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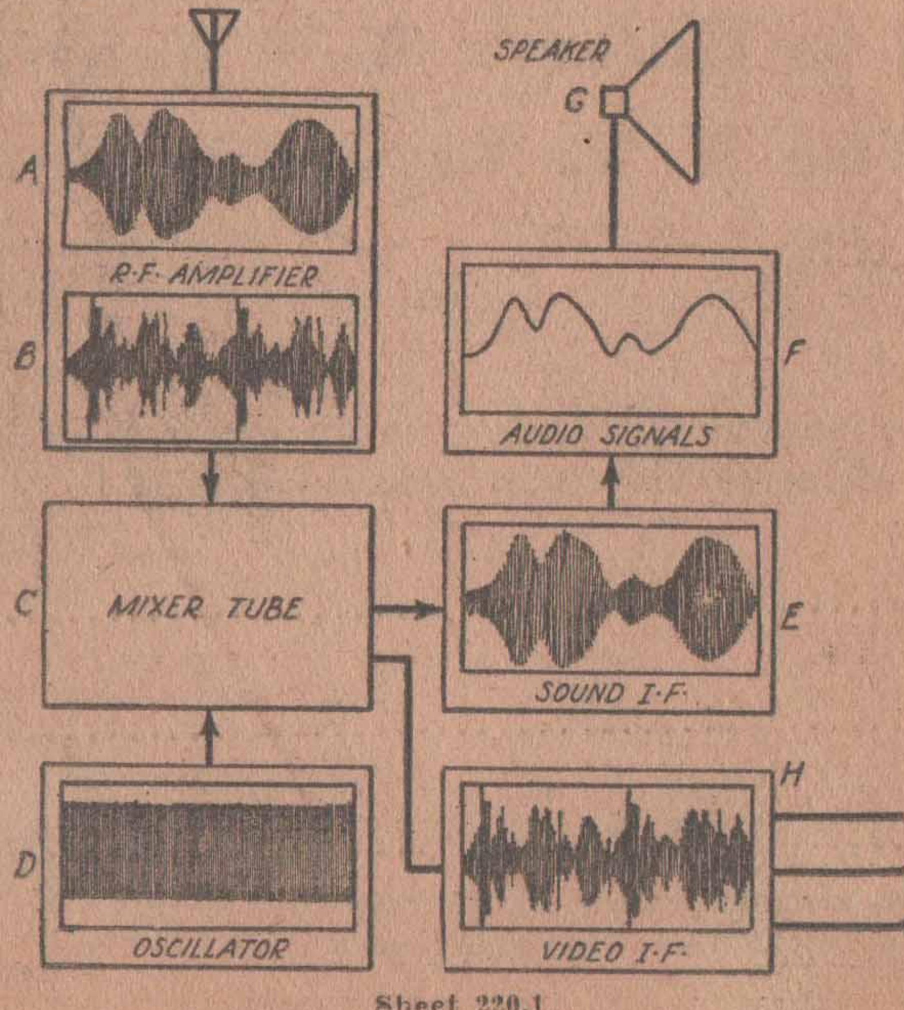
SIGNAL CONVERSION

Sheet 210.1 showed a block diagram of all the components of a television set, with their interconnections. The system will now be detailed from the viewpoint of the incoming signals and their conversion to other forms for controlling the various circuits. This will be done by showing in Fig. 1 what oscillograms of the currents in each part of the circuit would look like.

The antenna circuit, being broadly tuned so as to accept both frequencies at the same time, has the sound carrier frequency (A) and the video carrier (B) currents flowing in it. In these oscillograms, as in the others in this figure, the time interval assumed is equivalent to that of the scanning of two lines, viz., about one six-thousandth of a second.

These antenna currents (amplified) are then applied to a mixer tube, (C). A steady radio freqeuncy potential from an oscillator is also applied to this tube. This is represented by an r-f current of constant amplitude, (D). Two bands of frequencies result, and appear in the output circuit of this tube. One, the sound i-f, shown as block (E) is amplified and rectified, and the resulting audio frequency, (F), is applied to the loud speaker, (G).



