

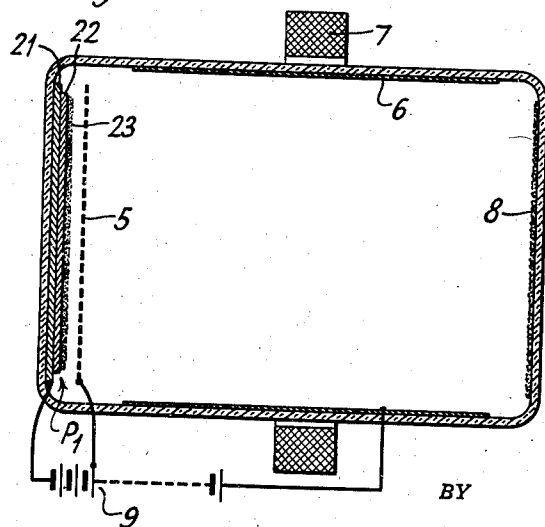
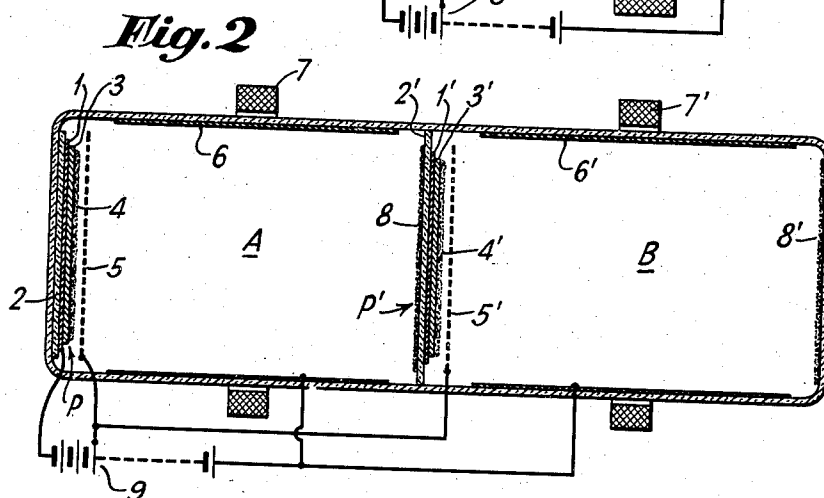
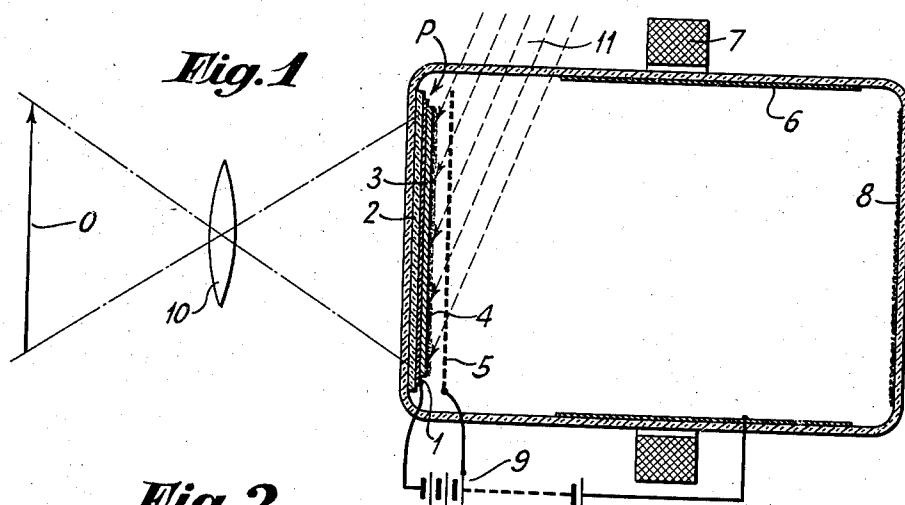
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PHOTOELECTRIC DEVICE

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PHOTOELECTRIC DEVICE

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The present invention relates to photoelectric devices and more particularly to devices such as are used in electron optical systems in which the response of the device over its surface varies in accordance with the local emission of each elementary area.

