July 2, 1929. R. S. CLAY 1,719,756

TELEVISION AND LIKE APPARATUS

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Fig. 1.

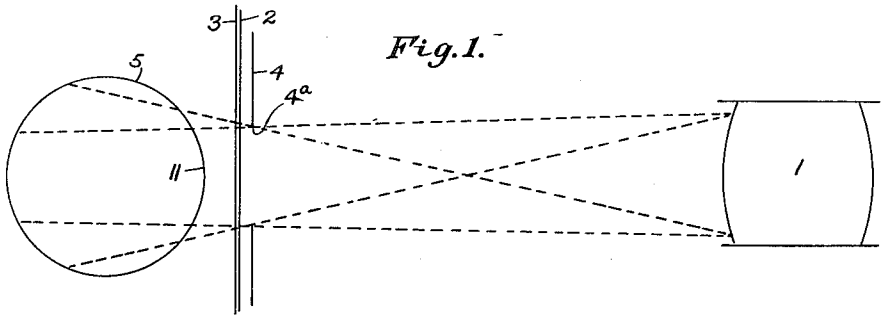


Fig. 2.

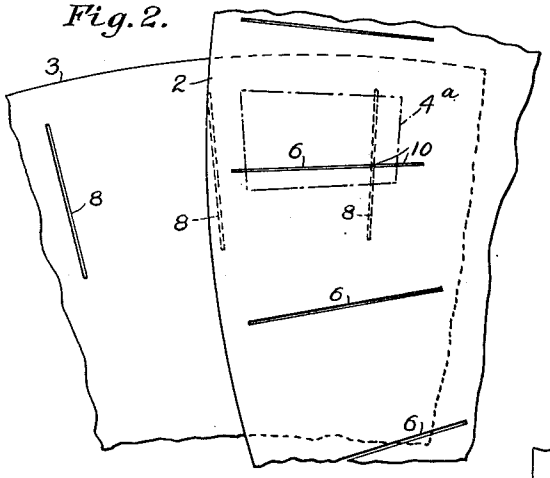


Fig. 4.

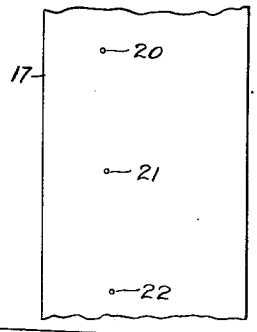


Fig. 3.

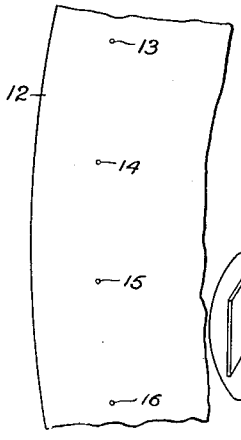
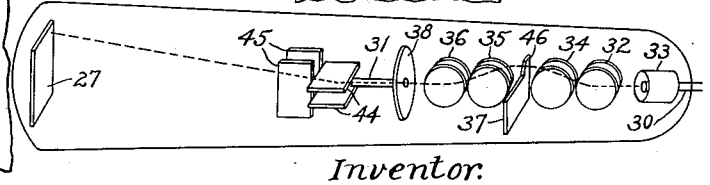


Fig. 11.



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Fig. 5.

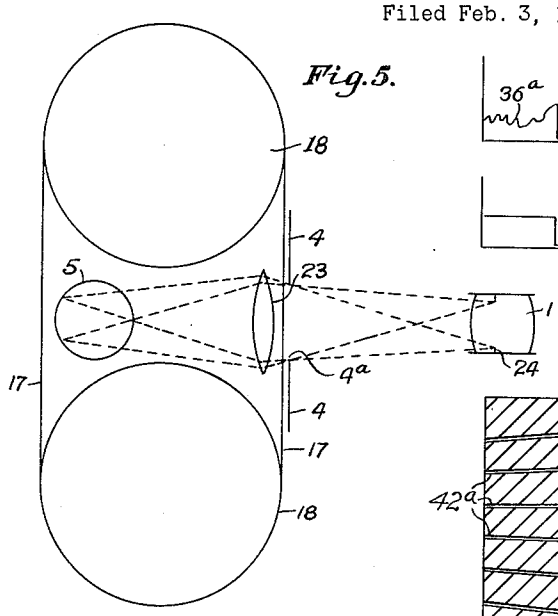


Fig. 9.

