Jan. 8, 1957 B. KAZAN 2,777,040

LARGE AREA PHOTOCELL

Filed Aug. 17, 1955

Fig. 1.

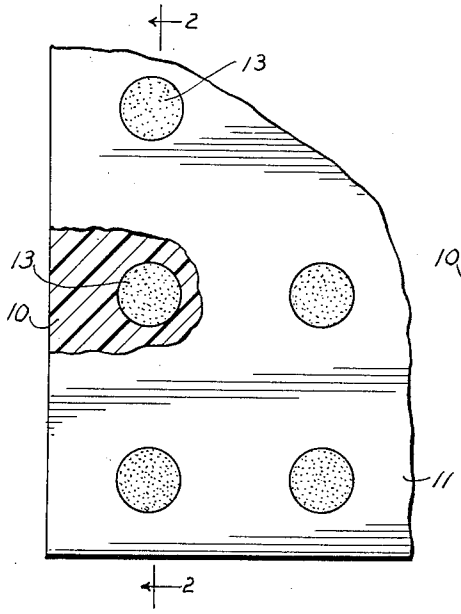


Fig. 2.

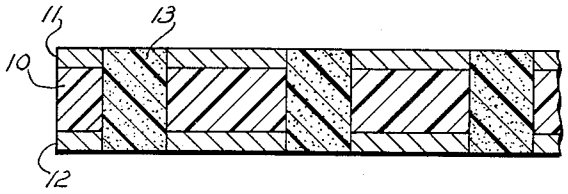


Fig. 4.

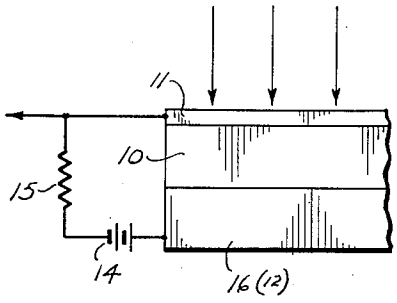
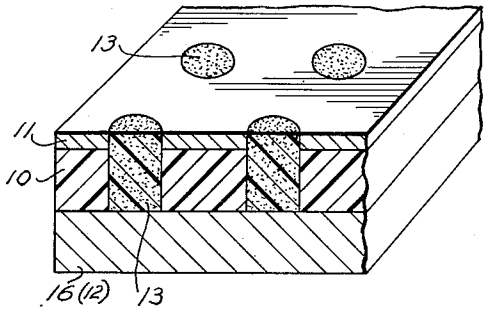


Fig. 3.



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United States Patent Office 2,777,040 Patented Jan. 8, 1957

2,777,040

LARGE AREA PHOTOCELL

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Application August 17, 1955, Serial No. 528,908

13 Claims. (Cl. 201—63)

This invention relates to light-responsive devices and more particularly it relates to light-sensitive devices of the photoconductive kind and of large surface area.

A principal object is to provide a light-sensitive device of the photoconductive kind having any desired surface area extent.

Another object is to provide novel methods of manufacturing large area light-sensitive devices.

A feature of the invention relates to a light-sensitive device which can be manufactured in flexible strip or sheet form and from which individual devices of any desired surface extent can be cut.

Another feature relates to a novel manner of making a photoconductive device in the form of a composite plastic and photoconductive material, wherein the photoconductive material is distributed at a multiplicity of accurately spaced points throughout the surface of the device.

Another feature relates to a photoconductive device constituted of a flexible carrier of normally insulating material such as an insulating plastic or glass or the like which is provided on opposite faces with respective conductive coats and with at least one conductive coat provided with windows in registry with corresponding perforations in the insulating material, forming a multiplicity of cavities containing a photosensitive, variably conductive material.

A further feature relates to a light-sensitive device constituted of an electrostatic condenser, comprising an insulating film dielectric, the opposite surfaces of which are provided with conductive layers and with a multiplicity of leakage paths between said conductive layers constituted of a multiplicity of discrete variably conductive fillings in respective perforations extending through the dielectric and contacting said conductive layers.

A still further feature relates to the novel organization, arrangement, and relative location and composition of parts, which constitute a large area photoconductive device which can be economically manufactured for example in continuous sheet-like form.

Other features and advantages will appear from the ensuing descriptions, the appended claims, and the attached drawing.

In the drawing which shows, for exemplification purposes, certain preferred embodiments,

Fig. 1 is a highly magnified plan view of part of a photoconductive device according to the invention;

Fig. 2 is a sectional view of Fig. 1 taken along the the line 2—2 thereof, and viewed in the direction of the arrows;

Fig. 3 is a highly magnified perspective view of a modification of Figs. 1 and 2;

Fig. 4 is a schematic diagram showing the manner of connecting and using the device of Figs. 1, 2, and 3.

