Feb. 28, 1939. O. VON BRONK 2,149,001

TELEVISION TRANSMITTING AND RECEIVING APPARATUS

Filed Feb. 17, 1937 2 Sheets-Sheet 1

Fig. 1

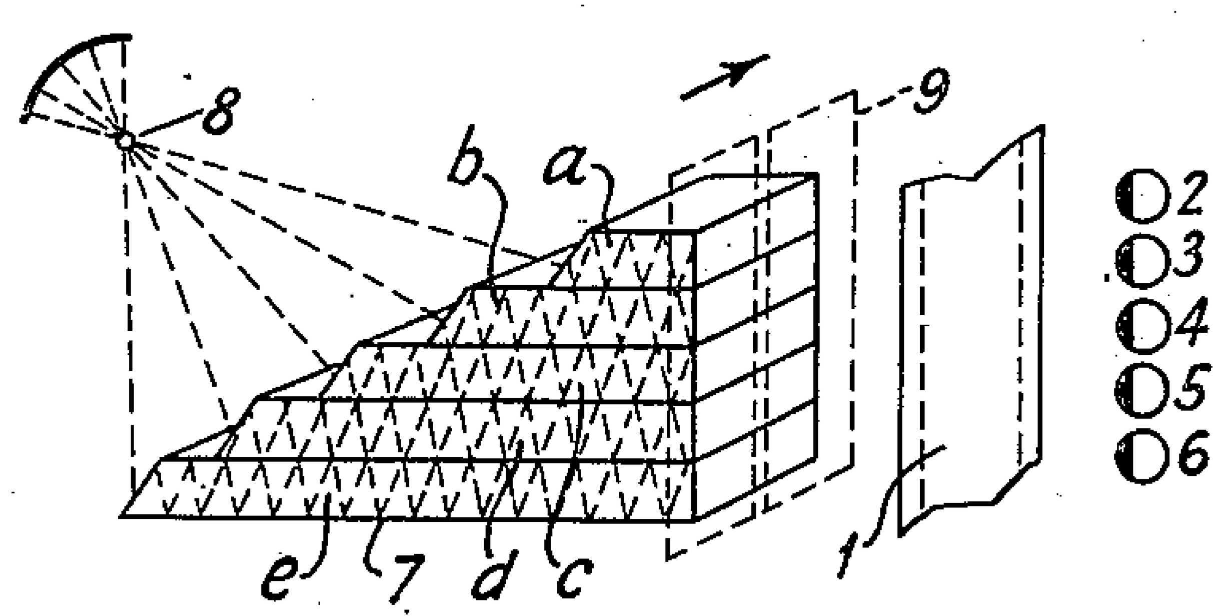

Fig. 2

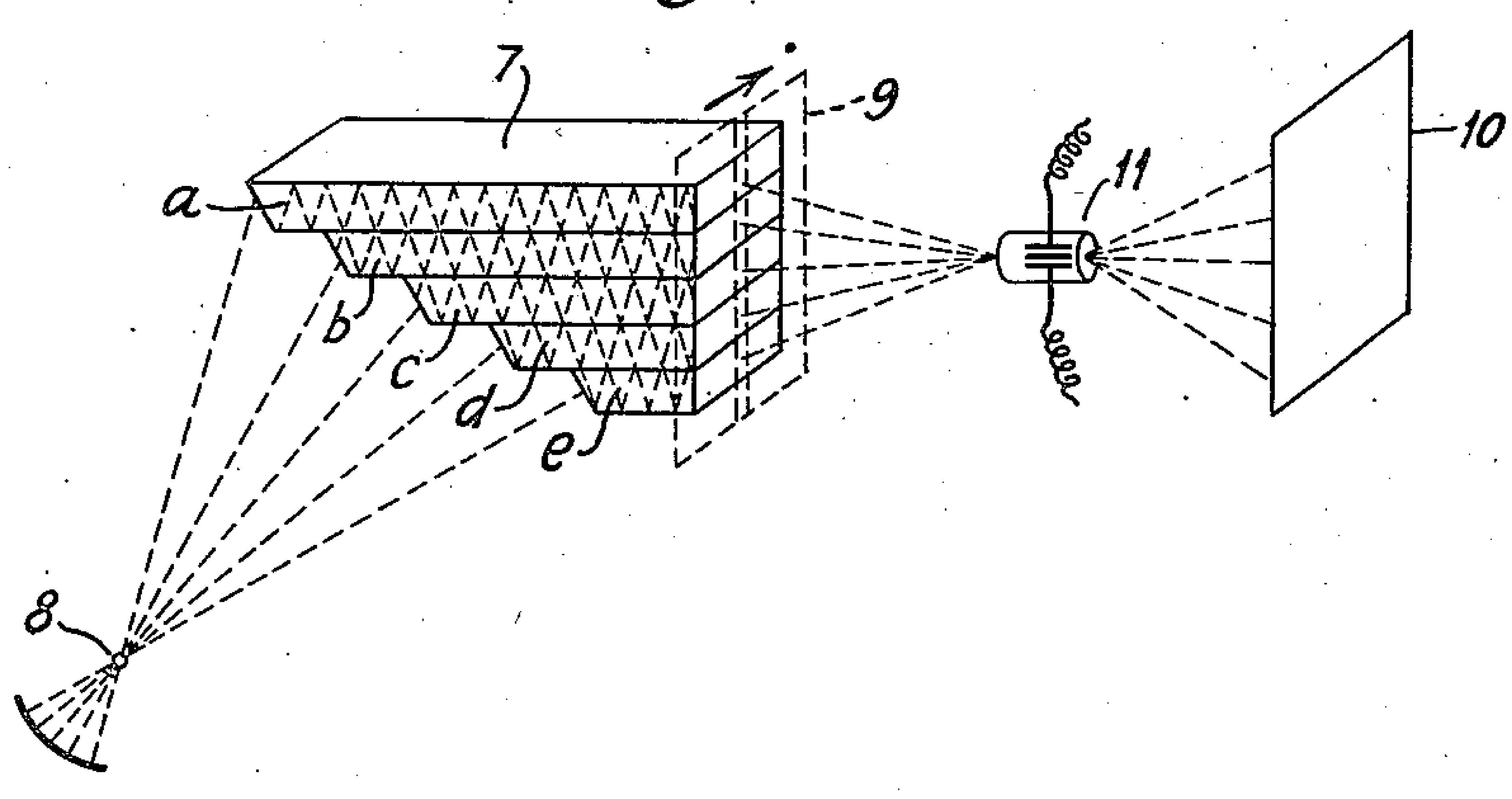

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Fig. 3

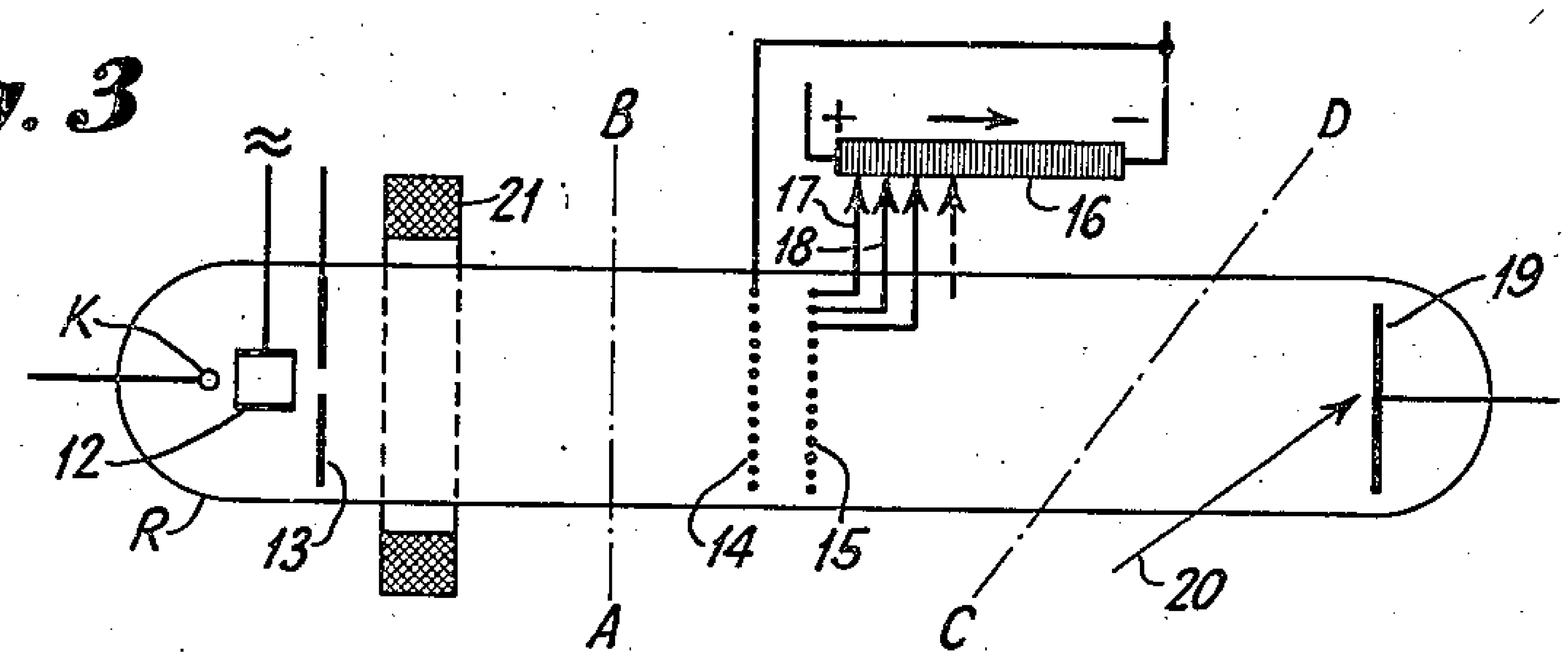


Fig. 4

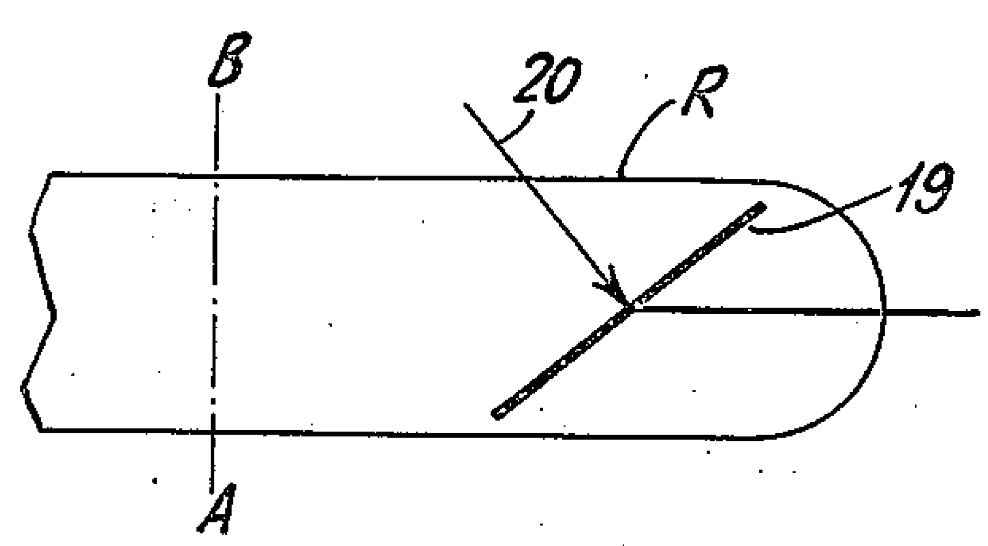


Fig. 5

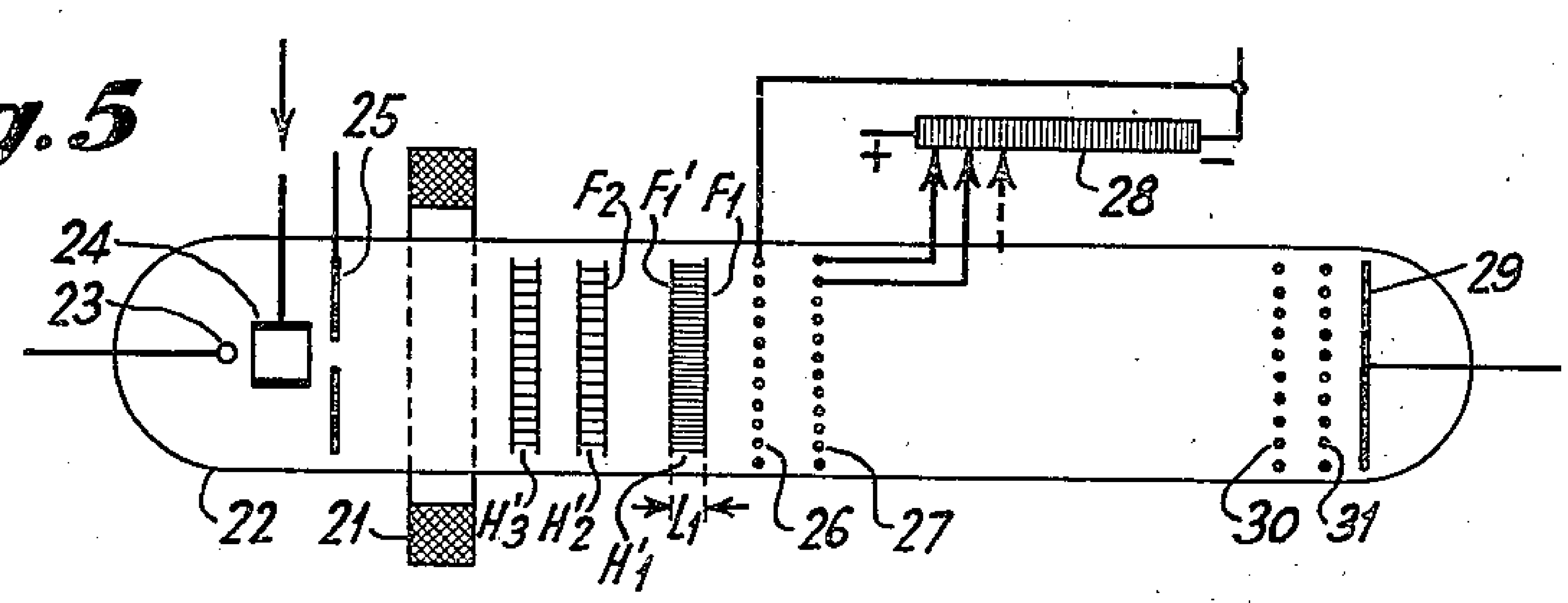


Fig. 9

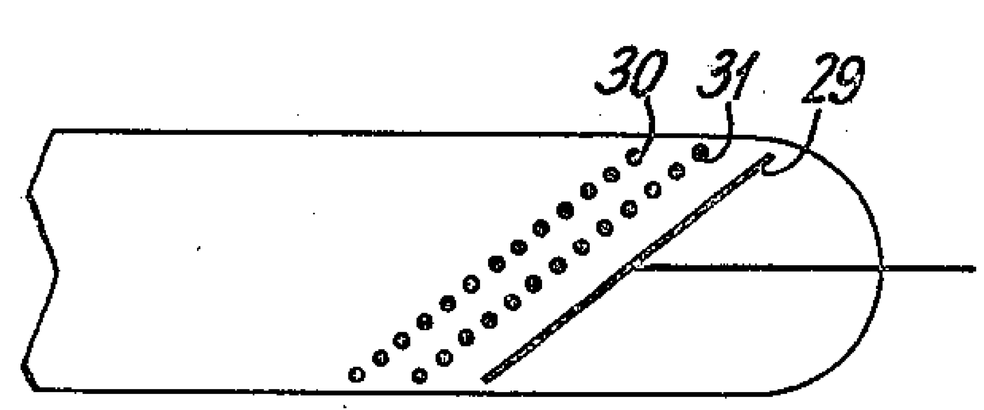


Fig. 6

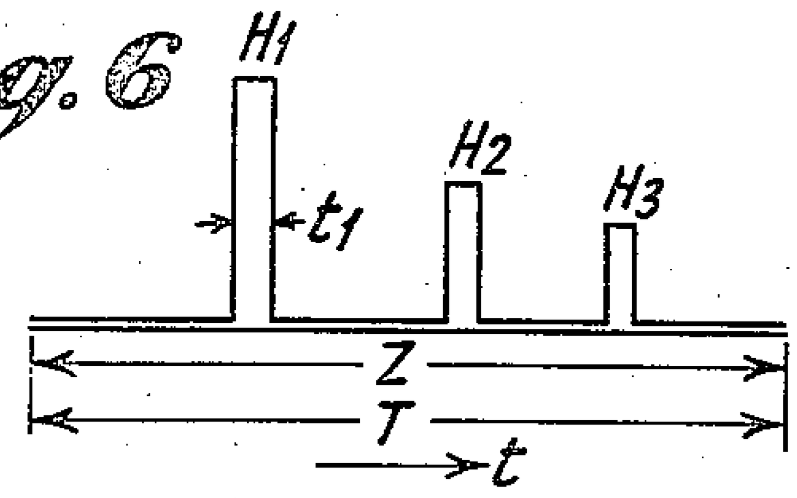


Fig. 8

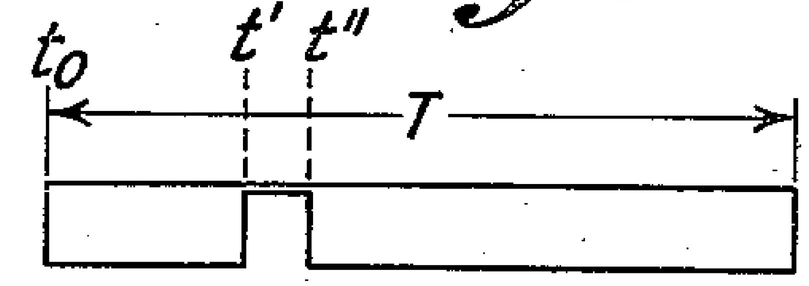
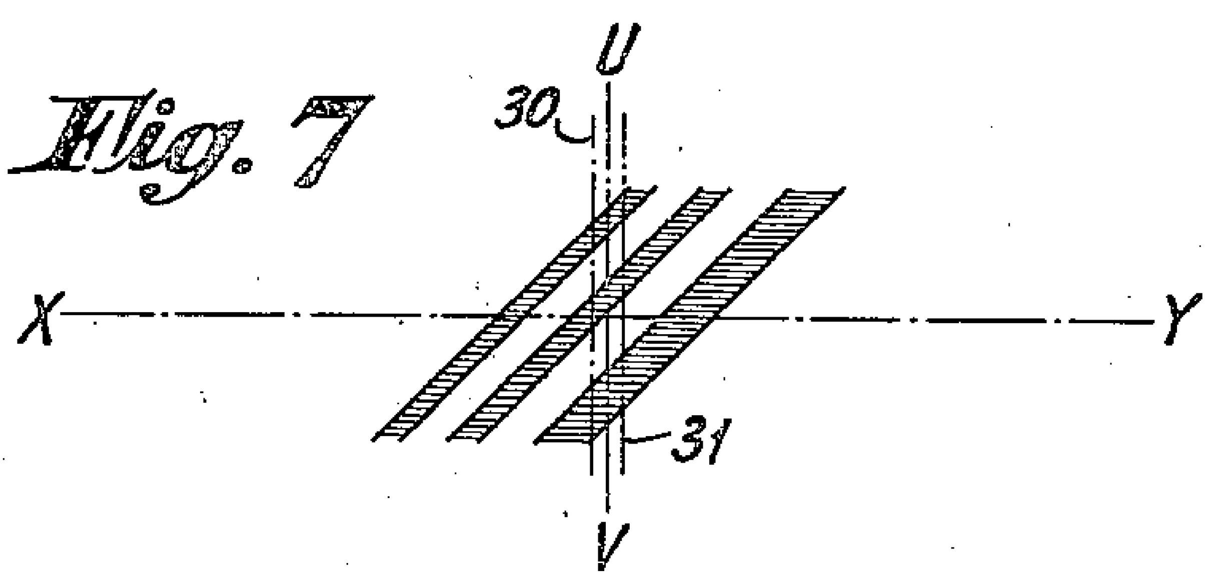


Fig. 7



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UNITED STATES PATENT OFFICE

2,149,001

TELEVISION TRANSMITTING AND RECEIVING APPARATUS