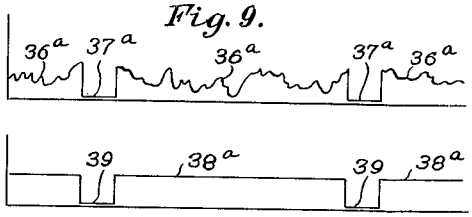


Fig. 10.

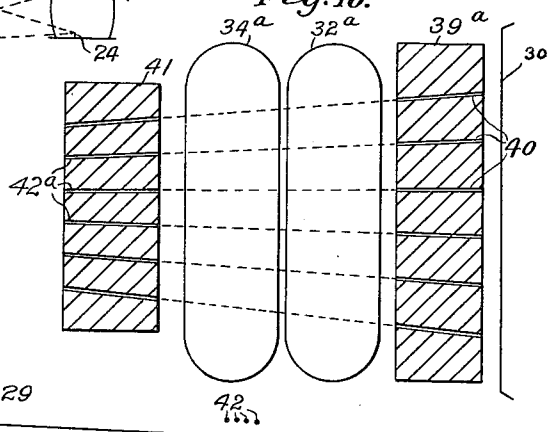


Fig. 6.

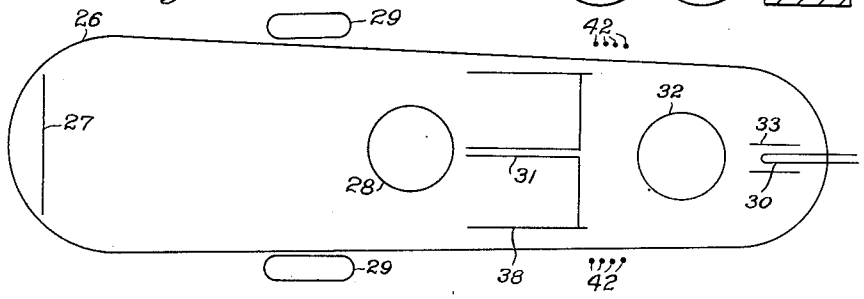


Fig. 8.

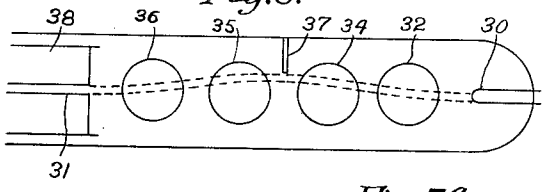


Fig. 7.

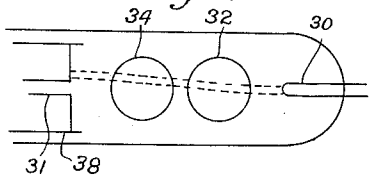


Fig. 7a.

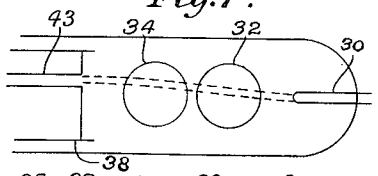
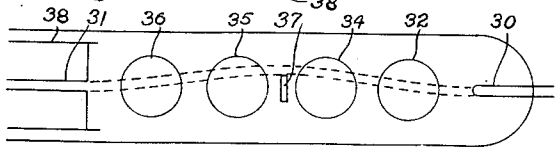


Fig. 8a.



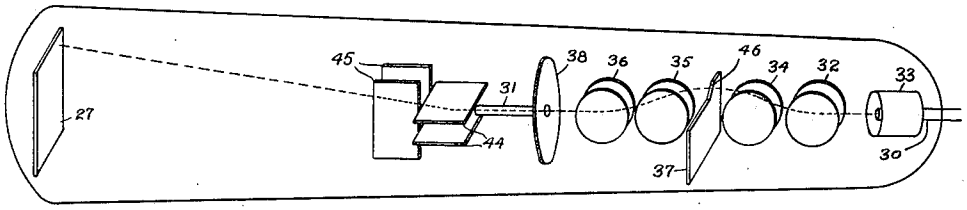
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TELEVISION AND LIKE APPARATUS

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Fig. 11.



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UNITED STATES PATENT OFFICE.

