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CONTENTS

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Purdue Engineer
Rose Technic
Sibley Journal of Engineering
Tech Engineering News
Illinois Technograph
Tennessee Engineer
Wisconsin Engineer

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Tomorrow's Television Set

W. R. Mitchell, E. E., '32

THERE is no doubt but that some time or other we have all come in contact with the word "television," but this has been the extent of contact for most of us. We know it is the art of transmitting vision, but the way this is accomplished is a mystery to the average person. There are two principal methods of scanning: the scanning disk and the cathode ray tube. The former method is the one in common use at the present, so we will confine ourselves to a discussion of this type and the problems involved.

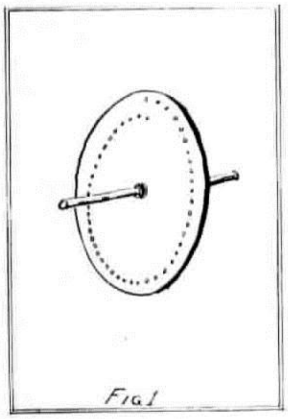

Fig 1

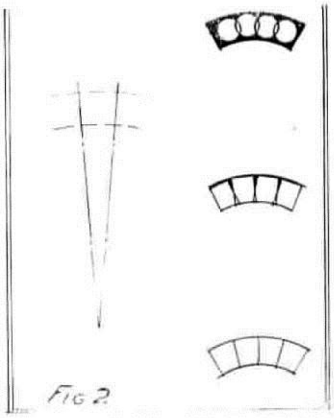

Fig 2

In order to understand the operation of television, it is first necessary to become acquainted with some of the apparatus that is new to us. Perhaps the first device that we should acquaint ourselves with is the scanning disk (Fig. 1). The scanning disk can be made of any material that will stand the centrifugal force and be fairly rigid; it must not be transparent. As can be seen in Fig. 1, a number of small holes are drilled around the outer edge of the disk in the form of a spiral; the central angles, formed by the radii drawn through any two adjacent holes, being equal. The spiral shown makes one complete turn; but this it not always the case, as some make two turns around the disk, while other disks have three spirals, each making one-third of a revolution. The holes in the disk are usually square instead of round, there being two principal reasons for this: one, the intensity of light; the other, the distribution of light. The percentage of light through a round hole compared to that of a square hole of the same size, is 78.54. A square hole, as stated, gives an evener distribution of light, as can be seen from Fig. 2. This figure shows the distribution of light through round holes, square holes, and holes bounded by arcs and radii. A hole of the latter type would be ideal, as far as light distribution is concerned, but such a hole is very difficult to cut. There have been a few disks made utilizing this type of hole which gave excellent results. The number of holes in a disk and the speed of a disk are arbitrary, but there are certain combinations that are more or less standard. Some of these combinations are: 45 holes, 900 R. P. M.; 48 holes, 900 R. P. M.; and 60 holes, 1200 R. P. M. At the present time the 60 hole disk seems to be the most popular.

Operation of the disk is as follows: (Referring to Fig. 3). A mask (A) is placed behind the disk, so that only the portion of the disk opposite the hole in the mask is exposed to the light source (B). The width of the opening in the mask is the distance between two adjacent disk holes; the height of the opening is that of the spiral. It is obvious that the only light that can pass through the disk is that light passing through the disk hole opposite the mask opening. Now let us assume a counter clock-wise rotation of the disk, as hole (1) moves across the mask opening. The light shining through the hole forms a pencil of light which moves in an arc across the object to be scanned. The hole (2) in turn also causes a pencil of light to move in an arc across the object, but a little lower than that of hole (1). The other holes in succession scan a path across the object, each a little lower than the preceding one, until every hole has passed the mask opening; the process is then repeated. The effect is that of a pencil of light moving across the object from left to right and from top to bottom; thus, for a single spiral disk, the object is scanned once every revolution. The effect of this process is to divide the object into parallel strips, as shown in Fig. 4. This dividing of the object into parallel strips is the object of the scanning disk. Just why this result is desired will be explained later.