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Application February 17, 1937, Serial No. 126,151
In Germany September 6, 1935

16 Claims. (Cl. 178—7.2)

This invention relates to television transmitting and receiving systems.

In one form of television transmitting system a cathode ray beam is caused to be deflected in both horizontal and vertical directions so as to scan a mosaic screen onto which an image of the object to be transmitted is projected, the action of scanning causing picture signals or impulses to be derived from the screen representative of elementary areas of the image. In reconstituting the image a cathode ray beam is modulated by the transmitted picture signals and is caused to scan or traverse a fluorescent screen both horizontally and vertically in synchronism with the movement of the cathode ray at the transmitter whereby an image of the object transmitted is produced on the fluorescent screen.

In another television transmitting system a Nipkow disc is employed and a light source is projected against the apertures in the disc whereby on rotation of the disc an image or object to be transmitted is scanned by spots of light projected through the apertures in the disc, picture signals representative of the object being thereby developed. A similar disc rotating in synchronism with the disc at the transmitter is employed at the receiver and light modulated by the transmitted signals is projected against the disc in such a manner that an image is reconstituted on a suitable screen.

In the present invention, however, a new principle is involved in that the transmission time of rays such as light rays or cathode rays is varied whereby scanning both at the transmitter and receiver can be effected without in the one case employing rotating discs for scanning and in the other case causing a cathode ray beam which is deflected both horizontally and vertically for scanning the image on screen.

According to the invention television transmitting or receiving apparatus is provided in which for the purpose of decomposing an object to be transmitted into elementary areas in order to obtain therefrom electric impulses suitable for transmission, or for the reconstitution of transmitted impulses representative of a transmitted object, means are provided which are so constructed as to delay the transmission time of suitable rays, for example light rays or cathode rays.