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TELEVISION AND LIKE APPARATUS.

Application filed February 3, 1927, Serial No. 165,694, and in Great Britain February 9, 1926.

This invention relates to the reproduction on a screen at a distant station by means of a varying current impressed on a wireless carrier wave, or carried by any other conductor, of any scene or illuminated transparency presented to a transmitting station.

I make use of a variable cathode-stream to reproduce the picture at the receiving station, and, in addition to deflecting the stream in the usual way to traverse the field, I vary the intensity of the cathode stream without varying its velocity or direction as it enters the traversing field, viz, by a preliminary deflection in accordance with the intensity of the light required. In this preliminary deflection the beam is not only intercepted in such a way that the intensity of the cathode-stream allowed to fall on a fluorescent screen varies according to the deflection, and therefore is controlled by the amplitude of the carrier wave, but also so as to avoid the tendency of this preliminary deflection to interfere with the accurate traverse of the stream over the field.

Attempts have already been made to use a cathode-stream in a reproducer, of which the intensity is varied by a grid as in the triode valve. But these have not been so arranged as to ensure that the variation in intensity so obtained does not disturb the traversing motion of the beam.

A grid alters the velocity of the electrons, but the deflection given to an electron in motion by the plates used to cause the stream to traverse the area to be illuminated, depends upon the velocity of the electron as well as upon the strength of the deflecting field. Thus the grid will not only produce a variation in the intensity of the electron stream, but it will also cause it to move unevenly over the screen, and it will thus injure the definition.

It has also been proposed in a cathode ray tube of the Braun type, to vary the intensity by a deflecting field inserted between the two apertures which define the pencil of rays entering the traversing field. These devices were impracticable, for the reason that, in this position, the deflecting field altered the direction of the pencil of rays entering the traversing field. This initial obliquity is necessarily superposed on the deviations produced by the traversing field, and differentially affects the point of incidence of the beam on the fluorescent screen according to its intensity.

According to the present invention the variation of intensity is produced by a preliminary deflection of the cathode-stream, but in such a way as to avoid any appreciable alteration in the direction or velocity of the pencil of rays which enter the traversing field.

In the accompanying drawings—

Figure 1 shows diagrammatically the general arrangement of the transmitter.

Figure 2 shows in elevation details of the slots of one of the selectors, consisting of a pair of rotating discs.

Figure 3 shows an alternative form of disc selector with a series of spirally arranged pin-holes.

Figure 4 shows a further alternative selector, the pin-holes being formed in echelon in a travelling ribbon.

Figure 5 shows an alternative to Figure 1, in which a ribbon is substituted for the rotating disc, and a condenser is added to the optical system.

Figure 6 shows diagrammatically the general arrangement of the reproducing mechanism.

Figure 7 shows diagrammatically one method of restoring the cathode-stream to its original direction after the preliminary deflection which produces the variation in its intensity.

Figure 7ª is a view illustrating a modification of the arrangement illustrated in Figure 7.

Figure 8 is a view illustrating a further modification of the arrangement illustrated in Figure 7.

Figure 8ª is a view illustrating a modification of the arrangement shewn in Figure 8.

Figure 9 shows diagrammatically the variations of amplitude which are made use of for synchronizing the transmitting and reproducing mechanism.

Figure 10 shows how a number of cathode-streams may be superimposed on the fluorescent screen to increase the brightness of the resultant picture.

Figure 11 is a diagrammatic view illustrating another modification of the receiver.

In one form of the transmitter a short-focus large aperture photographic objective 1, Figure 1, similar to those used for obtaining cinematograph pictures, faces the scene to be transmitted. In the focal plane of the lens is a selector consisting in one form of the apparatus, of two large flat and partly over-

lapping discs 2 and 3, each say two feet in diameter, or the equivalent, which rotate about horizontal axes parallel to one another and to the axis of the lens. These axes are so situated that the picture formed by the lens is projected on the discs near their circumferences; but while the axis of the one disc, 2, is in the same horizontal plane as that of the lens, that of the other disc, 3 is in the same vertical plane as that of the lens. Thus the circumference of the disc 2, is travelling vertically at the part where the image cast by the lens falls upon it, while that of the other disc 3, is moving horizontally. Each disc has a series of radial slots, one inch long, and 1/100th of an inch wide, spaced about one inch apart around the disc, and they are situated at such a distance from the centre, and the lens is so placed, that they pass across the image cast by the lens. The discs rotate at different speeds, such that while 16 slots of disc 3 pass over the image per second, 1600 slots of disc 2 pass over the image in that time. As the light has to pass in succession through the two discs, at any instant the open area forms a square 1/100th of an inch each way, and while the vertical slot of the disc 3 moves forward 1/100th of an inch, the horizontal slot of the disc 2 sweeps out the whole length of the slot of the disk 3 from top to bottom.