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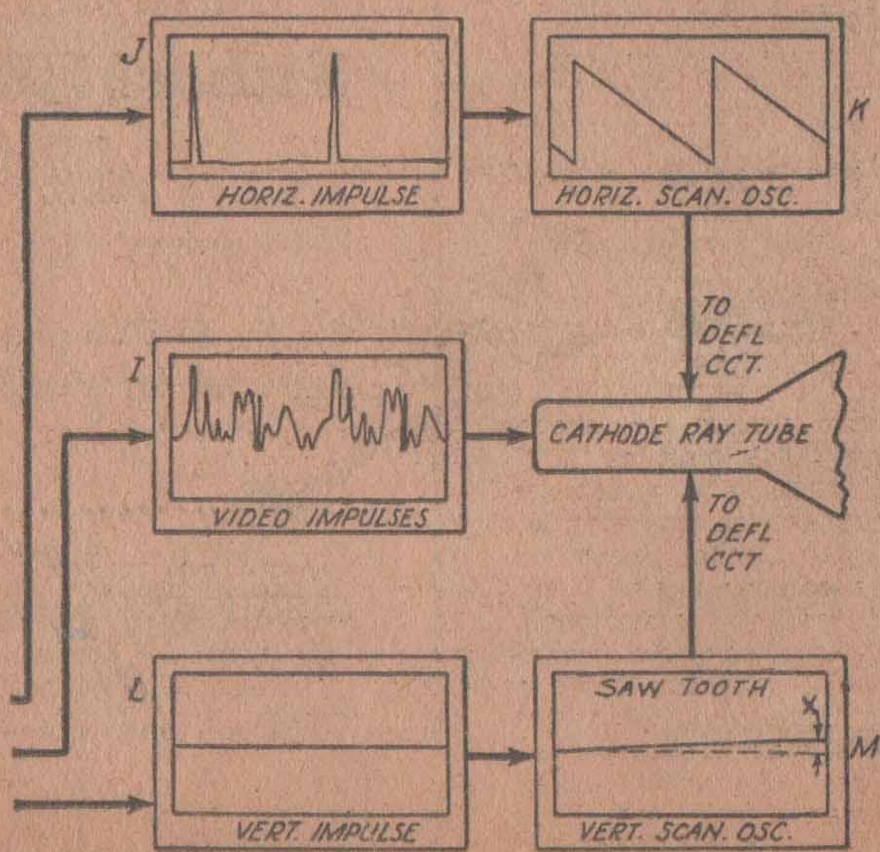
SIGNAL CONVERSION

The second output frequency, the video i-f shown in (H), is also amplified and rectified so that the video frequency variations (I) can be applied to the modulation grid of the cathode ray tube. The shape of (I) should be substantially the same as the contour of the incoming signal (B), or of the contour of the i-f carrier (H), if no distortion occurs. The rectifier circuit of the video i-f also provides two selective amplifiers with synchronizing pulses. The rapid pulses (J) control the horizontal scanning oscillator saw-tooth waves (K), which are in turn applied to the deflection system of the cathode ray tube. The peaks in (J) are seen in the pedestals shown in the curves (B) or (H).

At the instant assumed in this analysis, the vertical synchronizing pulse is not present, so that the output of the vertical pulse amplifier is a straight line (L). The vertical scanning oscillator during this interval has a steadily increasing potential, shown in (M) with the rise in voltage (indicated by the displacement x) equal to two scanning lines, which for interlaced scanning is about one one-hundred and tenth of the total deflection.

It will be seen that the incoming signals are divided into respective sound and video channels. The latter is redivided to give the video and the synchronizing pulses into separate circuits. The cathode ray tube is operated on in three ways, by two deflection controls, and the modulation control.



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FM AND TELEVISION RECEPTION

The two radio marvels of the times—Frequency Modulation and Television—have many features in common, so that there is some possibility of a more intimate linking of these two fields of entertainment. Since the carrier frequencies assigned to each are in the same part of the band, a single tuning system could probably be developed to cover both without great difficulty. Several possibilities are evident, including the use of FM to handle the sound program of the television system and the use of FM for both the sound and the video programs.

