

Dec. 2, 1958

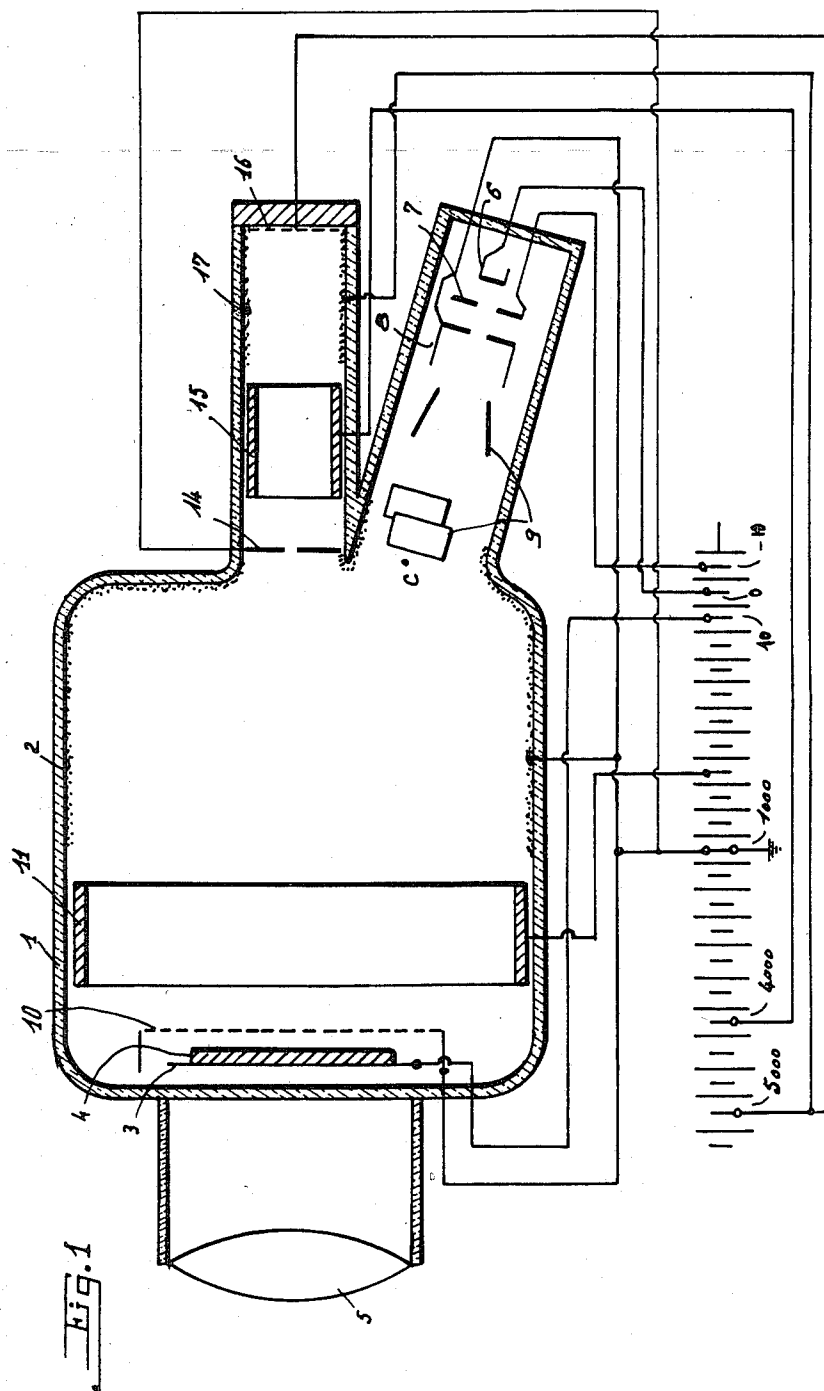
M. BARBIER

2,863,087

PHOTO-CONDUCTIVE ELECTRON DISCHARGE TUBE

Filed May 19, 1953

4 Sheets-Sheet 1



