May 16, 1939. P. W. WILLANS 2,158,450

ELECTRON DISCHARGE DEVICE

Filed Oct. 5, 1937

Fig. 1.

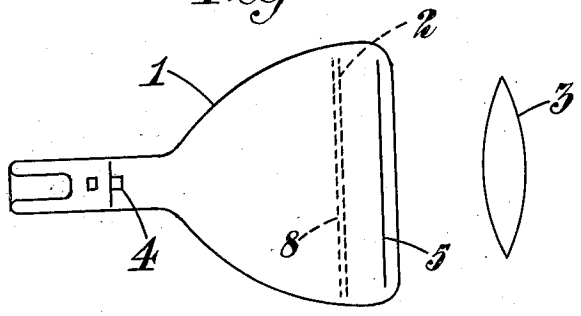


Fig. 2.

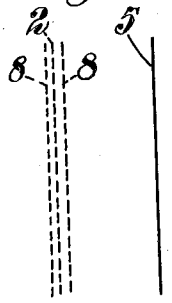


Fig. 3.

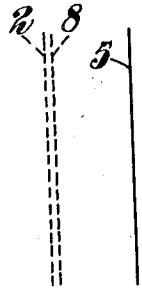


Fig. 4.

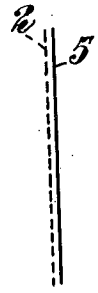


Fig. 5.

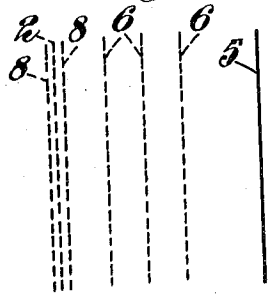
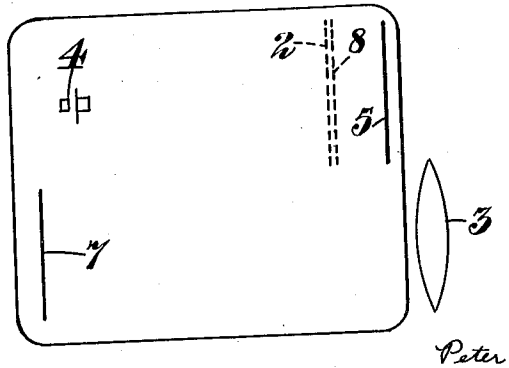


Fig. 6.



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ELECTRON DISCHARGE DEVICE

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Application October 5, 1937, Serial No. 167,445
In Great Britain October 8, 1936

1 Claim. (Cl. 250—153)

This invention relates to improvements in electron discharge devices for the transmission of television or like signals.

A previously proposed method of image analysis comprises forming a charge image spatially corresponding to the illumination of an optical image and passing an electron stream through successive elemental areas of said charge image. The intensity of the electron stream is modified by the charges constituting the charge image and the television signals are formed by collecting the electrons remaining in the stream after such modification.

The apparatus for the purpose of the invention comprises in combination an apertured control electrode on which can be formed a charge image of the kind above referred to, an electron gun and deflecting system adapted to scan the apertured electrode in such a manner that the electron stream from the gun passes through successive elemental areas of the electrode, and a collecting electrode placed on the side of the apertured electrode remote from the gun, which collects the electrons passing through the apertured electrode so as to give rise to a train of television signals.

In an apparatus of this kind, unless the apertured control electrode is arranged at a negative potential with regard to the electron gun, electrons from the scanning beam will pass to the control electrode and may discharge the charge image thereon. On the other hand unless it is arranged at a positive potential the electrons of the scanning beam may not have sufficient velocity to be sharply focussed upon or to pass through the control electrode.

According to the present invention there is provided an electron discharge device for the transmission of television or like signals in which a charge image induced upon a control electrode permeable to electrons spatially corresponding to the illumination of an optical image is used to control an electron stream arranged to pass through successive elemental areas of the said control electrode, characterised in that there is provided means for producing a positive field in the neighbourhood of the said control electrode. In one embodiment of the invention the said means consists of an auxiliary positively biassed equipotential apertured electrode or grid, arranged in juxtaposition to the apertured control electrode on which the charge image is set up.

The combination of two grids of this kind has been described in British application No. 13,302/36 in connection with the formation of an electron image beam and according to a feature of the present invention, an arrangement of grids as therein described is used for the purpose of the method of image analysis described above. The auxiliary grid may be on either side of the apertured control electrode and according to a feature of the invention there may be a grid on both sides of the control electrode.

In a preferred embodiment of the invention, the control electrode is made in the form of a grid having a conducting core coated with a material of high but finite insulation resistance, on the surface of which is formed, according to any of the methods known in the art, a photo-electrically active mosaic surface. This electrode may be termed the storage grid.

