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(71) Applicant: **OIS OPTICAL IMAGING SYSTEMS, Inc.**
1896 Barrett Street
Troy, Michigan 48084 (US)

(72) Inventor: **Yaniv, Zvi**
30257 High Valley Road
Farmington Hills, Michigan 48018 (US)

(74) Representative: **Kügele, Bernhard et al**
c/o NOVAPAT-CABINET CHEREAU 9, Rue du Valais
CH-1202 Genève (CH)

(54) Macroscopically sized liquid crystal display.

(57) A large area liquid crystal display (10) in which all of the picture elements (pixels) (32, 34, 36, 38, 40, 42, 44, 46, 48) thereof are macroscopically sized and operatively disposed within the correspondingly sized and shaped openings created between the adjacent rows and columns of a support structure (18). By also utilizing discrete, large area switching elements (50, 52, 54, 56, 58, 60, 62, 64, 66) such as diodes or transistors, for addressing the individual picture elements operatively disposed in any given row or column of the structure, all of the active elements of the large area display are capable of manual manipulation. In this manner, the cost of even very large area displays is minimized and inoperative or defective pixels or switching elements are readily replaceable. The use of V-shaped or "butterfly" lenses (82) about the e periphery of each of the pixels covers the interstices (72, 74) of the support structure (18).

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FIELD OF THE INVENTION

This invention relates generally to the field of liquid crystal displays and more particularly to the field of large area liquid crystal displays wherein the image is formed on an array of macroscopically sized picture elements, or pixels, for viewing by a large group of people. Examples of the foregoing type of macroscopically sized liquid displays are movie theater screens, projection television screens, marquis, or billboards.

BACKGROUND OF THE INVENTION

In the general field of liquid crystal displays and particularly in the field of active matrix liquid crystal displays, major international electronics companies have, for the last decade, expended hundreds of millions of dollars for the development of "large area" displays characterized by very high resolution. To date, these efforts have resulted in the development of high resolution displays only in a size approximating that of relatively small television sets. However, in order to attain high resolution in even two, three, or five inch diagonal liquid crystal television displays, the aforementioned electronics manufacturers utilized thin film amorphous silicon transistors and diodes to function as the switching elements by which the discrete liquid crystal pixels in the X-Y matrix defining the display could be addressed. And of course, as the size of the display increased, it was necessary that the number of rows and in the X-Y matrix defining the display could be addressed. And of course, as the size of the display increased, it was necessary that the number of rows and columns of pixels correspondingly increased in order to maintain the requisite resolution. However, as the number of rows and columns of pixels increased, additional problems arose as to the manner in which each discrete pixel of the display could be addressed in order to constantly update the input signals at video time rates.

It is one principle objective of the instant invention to deal with a problem diametrically opposed to the one described in the preceding paragraph. Rather than providing for a very high resolution display, this invention is concerned with meeting social and public needs by supplying pictorial information, both still and video, to many people at a time with a single display system. Such pictorial information would be supplied at a level of resolution adequate to satisfy the viewing requirements of the people watching the display when all factors such as distance from the display, viewing angle, screen size, contrast and response are taken into consideration.

It is a further objective of the instant invention to construct such a liquid crystal display from macroscopically sized liquid crystal pixels and switching elements, both of which are readily manipulable, easily purchased and/or fabricated, inexpensive, and readily replaceable. In this manner, not only will a large market materialize, but repair will be easily accomplished when it is necessary to replace defective elements.

These and other objects and advantages of the instant invention will become readily apparent to the reader when taken in conjunction with a perusal of the Brief Description of the Invention, the Brief Description of the Drawings, the Detailed Description of the Invention and the Claims, all which follow hereinafter.

BRIEF DESCRIPTION OF THE INVENTION

There is disclosed herein a large area liquid crystal display, such as a billboard, movie theater screen, projection television screen, or the like, specifically adapted for public viewing by a large number of people. The display comprises a substantially rectangular support structure defining an X-Y matrix of substantially parallel rows and columns. The space between each two adjacent rows and each two adjacent columns defines an opening of a given shape. Into each one of the openings, one of a plurality of discrete, macroscopically sized pixels is operatively disposed, the shape of the pixels corresponding to the shape of the openings. Each of said pixels presents a large image area to viewers of the information displayed thereupon and includes liquid crystal display material operatively disposed between the pixel electrodes thereof. It is important that the pixels be sized to be large enough to be manipulable by installers of repairers of the display. Also, discrete, non-thin film switching elements are electrically connected to the pixels for simultaneously addressing each individual pixel housed in the rows and columns of the support structure.