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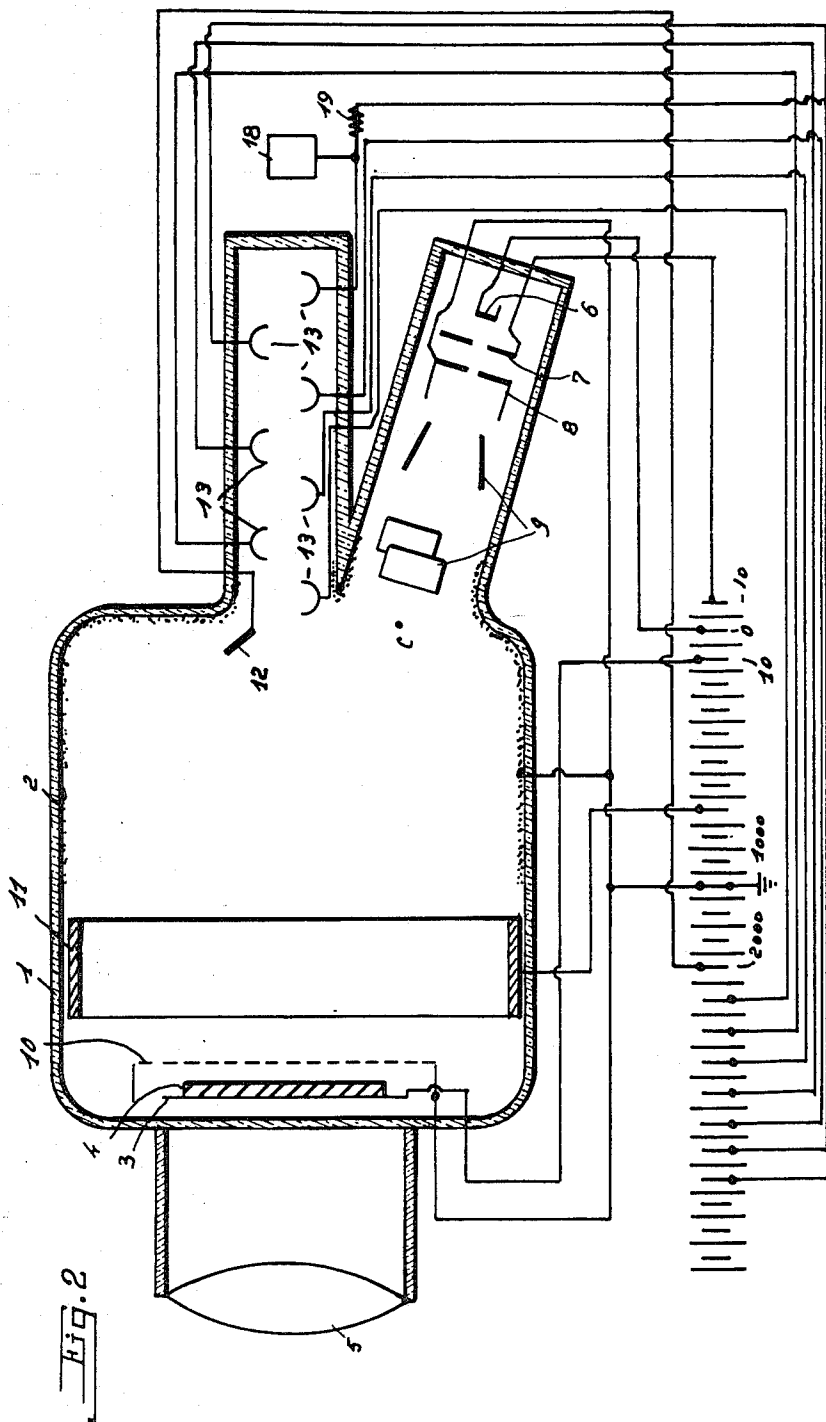
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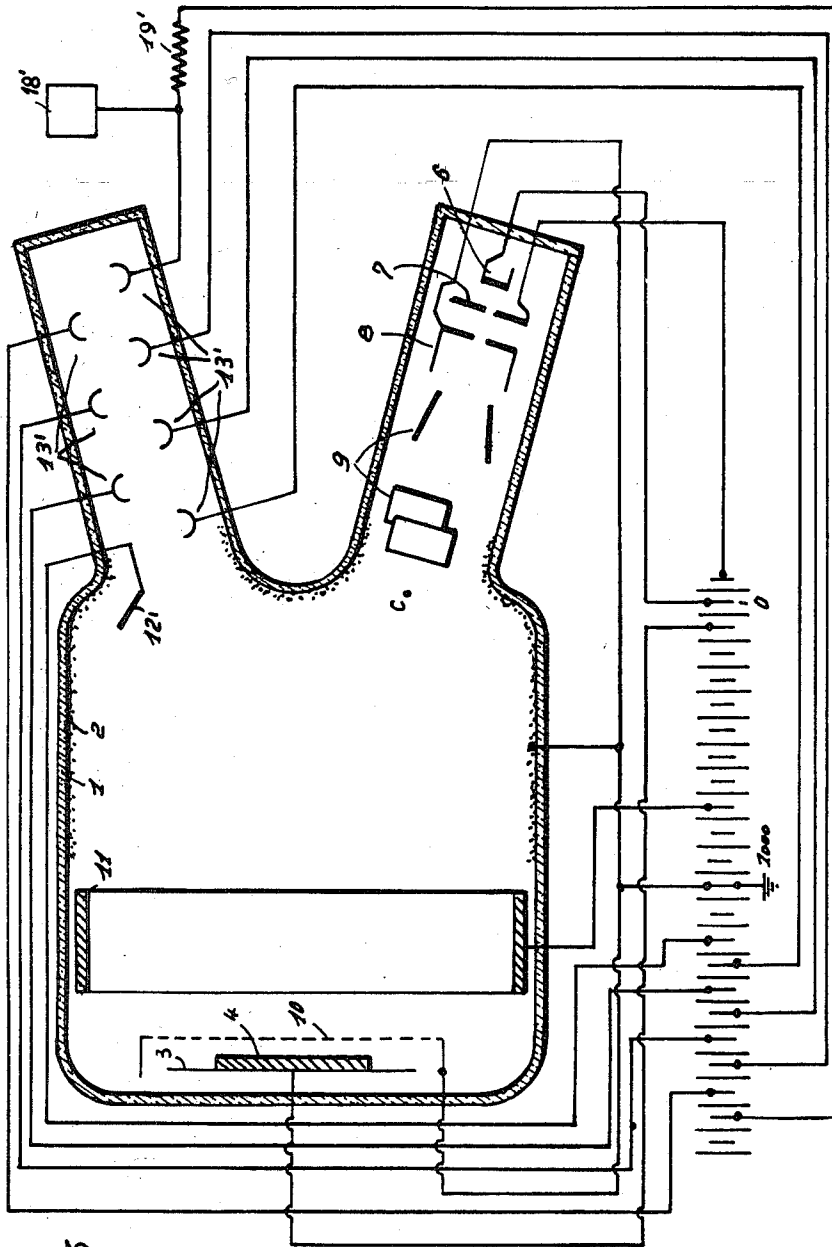