Hitherto devices of extended area of the type described have generally been of the photoemissive type, formed for example, by oxidising and treating with caesium vapour a layer of silver to render it photoelectric. Such devices are mounted in a suitable vacuum tube and when a picture is projected on to the surface of the device each portion of the photoelectric surface of the device emits electrons in accordance with the local distribution of light over the surface.

However, photoelectric cells of the emissive type have the drawback that their quantum efficiency is low, that is to say, the number of electrons that may be detached from the material per light quantum is small, the efficiency usually being to the order of 10^{-3} . However, photoelectric cells of the kind in which either the conductivity of an element is varied by the incident light or in which an E. M. F. is developed across the element due to the incident light have much greater efficiencies than cells of the photoemissive type, the efficiencies of photoconductive and photo-voltaic cells in some cases approaching unity. However, photoconductive and photo-voltaic cells have the disadvantage that they do not emit electrons into free space.

The object of the present invention is to provide a photoelectric device of the kind above described which will operate with the efficiency of a photo-voltaic or photoconductive cell but which is, in effect, a photoemissive cell.

According to the main feature of the present invention a photocathode is provided having a superficial electron emitting layer comprising effectively discrete emitting elements distributed over its surface and adapted to be rendered continuously electron emissive, said layer being mounted on or closely adjacent to a body whose electrical properties are modified from point to point in accordance with variations in the intensity of illumination over the said body in such manner as to alter the conditions of equilibrium of the emission from point to point in said emitting layer, whereby the emission from said emitting layer can take place in accordance with a predetermined pattern determined by the distribution of the illumination on said body.

According to a further feature of the invention,

a photocathode is provided having a superficial electron emitting layer adapted to be rendered continuously electron emissive, said layer being mounted on or closely adjacent to a body whose electrical properties are modified by variations in the intensity of illumination of the body in such manner that the effective emission from said layer depends on said intensity of illumination.

Where the invention is applied in picture transmitting devices, the electron emitting surfaces may comprise a mosaic of minute emitting elements arranged on a photosensitive support whose conductivity parallel to its surface is small compared with that through the layer, so that the emission from each of the minute cells in the mosaic may be determined by the local illumination of the support, whereby a picture image may be impressed on the beam of electrons emitted by the mosaic.

For example, the electron emitting layer may be a cold cathode such as a photoelectric mosaic rendered emitting by being constantly illuminated there being arranged in front of the emitting surface a positively charged grid electrode by which electrons tend to be accelerated away from the emission surface, the body whose properties cause the variation in the emission when light is incident on the body being a sheet of photoconductive or photovoltaic material of relatively small conductivity parallel to its surface, on which said emitting layer may be formed, and on which an optical image of a picture to be transmitted may be produced whereby the equilibrium condition of said emission is disturbed locally, in accordance with the light and shade of the optical image.

The nature of the invention and the method of carrying the invention into effect will be readily understood from the following description in detail with reference by way of example to Figures 1 to 3 of the accompanying drawing which are diagrammatic representations of embodiments of the invention in picture transformers.

Referring to Figure 1 of the drawing, the photocathode according to the invention is constituted by the assembly of elements indicated by reference letter P. The photocathode P comprises a continuous metal layer 1 which is so thin as to be transparent, supported on the sheet 2 of glass or mica or other suitable transparent material. A layer of photoconductive material 3 for example of zinc selenide, zinc sulphide or selenium with a relatively high resistance parallel to its surface is applied to the metal layer

