May 15, 1962 G. STONE 3,035,178

ELECTROLUMINESCENT PANEL

Filed Dec. 7, 1959 5 Sheets-Sheet 1

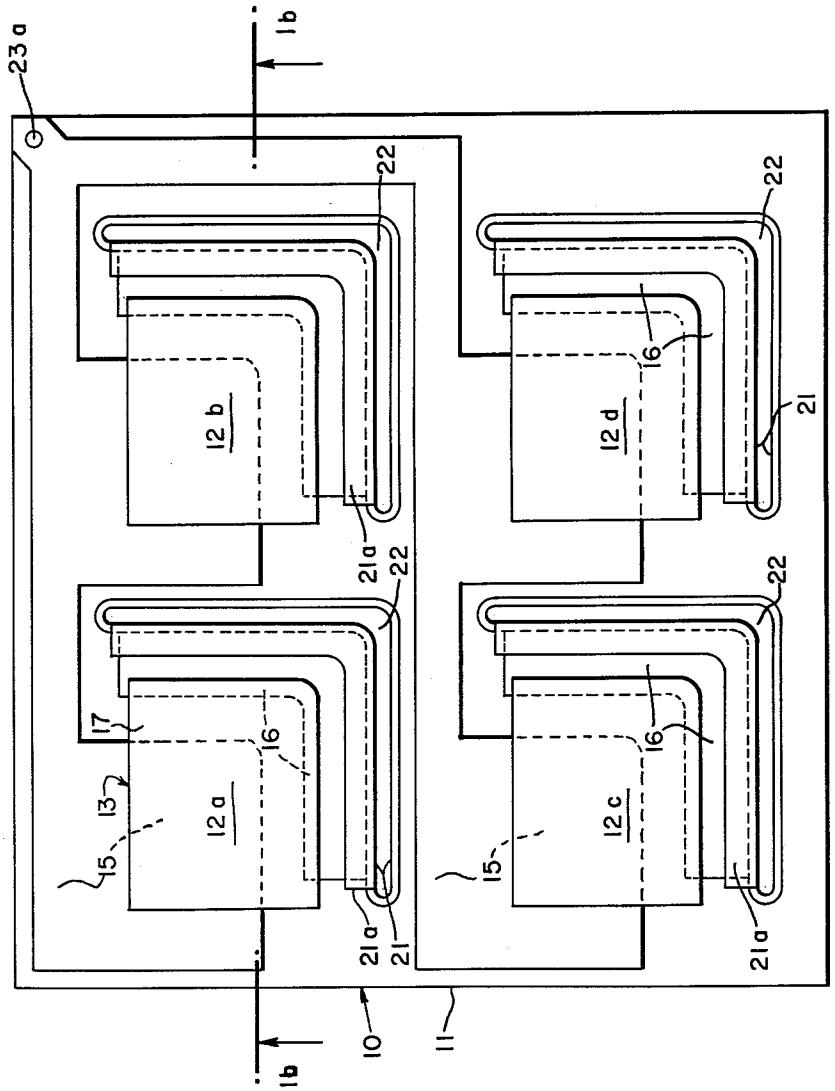


Fig. 1a

May 15, 1962 G. STONE 3,035,178

ELECTROLUMINESCENT PANEL

Filed Dec. 7, 1959 5 Sheets-Sheet 2

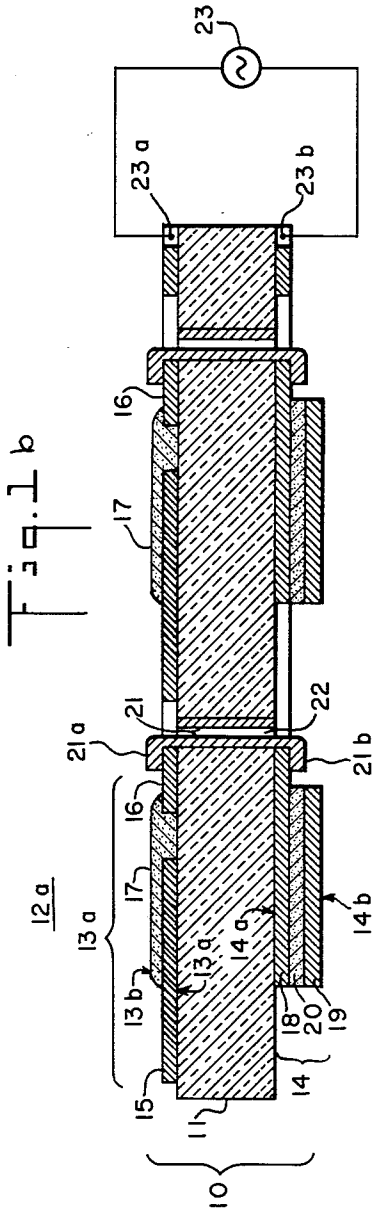


Fig. 1b

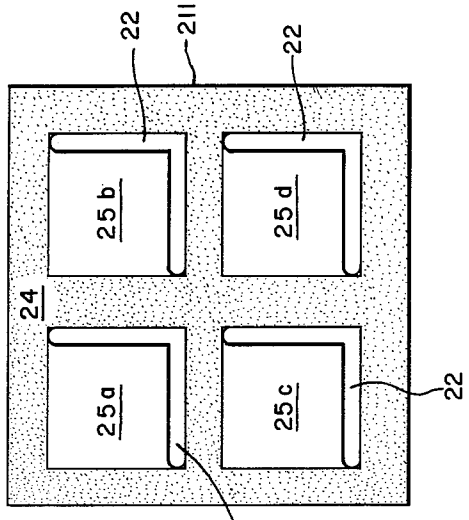


Fig. 2.