FIG. 3

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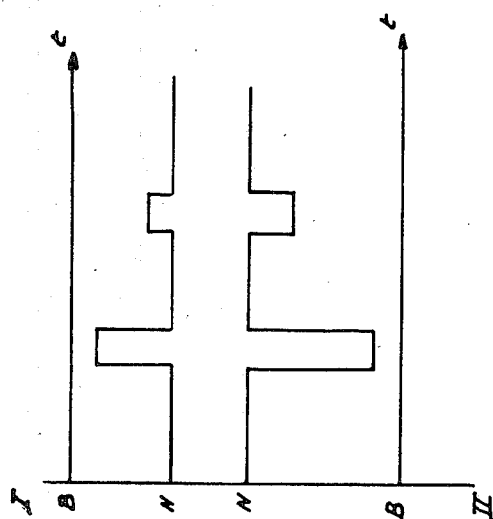
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PHOTO-CONDUCTIVE ELECTRON DISCHARGE TUBE

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2,863,087

PHOTO-CONDUCTIVE ELECTRON DISCHARGE
TUBEMarcel Barbier, Paris, France, assignor to Compagnie
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Application May 19, 1953, Serial No. 356,067

Claims priority, application France May 27, 1952

6 Claims. (Cl. 315—11)

The present invention relates to electron discharge tubes having a photo-conductive cell incorporated therein, more particularly for use as a television camera tube.

Television camera tubes are known the operation of which is based on the phenomenon of photo-conductivity. The advantage of this type of tube over those having a photo-emissive cell incorporated therein is that they have a far greater light sensitivity. A substantially smaller amount of radiant energy is sufficient for a photo-conductive cell to liberate a good number of conduction electrons than is required for a photo-emissive cell to emit the same number. The ratio of these two quantities of energy may be of the order of 100.

Tubes of this nature are based upon the principle that a photo-conductive layer is scanned by an exploring electron beam emitted by a cathode the potential of which is slightly negative relatively to that of the layer. The beam deposits on the layer a coating of negative charges whereby the layer is charged at the same potential as the emissive cathode. Under the influence of incident light, the individual points of the layer which have been irradiated become conductive, as a consequence of which they are capable of discharging toward a metal plate in contact with the layer a portion of the negative charge which they have acquired. Upon renewed scanning with the exploring beam, new charges are deposited in substitution for those which have been discharged toward the metal plate. It is known that this sequence of operations can be used for generating a television signal.

Although a tube of the nature hereinbefore described has an improved sensitivity in comparison with television camera tubes having a photo-emissive layer incorporated therein, it is possible for the latter to overcome the relative disadvantage by the use of electron multipliers. By reason of the fact that it is easier, in the present state of the art, to manufacture photo-emissive cells than to produce a photo-conductive layer, tubes based on the properties of the latter are not in general use. Furthermore, known tubes having a photo-conductive layer have additional disadvantages.