or formed on the metal layer 1, for example, by settling or evaporating or spraying on to that layer. Above the layer 3 is formed a mosaic 4 of minute photoemissive cells consisting for example of a mosaic of minute oxidised and caesiased silver globules. Arranged in front of the mosaic 4 is a grid 5 which is maintained at a positive potential to accelerate electrons away from the mosaic 4. Behind grid 5 as viewed from the cathode P is a further accelerating electrode system 6 which may for example be a tubular anode having associated with it a magnetic lens constituted by coil 7 which focuses electrons emitted by mosaic 4 and passing through grid 5 on to the fluorescent screen 8. Grid 5 is maintained at a relatively small positive potential, for example, of the order of three volts with respect to the conductive sheet 1, by a suitable source of potential such as the first part of the battery 9 and the anode 6 is maintained at a very high potential with respect to the conductive sheet 1, for example 2000 volts, for example, by the whole of the source 9. An image of an object O which it is required to transmit is projected from the rear of the sheet 1 through the sheet 2 on to the photoconductive layer 3 by means of the optical system represented by lens 10, and the mosaic 4 is flooded with a steady illumination indicated by the beam 11. The face of the photo-conductive layer 3, on which the mosaic 4 is formed is rendered opaque so that the steady illumination of the mosaic 4 has substantially no effect on the condition of the element 3.

It is believed that this arrangement operates somewhat in the following manner. As the photo-mosaic 4 is continuously illuminated and the grid 5 is at a slightly positive potential with respect to the conductive layer 1, as long as no emission penetrates into the photoconductive sheet 3 the emission from each element of the mosaic 4 will continue until the potential of the mosaic is slightly higher than that of the grid 5 in which case an equilibrium condition is established so that electrons emitted by the mosaic are forced to return thereto under the action of the retarding field due to the grid. If now a picture of the object O is projected through elements 2 and 1 on to the photoconductive layer 3 then the conductivity of the layer 3 perpendicular to its surface will be caused to vary over each elemental area in accordance with the local illumination thereof so that current may flow from the conductive film 1 to the elements of the mosaic 4, the current to each element varying in accordance with the distribution of illumination on the element 3. Thus the local emission from the element 4 will vary in accordance with the local illumination of the element 3 and more or less electrons will be emitted from the elements of the mosaic 4 in accordance with said illumination and will pass through grid 5 into the accelerating field set up in anode 6, the beam of electrons so emitted being focussed on the fluorescent screen S to form thereon an image of the object O. Moreover, the disturbance of the variation in the emission of the elements of the mosaic 4 will depend on the effect of the light from object O on the element 3 and will not be determined by response to light of the mosaic 4. Thus the quantum efficiency of the photocathode P will be that of the photoconductive layer 3. It is thus to be seen that the sensitivity of an electrode according to the invention may be increased

in respect of a mosaic electrode somewhere in the order of a thousand times.

As some photoconductive materials are highly sensitive to radiation far into the infra red, devices utilising a photocathode according to the invention may prove useful for fog penetrating devices or for devices for "seeing in the dark."

The control grid 5 in the arrangement of Figure 1 should be as fine as possible in order to necessitate the application of only a small bias potential between the grid and the conductive sheet 1 for full control, owing to the fact that a large grid bias voltage involves the setting up of a large potential difference across the photoconductive layer and thus there is a risk of a breakdown of the insulation.

If the layer 3 is formed of a material having a high specific resistance a flow of current of relatively small density through the element will set up a high potential thereover which is likely to be troublesome. Thus, it is of advantage to form the element 3 of photoconductive materials of low specific resistance, or alternatively, if such materials are not available, it is preferable to use cathodes of large area in order to keep the current density small. Another reason for keeping the bias potential on the grid 5 small is that the potential difference between elements of the mosaic adjacent points on the sheet 3 where the illumination is almost dark and bright respectively will result in chromatic aberration of the electron picture and it is therefore desirable to keep the potential variation between bright and dark elements over the mosaic as small as possible. It will also be advantageous from this point of view to accelerate the photoelectrons between the grid 4 and the fluorescent screen S to so high a velocity that the "chromatic" aberration becomes negligible.

In the case where the maximum potential between elements of the mosaic corresponding to light and dark respectively of the picture is three volts, it is sufficient to accelerate the electrons passing the grid 5 with a potential of 300 volts on the anode 6 to prevent the "chromatic" aberration having any objectionable effect. If necessary it may be possible to compensate this aberration by electron mirrors.