An optical image of the subject to be transmitted is projected upon the storage grid so that electrons leave elementary areas of the mosaic surface in varying numbers according to the degree of illumination of the said elementary areas. As a result positive potentials will be set up on the surface of the storage grid relatively to the inner conductor, said potentials being representative of the light and shade of the optical image. Equilibrium is reached in any elementary area when the rate of loss of electrons through photo-emission is equal to the rate at which they are supplied by conduction through the coating of the core of the storage grid.

The auxiliary grid is located parallel and in close proximity to the storage grid and the grids are scanned by an electron beam directed on to the auxiliary grid from a gun situated on the side of the latter grid remote from the storage grid. The electrons are brought into focus on the surface of the auxiliary grid and a part of the beam will penetrate through the meshes of this grid on to the storage grid. The potential of the storage grid is arranged to be always negative in relation to that of the source of electrons, so that the electron stream is retarded after it has passed through the auxiliary grid and its electron density becomes subject to control by space charges determined by the potentials from point to point of the storage grid.

An advantage of the above described arrangement over the use of a simple storage grid of the mosaic type lies in the fact that if the surface of the latter is set at a negative potential relative to the gun in order that the scanning electrons should not disturb the charge image, it becomes difficult if not impossible to focus the scanning beam upon the storage grid surface.

If a collecting electrode be located on the side of the storage grid remote from the auxiliary grid, electrons will be collected by it in

varying numbers according to the light and shade of the successive elementary areas of the image as it is scanned. A train of television signals may then be set up in the circuit of the collecting electrode.

It will be noted that the operation of the device is analogous to that of a thermionic valve, the control of the electron stream by space charge being effected by means of a composite grid the elements of which are given potential values more negative than that at which "grid current" flows. The charge image on the storage grid may then persist substantially unchanged during the process of scanning, an effect which is in marked contrast to the operation of a so-called iconoscope where the charge image is destroyed during the process of scanning and rebuilt during the intervals between successive scans.

As a consequence of this method of operation a greatly increased sensitivity of operation may be obtained; in fact the sensitivity appears only to be limited by the rate at which changes of visual subject matter are likely to take place since, in theory, it is possible to make the insulation resistance of the coating of the storage grid wires as high as is desired. An additional advantage lies in the fact that the output signal comprises a unidirectional component corresponding to the average illumination of the storage electrode, an effect which is not obtained with an iconoscope as normally employed. A further advantage is the absence of the effects, consequent on scanning a mosaic surface with an electron beam, commonly known as "tilt and bend".

According to a further feature of the invention the collecting electrode is made translucent, for example in the form of a coating on the interior of the containing vessel. By this arrangement the storage grid may be brought into close proximity with the wall of the containing vessel and no limits are therefore set in practice upon the shortness of the focal length of any lens that may be used in conjunction with the device. This circumstance conduces to optical efficiency under practical conditions.

According to a modification of the invention the grids may be "one dimensional" in operation, images of elementary strips of the subject to be transmitted being projected in sequence on to the storage grid, as for example by a moving optical system, and the grids being scanned along their length, as previously described by a beam of electrons. The grids in this case may take the form of slotted members.

According to another feature of the invention the storage grid may have an optically sensitive surface of the photo-voltaic type. In this case, since owing to the low internal impedance of a photo-voltaic cell a certain number of electrons in the scanning beam may fall upon the storage grid without discharging the charges thereon, the potential of the storage grid may be made equal to or slightly more positive than that of the cathode.

According to yet another feature of the invention the modulated electron beam may be multiplied by secondary emission after passing through the storage grid electrode. In this case the modulated beam after passing through the storage grid is increased in intensity by impact upon one or more secondary electron emitting surfaces before being collected to produce an image signal.

In order that the present invention may be more particularly described reference is now made to the accompanying diagrammatic drawing in which:

Figure 1 illustrates one embodiment of the invention;

Figures 2, 3 and 4 illustrate alternative modifications of Figure 1; and

Figure 6 illustrates another embodiment of the invention.

In Figure 1 is shown an electron discharge device comprising an evacuated envelope 1 within which is mounted a mosaic electrode 2 comprising a large number of photo-sensitive elements mounted upon but insulated from a support which is permeable to electrons. An optical image is cast by means of a lens 3 upon the electrode 2 which is scanned by means of an electron beam produced by an electron gun 4 and deflected over the electrode 2 by suitable means not shown. The electron beam is modulated by the charges appearing on the elements of the electrode 2 and is thereafter incident upon an optically transparent collecting electrode 5. The current flowing to the electrode 5 at any instant is therefore dependent upon the illumination at that point of the electrode 2 through which the beam is passing and may be utilised as an image signal. Between the gun 4 and the electrode 2 is a grid electrode 8 arranged at a positive potential relative to the mosaic electrode 2. The elements on the electrode 2 may be photoelectrically sensitive or alternatively they may be photo-voltaically sensitive in which case the electrode may be constructed in one of two ways according to whether the "back-wall" or "front-wall" type of photo-voltaic cell is employed.