There are no major difficulties in carrying out the first arrangement, since the band width allotted for the television sound program is plenty width to handle FM sound signals. The essential circuit differences between AM and FM reception lie in the detection methods following the i-f amplifier and not in the methods used in the r-f tuning and conversion to that i-f.

In order to get proper utilization of the advantages of FM, however the carrier band width allotted to this service should be several times the range of modulation signals to be handled. When a band upward of three megacycles is considered (the range necessary for a television video signal) it will be evident that television would have no chance for operation within a six-megacycle band—at least using the presently developed rules.

Frequency modulated television signals are already in use in an experimental television relay system established by the RCA Communications, Inc., for delivering television signals to particular points on Long Island. Vision signals from the Empire State transmitter were converted to an FM carrier of about 500 megacycles. This system can be extended to provide nationwide television network coverage, but the carrier frequencies involved make their reception by the public difficult. For this reason they must be re-converted into the normal television frequencies of the amplitude modulation (AM) type.

However, it is not technically impossible for the industry to adopt an FM sound signal for television and an AM video signal. A combination FM broadcast and television receiver would be considerably simpler than a combination television and AM broadcast receiver using the presently assigned range of frequencies. FM reception applied to television would overcome one of the greatest obstacles problems of television; picture clarity, by the elimination of a great deal of the effect of interference.

(To be continued.)

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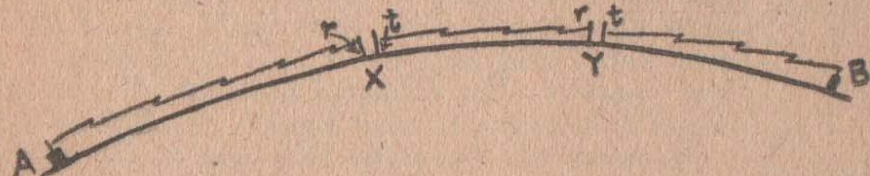
RELAYED PROGRAMS VIA FM

In the previous data sheet, reference was made to a practical application of FM to television, viz., the use of automatic receiver-transmitter signal-boasting stations for relay purposes. One of these stations would be located near the "horizon" of a particular television station, so as to pick up the signal from that station and then to relay it forward in a particular direction, generally by the way of a different carrier frequency. There are a series of carrier frequencies that are definitely laid aside by the FCC for this use, frequencies that are much higher than those used in regular television service. It is not the usual intention that the public should pick up these transmissions although there is no reason why they could not be received by any one who cared to build a proper receiver.



It is the goal of every station to transmit distortionless signals if possible so that no interference or static can be introduced into the transmitted signal, for this would be received on all receivers that are tuned in. For this reason FM has certain desirable characteristics: no interference and best operation on the ultra-high frequencies desired for relay work.

The figure shows how these television relay points are used. The points A and B are widely separated centers of population. Their separation prevents reception, at B, of the regular horizon-limited signals transmitted from A. However at the point X a good signal may be found, the location being inside the service range of A. An unattended receiver-transmitter (r and t) is installed at X, which picks up the signal from A, either on its regular frequency or on a special frequency assigned for this purpose. Its transmitter, t, sends the program on to a similar station at Y, and through additional points if necessary until the other point (B) of the broadcast network is reached.

In a noteworthy application of this principle, television signals from New York city were delivered to Riverhead (near the eastern end of Long Island) by two relay stations at Hauppauge and at Rocky Point, using frequencies between 450 and 500 megacycles at the intermediate points, with frequency modulated television picture signals. Television programs could therefore be provided over a nation-wide network by using an extended system of relay points.

SHEET 220.4.

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MECHANICAL SYSTEMS

While most emphasis is placed at this time on electronic methods of television, i. e., those centering around cathode ray tubes, other arrangements using optical and mechanical scanning systems have not been discarded. To the average person all mechanical systems are thought of as using high speed rotating disks and cylinders studded with mirrors or lenses, utilizing principles which have been tried and found deficient. This is not the case. While scanning disks are practical in some instances, high definition in the reproduction of scenes is impossible of attainment. More than 200 lines per picture cannot be obtained with equipment suitable in size for the home.