May 15, 1962 G. STONE 3,035,178

ELECTROLUMINESCENT PANEL

Filed Dec. 7, 1959 5 Sheets-Sheet 3

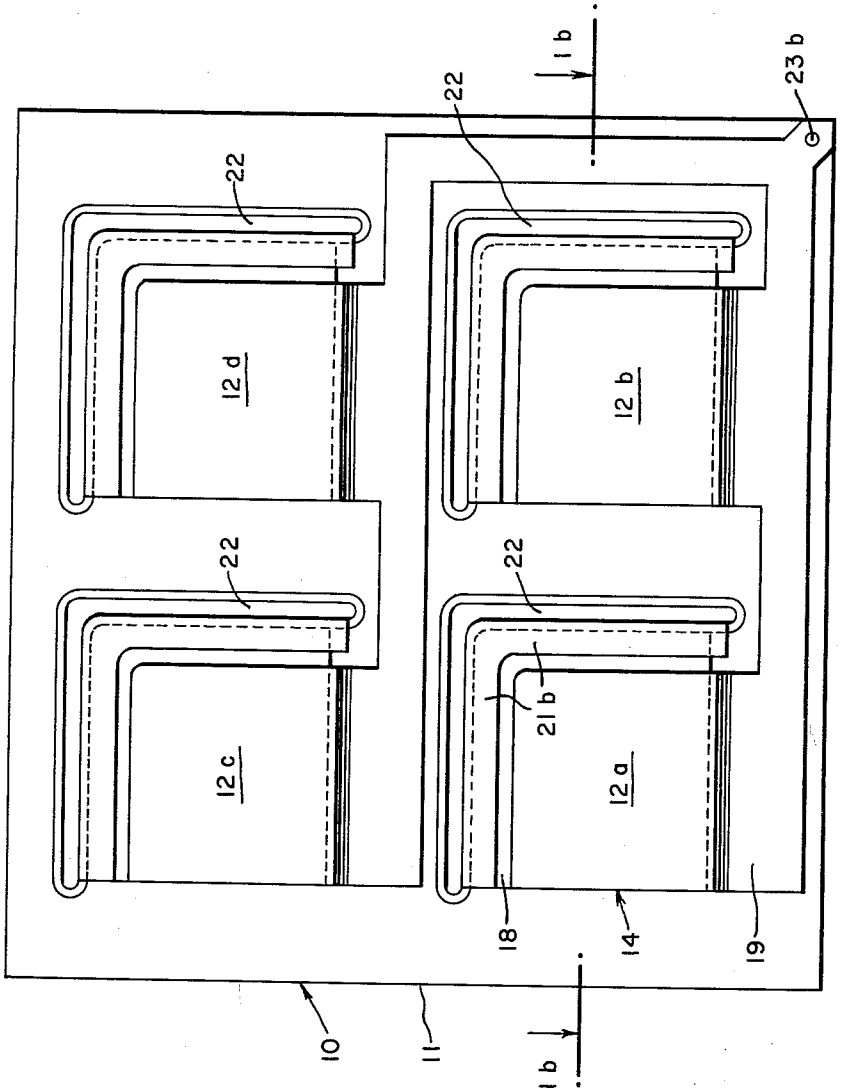


Fig. 1c

May 15, 1962 G. STONE 3,035,178

ELECTROLUMINESCENT PANEL

Filed Dec. 7, 1959 5 Sheets-Sheet 4

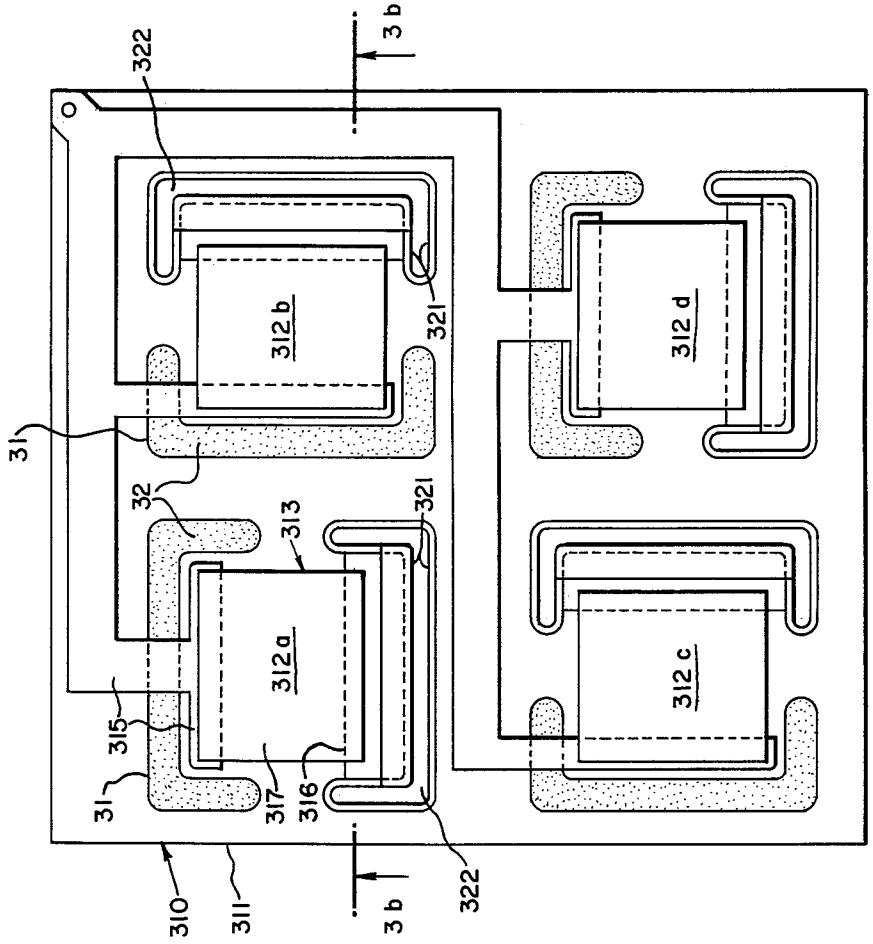


Fig. 3a

May 15, 1962 G. STONE 3,035,178

ELECTROLUMINESCENT PANEL

Filed Dec. 7, 1959 5 Sheets-Sheet 5

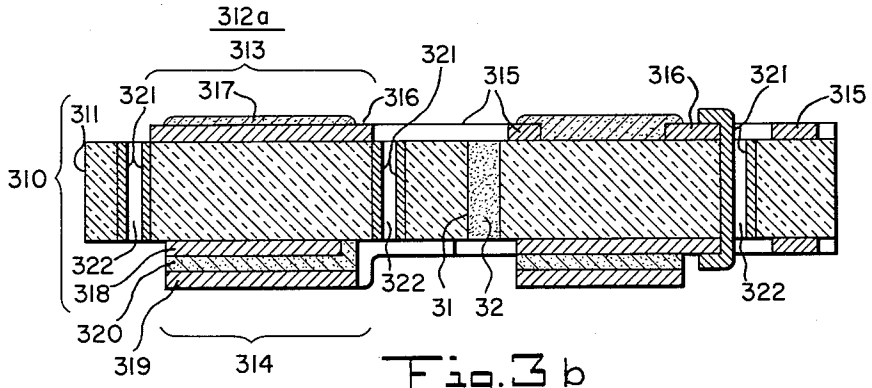


Fig. 3b

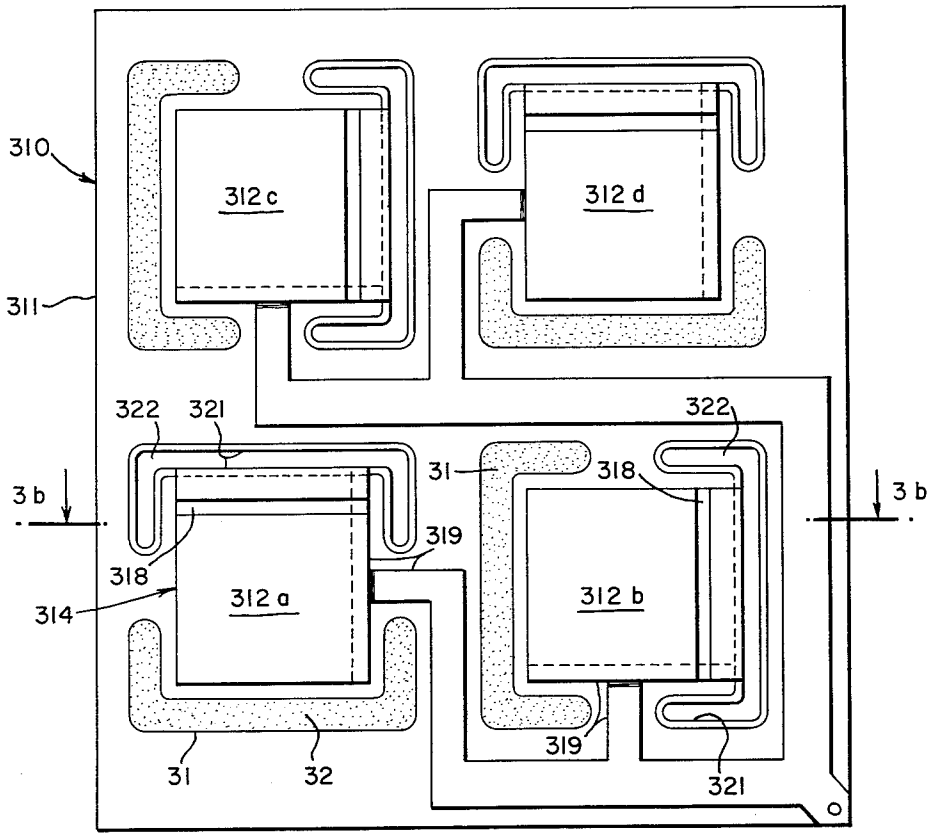


Fig. 3c

United States Patent Office 3,035,178
Patented May 15, 1962

3,035,178

ELECTROLUMINESCENT PANEL

Gerald Stone, Syosset, N.Y., assignor to Hazeltine Research, Inc., a corporation of Illinois

Filed Dec. 7, 1959, Ser. No. 857,969
10 Claims. (Cl. 250—213)