First of all, they require the use of slow electron guns the construction of which is difficult. Beyond that, it is difficult to adapt to the known tubes of this type an electron multiplier of simple construction because the electron optical elements thereof are positioned in the axis of the semi-transparent blade. Finally, there are no tubes in the present state of the art having a photo-conductive layer incorporated therein which are capable of reproducing directly for visual observation on a fluorescent screen positioned inside the vacuum-tight envelope of the tube an image having the property of emitting visible or invisible radiations such as infrared or ultra-violet rays.

The present invention relates to a photo-conductive layer tube devoid of these disadvantages.

In accordance with the present invention, there is provided an electron discharge tube having a photo-conductive layer incorporated therein and comprising an

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electron gun capable of emitting a beam of high velocity electrons by which the layer is scanned, means being provided for slowing down the electrons in the immediate vicinity of the layer. The tube further comprises means for separately collecting the secondary electrons emitted as a result of the bombardment of the layer by the primary electron beam and the primary electrons of the beam reflected by those parts of the photo-conductive layer which are at the same potential as the emissive cathode. Means are connected to the tube for converting the scanning of the layer by the electron beam into an image on a fluorescent screen which is connected to the tube either directly by its incorporation therein or indirectly through a television video chain.

In a preferred embodiment of the invention the photo-conductive layer tube comprises, inside a vacuum-tight envelope, a metal blade having the property of being semi-transparent to light waves and which is connected on one of its faces with a photo-conductive layer. An electron optical system is directed toward the photo-conductive layer, and it comprises, as is well known, an emissive cathode for emitting an electron beam, a control grid, an electron gun having its axis inclined to the axis of the blade, and means for deflecting the electron beam whereby it is caused to scan at least part of the blade. Means are also provided for applying to the blade a low voltage of the order of 0 to 30 volts relatively to the cathode. The characteristic feature of the invention is the provision of means for producing a substantial uniform electrical field in the immediate vicinity of the blade and directed toward the cathode, the lines of force of the electrical field being parallel to the axis of the blade, thus having a decelerating influence on the electrons in the vicinity of the blade.

The tube further comprises an electron lens co-axial with the blade and having a focal plane containing the center of deflection of the electron beam.

An optical image is projected onto the semi-transparent blade by optical means positioned outside the vacuum-tight envelope.

Inside the envelope, collecting means are provided for collecting at least one of the electron beams consisting respectively of the primary electrons reflected by the blade and the secondary electrons emitted by the blade under the impact of the primary electrons absorbed thereby, and for causing one of the collecting beams to inscribe an image upon a fluorescent screen which may be positioned either inside the vacuum-tight envelope or at the end of a video chain connected to the tube.

Preferably the uniform electrical field prevailing in the vicinity of the blade is produced by a planar close-meshed grid of conductive material positioned parallel to the blade. The distance between the grid and the blade is not critical but the mesh thereof is preferably finer than the cross-section of the electron beam. The grid is raised to a high positive potential relatively to the blade of the order of 1000 volts.

The electron lens may be in the form of a hollow conductive cylinder co-axial with the blade and positioned between the blade and the electron optical system, the potential of the lens being positive but less than the potential of the grid.

According to a second embodiment of the present invention, the photo-conductive tube comprises a second electron lens co-axial with the first and situated beyond the focal plane thereof. This second lens acts upon the beam of secondary electrons emitted by the blade under the impact of the primary exploring beam to form upon the fluorescent screen co-axial with the blade an electronic image of the photo-conductive layer. The second lens is preferably in the form of a hollow metal cylinder co-axial with the first lens.

An apertured diaphragm co-axial with the blade and with the two lenses is positioned in the focal plane of the first lens.

A tube according to this second embodiment can project upon the fluorescent screen a directly visible image of the object analyzed by the tube, and it can be used, in particular, for obtaining a visible image of an object which emits exclusively invisible, ultra-violet rays or infra-red rays.

According to a third embodiment of the invention, the tube comprises an electron optical system, a photo-conductive layer and a metal blade as previously described, and furthermore a collector electrode co-axial with the tube and positioned in the focal plane of the electron lens, the function of the collector electrode being to collect the secondary electrons emitted by the photo-conductive layer under the impact of the primary electron beam. This collector electrode is preferably the first plate of a known electron multiplier positioned co-axial with the tube and having a last plate connected to the input of a video chain.

According to a fourth embodiment of the invention, the tube comprises a collector electrode spaced transversely of the axis of the system and positioned in the focal plane of the electron lens, the center of the collector electrode being symmetrical, relatively to the axis of the tube, with the center of deflection of the electron beam. In this embodiment the collector electrode collects the primary electrons of the beam reflected by those points of the photoconductive layer which have acquired by photo-conductivity the same potential as the cathode. This collector electrode is preferably the first plate of a known electron multiplier the output or end plate of which is connected to a video chain.