When it was determined that reproduction of quality higher than that attainable with 60-line disks was essential, laboratories started to perfect the cathode ray tube method whereby a greater number of lines could be reached without exorbitant cost. Other research groups devoted their attention to mechanical systems. As a result many ingenious arrangements have been proposed, some of which have merited serious attention, such as small mirror-faced wheels, warped mirrors, &c.

One of the most important problems in mechanical systems is the source of light. An intense source can be obtained from ordinary tungsten lamps but when it comes to the matter of rapidly and accurately controlling its brilliance in conformity with the incoming television signals, the apparent simplicity vanishes.

Mechanical scanning is receiving equal attention with the cathode ray system in the experimental laboratories in Germany, and by several groups in Great Britain. In the former country 180 line pictures are standard, although some work is being done on 375 line pictures. Fernseh A. G. is using rotating disks with 375 holes as a part of studio pickup camera equipment, showing that disks with that number of lines are not impossible. However, even in this case reports have indicated that the laminated structure of the picture was very noticeable due to inaccuracies in the location of the holes. Many dark streaks appear across the images.

Mechanical systems have a decided advantage, it would seem when large projected pictures are considered, due to the light intensity limitations in the usual cathode ray tube, at least at the present time.

In later sheets we shall give attention to developments that seem to offer some promise, since the practical presentation of television programs in the theater may involve the adaptation of some mechanical system.

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ELECTRONIC TELEVISION

The question frequently is asked: Is the cathode ray television system here to stay? At this time no one is qualified to give an exact answer. Two factors tend to place the cathode ray system at a disadvantage: the limited size of the received picture and the first and replacement cost. It is assumed that the alternate system would be some form of mechanical scanning arrangement.

The ease with which a fluorescent picture can be enlarged through projection by a lens to a larger screen takes care of the size, so that the real problem becomes the limited illumination available. A picture cannot be enlarged too much or it becomes too dim to be seen. Cost is a matter of quantity production and present-day prices cannot be used as a basis of what can be done eventually.

Large screen television projection will have to be developed for theater use to provide for large audiences. A satisfactory amount of light is even now to be had in certain of the most promising of the mechanical systems, but the problem is that of getting sufficient detail and quality in the pictures. It has been shown that excellent strides have been made by the Scophony system and others in this line. In time the home television receiver may be the choice of either a small model of a mechanical scanning receiver copying the principles which will be in use in theaters or a cathode ray tube model—but in any event it is certain that any program transmitted will be receivable with either arrangement. Meanwhile a good design of cathode ray tube is capable of reproducing a picture with a higher quality than the present system requires. Most of what distortion is present can be generally traced to other parts of the system, in the studio camera, the transmitter and because of interference.

The usual home receiver will not embody a large screen projection of the picture on account of the problem of locating a sizable projection screen where it is convenient to view and yet be out of the way when not in use.

However, it is desirable to have a picture from 15 to 24 inches in size, so that it can be easily viewed by small groups of observers.

Any system that will give pictures with plenty of light may be easily viewed in a room that is not darkened, a decided advantage in many situations.

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TELEVISION SYSTEM ASPECTS

Since the FCC reopened the question of television system standards, by discrediting those set up by the engineering groups of the Radio Manufacturers Association, there is much speculation as to what should now be done. In view of this it might be of interest to analyze some of the alternate proposals. One system that has received serious consideration has been offered by Philco. A tabulation of these two systems shows:

	Lines	Frames	Lines per Second	Picture Elements per Second	Band Width
R. M. A.	441	30 interlaced	13,230	8.48 million	4.25 m. c.
Philco	605	24 interlaced	14,520	14.33 million	7 m. c.