Each pixel is preferably of a rectangular shape and most particularly of a square shape. Regardless of the precise size and shape of the pixel, it must be sized and shaped to mate with the configuration and dimension of the opening of the support structure. Further, as opposed to cathode ray tubes, the depth dimension of the pixels will be small relative to the length and width dimensions thereof. In a preferred embodiment, the pixels have an image boundary of about one centimeter on a side ; and in a still more preferred embodiment, the pixels have an image boundary of about ten centimeters on a side. In a most preferred embodiment, the pixels have an image boundary of about fifty centimeters or more on a side.

The support structure also includes a plurality of spaced, electrically conductive X address lines and a plurality of spaced electrically conductive Y address lines. In the most preferred embodiment, the discrete switching elements are transistors which include first, second and third terminals. The first terminal of each of the transistors is electrically connected to an X address line, the second terminal of each of the tran-

sistors is electrically connected to a Y address line, and the third terminal of each of the transistors is electrically connected to a pixel electrode associated with said X and Y address lines.

For purpose of ease of connection and repair, each opening in the matrix of said support structure further includes means for receiving the first and the second terminals of said transistors and electrically connecting said first and second terminals to the X and Y address lines, respectively. Finally, each of said discrete, large area pixels includes means for receiving the third terminal of one of the discrete transistors and electrically connecting said third terminal to a first electrode of the pixel. The second pixel electrode is electrically connected to ground.

In an alternative, but equally preferred embodiment of the instant invention, the discrete switching elements may be diodes. When diodes are employed, two diodes are associated with each pixel and they are electrically interconnected in anode to cathode relationship. More particularly, the cathode of the first diode is electrically connected to a first X address line and the anode of the second diode is electrically connected to an adjacent X addressed line with the first pixel electrode electrically connected to the common node formed between the two diodes. The support structure itself will preferably include means for electrically connecting the cathode of the first diode to the first X address line and the anode of the second diode to the adjacent X address line.

Either, each of the openings in the support structure or each of the switching elements will include pin connectors and the other of each of the openings in the support structure or each of the switching elements will include socket connectors, whereby the socket connectors are adapted to receive the pin connectors in electrical engagement. Both the pixels and the switching elements are sized to be manually affixed and electrically interconnected within the openings in the support structure.

Finally, the use of an elongated substantially V-shaped lens (also known as a butterfly lens) operatively positioned about the periphery of each of the macroscopically sized picture elements provides a coherent image across the entire length and width of the large area display and blocks the interstices of the support structure from being visible to the viewers thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a front plan view illustrating the large area liquid crystal display of the instant invention, which display is defined by a matrix array of macroscopically sized pixels and switching elements operatively disposed in a support structure ;

Figure 2 is a schematic illustration of the support structure for electrically interconnecting the pixels and switching elements of the liquid crystal display of the instant invention in a matrix array and specifically depicting the socket arrangement whereby the pin connectors of said pixels and switching elements are manually adapted for ready insertion thereunto ;

Figure 3 is a schematic view illustrating the manner in which the terminals of the transistors, in a first preferred embodiment of the instant invention, are electrically connected to a first pixel electrode and the X and address lines respectively ;

Figure 4 is a schematic view illustrating the manner in which the anodes and cathodes of the two diode switch, in a second preferred embodiment of the instant invention are electrically connected to each other as well as to adjacent X address lines and a first pixel electrode, respectively ; and

Figure 5 is a top cross-sectional view taken along line 5-5 of Figure 1 and illustrating the interstitial lens assembly of the instant invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 generally illustrates, by the reference numeral 10, the large area liquid crystal display system, including the support structure, embodying the concepts disclosed by the present invention. It is to be understood at the outset that the large area liquid crystal display system 10 may be either black-and-white or full color, and is adapted to generate either still or video images for a mass audience positioned remotely therefrom. The system 10 includes a large area, substantially rectangular support structure 18, defining there within a first set of X address lines including address lines 20, 22 and 24, a second set of Y address lines including address lines 26, 28 and 30, and a plurality of macroscopically sized, discrete liquid crystal pixels (or picture elements) 32, 34, 36, 38, 40, 42, 44, 46 and 48. The system 10 further includes a switching element 50, 52, 54, 56, 58, 60, 62, 64 and 66 operatively associated with each macroscopically sized, discrete liquid crystal pixel.