In one form of the invention television transmitting apparatus is provided in which impulses suitable for transmission are obtained by the use of a device which is constructed to delay the transmission of light rays whereby light projected onto said device is caused to emerge therefrom in the form of a series of successive light spots which are employed to effect scanning of a line of an image or object to be transmitted. A suitable shutter or diaphragm may be employed in conjunction with the device for dividing the image or object into lines and in a receiving system a device similar to the one aforesaid may be employed and in this case light modulated by picture signals is directed against the said device, the latter causing the modulated light impulses to emerge from said device in a pre-determined order representative of the elementary areas successively scanned at the transmitter.

In a transmitting system employing cathode rays a cathode ray tube is provided having means for intermittently interrupting the flow of cathode rays, and means for delaying successive portions of the beam during its passage through the tube whereby such portions of the beam are caused to impinge on successive portions of a screen on which an image of the object to be transmitted is projected whereby impulses suitable for transmission can be obtained. In a receiving system employing a cathode ray tube the beam is modulated by transmitted impulses and a similar means is provided for delaying the transmission of the rays through the tube whereby the rays impinge on for example a fluorescent screen in such a manner that an image of the object transmitted is reproduced by the screen. Successive portions of the beam may alternatively be caused to impinge on the screen by disposing the screen at an inclination to the tube axis.

Further features of the invention will hereinafter appear.

In order that said invention may be clearly understood and readily carried into effect, the same will now be more fully described with reference to the accompanying drawings in which:

Fig. 1 illustrates diagrammatically a transmission system in accordance with the invention in which the transmission time of light rays is delayed,

Fig. 2 is a diagrammatic view of a receiving system embodying a device similar to that employed in Figure 1,

Figs. 3 and 4 illustrate a cathode ray tube suitable for the transmission of images in accordance with an embodiment of the invention,

Fig. 5 is a diagrammatic illustration of a cathode ray tube suitable for use in a receiving system,

Figs. 6, 7 and 8 are explanatory diagrams, and

Fig. 9 illustrates a modification of the tube shown in Fig. 5.

Figure 1 shows a transmitter in which the picture to be transmitted can be decomposed into line by a number of photo-electric cells, 2, 3, 4, 5, 6, i. e., with the aid of a stationary optical scanning device 7. As shown the device consists of a stack or tier of glass plates *a*—*e* having a high refractive index, such as quartz or flint glass which may be silvered as hereinafter referred to, the short sides of which are directed towards a light source 8. The glass plates *a*—*e* are arranged in step formation as shown, the individual steps of which offer paths of different length to the light rays emanating from the light source 8. Figure 1 shows—for the sake of convenience—only five steps of the scanner 7, although it is, of course, necessary that as many steps are provided as the number of lines to be transmitted. All other devices necessary for the picture transmission as, for example, amplifier, ultra-short wave transmitter, are omitted and assumed to be known.

The electro-optical process of decomposition in scanning of the picture in the transmitter shown in Figure 1 is as follows:—

The light rays from the light source 8 are projective through the device 7, a slot diaphragm 9 and the picture film 1 against the photo-electric cells 2—6. If the diaphragm 9 is moved relatively to the surfaces of the device 7 as indicated by the arrow, such movement results in the breaking up of the picture into lines. The number of lines depends on the number of the photo-electric cells 2—6 or on the number of the plates *a*—*e* of the device 7. The photo-electric cells 2—6 would not be exposed to the light rays individually in succession, but simultaneously if the source of light 8 were continuous. The source of light 8 is, however, not continuous, but pulsating, or preferably flashing at a predetermined frequency. The light source can be influenced by a high-frequency alternating current so that the necessary intervals occur between the individual flashes. The device 7 comprises a medium for delaying the transmission time of the light. If in addition, as shown, the angle at which the light rays of the light source 8 enter the plates *a*—*e* of the device is so chosen that total reflection occurs at the walls of the plates as by silvering opposite surfaces, the path inside these plates can be so prolonged that only small geometrical differences of length between the various steps *a*—*e* are necessary to cause the required time delay in the transmission of the light. The photo-electric cells of the transmitter according to Figure 1 are, therefore, not simultaneously, but successively exposed in the sequence 2, 3, 4, 5, 6, etc. Although in the example shown a plurality of photo-electric cells are employed, it will be appreciated that in some cases only a single cell may be used.

The receiver is in principle constructed in the same way as the transmitter with the exception that the photo-electric cells 2—6 are replaced by a receiving screen or by the eye. Further, a fast shutter is provided which is only opened at certain times, namely, only when the light impulses arriving from the light source 8 are passing simultaneously in the proper position through the plane of the slot diaphragm 9. The source of light 8 of the receiver radiates the same short light impulses as the source of light 8 of the transmitter which operates in synchronism with the source of light of the receiver.

Figure 2 shows that the receiving device 7 is different from that of the transmitter, since in the transmitter the shortest light paths are arranged uppermost, whereas this is reversed in the receiver in which as shown, the longest paths of light are arranged uppermost. The effect of this is that the first impulse from the source of light 8 modulated by the photo-electric cell 2 of the transmitter which has to travel the shortest distance *a* in the transmitter, must travel through the longest distance in the receiver, namely, through the plate *a* if it passes through the plane of the diaphragm 9 simultaneously with the last impulse modulated by the photo-electric cell 6. The impulses of the source of light 8 must group themselves in accordance with their time of arrival to form the picture required. If at that moment at which the local distribution of the picture points at the diaphragm 9 is correct and the usually closed diaphragm is opened by the fast shutter 11, a portion of the picture will appear in this short time through the diaphragm in the plane 9 of the device 7 of the receiver, corresponding to the past scanned through the diaphragm of Figure 1. It is only necessary that the fast shutter 11 which can be controlled by the source of light 8 is always opened at that moment at which the local distribution of the picture points is correct. If, therefore, the diaphragm 9 is moved further on by one line at a time in the direction of the arrow in synchronism with the movement of the transmitter diaphragm 9 and the fast shutter 11 opened each time, but only as long as the correctly located picture points appear in the plane 9 the whole picture will be visible in the screen 10. It is obvious that the other impulses not correctly located have either not yet passed through the device 7 of Figure 2 or have already left the plane 9 and have, therefore, no effect on the formation of the picture on the screen 10. The diaphragm 9 can be a Kerr cell as the light passing through the device 7 is already polarised in view of the repeated total reflection. The Kerr cell, therefore, requires only the analyser and no polariser.