This invention relates to an electroluminescent panel of the type which may be used as the basic storage element of a computer memory circuit. In particular, it relates to a panel having individual storage units optically isolated from each other so that light from one storage unit will not cause an adjacent unit to be triggered into the lit condition when it is intended that the adjacent unit remain dark.

The use of electroluminescent cells in conjunction with photo-impedance cells to form a storage unit is well known in the computer art. In one known arrangement, a photoconductor cell is connected in series with an electroluminescent cell across a source of externally applied energizing voltage. Initially, when the electroluminescent cell is dark, the energizing voltage appears across the high impedance presented by the photoconductor cell thereby preventing the electroluminescent cell from becoming lit. When a trigger light is aimed at the photosensitive surface of the photoconductor cell, the impedance along the surface thereof is substantially reduced. This causes the majority of the energizing voltage to appear now across the electroluminescent cell, thereby triggering it into the lit condition. By arranging at least some of the light from the electroluminescent cell to be fed back to the photosensitive surface of the photoconductor cell, the trigger light may be turned off and the electroluminescent cell will remain in the lit condition since, with this arrangement, the electroluminescent cell performs the same function on the photoconductor cell as did the trigger light. In this way, a storage unit may be made which will store the information that the lit unit represents as long as the energizing voltage is applied to the unit or else until the electroluminescent cell is darkened by some other circuit arrangement.