Portions of the rotating discs forming the selector are shown in Figure 2. Both discs are rotating about axes perpendicular to the paper. In the disc 2, are radial slots 6, 6, each about one inch long and 1/100th of an inch wide. Similar radial slots 8, 8, are cut in the other disc 3. At 10 a pair of these slots 6 and 8 overlap forming a small aperture 1/100th of an inch square through which the light can pass. The dot and dash line 4^a in Figure 2 indicates the opening in the mask 4.

As these discs should both be as nearly as possible in the focal plane of the lens, they must be close together and thin. They are preferably made of sheet steel, say 1/1000th of an inch thick, which may be stretched over the rim of a steel wheel in a somewhat similar way to that in which a drum-head is stretched. The spokes of the wheels are arranged to clear the slots in the discs. The sheet steel faces of the two discs face one another and are as close together as possible. The wheels on which the steel is stretched must run with the greatest truth and be accurately balanced.

Alternatively, the so-called centrifugal force of the discs themselves may be made use of to secure their rigidity. In that case the velocity of rotation of both discs may be largely increased, with a proportional gain in steadiness of image and accuracy of representation of objects in motion, since the picture can be traversed a greater number of times per second, but at the expense of increased driving power at the transmitting station. As the overlapping parts of these discs are in rapid relative motion, it is preferable to place them in a vacuum to avoid the attraction consequent upon the diminished air pressure between the discs, caused by their motion.

It is necessary that the co-acting discs 2, 3 shall keep perfect time. They are therefore preferably controlled by a tuning fork and valve system (not shown) as used in the control of the frequencies of wireless waves.

Behind the discs is a photo-electric cell 5, which has a window 11, about one inch square, and which receives the light which passes through the slots in the discs 2, 3. This cell therefore gives a current which at any instant is proportional to the light falling on the small 1/100th of an inch square open area 10 in the said discs. This current is magnified by a series of triode valves (not shown) and imposed on the carrier-wave in the ordinary well-known manner.

In place of the selector consisting of the two slotted discs, Figure 2, rotating with velocities in the ratio of 100; 1, a single disc 12, Figure 3, with a series of pin-holes 13, 14, 15 and 16 etc., about one inch apart arranged spirally may be substituted to produce the same traverse of a small aperture over the picture. The angular distances between the pin-holes 13, 14, 15, 16, etc. are all the same, but the pin-hole 14, is 1/100th of an inch nearer the axis than 13; 15, is nearer than 14, and so on. Thus if the disc is of such a size that there are 100 pin-holes, the last will be one inch nearer the centre of the disc than the first. In each revolution of such a disc, the whole area of a picture one inch wide would therefore be traversed once.

Both of the above described selectors will produce slight distortion of the picture due to the curved path of the aperture. This can be avoided by the method shown in Figures 4 and 5. Here a continuous ribbon 17, preferably of thin steel, is carried over two pulleys 18, 18. The ribbon is pierced with a series of about 100 pin-holes 20, 21, 22 etc. Figure 4, which are about one inch apart, but the hole 21 is 1/100th of an inch nearer the right hand side of the ribbon than 20 and the hole 22 is another 1/100th of an inch nearer the right, and so on. If then, there are 100 such pin-holes, as the ribbon is carried round by the rotation of the pulleys, the whole area of the picture is traversed once. or twice, if two such series of 100 holes are punched instead of one series of 100. The exact number of holes in any of these selectors is determine by the degree of fineness of the reproduction required.

Instead of letting the light enter directly into the photo-electric cell 5 after passing through either of the selectors above described, e. g. the ribbon 17 of Figure 4, a

lens 23, Figure 5, may be used to form an image of the diaphragm 24, of the projecting lens 1, on the active surface of the cell 5. This has the important advantage of distributing the light from every point of the image over approximately the same area of the cell; so that the current given by the cell will not be affected by any variation of sensitivity that there may be in the coating of different portions of the active surface of the cell, as may be the case in the arrangement shown in Figure 1.

