theory and practice of today, with some data to help you in your experimental work, together with the assurance that, to the best knowledge of the greatest engineers, television is still an unsolved problem.

PROBLEMS TO BE SOLVED.

The sense of sight is a wonderful thing. Yet the human eye has limitations which make it difficult for us to transmit images to a distance for the eye to see. Our sense of hearing is much less limited. When you hear a quartet, or a band, or an orchestra, your ears respond to the entire range of impulses available at any one instant.

As you glance at this page for the first time, you see but a jumble of words. Gradually some item will stand out—an illustration, or a bold-face heading, or perhaps some one word; even in some simpler image—perhaps a single portrait, or the picture of a small radio part. Even here your eye must travel back and forth across the image in order for you to receive a complete mental concept of what is before you. Although you actually see but a small area in the picture at one time, yet, due to the fact that the retina of the eye retains the image for an instant, the first spot you saw is still apparently visible when you are actually looking at the last spot, so that you see the whole picture at once.

Television as practiced today makes use of this tendency of the eye. Both in the transmitter and the receiver we are successful merely because the human eye sees just one small spot in an image at a time. If it were not for this trait which seems to be almost a physical defect of our eyes we could not transmit television images as we now do. This same peculiarity of the eye, which is called "sight retention" or "time lag" also makes possible our "motion pictures." As everyone knows, the pictures do not move—they are merely presented in such rapid succession that the eye is deceived into the impression of motion. Television, as we now have it, is a far greater piece of sleight-of-hand.

The earlier attempts were along the line of transmitting the entire image at once. Of course that is the ideal way if we want a perfect picture.

In order to change light into electrical impulses we must use something that corresponds to the microphone in the projection of sound. For many years it has been known that there are substances that change their electrical resistance under varying conditions of light, just as the carbon granules in a microphone change their electrical resistance under the varying pressures set up in a microphone diaphragm by a sound wave. Because it possesses this characteristic, selenium was extensively used in the first television experiments. This substance in the dark will not conduct an electric current. In the light it will do so. In a bright light it will pass more current than in a dim light. Our first television apparatus was made of many selenium cells, each very small, all arranged in a frame upon which was reflected the image we wished to transmit.

Figure 2—This shows how the image seems to be reconstructed on the receiving scanning disc by beams of light shining through the spiral of holes.

Each cell had its pair of wires and this network of pairs of wires must extend to the television receiver. As the different parts of the image were made up of lighter or darker spots, the different cells allowed more or less current to pass over their wires to the little glow lamps that reproduced the picture at the receiving end. These lamps were connected to the proper pairs of wires so that the received image was a reproduction of what the selenium cells transmitted.

Manifestly there were many difficulties in this scheme. To begin with, even the smallest selenium cell was too large to reproduce close detail in a picture. Look at a photograph in a high-class magazine printed on enamelled paper. Use a magnifying glass and you will see that the picture is made up of many small dots. Compare this with a photograph in a newspaper. You can see the dots with the naked eye in the news photo, but only with a glass in the magazine photo.

Imagine an image made up of dots a quarter of an inch or more in diameter! That is almost impossibly fine for the selenium cell type of television projector, yet is so coarse as to look very crude to our eyes. Even this unsatisfactory and coarse image is too costly for use in any practical way—hundreds of small cells, each with its pair of wires; hundreds of wires in a cable to the receiver from the transmitter. You can readily see that this is no amateur proposition, and was discarded as entirely unsatisfactory.

Figure 3—(At Left) Small photo-electric cell, showing "window" through which light is projected onto the silvery coating of potassium hydride on the inside of the bulb, the negative terminal. The wire element in the center of the bulb is the positive terminal.