As already mentioned the surface of the film 3 on which the mosaic 4 is supported is rendered opaque. Thus, the interelement spaces of the mosaic 5 are preferably filled by an opaque insulating material. This may conveniently be done by making the elements of the mosaic of regular geometrical shape for example small squares or rectangles, and then putting down an opaque layer of insulating material such as magnesium oxide over the gaps in between the elements.

Instead of preventing the light from the beam 11 from penetrating into the photoconductive layer 3 the light used for the illumination of the mosaic 4 may be of such a wave length that the photoconductive material of the layer 3 is not effective, for example, some photoconductive materials do not respond to blue or ultra violet light, whereas potassium photoemissive cells are known to have a selective maximum in the blue.

Instead of using photoemission from the mosaic a thermionic mosaic kept at an elevated temperature may be used. For example, with a caesium activated mosaic a temperature of 300 to 400° C. is sufficient. Some photoconductive materials operate quite well at these temperatures.

A further possibility is to use secondary emission obtained by irradiating the electrode 4 with a beam of primary electrons, the image of the object O being then impressed on the beam of the secondary electrons. In this case it is possible to use the surface of the photoconductive layer itself as a mosaic.

Thus, instead of the single sided arrangement described a double-sided arrangement in which electron emission is set up from both sides of the layer 3 could be used.

A cathode constructed according to the invention may be used in tubes in which scanning is effected as well as in picture transformers. For example, in the case of a projection tube, the composite electron beam derived from a cathode according to the invention might be received on a mosaic electrode either of the single sided or double sided type such as are used in television transmitting tubes of the projection type. In this case the mosaic can be scanned to derive picture signals for transmission. Alternatively a cathode according to the invention might be arranged in a transmitting tube of the dissector type in which the composite beam emitted from the cathode is scanned across a small aperture to produce the desired signals. Moreover, if desired, instead of using a beam such as 11 in Figure 1 for causing an emission of photoelectrons to form a composite beam from a cathode according to the invention, a fasciculated beam might be used, this beam being caused to scan the cathode and in this way also, picture signals may be produced corresponding to the illumination of elemental area of the optical image produced on the layer 3 of Figure 1.

A cathode according to the invention may also be used in picture amplifiers or intensifiers in the manner indicated in Figure 2 of the drawing. In this arrangement the first stage, A, of picture amplification is similar to the transformer arrangement of Figure 1 same elements of the stage being indicated by the same reference numerals as the corresponding elements of Figure 1. In the case of this stage A the fluorescent screen 8 on which the first electron picture is focussed is settled on the back of a second transparent mica disc 2' similar to the disc 2, carrying a photoconductive assembly 1', 3', 4' similar to the assembly 1, 3, 4, of the stage A. This assembly forms a photo-cathode P' for a further stage of picture amplification B which comprises elements numbered 5' to 8' corresponding to the elements 5 to 8 of stage A, grids 5 and 5' and anodes 8 and 6' respectively being maintained at equal potentials. In such an arrangement as the photoconductive layers are screened from the influence of light arriving through the photoemissive layer in the cathodes P or P', no light from the fluorescent screens 8 or 8' can reach the photoconductive layer of the stage and cause back-ground illuminations. Thus the requirements in respect of the non-reflecting properties of the internal walls of the envelope in which the assembly is housed are not very exacting. It is desirable to match the colour of the fluorescent screen and the spectral response of the adjacent photoconductive material 8 in stage A and the adjacent photoconductive material 3' in the cathode P' of stage B so that the latter has its maximum sensitivity to light in the wave band radiated from the fluorescent screen. It may be possible to use a photoconductive material which has good fluorescent properties as well as being photocon-

ductive, so that the necessity of utilising an additional fluorescent screen is avoided.

If a response for only one waveband is required, suitable filters may be mounted in front of the cathode assembly or the transparent metal film 1 of the cathode might itself constitute a filter and in some cases it might be made thick enough to support the photoconductive layer 3 thereby enabling the supporting plate 2 to be eliminated.