The picture element per second value is obtained from the basis that 32 lines are lost in the R. M. A. system during each frame for synchronizing purposes and 35 lines in the Philco system. Also that the shape ratio of the visible area (that not blanked out) is 4 to 3. On this basis the Philco system has 570 visible lines with 760 visible picture elements per line. The R. M. A. system has 409 lines of 545 elements each. A picture element is assumed to be a square spot having dimensions equal to the width of a scanning line. The visible length of the scanning line is only 85 per cent of the actual length allowed, to provide an interval for the return sweep.

This analysis assumes that the discharge interval (back-trace time) for the 605-line system is the same as with the 441-line system. In either system approximately the same length of time is required for each horizontal back trace. Experience may alter these requirements slightly. In addition to this, the tabulation includes another assumption used by engineers, viz., that the video frequency band width required is one-half the number of picture elements sent per second.

The story is not complete here, however. It is desirable in any system to equalize horizontal and vertical definition—that is, to have equally clear pictures in either direction. Vertical definition depends upon the number of lines per frame. Such factors as the accuracy of interlace and the freedom from hum effects also affect the vertical definition.

Horizontal definition depends primarily on the number of picture elements, per scanning line, afforded by the system. Here the band width of the signals after handling by both transmitter and receiver is an essential factor. The accuracy of focusing, interlacing and absence of hum effects also contribute to the result.

It is not difficult to see the reasons why the "experts are stumped" when called on to give a "yes" or "no" answer to the question, "Should the system be changed?"

Sheet 230.3.

(To be continued.)

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TELEVISION SYSTEM ASPECTS

Some of the details of the controversy among television developers in the establishment of system standards were reviewed on Data Sheet 230.3. It was shown that one difficulty is that more experience in manufacturing is needed to show whether the accuracy of interlacing can be improved, and, what is more troublesome, whether the hum effect can be eliminated (or, as proposed by Philco, neutralized) if the framing rate is changed from the present standard of 30 per second.

There is an idea going around that the amount of picture detail and quality that can be transferred over a television system is proportional to the number of picture elements transmitted each second. This is not strictly true because of the importance of a correct balance between frames-per-second and lines-per-frame for a given transmitted band-width. It is desirable to use as low a framing rate as the flicker effect and the illusion of motion will allow. In scenes showing athletic events and rapidly moving objects too low a framing rate will introduce erratic and jerky movements.

However, it is questioned by many, whether the system should be tied up to the relatively high framing rate of 30 in order to decrease the possibility of these troubles.

The inadvisability of using interlaced scanning has never been proved, nor in fact has the necessity of interlacing been questioned. The system was in use in England and elsewhere, and has been the basic system used in all extensive tests in this country. The advantage generally stated is a decreased flicker effect. A 30 frame, 441-line system, gives 7% better picture detail, vertically, when not interlaced. However, since it costs no more to provide interlacing in the cathode ray system, then the general view is, why not use it?

Apparently there is one whole problem that has been lost sight of in the present debates: the present system in most respects favors the cathode ray system of reception and places greater difficulties toward adapting mechanical systems to television receivers. This is natural, because the developers of those systems have never shown results, at least in this country, that are comparable with electronic methods. However, unless new developments come about that will provide larger pictures economically from the basic cathode ray system, mechanically scanned receivers may come to supplant them. This is a matter that inventive rivalry will decide when the demand for television pictures increases and larger groups or audiences are to be satisfied.

The greatest difference in the system requirements will probably lie in the matter of synchronization, but if the accuracy of the synchronizing pulse separation, required by mechanical systems, is maintained at each transmitter, things should work out.

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TELEVISION HALTS TEMPORARILY

Television receiver owners in certain locations have often been bothered by interference (called man-made interference since it comes from manufactured devices) which temporarily distorts reception. Starting this week, however, a new type of man-made interference with the television program of progress put in its appearance in the form of an FCC order vacating the presently-used television frequencies to favor other services. This ruling has put a temporary stop to the current RCA-NBC programs.

It takes a certain amount of time to make the required change-over, since a modern television transmitting antenna is not a simple matter, and its characteristics must conform to highly involved principles. However, these changes are not a part of the commission's planned campaign to free television from its "frozen standards" since reception on the new wavelength will be in no way different from the present unless other variations are voluntarily introduced by the NBC at the same time.