It is also possible to transmit coloured pictures if the exposure and reproduction is done by colour filters blue, green, red, in a known way.

Instead of employing a mechanical diaphragm 9, etc., the action of the diaphragm may be effected by a second optical device 7, if the plates of the second device are arranged vertically to the plates of the first and the transmission times for the light are correspondingly large. The individual lines are thereby broken up into points. The system according to the invention is particularly suitable for the television transmission of talking films for cinemas.

The invention can also be applied for the scanning and recomposing a picture by means of cathode rays. In accordance with this aspect of the invention a Braun tube can also be used which is so constructed that the transmission time of the cathode rays from their start to the screen in the transmitter or receiver is varied.

Two further constructions based on the invention which deal with cathode ray scanners are shown in Figures 3 and 4 of the drawings.

The picture scanner according to Figure 3 includes within an evacuated glass container R a glowing cathode K, a ray interrupter 12 shown in form of a Wehnelt cylinder and an anode 13. Within the tube 10 are also two grids 14 and 15. The bars of grid 14 correspond in number of the number of lines to be transmitted and are interconnected and connected to one end of a potentiometer resistance 16, whereas bars of grid 15 are connected by the leads 17, 18 etc., with various points of the resistance 16. The scanner screen 19 may, for example, consist of a photoelectric mosaic screen as already known in cathode ray scanners. In the direction of the arrow 20 an optical reproduction of the object to be transmitted is projected on the screen 19. The screen 19 may, however, also consist of a nonsensitive mosaic to which are led electrons originating from a continuous photo layer by means of an electron optical lens.

The method of operation of the cathode ray scanner for the scanning of one line only is as follows:

The scanning of the picture ordinate vertical to the line direction can be effected either in accordance with the principle suggested by the invention or in the usual way by means of magnetic or electrostatic deflection of the cathode ray. A voltage periodically interrupting the cathode ray is applied between the Wehnelt cylinder 12 and the cathode K so that the cathode ray beam leaving the anode 13 and focussed by the electron lens 21 passes through the grid 14 simultaneously at all points of its cross-section. As the cathode ray is periodically interrupted by means of the Wehnelt cylinder 12 a beam front AB occurs between the collector 21 and the grid 14 vertically to the tube axis and progressing towards the grid 14. In view of the different potential which the individual bars of the grid 15 possess relatively to, the grid 14 the electrons are accelerated with different velocities at different points of the beam so that at some distance from the grid 15 the front CD of the ray beam must be inclined to the tube axis. This beam front impinges on the screen 19 not simultaneously, but within a finite period of time, consequently the picture can be transmitted in the same way as it is effected with known cathode ray scanners by the deflection of the scanning ray. The picture signals representing one picture line are emitted successively with a difference of time in the arrangement according to Figure 3 in the same way as with the known cathode ray scanners.

In the arrangement according to Figure 4 the screen 19 is placed inclined to the tube axis and the ray front AB is always vertical to the tube axis. Elements 14 to 18 of Figure 3 are not required with the construction shown in Figure 4, but the elements K and 12 to 21 must of course be employed. The image of the object to be transmitted is projected onto the screen 19 of Figure 4 in the direction indicated by the arrow 20.

The construction shown in Figure 4 also operates in such way that the various points of a line on the screen 19 are successively hit by the beam front so that the transmission of the picture is effected within a certain period of time in the same way as if a picture line were scanned by a deflected cathode ray.

Two receiver constructions using cathode rays in accordance with the invention are shown in Figures 5 and 9. According to Figure 5 a glowing cathode 23, a control arrangement to influence the intensity of the cathode ray represented by a Wehnelt cylinder 24 and an anode 25 are disposed within an evacuated glass container 22, which also contains two grids 26 and 27, the latter being connected with a potentiometer resistance 28 in a manner similar to that described in connection with the grid 15 in Figure 3. The screen 29 of the tube carries fluorescent material; the electron lens 21 causes a parallel distribution of the cathode rays emitted from the anode 25 similar to the arrangement of Figure 3.