Finally the arrangement may be applied to increase the sensitivity of normal photoelectric cells in which a continuous photoemissive layer is used instead of the mosaic 4 on top of the photoconductive material.

Figure 3 of the drawing shows an arrangement in which instead of a photoconductive material, a photovoltaic material is used to increase the sensitivity of the photocathode assembly according to the invention.

In the arrangement of Figure 3 the cathode assembly comprises a thin transparent film of metal 21, for example, platinum, on which a thin layer of copper 22 is deposited and completely oxidised. On top of the layer of cuprous oxide thus formed a mosaic 23 of silver particles is formed preferably by sputtering through a grid or by sputtering a continuous layer which is subsequently aggregated by heat treatment, the silver particles thus formed being sensitised to light by being caesiated in well known manner. Alternatively, the cathode P1 may be formed by heating a sheet of copper to convert it into cuprous oxide, a layer of silver being sputtered onto the one side of the oxidised sheet and aggregated, and a transparent conducting layer of platinum evaporated on the other side of the sheet. The composite layer may be mounted on a suitable insulating support such as the support 2 of Figure 1 with accelerating arrangements arranged in front of the photocathode and focusing arrangements similar to the elements of 5 to 7 of Figure 1. The potentials V_1 and V_2 respectively of electrodes 5 and 6 are arranged so that if the silver layer 23 is at the same potential as the platinum 21, the emission of photoelectrons from the silver film due to the steady illumination thereof would just be saturated. When no light falls on the cuprous oxide through the plate 21, the potential of the silver particles will become adjusted to an equilibrium value such that just as many photoelectrons are emitted as fall back into the photoelectric layer, so that no electrons will pass the grid 5. When the photovoltaic layer 22 of cuprous oxide is illuminated, however, an E. M. F. will be set up between plates 21 and 23 such that plate 23 will be negative with respect to plate 21 and consequently electrons will be able to pass the grid 5 and be accelerated towards the screen 8.

Theoretically, the arrangement of Figure 3 will, assuming the photosurface 23 has a sensitivity of about 20 micro amperes per lumen, have an over-all sensitivity of about 100 micro amperes per lumen.

We claim:

1. A photocathode comprising a transparent support surface, a thin layer of metal deposited upon said transparent support, a layer of photosensitive material supported upon the thin metal layer, and electron emitting material supported upon said photosensitive layer said material being only in contact with said photosensitive layer and possessing areas from which unobstructed electron emission may emanate.

2. A photocathode comprising a transparent

support surface, a thin layer of metal deposited upon said transparent support, a layer of photosensitive material supported upon the thin metal layer, and photoelectric material supported upon said photosensitive layer said material being only in contact with said photosensitive layer and possessing areas from which unobstructed electron emission may emanate.

3. A photocathode comprising a transparent support surface, a thin layer of metal deposited upon said transparent support, a layer of photosensitive material supported upon the thin metal layer, and a mosaic of isolated photoelectric particles supported upon said photosensitive layer said particles being only in contact with said photosensitive layer and possessing areas from which unobstructed electron emission may emanate.

4. A photocathode comprising a transparent support surface, a thin transparent metal layer supported upon said transparent support, a layer of photoconductive material positioned upon said metal layer and a mosaic of photoelectric particles supported upon said layer of photoconductive material, said particles being in contact only

with said layer of photoconductive material and possessing areas from which unobstructed electron emission may emanate.

5. A photocathode comprising a transparent support surface, a thin transparent metal layer supported upon said transparent support, a layer of photovoltaic material positioned upon said metal layer, and a mosaic of photoelectric particles supported upon said layer of photovoltaic material, said particles being in contact only with said layer of photovoltaic material and possessing areas from which unobstructed electron emission may emanate.

6. A photocathode comprising a transparent support surface, a thin metal layer upon said surface, a layer of photosensitive material containing at least an element chosen from the group consisting of sulphur and selenium, and a photoelectric mosaic of isolated particles supported upon said photosensitive material, said particles being only in contact with said photosensitive material and possessing areas from which unobstructed electron emission may emanate.

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