To change the operating frequency new antenna structures are needed atop the Empire State Building involving new sizes for the radiating elements and careful adjustment of the spacing between them so that they will not react on each other. Another highly exacting job is the design and installation of a new side-band absorption filter which removes all but a certain definitely prescribed amount of the lower side-band from the radiated signal. In the transmitter itself the circuit elements in dozens of stages must be altered, on both the video and the sound transmitters, going as far back in the system as the crystal oscillators themselves.

The carrier frequency of a television transmitter is usually obtained from a crystal oscillator working at a substantially lower frequency. For example, a 3.203 megacycle crystal might be used, operating through frequency multiplying arrangements, such as four frequency doublers, until a carrier frequency of 51.25 megacycles is obtained. The sound carrier of 55.75 could likewise incur a crystal frequency change to 3.485 megacycles followed by four stages of frequency doubling.

However, when this changeover is finished, a few weeks hence, the television art will be no farther ahead than it is now, but there is some comfort in the fact that a few more wavelengths have been made available for the new frequency modulated-broadcasting services.

SHEET 230.5.

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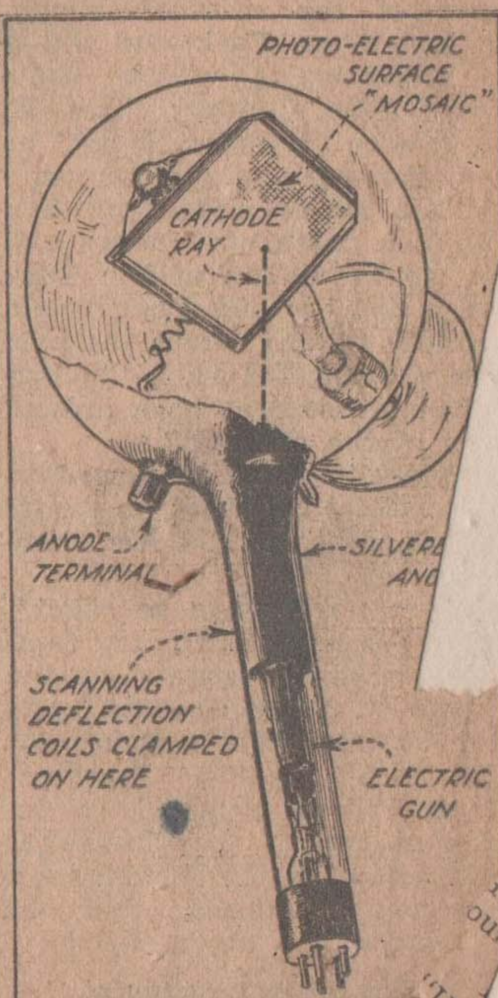
THE ICONOSCOPE

The outstanding piece of apparatus in the television studio is the pick-up camera, an instrument that corresponds in the visual studio to the microphone of the sound program. It consists of a lens arrangement not unlike the ordinary camera lens, which is focused on the scene to be televised. Thereupon an image is projected on a screen in a special cathode ray tube which is a part of the camera. Different television laboratories have developed their own versions of tubes for this purpose. In the RCA system their design of tube is called an Iconoscope.



It is characterized by a large rectangular plate of thin mica (see figure) upon which a large number of small photo-sensitive spots are applied. These spots are very closely spaced, possibly as many as one hundred thousand per square inch, giving the screen the designation of a "mosaic." When the televised scene is projected on this screen photo-emission takes place from each individual spot, but the space charge near the surface of the plate prevents much current from flowing, so that a condenser charge continues to build up on each spot.