The invention having been briefly defined will now be described in greater detail, reference being had to the accompanying drawings, wherein:

Figure 1 is a diagrammatic longitudinal section through the plane of symmetry of a first embodiment of a tube according to the invention;

Figure 2 is a view similar to Figure 1 of a second embodiment of the invention;

Figure 3 is a view similar to Figures 1 and 2 of a third embodiment of the invention;

Figure 4 is a graphic representation of the television signals generated by the tubes according to Figures 2 and 3, and

Figure 5 is a view similar to Figures 1 to 3 of an embodiment combining some of the features of the tubes of Figures 1 and 3.

In Figure 1 there is shown a vacuum-tight envelope 1 part of the interior surface of which is coated with a metal layer 2. A very thin metal blade 3, for example a thin layer of platinum deposited on a glass support, is positioned at one end of the tube. This blade is so thin as to be semi-transparent to light rays and it is preferably in the form of a planar disc. One face of the blade is exposed to light projected through the glass envelope of the tube, and the other face is covered with a photo-conductive layer 4. An optical system comprising, for example, a lens 5 coaxial with the blade 3, projects onto the latter an optical image of an object to be analyzed.

An electron optical system comprising a cathode 6, a control electrode 7, a gun 8 and a system of deflecting plates 9 is positioned with the axis of its gun inclined relatively to the axis of the blade 3. The potential of the cathode 6 is taken as the base reference for the potentials of the tube and in these circumstances a source of D. C. voltage is connected to the blade in order to raise it to a potential of 10 to 15 volts.

In the immediate vicinity of the blade, between the blade and the electron optical system a planar grid 10 parallel to the blade and having a close-mesh is raised to a high positive potential of the order of 1000 volts.

The distance between the blade and the grid is not critical, but the mesh thereof is preferably smaller than the cross-section of the electron beam emitted by the cathode 6 and the gun 8. The same potential is applied to the metal coating 2 as to the grid 10 and the gun 8.

An electron lens 11 is positioned between the grid 10 and the electron optical system preferably in the form of a hollow metal cylinder co-axial with the blade. It is raised to a lower potential than the grid of the order of 500 volts and it is so dimensioned as to have a focal plane containing the center of deflection C of the electron optical system. The focal plane of the lens also contains a diaphragm 14 co-axial with the blade and raised to the same potential as the grid. Beyond the diaphragm in the direction away from the blade and co-axial therewith is positioned a second electron lens 15 also in the form of a hollow metal cylinder the potential of which is so calculated as to project upon a fluorescent screen 16 an electronic image of the photo-conductive layer 4. The screen 16 is also co-axial with the blade 3 and the two lenses and it is raised to a potential of the order of +4000 to 5000 volts.

The operation of a tube of this nature is relatively easy to follow when considered first in the static condition where no light impinges upon the photo-conductive layer 4. The electron beam emitted by the electron optical system 6, 7, 8 and 9 scans the layer 4. Since the center of deflection C is positioned in the focal plane of the lens 11, all the electrons will strike the layer 4 with the same incidence. The electrons are first accelerated by the gun 8, then decelerated by the lens 11 and again accelerated by the grid 10. In the space between the grid 10 and the layer 4, the electrons are decelerated by the lower potential of the layer relatively to the grid of 10 to 15 volts as compared with 1000 volts. The longitudinal component of velocity of the electrons extending parallel to the axis of the system decreases but the transverse component thereof remains constant. The electrons impinge upon the photo-conductive layer which is at the same potential as the blade 3, at a velocity which is proportional to the square of the blade voltage of 15 volts. The photo-conductive layer, in the absence of light incident thereupon, behaves as a dielectric element and it, therefore, emits secondary electrons. Due to the low velocity of the incident or primary electrons the rate of secondary emission is less than 1. In other words the emission of a single secondary electron from the layer cannot occur without the impact of a plurality of primary electrons. Consequently, the layer gains negative charges and the potential thereof is lowered by reason of the fact that the electrons are not discharged from the layer until it reaches the potential of the cathode. This potential is a potential of equilibrium because the primary electrons cannot reach it and will be returned toward the grid if the potential of the plate 4 drops to zero. Thus, the potential of all points of the layer is uniformly brought to the same zero or base level as the potential of the cathode. The transverse component of the velocity of the primary electrons remains constant while the longitudinal component of their velocity changes sign, which has, in a way, a mirror effect. The primary electrons are accelerated by the grid 10 and then concentrated by the lens 11 onto a point of the metal coating 2 substantially symmetrical with the center of deflection C of the electron beam relatively to the axis of the tube.