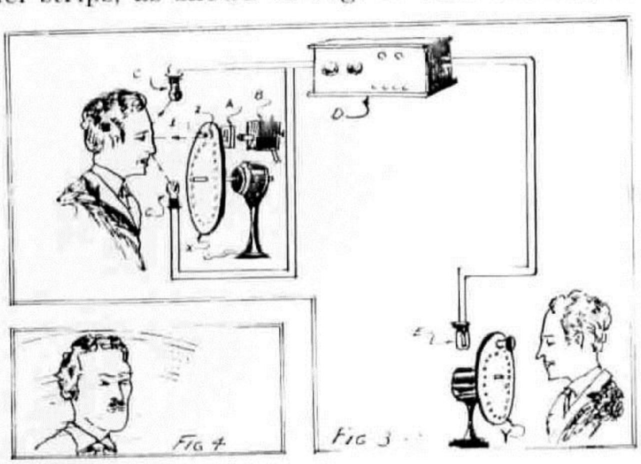

Fig 3

Fig 4

PERHAPS the next piece of apparatus to acquaint ourselves with is the photo-electric cell. The photo-electric cell is the device which makes possible the transmission of television. In constructing a photo-electric cell, a thin layer of potassium hydride or similar substance is deposited on the wall of a glass bulb. This layer constitutes the cathode or the electron-emitting element. The other electrode, the anode, is usually a wire loop, mounted in the center of the tube, directly between the sensitive wall or cathode and a transparent window in the coating of the bulb.

When light is caused to fall upon the cathode, a stream of electrons is given off; this is accelerated toward the anode because of the fact that the anode is maintained at a high positive potential with respect to the cathode. The path between the two electrodes becomes conductive, this conductivity depending on the value of the

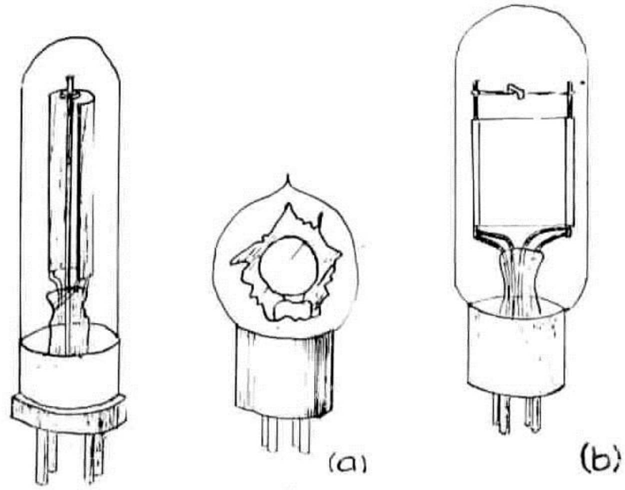

Fig. 5

cathode electron emission. The value of this electron emission from the cathode is dependent on the light striking the cathode, and varies in direct proportion to the intensity of this light. We therefore have a device that changes its resistance with the intensity of light falling upon it. The construction of two types of photo cells is shown in Fig. 5 (a). As to why a device of this type is necessary in television will be taken up later in this discussion.

Let us turn for the present to the third and last device that is unfamiliar to us; namely, the neon lamp. In television, it is necessary to have a light source that can be varied with great rapidity. Frequencies of 50,000 cycles are used, making it necessary to have some special form of lamp. The neon lamp provides a solution of this problem.

THE neon lamp consists of two electrodes: the cathode, a flat metal plate about one and one-fourth inches square; and the anode, which consists of a turn of wire placed around the outer edge of the cathode and three thirty-seconds inch in back. These electrodes are sealed in a glass bulb filled with low pressure neon gas. When the tube is connected to a D. C. supply of the proper voltage, the plate of the tube is seen to glow with a light orange light. If an A. C. voltage is also impressed on the electrodes, the glow will vary in intensity with the impressed A. C. voltage. A tube of this type can be modulated with frequencies as high as 100,000 cycles. The construction of one type of neon lamp is shown in Fig. 5 (b).