The resulting current of varying amplitude from the photo-electric cell is then amplified and impressed on a carrier wave in the usual way, or alternatively, is transmitted directly by electric wire or cable, or otherwise, to the reproducing station.

In one form of the reproducer described below, the electrical circuits must be so arranged that the intensity of the preliminary deflecting fields shall vary inversely (instead of directly) with the light entering the photo-electric cell.

The reproducing apparatus is a cathode tube 26, Figure 6, in the end of which is a fluorescent screen 27. Associated with the cathode tube within or without the said tube are two pairs of coils or plates 28, 29, fixed in planes at right angles to one another to deflect the cathode-stream as in the ordinary Braun tube. One of these coils or plates 28, deflects it horizontally 16 times a second, to correspond with the movement of the slots in disc 3, and the other deflects it vertically 1600 times a second to correspond with the movements of the slot in disc 2. These deflections may be controlled in any convenient way, preferably by a tuning-fork and valve controlled circuit, which also contains a neon lamp, as this, as is well known, (see, for example F. Bedell & H. J. Reich, "Science," IXIII, page 619, June 1926; and W. H. Eccles & W. A. Leyshon, "Electrician," XCVII, No. 2511, page 65, 1926), gives a deflection moving nearly uniformly in one direction followed by a quick return.

Instead of a neon lamp and condenser, a condenser charged periodically and then discharged through a resistance may be used. In either case the circuit is kept in synchronism with the traverse motion of the transmitter as described below. In this way, the whole screen is traversed by the illuminating pencil 16 times a second. If a higher speed is adopted at the transmitting station, these figures must be correspondingly increased. This action alone would produce the effect of a uniformly illuminated field by persistence of vision, but between the source of the cathode rays 30, Figure 6, and the tube 31, or its equivalent, through which they pass before reaching the oscillating system just described, there is a pair of deflecting coils 32, or their equivalent, which is energized by the rectified carrier-wave amplified as much as necessary by valves in the usual manner. The cathode-stream passing through the tube 31, will obviously be weakened to a greater or less extent according to the curvature of path of the electrons which the deflecting coils 32, produce, that is to say, according to the intensity of the signal that has been transmitted by the original photo-electric cell.

In order to ensure that the preliminary deflecting field produced by the coils 32 shall not affect the position of the spot on the screen, the stream in the tube 31 is screened from the influence of this preliminary field by enclosing the tube 31 in a magnetic shield of iron, or one of the new alloys giving good magnetic shielding. If an electrostatic field is used for the preliminary deflection instead of the electro-magnetic one, it is sufficient to make the tube 31 of a good conductor of electricity. The electrons will then move down the tube 31 in straight lines, but as the tube 31 has to be of moderate size in order to obtain adequate brightness of the image on the screen 27, there will still be a tendency for the axis of the stream to be deflected and to spoil the definition.

To counteract this deflection, the method shown in Figure 7 may be employed, where, in addition to the preliminary deflecting field produced by the pair of coils 32, there is a second pair of coils 34, or their equivalent, producing a deflecting field of the opposite sense. In this way the deflection produced by the first field is exactly compensated by the second, and the electrons are restored to their original direction, but are displaced laterally to an amount depending upon the strength of the fields. Thus the electrons will issue from the tube 31, travelling with a velocity and in a direction which are unaffected by this preliminary deflection, and the point of incidence upon the screen 27 will depend only upon the deflections produced by the coils 28 and 29 of Figure 6, which is the condition that must be satisfied if good definition is to be obtained.