Referring to the embodiment of Figs. 1 and 2, there is shown a highly magnified portion of a photoconductive sheet according to the invention, wherein the numeral 10 represents a sheet or film of insulating material such as plastic, glass, ceramic or the like. In one embodiment of the invention, the sheet or film may be of any flexible insulator or elastomer, such for example as a thermoplastic or thermosetting resinous material, of which well known polyvinyl alcohol films are typical. It will be understood, of course, that the invention is not limited to any particular composition of the plastic sheet, provided it is normally an electric nonconductor. The plastic sheet 10 is then subjected to any well known perforating operation whereby it is provided with a multiplicity of minute perforations through its thickness. The number and size of these perforations and their spacings can be chosen in accordance with the desired sensitized area for the finished device. Likewise, the thickness of the plastic film 10 is not critical, but may be of the order of .010 inch. Furthermore, while the drawing shows the perforations as of circular shape, they may be of any other shape.

The opposite surfaces of the perforated plastic film 10 carry respective electrically conductive coats 11 and 12 which are preferably permanently bonded to the said surfaces of the plastic film. Any suitable conductor material may be used, such for example as silver paint, although any other metal or non-metal conductive material may be employed. The conductive coating may be opaque or partially or completely transparent. The electrical conductive coatings 11 and 12 may be applied, for example, by spraying, brushing, dipping, etc., it being understood that the coatings are such that they do not bridge or cover the perforations in the plastic sheet 10. These conductive coatings 11 and 12, since they cover the entire opposite surfaces of the plastic film except at the perforated areas thereof, constitute the opposite electrodes for the device.

After the electrodes have been applied to the plastic 10, the perforations therein are filled in with a photoconductive material 13, of which cadmium sulfide, antimony trisulfide are typical. It will be understood that any other well known photoconductive material may be employed for this purpose, providing it is normally and substantially a non-conductor when not exposed to light rays but which becomes a conductor in accordance with the intensity of the light rays incident thereon. The photoconductive material may be provided in the perforations by dipping, painting or the like depending on the way the material is prepared. Since the photoconductive material 13 may be powdery, it is, in accordance with another feature of the invention, held together with a suitable binder which may be, for example, ethyl cellulose dissolved in amyl alcohol. It will be understood, of course, that the invention is not limited to any particular binder that may be used for this purpose. It will also be understood that the photoconductive material may be compacted within the perforations in the plastic sheet while in the dry state. However, the mixture of the binder and photoconductive material can be filled into the perforations while the mixture is in a fluid or semi-dry condition, and then the mixture can be dried to form a permanent bond with the peripheral wall of each perforation. Preferably, each perforation is filled with photoconductive material so that the said material is flush with the surface of the coatings 11 and 12. If desired, however, a suitable light-transparent protective coating (not shown) of plastic or other similar material may be applied over the filled perforations. After the plastic sheet has been processed and filled with the photoconductive material as above noted, it may be cut into any desired length or shape.

In using the sheet, the conductive coatings 11 and 12 are connected to a source of direct current potential, represented schematically in Fig. 4, by the battery 14 and in series with a suitable load device such as a resistor 15

for coupling to a suitable amplifier (not shown). When neither of the opposite surfaces of the sheet is exposed to light, negligible current flows between the coatings 11 and 12 and, therefore, negligible output signal voltages are produced. However, when either or both the opposite surfaces of the sheet are exposed to light of varying intensity, corresponding currents flow through the sheet and develop corresponding signal voltages across the load resistor 15.

One of the important advantages of the type of device described above is that since it can be made in thin sheets or films, it can be manufactured in a continuous process and can be wrapped or wound in suitable rolls. Another advantage is that the sheet is light-sensitive on its opposite sides so that it can be used for any desired purpose, for example to compare the intensity of two lights which impinge on opposite sides of the sheet.

In certain fields of usefulness, it may be desirable to have only one side of the sheet light-responsive. In that case the perforated plastic film or sheet 10, carrying the photoconductive material 13, can be provided on one side with the thin, flexible conductive paint or coating 11, but without covering the material 13, while the other side may have attached or bonded thereto any non-perforated opaque conductive material 16, such as a solid metal, which extends over the entire face of the plastic.

In one particular sample according to the embodiment of Figs. 1 and 2 that was found to produce the desired results, the plastic layer 10 had a thickness of .010 inch and it was perforated with perforations having an average diameter of approximately .040 inch and with approximately 144 perforations to the square inch. Such a device gave, for an applied potential of 300 volts and for 1 square centimeter of surface area, an output current through the load resistor 15 of approximately 5 milliamperes in ordinary room lighting, while in the dark the said output current was reduced to .002 microampere. Likewise a sample made according to the embodiment of Fig. 3, with a plastic thickness of approximately .010 inch and with the same size and distribution of perforations and for an applied voltage of 300 volts and for a surface area of 2.5 square inches, produced an output current of approximately 100 milliamperes in ordinary room lighting and only .2 microamperes in the dark.

Various changes in the materials and the dimensions hereinabove mentioned may be made without departing from the spirit and scope of the invention. For example, while reference has been made to the perforating of the plastic sheet and then the application of the electrode coatings, it will be understood that the perforating operation may be performed after the conductive coatings have been applied to the plastic sheet.