The secondary electrons are emitted by the photo-conductive layer 4 with zero initial velocity in a direction parallel to the axis of the tube and accelerated in that direction by the grid 10. Thus, the first effect of this phenomenon is to prevent the secondary electrons from falling back onto the layer thereby avoiding the phenomenon known as redistribution of secondary electrons. This redistribution which occurs frequently in known tubes causes the appearance of a strain of negative

charges upon impact of a primary electron thereby restricting the clarity of the image of potentials produced on the layer.

The secondary electrons passing through the grid 10 are focused by the lens 11 into the aperture of the diaphragm 14 and accelerated by the lens 15 to impinge upon the fluorescent screen 16 having a potential of the order of 5000 volts.

The foregoing explanation of the operation of the tube is based on the assumption that the photo-conductive layer 4 is not illuminated. If, however, the lens 5 projects a real image of an object on the layer 4, there will be a greater or lesser illumination of the respective points of the layer. Due to the laws of photo-conductivity, the photo-conductive layer which may be assumed for the purpose of approximation as having an infinitely negligible thickness is all the more conductive at each point as the illumination of that point is substantial. This being so, the photo-conductive layer will behave at any given point in the manner of a capacitor shunted by a resistance of lesser value as that point is the more illuminated. The value of the shunting resistance may be considered as inversely proportional to the quantity of light falling upon the point under consideration. The charge accumulated at that point will, therefore, be discharged therefrom after an interval of time t which can be calculated from the formula

$$t = \rho \epsilon$$

ρ being the resistivity of the material and ϵ the dielectric constant. t will be all the greater as the resistivity ρ is large.

It may be assumed that at the end of a sufficiently short interval of time t , the loss of charge on each point responsive to illumination is proportional to the degree of illumination. In other words, each point of the photo-conductive layer will have been subjected to an increase of potential dV proportional to the number of electrons discharged by photo-conductive effect.

It at the end of a duration t the layer is again scanned by the electron beam, the beam will tend to deposit charges in replacement of those which have been discharged and to bring the potential of each point to zero. Secondary electrons will be emitted by each point in a quantity substantially proportional to the difference of potential dV resulting from illumination at the zero potential of equilibrium. The second scanning will give rise, so to speak, to the emission of secondary electrons in a number which will be all the greater as the point is more illuminated. This theoretical explanation sets forth an elementary idea of the various phenomena occurring inside the tube but practical experiments have shown that the theoretical assumptions are completely justified.

The secondary electrons will leave the layer 4 and be accelerated by the grid 10 then focused by the lens 11 onto its focal plane and accelerated by the lens 15 to reproduce on the screen 16 an electronic image of the layer 4. In order that the image on the screen 16 may be sufficiently luminous, it is advisable to accelerate the electrons once more in the zone between the lens 15 and the screen 16, and this may be done by providing a metal coating 17 on the interior surface of this portion of the tube and by raising it to a very high potential of say 5000 volts. The illumination of the screen 16 by the accelerated secondary electrons is proportional to the illumination by the lens 5 of the corresponding point of the layer 4. Thus, the screen 16 will yield an optical image of the object analyzed by the tube through the lens 5.

Apparatus including tubes according to the present invention and more particularly in accordance with the first embodiment hereinbefore described may be constructed for numerous applications of a military nature, for example the detection in darkness of targets which emit

infrared rays such as internal combustion engines. Furthermore, the image is directly visible without having to pass through a television channel as is generally the case with known photo-conductivity tubes.

Figure 2 shows how a tube according to the invention may be used as a television camera tube. The view of the tube of Figure 2 is taken similarly to the view of Figure 1 and the tube of Figure 2 differs from that of Figure 1 in that the apertured diaphragm 14, the electron lens 15, the fluorescent screen 16 and the metallic coating 17 are omitted. All the other elements of the tube of Figure 1 are reproduced in Figure 2 with the same reference numerals.

In the tube of Figure 2, there is provided a collector electrode 12 in the focal plane of the lens 11 at a higher potential than the grid 10. Consequently, this collector electrode 12 receives the secondary electrons emitted by the photo-conductive layer 4. The collector electrode 12 is the first plate of an electron multiplier of known conventional construction, the various plates of which are designated with the reference numeral 13. The output or last plate of the electron multiplier is connected to a video chain 18 and to a load resistance 19.

The operation of the tube of Figure 2 will be readily understood in the light of the preceding explanations given in connection with the tube of Figure 1. After multiplication by the electron multiplier 13 the secondary electrons produce a video signal on the output plate, the intensity of which is proportional to the degree of illumination of the point of the layer 4 struck by the primary electron beam.

Both of the tubes described in connection with Figures 1 and 2 possess, however, a slight disadvantage. The potential of the metal plate 3 is of the order of 15 volts, and the rate of secondary emission is always relatively small, well below unity and generally of the order of 1/10. In other words, in order to produce sufficient brilliance on the fluorescent screen 16 of Figure 1, the secondary electrons must be accelerated in the zone between the electron lens 15 and the fluorescent screen 16 by providing a suitable voltage of the order of 5 kv.