Now that we are acquainted with the apparatus, let us turn back to Fig. 3 and follow through a complete television process. Disk (X) is the transmitting disk and (Y) the receiving disk. These two disks are so regulated that they are in synchronism and in step. Light from (B) passes through (A) and scans the man's face, as explained earlier in this discussion. Referring to Fig. 4, it can be seen that the action of the disk is to divide the face into parallel strips that vary in light values along their length. The width of the strips shown is greatly exaggerated for clearness. As can be seen in Fig. 3, the photo-electric cells are so placed as to catch the reflected light from the face. It is obvious that this reflected light will vary in intensity, depending on whether a light or dark portion of the face is being illuminated. As the reflected light changes, the current through the photo cells changes. The light reflected from the scanned object is of low intensity, so that it is common practice to use several photo cells wired in parallel. The change in current through the cells, due to the change in the reflected light, is amplified by the amplifier (D) and sent on to the neon lamp (E). When the light shining through the disk (X) illuminates a light spot on the face, the current through the photo cells is increased and this in turn increases the brightness of the lamp (E). We in turn see this light spot through the hole, in disk (Y), opposite the lamp. As the disk (X) turns, a dark spot may be next illuminated, causing the lamp (E) to glow less brightly. We will observe this dark spot at disk (Y) and in its proper position, due to the fact that disks (X) and (Y) are running in step. It is now obvious that the disk (Y) will produce the strips shown in Fig. 4, in their proper order and in their proper light values. The object is scanned once for every revolution of the disk. As the disk is revolving at a speed corresponding to 20 revolutions per second, the individual strips are not apparent, but the picture is seen as a whole. Were it not for the inability of the human eye to follow a quick motion, television and motion pictures would not be possible.

TELEVISION, like other new developments, has its problems which must be solved. There is no doubt that television must reach a higher state of development than our first radios before being offered to the public. When the first radios appeared, we were content to listen to something that bore a suspicious likeness to a combined cat-fight and charivari and call it music; but we would not be content to look at a picture that is blurred and lacking in detail. In the early days of radio, we were thrilled—by wearing head-phones, holding our breath, and keeping everyone quiet—to hear the announcer give the call of a station as far away as Chicago; but today we would not experience nearly the thrill in seeing a picture the size of a postage stamp.

(Continued on page 17)

installation of electric elevators in the Kansas City Power and Light building and also in the Fidelity Trust building. While making a recent visit here he talked to the E. E. seminar on the subject of electric elevators.

Irvin Peffley, C. E. '25, and family were recent visitors in Manhattan. During his stay here he made a talk in C. E. seminar on an engineer's chances in a public utility company. Mr. Peffley is employed as a leakage engineer for the Colorado Power and Fuel Company of Denver, Colo. His visit here was made while on a vacation.

R. J. Smith, C. E. '23, was recently in the office of the civil department. Smith is chief of the division of road plans for the Kansas state highway commission.

TOMORROW'S TELEVISION

(Continued from page 5)

Let us now turn our attention to television receivers. A good television receiver must have a reasonable degree of sensitivity, amplify all frequencies up to 50,000 cycles, and be flexible and easily controlled.

We have designed and built such a receiver at the Kansas State College which is a new departure from the usual television practice. The principal difference in this receiver is the radio frequency (R. F.) section. The usual television receiver employs two stages of tuned R. F. detector, and three stages of audio frequency (A. F.) amplification—a total of 6 tubes, less the rectifier. The set used here at the college is a super-heterodyne, employing one stage R. F. first detector, oscillator, two stages incoming frequency (I. F.), second detector, and three A. F. stages—or a total of 9 tubes, less rectifier.

Our first consideration was the sensitivity of the receiver. No matter how excellent the receiver in other details, it is useless unless sufficiently sensitive. It was for this reason we chose the super-heterodyne. The super has a reputation for sensitivity on the broadcast band; but at the higher frequencies this increase in sensitivity is still more apparent.