Although one of the main advantages of this type of storage unit is that it may be extremely small in size, thus permitting many of the units to be placed on a relatively small panel, much attention has been directed to the problem of insuring that storage units which should remain dark are not accidentally triggered into the lit condition. This can occur when light from the electroluminescent cell of a lit storage unit travels internally along the supporting layer (called the substrate) on which the cells are placed and strikes the photoconductor cell of an adjacent dark storage unit. When this adjacent unit becomes lit, it, in turn, can cause a further unit to become lit and so on until all the units in the panel are lit. This undesired spreading of light is called "blooming."

Attempts to optically isolate the units have been made by using a substrate, known in the art as Fotoform glass, developed and produced by Corning Glass Works, Corning, New York, with areas or strips in the glass between the storage units darkened by a photographic process. These dark strips serve as light attenuators with the amount of attenuation dependent upon the thickness of the strip. However, this technique proved unsatisfactory for miniaturized panels where unit spacing of about one to two-hundredths inch wide is desired, since at least one-sixteenth inch of the darkened glass is required to attenuate the light by an amount sufficient to effectively isolate the storage unit. Where the unit itself is one-sixteenth inch square, this would result in undesirably doubling the size of the panel.

Also, in designing electroluminescent storage panels, it

is best to have the photosensitive surface of the photo-impedance cell parallel to the light-emissive surface of the electroluminescent cell so that maximum light coupling between the two surfaces is obtained for most efficient operation. Heretofore, this has not been considered feasible due to the requirement that there must be an electrical connection between the two cells. This makes it virtually impossible to place the cells on opposite sides of the substrate as would be required to make the surfaces parallel.

Accordingly, it is an object of the present invention to provide a new and improved electroluminescent panel that avoids one or both of the above disadvantages.

It is also an object of the present invention to provide an electroluminescent panel with extremely small-sized optically isolated electroluminescent storage units.

It is also an object of the present invention to provide an electroluminescent panel with maximum light coupling between the electroluminescent and photo-impedance cells in a storage unit.

In accordance with the invention, an electroluminescent panel comprises a light-transmissive substrate with optically isolated storage units in which each unit comprises a photo-impedance cell on one face of the substrate and an optically associated electroluminescent cell on the other face. The storage unit in the electroluminescent panel also comprises means including an opaque conductive connection through the substrate for electrically connecting the cells together and for preventing light from the electroluminescent cell from reaching other storage units.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description, taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

Referring to the drawings:

FIG. 1*a* is a plan view of one face of an electroluminescent panel constructed in accordance with the present invention and showing the photo-impedance cells of four storage units;

FIG. 1*b* is a cross-sectional view of the FIG. 1*a* panel;

FIG. 1*c* is a plan view of the reverse face of the FIG. 1*a* panel showing the arrangement of the electroluminescent cells;

FIG. 2 is a plan view of a substrate which may be used in constructing the electroluminescent panel of FIG. 1, and

FIGS. 3*a*–3*c* are top, side and bottom views of an alternative form of an electroluminescent panel similar to that of FIGS. 1*a*–1*c* and constructed in accordance with the present invention.

Referring now more particularly to FIGS. 1*a*, 1*b* and 1*c* of the drawings, there is shown an electroluminescent panel **10**, including a light-transmissive substrate **11** about ten to fifteen-thousandths of an inch thick preferably having parallel opposing faces which, for ease in referring thereto, will be called the forward and reverse faces. The aforementioned Fotoform glass in addition to having the property that areas of the glass may be darkened, also has the further advantage that very small holes may be etched in the glass with extreme accuracy up to a depth of ten times the hole diameter. As will be seen, this additional property makes this glass useful as the substrate **11** for the electroluminescent panel **10** in the present invention. However, it will be understood that other etchable substrates may be used as long as they are capable of light transmission, i.e. transparent or translucent, between opposite faces. A description of Fotoform glass may be found in the article "Chemical Machining Photosensitive Glass" by Marshall Byer ap-

pearing in the June 1956 issue of Materials and Methods, Reinhold Publishing Corporation, New York, New York.