The embodiment according to Figure 2 overcomes this disadvantage at least to some extent, since it comprises an electron multiplier, whereby the video signal can be boosted to a level at which it can be amplified in a conventional video chain.

With the embodiment according to Figure 3 there is another possibility of generating a television signal from the latent image appearing on the photo-conductive layer 4. In Figure 3 there is shown a tube comprising the same elements as those of Figure 2 with the exception that there is no collector electrode in the axis of the tube. In contra-distinction electrode 12' is positioned in the focal plane of the lens 11 symmetrically to the center of deflection C of the electron optical system relatively to the axis of the tube. The collector electrode 12' is the first plate of an electron multiplier 13' of similar construction to that of Figure 2 and having an output or end plate connected to a video chain 18' and a load resistance 19'. The other reference numerals appearing in Figure 3 designate elements similar to those of Figures 1 and 2. In the operation of the tube of Figure 3, the primary electrons emitted by the electron optical system impinge upon points of the photo-conductive layer 4 having greater or lesser charges. The secondary electron emission resulting therefrom reduces the potential of these points to zero in a time interval substantially proportional to the order of magnitude of the charge, by reason of the absorption of a number of primary electrons substantially proportional to that charge.

When the potential of a given point has been reduced to zero, this point will act upon the further electrons of the beam with mirror effect. These further primary electrons no longer impinge upon the photo-conductive

layer but are reflected thereby without losing the component of their velocity directed perpendicularly to the axis of the tube, this component remaining constant. As has been explained above, these reflected primary electrons are focused by the lens 11 upon the collector electrode 12' which is the first plate of an electron multiplier 13'.

Thus, the collector electrode 12' will receive the electron current emitted by the cathode 6 after extraction therefrom of a certain number of electrons varying from point to point of the scanned layer in accordance with the degree of illumination thereof. Practical experiments have shown that the absence of a determinable number of electrons can be used for producing video signals capable of transmitting the image with high fidelity.

Figure 4 is a graphic representation of the signals obtained respectively with the tubes of Figures 2 and 3, curve I being applicable to Figure 2 and curve II to Figure 3. It will be seen in Figure 4, wherein B and N represent respectively the levels of white and black color for equal illumination subject to identity of physical and electrical structural characteristics, that the first plate of the electron multiplier of the tube of Figure 3 receives a video signal of much greater amplitude than the first plate of the tube of Figure 2. The number of the secondary electrons is always low relatively to the primary electrons by which they are caused, since the photo-conductive layer is at a low potential. On the average it can be estimated that up to ten primary electrons are required in order to produce a single secondary electron for a voltage of the order of 15 volts on the photo-conductive layer. The signal collected in the tube of Figure 3 is negative, however, which means that the current picked up by the electron multiplier is maximum for zero illumination at the black level and minimum for maximum illumination at the white level.

In the tube of Figure 2 on the contrary the current collected on the first plate is maximum for maximum illumination and minimum for minimum illumination. Thus, the tube of Figure 2 has a smaller draft than the tube of Figure 3 and the electron multiplier thereof will have to be more powerful for equal illumination in order to give the same signal level at the output.

In Figure 5 there is shown a tube which represents in a way a combination of the tubes of Figures 1 and 3. In Figure 5 the same reference numerals designate the same elements as in Figures 1 and 3. The primary electrons reflected by the photo-conductive layer are put to work to produce video signals while the secondary electrons emitted by the layer are put to work to produce a visual image on the fluorescent screen as in Figure 1. A tube of this nature finds its application in a television camera because it incorporates an electronic viewer combined with the camera.

It is, of course, understood that the present invention is not restricted to the tubes disclosed herein but that it also includes the electronic circuits with which the tubes may be used.

What is claimed is:

1. An electron discharge tube comprising, in combination, a vacuum-tight envelope and, inside the envelope: a semi-transparent metallic blade having a first free face and a second face at least partly covered with a photo-conducting layer, said first and second faces being parallel; an electron optical system directed toward said second face and including at least an emissive cathode, an electron gun having at least one anode, said gun having its axis inclined to the axis of the tube and means for deflecting the electron beam emitted by the cathode and for defining a center of deflection thereby to scan at least part of said second face; means for applying to the anodes of said gun substantial positive potentials relatively to said cathode; means for applying to said blade a low pos-

itive potential relatively to said cathode; a planar close-meshed grid of conducting material in the immediate vicinity of said photo-conducting layer and disposed parallel thereto; means for applying to said grid a potential substantially equal to that of one of the anodes of said gun; means for projecting an optical image through said blade onto said layer; an electron lens between said blade and said gun, said lens being coaxial with said blade and defining a focal plane containing said center of deflection; and means for collecting at least one of the two streams of electrons resulting respectively from reflection off said second face of the electron beam emitted by said system and from secondary emission of said layer under the impact of said beam and for generating a reading signal.