At frequent intervals, however, a cathode ray spot is swept back and forth over this screen, in the manner of scanning, so as to neutralize this space charge and thus discharge the secutively. Since the spot diameter may cover a photo-electric cell elements at one time, the actual each instant depends upon the size of the cathode r

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THE ICONOSCOPE

The intensity of the charge that has accumulated on the spots in a certain small area depends upon the intensity of the light that has fallen on the screen from the televised scene, and upon the amount of time that elapses between scanning sweeps. These sweeps occur at regular intervals, set by the standard framing frequency of the television system, so that the photo-electric output at any time is proportional to the projected light intensity. collector

It will be noted that the ~~condenser~~ elements are not all discharged at the same time, but only those that are located within the small area covered by the cathode ray tube spot in its travels. As each group of elementary cells are discharged a small potential is induced on the sheet of conductive material attached to the back of the mica sheet. The potential on this backing plate is tied in with the normal potential level of the cathode ray tube anode circuit (together with an appropriate bias) so that when the cell discharges take place, this induced potential can be picked off and amplified.

Acting as it does on the accumulated charge between scanning intervals, the Iconoscope is sensitive enough to permit its use either indoors or out of doors as required. The illumination level is not excessive, due to the use of very sensitive photo-electric materials on the screen. These have been, for the experimental tubes used so far, cæsium applied to either a silver-oxide, aluminum-oxide or zirconium-oxide, &c., base layer.

The lens used for out-door pickups is of the order of F/4.5, which seems sufficient even on cloudy days. The Iconoscope therefore can be considered as more sensitive than the human eye, since a scene viewed through such a lens under those conditions would be very dim indeed. It was found in actual tests that a surface illumination of fifteen candles per square foot was satisfactory.

The cathode ray portion of the tube, mentioned above, is not unlike the usual cathode ray tube, except that special means are used to insure that the spot keep in focus even while projected on a slanting screen as shown, and that the spot remains round under these conditions. Magnetic deflection circuits to produce scanning, are usually used, in which the circuits are compensated to keep the scanned area square.

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SHADING CONTROL

Observers who have viewed television reception demonstrations have frequently inquired as to the cause of unnatural shadows that appear at times in the scene, especially in title plates, where the background near the lettering appears streaked. This effect is frequently due to a characteristic of the Iconoscope (sheet 240.1). It is brought about by the tendency of electrons emitted by the portions of the Mosaic that have been strongly illuminated (as is the case in the lettered portions of the title scenes) to hop over to the neighboring areas that have less illumination.

The emission of numerous electrons (which are negative) from one group of photosensitive mosaic elements, leaves them with a positive charge. In order to register the magnitude of the light received from the scene it is necessary that all electrons that are emitted by the illuminated areas reach the main anode of the tube. Those that go elsewhere, such as to nearby parts of the mosaic, cause false shadows to appear. A great deal of this distortion is corrected in the studio control room, by the expert handling of the "Shading Panel" controls, whereby operators keep up with and if possible anticipate where these false shades are likely to appear, by a knowledge of how their movements are affected by the relative positions of light and dark parts of the scene. Where the contrast between black and white is sharp, as in the handling of letters in a title, it is not possible to apply the same back-ground correction measures that are effective when regular scenes are handled.

The adjustment of the shading control is one of the difficult technical problems which engineers hope to solve before long. Already there have been numerous improvements which have tended to make the effect of "migrating" electrons less noticeable. For example in the Farnsworth "Image Dissector" tube recently reported, a perforated mosaic is substituted for the regular mosaic used in the Iconoscope. Emitted electrons are drawn through the holes nearest the point of emission, so they do not stray to unwanted areas. The necessity for the complicated shading panel adjustments is therefore avoided.

The shading panel consists of a number of attenuation pads that can be switched in at will. These pads are such that they act only in certain parts of each frame, their effectiveness being altered by scanning waves pulses. For instance one pad can be made to act only when the scanning ray is in a certain corner of the picture, another to control the upper edge, and so on. In any case they subdue the video frequency pulses coming from those areas where it is seen that false shadows appear.

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MODERN DEVELOPMENTS IN PICKUP TUBES

Television viewers who have followed television programs during the last six months have doubtless noted the marked superiority of some program pickup over others, even those on the same period. Differences in the picture detail and contrast can often be ascribed to differences in the positioning or focusing of camera or in the studio lighting. In other cases it may be due to differences in the Iconoscope tubes, whose effectiveness depends upon the formation of the sensitive mosaic surface during its construction, a procedure that has many attending difficulties. In other cases the difference may be due to the handling of the shading controls which require frequent and accurate adjustment as the picture changes.