On this substrate are placed a number of optically isolated storage units **12***a*–**12***d*, inclusive, each of which comprises a photo-impedance cell **13** on the forward face of substrate **11** and an optically associated electroluminescent cell **14** on the reverse face of substrate **11**. Photo-impedance cell **13** includes conductors **15** and **16** deposited on the face of substrate **11**. These conductors may be transparent layers of tin oxide deposited to a thickness of the order of magnitude of a wavelength of light and may have a resistance on the order of 50–500 ohms per square. There is shown in FIG. 1 one arrangement by which conductor **15** may connect together one electrical side of all the photo-impedance cells **13** in panel **10** by serving as a common bus terminating in input terminal **23***a*. Conductor **16** serves as a positive connection between the other electrical side of photo-impedance cells **13** and their respective conductive coatings **21**, which coatings are described in greater detail hereinafter. Photo-impedance cells **13** also include a layer of photo-impedance material **17** laid down on the face of substrate **11** to a thickness of about two to three-thousandths of an inch extending from conductor **15** to conductor **16**. The photo-impedance material may be of the photoconductive type consisting of cadmium sulphide activated with cupric chloride and cadmium chloride. This type of photoconductor usually has a dark impedance of approximately 3500 megohms per square and a light impedance of approximately 100 kilohms per square.

Referring to FIGS. 1*b* and 1*c*, electroluminescent cell **14** on the opposite face of substrate **11** may be comprised of transparent conductive layers **18** and **19** of the same composition and thickness as the aforementioned conductors **15** and **16**. Between the conductors **18** and **19** there is deposited an intermediate layer about two-thousandths of an inch thick of any conventional electroluminescent phosphor **20**, for example, crystalline zinc sulphide embedded in a suitable dielectric binder such as lacquer. With the cells located on opposite sides of the substrate in the manner just described, it can be seen in FIG. 1*b* that the photo-sensitive surface **13***a* of cell **13** is parallel with the light-emissive surface **14***a* of cell **14** thereby permitting maximum light coupling between the two surfaces.

Storage unit **12***a* also comprises means including an opaque conductive connection, for example, copper coating **21** through substrate **11** for electrically connecting conductors **16** and **18** of cells **13** and **14** together and for preventing light from electroluminescent cell **14** from reaching other storage units in panel **10**. This means may include slot **22** etched through substrate **11** with a width of, for example, five-thousandths of an inch. Slot **22** extends through substrate **11** along, for example, two sides of storage unit **12***a* and is oriented relative to similar slots in the adjacent storage units **12***b*–**12***b*, inclusive, so that no light from electroluminescent cell **14** may directly reach the adjacent storage units **12***b*–**12***d*, inclusive. The nature of this arrangement is clearly seen in FIG. 1. Copper coating **21** may be deposited to any desired depth on the sides of slot **22** in the same manner as with respect to the conventional process of hole plating in printed wiring boards. If desired, coating **21** may entirely fill the space in slot **22**. To insure a good electrical connection between plating **21** and the two conductors **16** and **18**, plating **21** is permitted to extend beyond the edge of slot **22** by means of extensions **21***a* and **21***b* along the surface of conductors **16** and **18**, respectively. These extensions **21***a* and **21***b* are preferably in integral part of coating **21** and may therefore conveniently be deposited thereon at the same time as coating **21**.

As shown in FIG. 1*b*, an energizing voltage source **23** may be coupled to input terminals **23***a* and **23***b* of conductors **15** and **19** respectively, for supplying an energizing voltage to storage units **12***a*–**12***d*, inclusive.

While, as can be seen in FIG. 1, the L-shaped coated slots **22** of panel **10** prevent any direct light transmission between adjacent storage units, some light transmission in an indirect path around the slots may be possible especially if substrate **11** is perfectly transparent. In this case, the Fotoform glass substrate **211**, shown in FIG. 2 previous to the formation of the cells thereon, may be utilized. Substrate **211** is similar to substrate **11** of FIG. 1 except that substrate **211** is treated as explained in the aforementioned article to provide light attenuating areas or strips **24** which serve to separate the individual light-transmissive areas **25***a*–**25***d*, inclusive. These darkened areas **24** of the glass preferably extend through the glass thereby completely separating areas **25***a*–**25***d*, inclusive. As explained above, the light path through one of these strips **24** must be at least one-sixteenth inch long before the light is sufficiently attenuated to effectively optically isolate each of areas **25***a*–**25***d*, inclusive. Therefore, by making the total size of any one of storage units **12***a*–**12***d*, inclusive, about one-sixteenth inch square, including slot **22**, any substantial amount of light from one storage unit must travel longitudinally through about one-sixteenth inch of strips **24** before reaching any adjacent storage unit, thereby achieving the proper light attenuation to isolate each of the storage units.