In order to explain the method of operation of the construction shown in Figure 5 reference will now be made to Figure 6 in which the light distribution along a picture line 3 is shown for a simple case. The abscissa of this figure can be regarded as "time" since the light values of one picture line are successively transmitted as explained with Figures 3 and 4. The total length of the horizontal distance in Figure 6 corresponds, therefore, with the line duration T. The rays leaving the cathode 23 are modulated at the Wehnelt cylinder 24 corresponding to the light values so that after leaving the anode 25 and after the rays have been distributed in a parallel formation by the electron lens 21 the light values, H_1, H_2, H_3, within the picture line induce a source of rays as shown in Figure 5 by H_1', H_2', H_3'. As long as the light impulse H_1 acts on the Wehnelt cylinder 24 a quantity of cathode rays corresponding to the power of the impulse will pass through the Wehnelt cylinder. The increase of the impulse H_1 in Figure 6 is, therefore, in correspondence with a beam front F_1, which after passing through the electron lens 21 is vertical to the tube axis. The length t_1 of the impulse H_1 corresponds—after the rays have passed through the electron lens 21—with a line L_1 parallel to the tube axis within which line are electrons behind the ray front F_1. The decrease of the impulse H_1 corresponds with a limiting front F_1 which separates the space filled with electrons behind the front F_1 from a space free from electrons which is in front of F_2 (attributed to the impulse increase of H_2). All impulse fronts are at present still vertical to the tube axis. When passing through the grid arrangement 26, 27, the electrons in various parts of the ray cross section are accelerated with varying velocities so that the beam front is caused to assume an inclination to the tube axis at some distance from the grids 26, 27. In Figure 7 the position of the beam fronts is shown at a certain distance from the grid arrangements 26, 27 XY being the tube axis. It will be noted that in the cross section UV the cathode rays have an intensity corresponding to the light distribution along the picture line of Figure 6. It is thus necessary to arrange that only those electrons which are near the cross section UV in Figure 7 should hit the screen and those electrons which are at some distance from UV should be prevented from impinging thereon. This can be achieved by applying a voltage impulse having the line frequency to the grids 30, 31, which are disposed near the cross section UV which permits current to pass only once during the duration of each line for a short period and prevents the passing of rays through the grids 30, 31 during the remaining time. Figure 8 shows the necessary course of the voltage between the grids 30, 31 for the line duration T. From the time t_0 to t' a stop voltage must be present between the grids, i. e., a voltage equal or larger than the sum of the anode voltage (voltage between cathode 23 and anode 25) and the highest voltage between the grids 26, 27. During the period t' to t'' the voltage should be zero or be such as to further accelerate the cathode rays (i. e., the grid 31 must be on a higher positive potential than the grid 30) and from t'' to the end of the line the voltage must be the same of from t_0 to t'.

Another form of construction of the receiving arrangement is shown in Figure 9. In this arrangement the screen **29** is inclined to the tube axis, and the grids **30**, **31** are likewise inclined. Apart from this the receiver according to Figure 9 is constructed in the same way as that shown in Figure 5 with the exception that the grid arrangement **26**, **27** is omitted.

The arrangement according to Figure 9 operates in such a manner that the beam fronts F_1, F_1', F_2, etc., are always vertical to the tube axis over the whole length of the tube. It is obvious that the same effect can be obtained with a beam front always parallel to the tube axis and a luminous screen inclined to the tube axis as with beam fronts inclined to the tube axis and a luminous screen vertical to the tube axis as demonstrated in Figures 3 to 5.

In the arrangements described above with reference to Figures 3 to 5 it is necessary that the electrons after passing through the grids **14**, **15**, in Figure 3 or **26**, **27**, in Figure 4, have to pass a certain distance so that the speed difference over the beam cross section obtained by these grids can cause a sloping of the beam fronts. In the arrangement according to Figures 4 and 9 the sloping of the screens **19** and **29** respectively relatively to the tube axis should not be too small. In order to avoid making the gap too large (in Figure 4) and the length of the tube too long (in Figure 9) it is preferred to operate with voltages as small as possible between anode and cathode and between grids **14**, **15** and **26**, **27** and to obtain the necessary intensity of rays directly in front of the screen **19** or **29** by an additional accelerating field. This constant field may be arranged in the receiver for example, between grid **31** and the luminous screen **29** in Figures 5 and 9. Instead of such an arrangement it is also possible to apply a high acceleration voltage to the cathode rays during the period t', t'' (in place of the zero voltage or the low positive voltage as discussed with reference to Figure 6). If this latter method of introducing an acceleration voltage is employed, one grid only in front of the luminous screen may be used instead of the two grids **30**, **31** and the line frequency voltage impulse aforesaid in this case may be applied between such grid and the screen itself. It is important that the operating voltages can be applied so that the cathode rays in order to obtain larger differences in their transmission time, pass the delay grids with as low speed as possible and are then accelerated to obtain a larger intensity effect on the screen.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed I declare that what I claim is:—

1. In the method of television signalling, the steps which comprise projecting constant radiant energy from a source along a predetermined path toward a surface, periodically interrupting the projected radiant energy at a predetermined frequency, delaying with respect to each other successive contiguous portions of the projected interrupted radiant energy so that the successive contiguous portions of energy arrive at the surface sequentially, variably preventing according to a predetermined pattern portions of the delayed portions of energy from arriving at the surface, and converting those portions of energy which arrive at the surface into a different form of energy.

2. In the method of television signalling, the steps which comprise projecting constant light from a source along a predetermined path toward a surface, periodically interrupting the projected light at a predetermined frequency, delaying with respect to each other successive contiguous portions of the projected interrupted light so that the successive contiguous portions of light arrive at the surface sequentially, variably preventing according to a predetermined pattern portions of the delayed portions of light from arriving at the surface, and converting those portions of light which arrive at the surface into a different form of energy.

3. In the method of television signalling, the steps which comprise projecting a constant beam of electrons from a source along a predetermined path toward a surface, periodically interrupting the projected beam of electrons at a predetermined frequency, delaying with respect to each other successive contiguous portions of the projected interrupted beam of electrons so that the successive contiguous portions of the beam of electrons arrive at the surface sequentially, variably preventing according to a predetermined pattern portions of the delayed portions of the beam of electrons from arriving at the surface, and converting those portions of the beam of electrons which arrive at the surface into a different form of energy.