When the "back-wall" type of cell is employed the electrode is not a true mosaic but preferably comprises a copper grid of appropriate mesh upon which is deposited a layer of cuprous oxide or other appropriate material. The layer of light sensitive material must be made so thin that the resistance of the layer between adjacent picture points may be regarded as high compared with the resistance of the layer from front to back. This condition is necessary in order that loss of definition of a transmitted image shall not occur. An advantage of this type of electrode is that the construction is very simple. It is to be understood that the term "mosaic of photo-voltaic elements" used in the appended claim includes a mosaic employing cells of this type.

When the "front-wall" type of cell is employed the electrode comprises a copper grid upon which a relatively thick layer of cuprous oxide or selenium is deposited. A mosaic of discrete areas of an optically transparent conducting material is then deposited upon the surface of the cuprous oxide, for example by sputtering or evaporation through a mesh electrode.

When the electrode is illuminated electrons flow from the semi-conductor into the mosaic elements and build up charges therein corresponding with the light and shade of the optical image on the mosaic. These charges cannot escape through the semi-conductor as this would necessitate work being done against the photo-voltaic E. M. F.

The embodiment shown in Figure 1 may be modified by including an extra equipotential grid between the electrode 2 and the collecting electrode 5. Such an electrode arrangement is illustrated in Figure 2. Again the electrode 8 may be arranged between the electrode 2 and the electrode 5, as shown in Figure 3, but in this case the electrode 8 must be arranged so that a

positive field penetrates through the interstices of the control electrode **2**.

In another alternative embodiment detail of which is illustrated in Figure 5 the electron beam after passing through the mosaic grid **2** is multiplied by impact upon a series of secondary electron emitting electrodes **6** and is finally collected by the collecting electrode **5**.

Instead of casting an optical image upon the electrode **2** an electronic image may be cast thereupon and an embodiment employing this mode of working is illustrated in Figure 6. In this drawing the image is cast by the lens **3** upon an auxiliary photoelectric cathode **7** and the electrons emitted therefrom are focussed by means, not shown, upon the mosaic electrode **2** which is charged by secondary emission. In this case, of course, the mosaic electrode **2** need not be photoelectrically sensitive.

In the embodiment described with reference to Figure 1 the collecting electrode **5** is transparent but this is not essential. For example the image may be projected upon the electrode **2** through the grid **8** and in this case the mosaic elements on the grid **2** may be formed by evaporation of silver through the interstices of the grid **8** for where the evaporated silver goes light can be projected to form the required image.

Methods of making the mosaic grid **8** are now well known in the television art but in choosing the insulating material the following considerations should be borne in mind. If the area of a mosaic element is A and it is separated from the main conducting structure of the grid by a thickness d of insulating material then the resistance between the element and the main grid structure is $(\rho d/A)$ where ρ is the specific resistance of the insulating material expressed in ohm-cms. units and the capacity between the element and the main grid structure is $(KA.10^{-11}/36\pi d)$ farads where K is the specific inductive capacity of the material. The time constant determining the rate of discharge of the element therefore is the product of these two expressions, that is $(\rho K.10^{-11}/36\pi)$ and for television purposes this time constant is preferably between one-tenth and one-fiftieth of a second but it may be made greater or less for special purposes. An insulating material to give the required value of the product ρK may be found by inspection of tables of physical constants. Alternatively the specific resistance of a given insulator may be adjusted by combining it with metal or a metallic oxide. For example the grid may be insulated by an evaporation process employing for example silica or cryolite as the insulating material and the resistance may be controlled by simultaneously evaporating a conductor, for example silver or tungsten. Again an enamel may be used which has the property of absorbing metallic oxides.

Alternatively again instead of using an insulating material of finite resistivity, one of practically infinite resistivity may be employed and the storage grid potential controlled by an auxiliary source of electrons, the emission and potential of which are controlled to simulate the effect of the grid of the required resistivity. Alternatively, the grid may employ a perfect insulator and charges may be neutralised by an auxiliary cathode ray beam.

I claim:

An electron discharge device for the transmission of television or like signals comprising an evacuated envelope, a source of an electron stream, a storage grid electrode adapted to have a charge image induced thereon, which electrode is permeable to said electrons according to the form of the charge image on said storage grid electrode and is adapted to be maintained at a potential near to that of the source of the electron stream, an auxiliary grid adapted to be positively biased and arranged in juxtaposition to the storage grid electrode, on the side of the storage grid remote from the source of the electron stream so that a positive field penetrates through the interstices of the storage grid electrode, and a collecting electrode placed on the side of the storage electrode remote from the source of electrons, which charge image during operation of the device controls the electron stream which is arranged to pass through successive elemental areas of the storage grid electrode and to impinge on the collecting electrode so as to give rise to a train of signals.

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