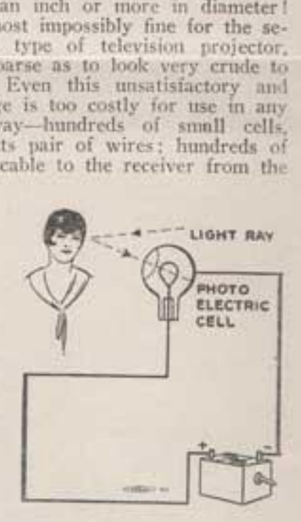
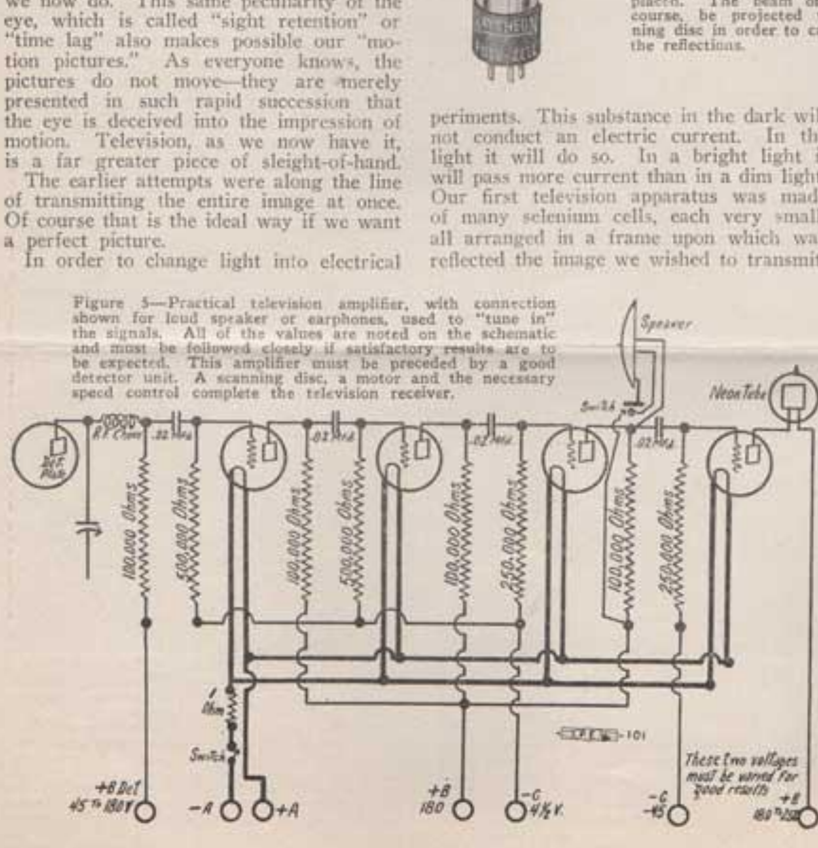


Figure 4—This illustration shows how light affects the current in a circuit in which a photo-electric cell has been placed. The beam of light must, of course, be projected through a scanning disc in order to cause variations in the reflections.

Modern television does not attempt to transmit the entire picture at one time. As the eye travels across the image, seeing only a spot at a time, so our transmitting scanning disc passes a shaft of light rapidly over the object, illuminating one small spot at a time, and the reflection from each spot on the picture is transmitted—a signal of greater or lesser intensity, according to the light or shade of the spot then reflecting. (See Figures 1, 2 and 9.) Thus but one electrical impulse is being transmitted at one time, and this is of course a simple radio or wire proposition.

With few exceptions, television signals are transmitted as follows: A powerful light projector furnishes the illumination, and in front of the projector lens is mounted a metal disc about 20 inches in diameter. This size varies with different stations. (See Figures 1, 2, 6, 7, 8 and 9.) In this disc are punched holes located in a spiral. (See Figures 1, 2 and 9.) This disc is rotated by a motor at approximately 900 revolutions per minute. The result is that the projector throws a pencil of light through each hole in the disc 900 times per minute or 15 per second. (See Figure 1.) Since these holes are arranged in a spiral, (Figure 9), this pencil of light travels over the object or person upon which the projector is focused, only one

Figure 5—Practical television amplifier, with connection shown for loud speaker or earphones, used to "tune in" the signals. All of the values are noted on the schematic and must be followed closely if satisfactory results are to be expected. This amplifier must be preceded by a good detector unit. A scanning disc, a motor and the necessary speed control complete the television receiver.



spot being lighted at any one instant, but the entire object being "scanned" with light fifteen times per second. Due to the tendency of the eye to retain images for an instant after the light has shifted, these objects seen only in the light of the scanning apparatus seem to be illuminated uniformly over the entire surface. However, by stopping the motor and operating the disc slowly by hand, you readily see that there actually is a pencil of light touching only part of the object at a time.

Since we really light only one spot at a time, we have fulfilled the main requirement for television transmission, for we will now have a simple or single impulse to transmit instead of a complex one. The light is reflected from that one spot on the object, not onto a selenium cell as in the past, but into a number of newer and more wonderful light sensitive devices known as photo-electric cells. (See Figures 1, 3 and 4.) These cells are glass globes filled with an inert gas, and with two terminals, the negative being connected to a silvery coating of potassium hydride which covers the inside of the glass all but the window or clear space left for the entrance of light. (See Figures 3 and 4.) The positive terminal is a loop of wire similar to filament wire, but actually never heated. These two terminals are connected in series with the battery and the input of an ordinary vacuum tube amplifier. Now let us see what happens. (Figures 1 and 4.)

As the pencil of light scans the object, one spot at a time, the light is reflected through the window of the photo-electric cell. (See Figure 1.) Here a wonderful thing takes place. In the dark, almost no current flows from the positive to the negative terminal of the cell, and the amplifier would give very little tone to a head phone connected across the output. But when the light enters the window the cell wakes up at once—current flows, and there is an impulse to amplify.