The greatest improvement, however, according to reports, comes from the use of certain experimental pickup tubes which operate on a principle that is quite different from that used in the Iconoscope type of camera. The new tubes have complete freedom from the dark-spot (or shading) trouble which has been the greatest difficulty encountered in the Iconoscope. They are known as Orthiconoscopes.

In either tube, the incoming picture is focused on the "mosaic" screen by the camera lens, as described in Sheets 240.1 and 240.2. The effects of photoelectric emission produced thereby cause the picture to become stored up, momentarily at least, as electrostatic charges on the individual elements of this mosaic. These changes are wiped off, line after line, by a high speed electron beam which is directed against its surface.

In the case of the earlier Iconoscope, the velocity of this beam was great enough so that the individual electrons that compose it (which are, of course, negatively charged) were not repelled by the negatively-charged electrons emitted by the photoelectric surface of the mosaic. These high speed electrons caused a scattering of the electrons, leading not only to a loss of efficiency but a loss of definition as well, since a greater part of the electronic energy stored up by the mosaic elements does not produce any useful output signal, but are scattered about, causing trouble at other parts of the sensitive area. Luckily this scattering has been found to be rather consistent in its effects, since the straying electrons tend to migrate toward certain areas of the mosaic plate. Shading controls can then be arranged to compensate for their effects and this is what is done whenever the Iconoscope type of pickup tube has been used.

Subsequent investigations showed that the dark-spot effect would be reduced if the velocity of the impinging electronic ray was slowed down. This is the principle upon which the new Orthiconoscope pickup tube operates. It will be described in following sheets.

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RECENT DEVELOPMENTS IN PICKUP TUBES

As mentioned on sheet 240.4 an Orthiconoscope is a new type of camera pickup-tube operating on new and improved principles, which avoids some of the difficulties present when televising scenes in a studio or elsewhere. In an ordinary electric light bulb the heated filament gives off electrons, but as there is no place for these electrons to go (since no auxiliary electrodes are found in such a bulb) the emitted electrons remain as a cloud of electrons hovering around the heated surface. This is the space-charge effect mentioned in the last sheet. The density of the cloud is proportional to the intensity of the emission.

In the case of an illuminated mosaic this density depends on the intensity of illumination, so that its various parts have different space-charge densities, in accordance with the lights and shades of the picture. When a low velocity ray from the electron gun enters the electron cloud over the mosaic its progress is slowed down and its striking velocity depends upon the density of that cloud. The latter may be thought of as an insulating layer of variable thickness having a resistivity at each point proportional to the amount of light falling on the mosaic from the corresponding point in the scene.

The guidance without loss of the low velocity beam and the photo-emission currents to the collector electrode is not a simple matter since the beam is easily affected by any kind of stray field. A complete description of the basic principles of orthiconoscope operation was outlined in the September issue of the Proceedings of the Institute of Radio Engineers.

Commercial development of tubes using the principles are now under way and numerous experimental models are being tested. Among the principal operational features the following conditions were especially cited: a low velocity scanning beam with the electrons directed along a path exactly at right angles to the mosaic screen so that they strike the latter squarely. As to the actual velocities of the electrons in this tube an accelerating potential of 20 volts gives a velocity of about 1,800 miles per second. This can be compared with a velocity of 34,000 miles per second which is the electron speed in an ordinary 9-inch television receiving tube, about eighteen times as fast. A special system of magnetic and variable electrostatic fields are applied to accomplish scanning in both directions on the mosaic. A translucent mosaic is provided upon which the picture is projected from the rear.

In one form, the Orthiconoscope has an active mosaic of 1⅝x2¼ inches and gives an output signal of about .002 volt when the high lights in the picture are being scanned. In addition to greater efficiency the main advantage of the new tube is the complete absence of dark-spot signals, so that no shading compensation is necessary.