In operation, an electroluminescent cell **14** of storage unit **12***a* is triggered into the lit condition as previously explained by means of a trigger light (not shown) aimed at the exposed photosensitive surface **13***b* of the cell **13**. Since both conductors **18** and **19** are transparent, light is emitted from both of surfaces **14***a* and **14***b* of electroluminescent cell **14**. The light from surface **14***a* travels through substrate **11** and is incident on photosensitive surface **13***a*, thereby permitting storage unit **12***a* to remain in the lit condition when the trigger light is removed. Light emitted from surface **14***b* may be detected by some external read-out device such as a conventional photorectifier. Since the present invention relates only to the novel construction of panel **10**, the read-in and read-out devices are not shown.

The light from surface **14***a* is captured along two sides of storage unit **12***a* by means of copper coating **21** while any light from the open sides of adjacent storage units **12***b*–**12***d*, inclusive, is prevented from directly reaching storage unit **12***a* by the same coating **21**. As previously described, any stray light transmitted through substrate **11** around coating **21** may be substantially eliminated by use of the "egg crated" substrate **211** of FIG. 2.

In FIGS. 3*a*–3*c*, inclusive, there is shown an electroluminescent panel **310** utilizing a slightly different configuration for optically isolating the storage units. For ease in comparison, those elements in FIGS. 3*a*–3*c*, inclusive, having counterparts in electroluminescent panel **10** of FIGS. 1*a*–1*c*, inclusive, carry the same reference numerals prefixed by the number 3. Thus, electroluminescent panel **310** includes a light-transmissive substrate **311** with optically isolated storage units **312***a*–**312***d*, inclusive. Storage unit **312***a* comprises a phase-impedance cell **313** on one face of substrate **311** and an optically associated electroluminescent cell **314** on the other face of substrate **311**. Photo-impedance cell **313** includes conductors **315** and **316** and photo-impedance material **317**, all deposited in a similar manner as with respect to cell **13** of FIGS. 1*a* and 1*b*. Electroluminescent cell **314** includes conductors **318** and **319** separated by a layer of electroluminescent material **320** in the same manner as with respect to FIGS. 1*b* and 1*c*.

The essential difference between panel **310** of FIGS. 3*a*–3*c*, inclusive, the panel **310** of FIGS. 1*a*–1*c*, inclusive, lies in the fact that panel **310** comprises means including a pair of slots **322** and **31** extending through substrate **311** along opposite sides of storage units **312***a*–**312***d*, in-

clusive. Slot **31** may be filled in with an opaque material **32**, such as black glass, while slot **322** has an opaque conductive coating **321** along its sides electrically connecting the photo-impedance cell **313** and the electluminescent cell together. Instead of being filled in with an opaque material, slot **31** may alternatively have an opaque conductive coating along its sides deposited there at the same time and in the same manner as coating **321** is deposited on the sides of slot **322**. In this case care must be taken that this conductive connection in slot **31** does not connect the photo-impedance and electroluminescent cells together since this would short out the energizing voltage applied to storage units **312***a*–**312***d*, inclusive. Conductive coating **321** electrically connects conductors **316** and **318** together as in FIG. 1.

For most effective capturing of the light within storage units **312***a*–**312***d*, inclusive, slots **31** and **322** are preferably formed so that they bend around the respective storage unit along a portion of its common sides as shown in FIGS. 3*a* and 3*c*. Since each storage unit has light-transmissive openings along two of its sides, the slots in adjacent storage units are preferably oriented relative to those of adjacent units to prevent direct light transmission from one storage unit to the next as shown in FIGS. 3*a* and 3*c*. Further, to prevent light transmission around the opaque conductive coatings, the darkened substrate **211** of FIG. 2 with its light attenuating strips may be used in place of the clear substrate **311** in FIG. 3.

While only four storage units per substrate are shown for purposes of illustration, it will be readily apparent that many more such units may be included in the substrate. For example, it has been proposed that 225 to 256 such storage units be built into a single square inch of substrate. More or less units may be included as the need warrants. In this way, for example, a quarter-million separate bits of information may easily be stored in a unit (which includes read-in and read-out apparatus) about one cubic foot in size.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention and it is, therefore, aimed to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An electroluminescent panel comprising: a light-transmissive substrate with optically isolated storage units in which each unit comprises a photo-impedance cell on one face of the substrate and an optically associated electroluminescent cell on the other face; and means including an opaque conductive connection through the substrate for electrically connecting the cells together and for preventing light from the electroluminescent cell from reaching other storage units.