What is claimed is:

1. A light-sensitive device, comprising a layer of insulation having at least one perforation through its thickness, a quantity of light-responsive material in said perforation, a conductive sheet on at least one surface of said insulation layer and integrally bonded thereto, said conductive sheet having a window in registry with the said perforation, and another conductive sheet integrally bonded to the opposite surface of said insulation layer, both of said sheets constituting contact electrodes between which the conductivity is varied by said light-responsive material when subjected to incident light.

2. A light-sensitive device, comprising a sheet of insulation having a plurality of discrete perforations through its thickness, a quantity of light-responsive material in each perforation, and electrode means in contact with the opposite faces of said sheet and with the said light-sensitive material.

3. A light-sensitive device, comprising a sheet-like dielectric having its opposite surfaces provided with conductive coats to form an electrostatic condenser, and means providing a multiplicity of light-responsive leakage paths of variable conductivity between said conductive coats, the last-mentioned means comprising a plurality of cavities extending through the dielectric and each cavity having a filling of light-responsive variably conductive material contacting said conductive coats.

4. A light-sensitive device of the variable conductivity photo-responsive kind, comprising a plastic sheet having a plurality of discrete perforations through its thickness, each of said perforations having a filling of a material which is substantially an electric non-conductor when unexposed to light but which varies its conductivity in accordance with light incident thereon, and conductive electrode means carried by the opposite faces of said plastic sheet for making contact with the material in each perforation and thereby to provide a light-responsive variably conductive path between said electrodes.

5. A light-sensitive device of the photoconductive kind, comprising a layer of insulation having a multiplicity of discrete cavities therein, a filling of photoconductive material in each cavity, first electrode means for making electric contact with the corresponding ends of the fillings in each cavity, and other electrode means for making electric contact with the opposite corresponding ends of the fillings in each cathode.

6. A light-sensitive device of the photoconductive kind, comprising a plastic film having a multiplicity of perforations through its thickness, a filling of photoconductive material in each perforation, a conductive electrode integrally bonded to one face of said film and having a multiplicity of openings each in registry respectively with a corresponding perforation in said film, and another conductive electrode carried by the opposite face of said film.

7. A light-sensitive device of the photoconductive kind, comprising a plastic film having a multiplicity of perforations through its thickness, a filling of photoconductive material in each perforation, a conductive coat on one face of said film and another conductive coat on the opposite face of said film, at least one of said coats having a multiplicity of perforations in registry respectively with the perforations in said film.

8. A light-sensitive device of the photoconductive kind, comprising a plastic film having a multiplicity of perforations through its thickness, a filling of photoconductive material with a binder in each perforation, a conductive electrode coat integrally bonded to one face of said film and having a multiplicity of perforations in registry with the perforations in said film, another conductive electrode coat integrally bonded to the opposite face of said film and having a multiplicity of perforations in registry with the film perforations, the filling in each of said perforations being in contact with said coats to provide a light-responsive variably conductive path therebetween.

9. A light-sensitive device of the photoconductive kind, comprising a laminated body consisting of an insulating plastic sandwiched between and integrally bonded to oppositely disposed sheet-like conductor electrodes, said plastic having a multiplicity of perforations through its thickness, each perforation having a filling of a photoconductive material, one of said electrodes having a similar multiplicity of perforations through which said fillings are exposed, the other electrode being in electrical contact with all of said fillings but being opaque.

10. A light-sensitive device of the photoconductive kind, comprising a flexible sheet of insulating plastic having a multiplicity of perforations through its thickness, a filling of light-responsive variably conductive material in each perforation and extending beyond the opposite faces of said insulating plastic, and electrode coats on opposite faces of said plastic for contacting the said extending ends of said fillings, at least one of said conductive coats having a series of perforations for exposing the fillings therein to light excitation.

11. The method of making a photosensitive device, which comprises providing an insulating sheet with a multiplicity of perforations, filling the perforations with photo-

responsive material of the variably conductive kind, and applying electrodes respectively to the opposite surfaces of said sheet, with at least one electrode having a series of openings in registry with said perforations to expose the photoconductive material therein.

12. The method of making a photosensitive device, which comprises coating a surface of a plastic insulating sheet with a conductive material, perforating the coated sheet with a multiplicity of perforations, filling the perforations with photo-responsive material of the variably conductive kind and applying electrode means to the opposite surface of said sheet to make contact with the material in the respective perforations.

13. The method of making a photosensitive device of the large area kind, which comprises perforating an insulating sheet with a multiplicity of discrete perforations,

filling the perforations with photo-responsive material of the variably conductive kind, applying electrode surfaces to the opposite faces of the sheet to make contact with the material in the said perforations, one of said electrode surfaces having a multiplicity of openings in registry with the perforations in the insulating sheet to expose the material therein, and severing the sheet between perforations to sub-divide it into a plurality of smaller photosensitive units.

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