Some of the spots on the object reflect more light than others do. It is the light and shade of the reflection that make up an image in any picture. Similarly these same lighter or darker spots affect the photo-electric cell in varying degree. The lighter ones cause a greater flow of current through the cell than the darker ones do. The photo-electric cell is many times more sensitive than is the human eye, and it proportions the current passing through it exactly to the intensity of the light entering the window. The human eye retains an impression for an instant. The photo-electric cell does not. There is no "lag." Thus hundreds of light changes per second would be accurately measured by the cell in the amount of current it would allow to pass. However, since television must be limited by the eye after all, and the eye is relatively slow, it is necessary to scan the object only fifteen times per second in order to deceive the eye. The variations of current resulting are amplified, and are then used to modulate the carrier wave of a broadcasting station in exactly the same way in which a microphone current is used.

Figure 6—One of the newest "home" televisors, with powerful lens in front of the scanning disc so as to magnify the image which is very small.

HOW TELEVISION IS RECEIVED

So far so good. Now for the television receiver, which is what most of you are interested in. A battery-operated television amplifier and neon tube are presented schematically in Figure 5. In Figures 10 and 11 are presented schematically a modern a. c. television detector and amplifier.

A television receiver is exactly like any radio receiver. It receives the signals impressed on the aerial, amplifies them in the radio-frequency amplifier, detects or demodulates or rectifies them, amplifies the now audible signals in the audio-frequency amplifier, and then real television reception starts—in the televisor! (See Figures 2, 6, 7 and 8.)

Figure 7—A compact television receiver, showing scanning disc, neon tube, motor and control. The hood in front of the disc contains a powerful magnifying lens. To this apparatus must be attached the television amplifier which in turn is hooked up with the detector unit.

The television signal obtained from the audio amplifier is audible—you can hear it in the speaker—but no one cares to listen to it very long. It is a high-pitched purring tone made up of the dots transmitted by the reflection of light from the object to the photo-electric cells.

For television purposes we connect a neon tube or a kino lamp in place of the loud speaker. (See Figures 5, 7 and 8.) This type of lamp is filled with neon gas, and has the peculiar property of glowing with light when a voltage is impressed across the terminals. The especially wonderful thing to remember about the glow lamp is that the intensity of the glow varies exactly in proportion to the current variations supplied to it by the audio amplifier. In other words, it is the opposite of the photo-electric cell—the other half of a marvelous combination. You might call it the television detector for it converts the electrical impulses into light variations.

Even now you would see no image, just a variation in the light glowing in the neon tube or kino lamp. The televisor must also unscramble these light variations and show them to your eye in the right order so that the image will be reconstructed from the signal received. You remember that the transmitter divided the image into hundreds of points of light. The televisor reconstructs it for you by allowing you to look at the glow lamp only through the apertures of a scanning disc which is rotating at the same speed as and in step with the transmitter's scanning disc, so that you see the spots of light one after the other in the same order and in the same position as the pencils of light travels over the object in the transmitting station. (See Figures 2 and 9.)

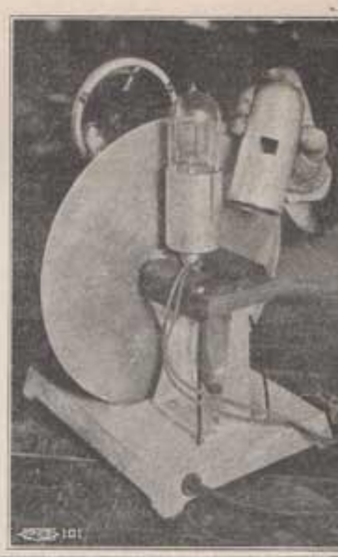


Figure 8—Rear view of one of the newest "home" televisors, showing the neon tube. When set is in operation hood is placed over the tube with the small aperture or "window" facing disc.

So simple? Yes, television is ridiculously simple to tell about. It is only the actual performance that is so difficult that hundreds of thousands of dollars have been and must still be spent in developing it. However, for you as a student of television a television receiver consists only of a radio receiver capable of picking up the signals and amplifying them sufficiently to produce the necessary glow in a lamp which you see through a scanning disc, the speed of which can be controlled by a rheostat in the power circuit of the motor.

Yes, you who protest are right. There are types of televisors other than those using the scanning disc. But listen carefully—the drums, bands, and all the rest do just what the scanning disc does—no more, no less. The principle is the same; the method different.

The attempts to make the image larger than the very small one seeming to appear on the scanning disc have been many and disappointing. Seldom is the enlargement over four inches square. The various drums and other devices usually are intended to throw the points of light against a screen, magnifying the image greatly, somewhat as the movie projector does. Of course the result is loss of light intensity, or illumination, and the accentuation of the the already too noticeable lack of detail, and the ever present blurring.

Some of you will ask, "Is not the amplifier to blame?" Yes, but only partially. Watch the object under the light penciled through the scanning disc at the transmitting station and you will note that the picture has a very poor start indeed. It is wavy and blurred—there seems to be a succession of black lines projected on to it. These lines pass across the picture, moving from top to bottom.

While it has generally been considered that almost any radio-frequency and detector system was good enough if it would pick up a television broadcast at all, we are now finding out that the brilliancy of illumination, the amount of detail, and the ease of speed control (synchronizing