Let us acquaint ourselves with the super-heterodyne. If we take a modulated wave of 500 kilocycles and mix with it a wave of 600 kilocycles, we will have a 100 kilocycle wave component that is modulated the same as the incoming wave. The same effect would be produced by mixing with the 500 kilocycle wave a frequency of 400 kilocycles. The wave in which we are interested is the difference between the incoming wave and the oscillator frequency. The frequency of the oscillator is under control, so that the frequency difference of the two waves is always under control. The frequency difference between these two waves is called the intermediate frequency. We now take several vacuum tube circuits which are fixed tuned to the intermediate frequency and couple these circuits to the detector tube plate circuit. The incoming wave is impressed on the grid of the first detector, but we also have introduced the oscillator frequency into this same tube by some suitable coupling. If we now vary the oscillator frequency until the difference between the oscillator frequency and the incoming wave is the frequency of the intermediate stages, the wave is then amplified and detected by a second detector in the usual manner. The principal difference between the ordinary tuned R. F. set and the super is the changing of the incoming wave frequency. In the ordinary television set, all the radio frequency amplification is done at the incoming frequency. These circuits are tuned to different frequencies to receive different signals. Tuning is accomplished by using a fixed inductance and a variable capacity. This method gives a variable LC ratio; and as the gain of a vacuum tube circuit is dependent on the LC ratio, it can be seen that the sensitivity would vary—depending on the wave length being received. There is still another more important factor affecting sensitivity. As has been before stated, in the tuned R. F. set, the tubes are amplifying at the incoming radio frequency. This is all right on the broadcast band, but as we move to higher frequencies, the amplification factor of the tubes decreases. The ordinary three electrode vacuum tube has a gain of eight at our broadcast frequencies, but it loses all its gain around 50 meters, and may even act as a loser. The screen grid tube, with a voltage gain of perhaps 60 on the broadcast band, has a doubtful gain of two around 20 meters.

The super does not have these disadvantages, as the intermediate frequency stages are fixed tuned, making the LC ration a constant. Practically all the radio frequency gain in a super is due to the I. F. stages; and as these stages can be operated at a low frequency, regardless of the incoming signal, the full gain of the tubes can be realized. For example, if we use an intermediate frequency of 500 kilocycles, we can tune in a 10-meter station, or 30,000 kilocycles, by adjusting our oscillator frequency to 30,500 kilocycles. We would then realize practically the same gain as if the incoming signal were 500 kilocycles.

The audio amplifier of the K. S. C. set is more or less conventional, being three stages resistance couples, employing one screen grid, one type 27, and one pentode tube in the last stage. The televisor used is a standard commercial televisor.

The average television receivers are equipped with plug-in coils so as to cover the short wave bands. They usually use a three gang condenser whose capacity is around .00025MF., but the capacity of such a condenser is too high for efficient operation on the shorter waves.

I know of no receiver with the same flexibility as the set used at K. S. C. The set has a wave length range of 7.5 to 4,000 meters by means of plug-in coils. The selectivity of the set is also variable, as the I. F. stages are plug-in.

It is obvious that the super-heterodyne oscil-

(Continued on page 20)

TOMORROW'S TELEVISION

(Continued from page 17)

lator frequency should be as nearly constant as possible; and due to the wide range of this set, it must be very stable over a wide band of frequencies. The dynatron oscillator is noted for its stability and wide range, but it was not believed that such an oscillator would operate below 85 meters; it is therefore not used in short wave super-heterodynes. The advantages of the dynatron over other types of oscillators were obvious, with this one exception. We therefore experimented with the dynatron to see what could be done. It was found to be a simple matter of the proper adjustment of voltages and circuit coupling. The dynatron in the set at K. S. C. operates as smoothly at 15 meters as it does at 150 meters.

The set has six variable condensers in three groups of two each; each group consisting of a .00015MF. and a .00025MF. condenser, the former tuning the short wave band, and the latter the television band. The two condensers in parallel tune the broadcast band and long waves. The condensers are connected into the circuit automatically, as the coils when plugged in connect to the proper condenser. The set is tuned with two dials, one tuning the R. F. and first detector stage, the other the oscillator. The set is completely shielded in 1-16th inch aluminum to eliminate all circuit and external coupling.

As to the results, the author has for the past five nights, at Manhattan, Kansas, received the television stations W3XK at Washington, D. C., W2XAB at New York City, and W1XAV at Boston, as well as the closer Chicago stations. On the short wave bands, the following stations have been received: G5SW Chelmsford, England; GBS Rugby, England; 12RO Rome, Italy; KIO Kahuhu, Hawaii; VK3ME Melbourne, Australia; FYA Pontoise, France, and HKC Botoga, Columbia, S. A., as well as the American stations.

I believe it highly probable that the television set of tomorrow will be the super-hyterodyne.