4. In the method of television signalling, the steps which comprise projecting constant light from a source along a predetermined path toward a surface, periodically interrupting the projected light at a predetermined frequency, delaying with respect to each other successive contiguous portions of the projected interrupted light so that the successive contiguous portions of light arrive at the surface sequentially, variably preventing according to a predetermined pattern portions of the delayed portions of light from arriving at the surface, and photo-electrically converting those portions of light which arrive at the surface into a different form of energy.

5. In the method of television signalling, the steps which comprise projecting a constant beam of electrons from a source along a predetermined path toward a surface, periodically interrupting the beam of electrons at a predetermined frequency, transmitting with respect to each other successive contiguous portions of the projected interrupting beam of electrons with varying velocity so that successive contiguous portions of the beam of electrons arrive at the surface sequentially, variably preventing portions of the transmitted portions of energy from reaching the surface according to a predetermined pattern, and converting the energy which reaches the surface into electrical signals.

6. In the method of television signalling, the steps which comprise projecting a constant beam of electrons from a source along a predetermined path toward a surface, periodically interrupting the beam of electrons at a predetermined frequency, transmitting with respect to each other successive contiguous portions of the projected interrupting beam of electrons with varying velocity so that successive contiguous portions of the beam of electrons arrive at the surface sequentially, variably deflecting the delayed portions of the beam to prevent according to a predetermined pattern portions of the delayed por-

tions of the beam from reaching the surface, and converting the portions of energy which reach the surface into electrical signals.

7. In the method of television signalling, the steps which comprise supplying a source of light of constant intensity, interrupting the light periodically at a predetermined frequency, optically delaying successive contiguous portions of the light, projecting the light upon a surface, variably masking the projected delayed light according to a predetermined pattern intermediate the delaying and projection of the light, and subsequently modulating the intensity of the unmasked light intermediate the masking and the surface.

8. In the method of television signalling, the steps which comprise supplying a source of light of constant intensity, interrupting the light periodically at a predetermined frequency, optically delaying successive contiguous portions of the light, projecting the light upon a surface, variably masking the projected delayed light according to a predetermined pattern intermediate the delaying and projection of the light, and subsequently converting the unmasked light into electrical signals.

9. Television apparatus comprising means for projecting constant radiant energy from a source along a predetermined path toward a surface, means for periodically interrupting the projected radiant energy at a predetermined frequency, means for delaying with respect to each other successive contiguous portions of the projected interrupted radiant energy so that the successive contiguous portions of energy arrive at the surface sequentially, means for variably preventing according to a predetermined pattern portions of the delayed portions of energy from arriving at the surface, and means for converting those portions of energy which arrive at the surface into a different form of energy.

10. Television apparatus comprising means for projecting constant light from a source along a predetermined path toward a surface, means for periodically interrupting the projected light at a predetermined frequency, means for delaying with respect to each other successive contiguous portions of the projected interrupted light so that the successive contiguous portions of light arrive at the surface sequentially, means for variably preventing according to a predetermined pattern portions of the delayed portions of light from arriving at the surface, and means for converting those portions of light which arrive at the surface into a different form of energy.

11. Television apparatus comprising means for projecting a constant beam of electrons from a source along a predetermined path toward a surface, means for periodically interrupting the projected beam of electrons at a predetermined frequency, means for delaying with respect to each other successive contiguous portions of the projected interrupted beam of electrons so that the successive contiguous portions of the beam of electrons arrive at the surface sequentially, means for variably preventing according to a predetermined pattern portions of the delayed portions of the beam of electrons from arriving at the surface, and means for converting those portions of the beam of electrons which arrive at the surface into a different form of energy.

12. Television apparatus comprising means for projecting constant light from a source along a predetermined path toward a surface, means for periodically interrupting the projected light at a predetermined frequency, means for delaying with respect to each other successive contiguous portions of the projected interrupted light so that the successive contiguous portions of light arrive at the surface sequentially, means for variably preventing according to a predetermined pattern portions of the delayed portions of light from arriving at the surface, and means for photoelectrically converting those portions of light which arrive at the surface into a different form of energy.

13. Television apparatus comprising means for projecting a constant beam of electrons from a source along a predetermined path toward a surface, means for periodically interrupting the beam of electrons at a predetermined frequency, means for transmitting with respect to each other successive contiguous portions of the projected interrupting beam of electrons with varying velocity so that successive contiguous portions of the beam of electrons arrive at the surface sequentially, means for variably preventing portions of the transmitted portions of energy from reaching the surface according to a predetermined pattern, and means for converting the energy which reaches the surface into electrical signals.

14. Television apparatus comprising means for projecting a constant beam of electrons from a source along a predetermined path toward a surface, means for periodically interrupting the beam of electrons at a predetermined frequency, means for transmitting with respect to each other successive contiguous portions of the projected interrupting beam of electrons with varying velocity so that successive contiguous portions of the beam of electrons arrive at the surface sequentially, means for variably deflecting the delayed portions of the beam to prevent according to a predetermined pattern portions of the delayed portions of the beam from reaching the surface, and means for converting the portions of energy which reach the surface into electrical signals.

15. Television apparatus comprising means for supplying a source of light of constant intensity, means for interrupting the light periodically at a predetermined frequency, means for optically delaying successive contiguous portions of the light, means for projecting the light upon a surface, means for variably masking the projected delayed light according to a predetermined pattern intermediate the delaying and projection of the light, and means for subsequently modulating the intensity of the unmasked light intermediate the masking and the surface.

16. Television apparatus comprising means for supplying a source of light of constant intensity, means for interrupting the light periodically at a predetermined frequency, means for optically delaying successive contiguous portions of the light, means for projecting the light upon a surface, means for variably masking the projected delayed light according to a predetermined pattern intermediate the delaying and projection of the light, and means for subsequently converting the unmasked light into electrical signals.

OTTO v. BRONK.