A further development of this method is shown in Figure 8, where four sets of deflecting coils 32, 34, 35, 36 or their equivalent, are employed. Of these, 32 and 36 are of opposite sense to 34 and 35. By these deflecting fields the electrons are not only restored to their original direction but they also suffer no lateral translation. An obturating screen 37, is placed between 34 and 35. This method has the further advantage that the deflection may be as large as desired, and yet such electrons as are not cut off by the screen 37 will still pass axially down the tube 31. The tube 31 will, in all these cases, be screened from the fields so that the electrons may travel through it in a rectilinear path. The large deflection possible by this method of varying the intensity of the beam, make the actual construc-

tion of the apparatus easier, by reducing the need for such accurate workmanship. It also makes it possible to shape the screen 37, e. g. by cutting a notch 46, Fig. 11, in its edge, so as to modify the relation between the deflection and the amount the screen cuts off the stream. In case of any want of linear relation between the initial and final light intensities, that is, of the light entering the photo-electric cell 5, and the corresponding illumination of the screen 27, any of the deflecting coils 28, 29 and/or 32, Figure 6, may be replaced by a pair of plates in corresponding positions (i. e. with the normals to their surfaces at right angles to the axes of the coils) and acting electro-statically instead of electro-magnetically. More than one obturating screen 37 may be used.

Also, the tube 31, Figure 8, may be arranged between the filament 30 and the coils 32, 34, in which case, a screen with a small aperture may be placed to limit the beam in the later position of its path.

Instead of arranging the tube 31 so that the undeviated beam passes through it, and the light is progressively reduced as the deflection produced by the coils, or plates 32, is increased, the aperture may be placed as shown at 43 in Figure 7[a], to one side of the direct beam, so that initially all electrons are intercepted and the screen dark. In this case, the deflecting field will cause the electrons to pass in greater or less degree through the tube according to the strength of the field, and the intensity of the light will rise to a maximum value as the deflection is increased. The method employed in Figure 7[a] can also be applied to the arrangement shown in Figure 8, as illustrated in Figure 8[a], by arranging the screen 37 in the position indicated.

A neutral gas, such as argon, may be introduced into the tube 26 and a solenoid 42, Figure 6, may be put round the said tube to increase the intensity and help the concentration of the beam into a point on the screen, and/or a tube 33 may be placed around the filament 30 for the same purpose.

The illumination at any point on the reproducing screen will correspond with that of the corresponding point at the transmitting station, providing only that there is perfect isochronism between the traversing action at the two stations. One way of ensuring this, is to adjust the area of the mask 4, Figures 1 and 5, in relation to the amplitude of the traverse in one or both directions so that there may be an interval of darkness after one aperture has passed over the picture before the next one reaches it. These intervals of darkness are transmitted by the conductor or carrier-wave and are used to synchronize the traverse of the reproducer.

Figure 9 shows diagrammatically the variation in the current from the cell 5, 36[a] being the current due to the picture and 37[a] the dark intervals. These are equivalent to average currents 38[a] and to zero current 39. Thus, if 1600 dark intervals occur every second at the sending station, the carrier-wave at the receiving station is able to keep an oscillating circuit, (which may or may not contain an oscillator such as a fork or piezo-electric crystal) with a frequency of 1600, in phase with it. This circuit will control the deflecting coils or plates 29 of Figure 6. For example, this circuit may be coupled to a second circuit containing inductance and capacity tuned to the same frequency, with or without the addition of a tuning fork or crystal, and containing the coils 29, and either a neon lamp or condenser, or a condenser discharging through a resistance, so as to control the amplitude and phase of the traversing deflection.

After the selector has traversed the picture, a gap is left between the slots, or pinholes, so that there is a comparatively long interval before the selector starts to retraverse the picture. This interval is used in a similar manner to the shorter intervals above referred to, to keep the slower traversing field in the reproducer in synchronism with the transmitter, by causing an oscillating circuit containing suitable capacity and self induction to be in resonance with this slower frequency.

To increase the intensity of the light upon the screen, several pencils may be caused to converge simultaneously upon the same spot on the screen, all the pencils being acted upon simultaneously both by the deflecting field which varies their intensity, and by that which traverses them over the fluorescent screen. For instance, in Figure 10, 39[a], and 41 are blocks in which are drilled or cut a number of fine radiating holes 40 and 42[a]. The electrons from an extended cathode 30 pass in succession through the holes 40, the fields 32[a] and 34[a] of opposite polarity, and then through the holes 42[a]. The holes are so radiated that the electrons all converge upon one spot on the fluorescent screen 27. Their convergence may be aided by the addition of a solenoid surrounding the beam, and/or also by the presence of a residual neutral gas. Fig. 10 is diagrammatic only, and drawn to a greatly enlarged scale. The actual holes would be very close together, e. g., the outermost of ten such holes need not be more than a quarter of an inch apart. Thus the deflection produced by the deflecting field upon all the rays will be approximately equal, and if the screen is so adjusted that they converge to a point before deflection they will continue to do so, approximately.