2. An electron discharge tube comprising, in combination, a vacuum-tight envelope and, inside the envelope: a semi-transparent metallic blade having a first free face and a second face at least partly covered with a photo-conducting layer, said first and second faces being parallel; an electron optical system directed toward said second face and including at least an emissive cathode, an electron gun having at least one anode; said gun having its axis inclined to the axis of tube and means for deflecting the electron beam emitted by the cathode thereby to scan at least part of said second face; means for applying to said anode of said gun substantial positive potentials of the order of 1000 volts relatively to said cathode; means for applying to said blade a low potential of the order of 0 to 30 volts relatively to said cathode; a planar close-meshed grid of conducting material in the immediate vicinity of said photo-conducting layer and disposed parallel thereto; means for applying to said grid potential substantially equal to that of said anode; means for projecting an optical image through said blade onto said layer; an electro-static electronic lens comprising a hollow conducting cylinder, said cylinder being positioned between said grid and said electron optical system and having its axis perpendicular to the plane of said blade and a focal plane containing the center of deflection of the beam emitted by said cathode; means for applying to said cylinder a fixed potential of the order of 100 volts less than the potential applied to said grid; and a second lens co-axial with said first lens and positioned beyond the focal plane thereof relatively to said first lens, a fluorescent screen being positioned beyond said second lens and being co-axial with said first and second lenses; said second lens having physical and electrical parameters of a value to cause the secondary electrons emitted by said layer under the impact of said beam to produce an electronic image on said fluorescent screen.

3. An electron discharge tube comprising, in combination, a vacuum-tight envelope and, inside the envelope: a semi-transparent metallic blade having a first free face and a second face at least partly covered with a photo-conducting layer, said first and second faces being parallel; an electron optical system directed toward said second face and including at least an emissive cathode, an electron gun having at least one anode, said gun having its axis inclined to the axis of the tube and means for deflecting the electron beam emitted by the cathode and for defining a center of deflection thereby to scan at least part of said second face; means for applying to said anode substantial positive potentials of the order of 1000 volts relatively to said cathode; means for applying to said blade a low potential of the order of 0 to 30 volts relatively to said cathode; a planar close-meshed grid of conducting material in the immediate vicinity of said photo-conducting layer and disposed parallel thereto; means for applying to said grid a potential substantially equal to that of said anode means for projecting an optical image through said blade onto said layer; an electron lens positioned between said grid and said electron optical system and having its axis perpendicular to the plane of

said blade and a focal plane containing the center of deflection of the beam emitted by said cathode; a collecting electrode co-axial with said electron lens and positioned in the focal plane thereof for collecting secondary electrons emitted by said blade; means for applying to said collector electrode a high potential relatively to that of said grid; and means for connecting said electrode to the input of a video chain.

4. A tube as in claim 3 comprising an electron multiplier co-axial with said lens, said collecting electrode being the first plate of said multiplier; means for connecting the last plate of said multiplier to a video chain.

5. An electron discharge tube comprising, in combination, a vacuum-tight envelope and, inside the envelope: a semi-transparent metallic blade having a first free face and a second face at least partly covered with a photo-conducting layer, said first and second faces being parallel; an electron optical system directed toward said second face and including at least an emissive cathode, an electron gun having at least one anode, said gun having its axis inclined to the axis of the tube and means for deflecting the electron beam emitted by the cathode and defining a center of deflection thereby to scan, at least part of said second face; means for applying to said anode substantial positive potentials of the order of 1000 volts relatively to said cathode; means for applying to said blade a low potential of the order of 0 to 30 volts relatively to said cathode; a planar close-meshed grid of conducting material in the immediate vicinity of said photo-conducting layer and disposed parallel thereto; means for applying

to said grid a potential substantially equal to that of said anode; means for projecting an optical image through said blade onto said layer; an electronic lens positioned between said grid and said electron optical system and having its axis perpendicular to the plane of said blade and a focal plane containing the center of deflection of the beam emitted by said cathode; a collecting electrode positioned in the focal plane of said lens and containing a point symmetrical with the center of deflection of said beam relatively to the axis of said lens; means for applying to said electrode a high potential relatively to that of said grid; and means for connecting said electrode to the input of a video chain.

6. A tube as in claim 5 comprising an electron multiplier having its axis inclined relatively to that of said lens, said collecting electrode being the first plate of said electron multiplier; means for connecting the last plate of said multiplier to a video chain.

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