2. An electroluminescent panel comprising: a light-transmissive substrate having parallel opposing faces with optically isolated storage units in which each unit comprises a photo-impedance cell having a photosensitive surface lying along one face of the substrate and an optically associated electroluminescent cell having a light-emissive surface lying along the opposing face of the substrate; and means including an opaque conductive connection through the substrate for electrically connecting the cells together and for preventing light from the electroluminescent cell from reaching other storage units.

3. An electroluminescent panel comprising: a light-transmissive substrate with optically isolated storage units in which each unit comprises a photo-impedance cell having a photosensitive surface on one face of the substrate and an optically associated electroluminescent cell on the other face with a light-emissive surface in parallel relation with said photosensitive surface; and means including an opaque conductive connection through the substrate for electrically connecting the cells together and for preventing light from the electroluminescent cell from reaching other storage units.

4. An electroluminescent panel comprising: a light-transmissive substrate with optically isolated storage units in which each unit comprises a photo-impedance cell on one face of the substrate and an optically associated electroluminescent cell on the other face; and means including a slot extending through the substrate and an opaque conductive connection through the slot for electrically connecting the cells together and for preventing light from the electroluminescent cell from reaching other storage units.

5. An electroluminescent panel comprising: a light-transmissive substrate with optically isolated storage units in which each unit comprises a photo-impedance cell on one face of the substrate and an optically associated electroluminescent cell on the other face; and means including a slot extending through the substrate along at least two sides of the storage unit and an opaque conductive connection through the slot for electrically connecting the cells together and for preventing light from the electroluminescent cell from reaching other storage units.

6. An electroluminescent panel comprising: a light-transmissive substrate with optically isolated storage units in which each unit comprises a photo-impedance cell on one face of the substrate and an optically associated electroluminescent cell on the other face; and means including a pair of slots extending through the substrate along opposite sides of the storage unit, one of which is filled in with an opaque material, the other of which has an opaque conductive coating along its sides electrically connecting the cells together, said slots being oriented relative to corresponding slots in adjacent storage units for preventing light from the electroluminescent cell from reaching said adjacent storage units.

7. An electroluminescent panel comprising: a light-transmissive substrate with optically isolated storage units in which each unit comprises a photo-impedance cell on one face of the substrate and an optically associated electroluminescent cell on the other face; and means including a pair of slots extending through the substrate along opposite sides of the storage unit and bending around the unit along a portion of its common sides, said slots having opaque conductive coatings along their sides, one of said coatings electrically connecting the cells together, said slots further being oriented relative to corresponding slots in adjacent storage units for preventing light from the electroluminescent cell from directly reaching said adjacent storage units.

8. An electroluminescent panel comprising: a light-transmissive substrate with optically isolated storage units in which each unit comprises a photo-impedance cell having a photosensitive surface on one face of the substrate and an optically associated electroluminescent cell on the other face with a light-emissive surface in parallel relation with said photosensitive surface; and means including a slot extending through the substrate along two sides of the storage unit and an opaque conductive connection through the slot for electrically connecting the cells together and for preventing light from the electroluminescent cell from reaching other storage units.

9. An electroluminescent panel comprising: a substrate with individual light-transmissive areas separated by light-attenuating areas in the substarate and having one optically isolated storage unit in each transparent area which comprises a photo-impedance cell positioned on one face of the substrate over a transparent area and an optically associated electroluminescent cell positioned on the other face of the substrate over the same transparent area; and means including an opaque conductive connection through the substrate for electrically connecting the cells together and for preventing light from the electroluminescent cell from directly reaching other storage units without having passed longitudinally through said light-attenuating areas.

10. An electroluminescent panel comprising: a substrate with individual light-transmissive areas separated by light-attenuating areas in the substrate and having one optically isolated storage unit in each transparent area which comprises a photo-impedance cell having a photosensitive surface positioned on one face of the substrate over a transparent area and an optically associated electroluminescent cell with a light-emissive surface positioned on the other face of the substrate over the same transparent area in parallel relation with said photosensitive surface; and means including a slot extending through

the substrate along two sides of the storage unit and an opaque conductive connection through the substrate for electrically connecting the cells together and for preventing light from the electroluminescent cell from directly reaching other storage units without having passed longitudinally through said light-attenuating areas.

References Cited in the file of this patent

UNITED STATES PATENTS

2,837,661 Orthuber et al. ---------- June 3, 1958