Other variations in the method of transmitting or re-producing the picture which involve the same principles may be employed. For instance, the oscillating system may use electrostatic fields instead of magnetic fields,

as shown in Fig. 11, where 44 and 45 represent two pairs of such deflecting fields.

It should be observed that as the electrons are being accelerated as they travel from the filament 30 to the aperture in the screen 38, the preliminary deflecting fields 32 and 34, or 32, 34, 35, and 36, will have to have progressively increasing intensities in order to produce equal deflections and restore the stream to its original direction, for example, the coils 32, 34, 35, 36 will have progressively increasing numbers of turns of wire if the same current flows through them in series.

Instead of using the projecting lens 1, Figure 1, or Figure 5, to throw an image on the selector, a transparency, e. g. a cinematograph film or handwriting, may be placed in front of the selector and illuminated by transmitted light, or such a transparency may be projected on the selector by the lens 1. Such a transparency will then be faithfully transmitted and reproduced. Moreover, if a permanent record is desired the cathode stream may be allowed to fall on a photographic plate which would be substituted for the fluorescent screen 27; or the image on the fluorescent screen may be photographed.

Claims—

1. In apparatus for television, means for varying the intensity of a cathode beam traversing the surface of a light-sensitive screen, by a preliminary variable deflection of the beam, proportionate to the varying intensity of the illumination to be transmitted, and means for restoring the original direction of the beam before it enters the traversing field.

2. In apparatus for television, according to claim 1, a deflecting field between the source of the cathode beam and the tube which determines the axial direction and cross-section of the emerging beam, the beam within the tube being shielded from the deflecting field.

3. In apparatus for television, the combination of means for varying the intensity of a cathode beam by a preliminary variable deflection thereof without variation of its direction or velocity, with means for causing the beam to traverse a reproducing surface by a synchronized, two-dimensional, electromagnetic deflection of the beam.

4. In apparatus for television, in which variations of intensity of a cathode beam are produced by a preliminary deflecting field, the use of at least one pair of reversed fields in combination with at least one obturator, to restore the original direction of the beam.

5. In apparatus for television, according to claim 1, the two said means causing the beam to pass in succession through two fields of opposite polarity, before entering the tube which determines the axial direction and cross section of the emergent beam.

6. In apparatus for television, according to claim 3, two pairs of equal fields of opposite polarity to restore the beam to its original direction and correct the lateral displacement of its axis.

7. In a receiver of a television system, a cathode tube, a reproducing screen, a cathode beam traversing the surface of said screen, means for varying the intensity of said beam by a preliminary variable deflection thereof proportionate to the intensity of the transmitted illumination, and means for restoring the original direction of the beam before it enters the traversing field.

8. In a television system, a receiver comprising a cathode beam and a reproducing screen, a source for said beam, a tube receiving said beam for determining the axial direction and cross section of the emerging beam, means producing a preliminary variable deflection of the beam to vary the intensity thereof, means for restoring the original direction of the beam before it enters the traversing field, and means shielding the said tube from the action of the latter two means.

9. In a television system, a receiver comprising a screen and a source for a cathode beam, a tube for receiving said beam to control its emerging direction and cross section, a deflecting field between said source and said tube, and means for shielding the beam within the tube from said deflecting field.

10. In a television system, a receiving apparatus including a cathode beam and its source, a picture receiving surface, means for varying the intensity of said beam by a preliminary variable deflection thereof, the beam having the same direction and velocity after its deflection, and means for thereafter causing the beam to traverse said picture receiving surface by a synchronized, two-dimensional, electrically influenced deflection of the beam.

11. In a receiving apparatus for a television system, in which variations of intensity of a cathode beam are produced by a preliminary deflecting field, the combination of at least two pairs of substantially equal fields of opposite polarity through which the cathode beam passes, one pair acting to deflect and redirect the beam in its original direction while the other pair acts to restore the redirected beam to its original axis, at least one obturator cooperating with said fields, a tube-like member for receiving said intensified and restored beam, and a surface traversed by the beam upon emergence from said tube-like member.

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