As can be noted in Figure 1, the X address lines 20, 22 and 24 and the Y address lines 26, 28, and 30 cross at an angle, defining an X-Y matrix of substantially parallel rows and columns, and are spaced from one another to form a plurality of crossover points 70, 72, 74, 76, 78, 80, 82, 84 and 86. The X and Y address lines are each adapted to transmit separate, independent electrical impulses, supplied by off-board electronic drivers (not shown), to each of the macroscopically sized, discrete liquid crystal pixels. Hence, while said X address lines and said Y address lines do cross at angles, it is important to understand that said X address lines 20-24 are electrically insulated from the crossing Y address lines 26-30.

Associated with each of the crossover points 70-

86 is a respective one of the macroscopically sized, discrete liquid crystal pixels 32-48. The macroscopically sized, discrete liquid crystal pixels 32-48 are individually attached to the support structure 18 and are uniformly distributed there over in spaced apart relation to minimize the interstitial spaces therebetween. In this way it is possible to provide a large area, substantially continuous either still or video image unimpeded by spaces between the macroscopically sized, discrete liquid crystal pixels 32-48 occasioned by, for example, the grid pattern of the X and Y address lines, or the support structure 18 itself. Note that while three rows and the three columns of pixels have been illustrated in Figure 1, any number of rows and columns of macroscopically sized pixels may be employed without departing from the spirit or scope of the instant invention. Further, note that while Figure 1 has been illustrated having substantially square shaped pixels, the shape of the pixels need not be so limited. Other shapes, such as rectangular or triangular may also be employed.

It is of course understood that since the instant large area display system is primarily intended and designed for mass audience viewing, said display system will be located remotely from the viewers. Hence, small interstitial spacing between said macroscopically sized liquid crystal pixels is acceptable since the human eye's ability to discern the magnitude of that interstitial space decreases with increasing distance from the plane of the display system. In fact, experimentation has shown that an interstitial space of 3 mm is indiscernible to the human eye from a distance of 10 meters and that said relationship is linear (i.e., 30 mm is indiscernible to 100 meters). Further, as will be discussed in greater detail hereinbelow with respect to Figure 5, should the interstitial spacing become too large, thereby deleteriously effecting the quality of the generated image, an elongate lens means 82 (in phantom outline in Figure 1) may be provided to obscure the offending spaces. Accordingly, it is possible to provide a large area video display for mass public viewing in applications such as billboards, movie theater screens and marquis, as well large area television.

As alluded to hereinabove the macroscopically sized, discrete liquid crystal pixels 32-48 are preferably rectangular in shape, and more particularly, square in shape. Regardless of the precise size and shape of the macroscopically sized, discrete liquid crystal pixels it is important that the pixel and the openings defined by the X-Y matrix of row and columns on the support structure 18 cooperate so that the large area pixels completely fill the open area. In a first preferred embodiment, the pixels are squares, each side of which is dimensioned so as to be about one centimeter on a side ; in a still more preferred embodiment, the pixels are square, each side of which is about 10 centimeters on a side. In the most preferred embodiment, the macroscopically sized, discrete liquid crystal pixels 32-48 are truly large area squares being about 50 centimeters or more on a side. Thus, the opening defined between adjacent rows and columns must completely accommodate both the length and width dimension of each large area pixel while minimizing the interstitial spaces between each adjacent large area pixel.

The macroscopically sized, discrete liquid crystal pixels 32-48 are further of the type which have a depth dimension which is relatively small as compared to the length and width dimensions described hereinabove. In the preferred embodiment, the image boundary of the macroscopically sized, discrete liquid crystal pixels 32-48 is about 50 centimeters or more on a side. This length and width dimension is to be compared with the depth dimension of about 5 centimeters or less, and in a preferred embodiment, about 1 centimeter or less. This thin, substantially flat, profile is accomplished by employing pixels having liquid crystal material housed within and operatively disposed between substantially parallel two pixel electrodes, which electrodes themselves are deposited upon opposing transparent substrate formed of, for example, thin sheets of high quality glass. The opposing transparent glass substrate should also be light-weight, but mechanically sturdy, so as to provide structural rigidity, thus preventing breakage and allowing for easy manipulation by installers or repairers servicing the large area display.

Each of the macroscopically sized, discrete liquid crystal pixels 32-48 further includes a switching element 50-66 operatively associated therewith, which switching element may be affixed or affixable to one of said transparent substrate, preferably on the side thereof opposite the deposited pixel electrode and in electrical communication with said pixel electrode. Regardless of whether the switching element is mechanically affixed to the pixels, in a preferred embodiment, the switching elements 50-66 must be placed in electrical communication with one of the electrodes thereof. It is preferred that one terminal of said switching element electrically communicate with the pixel electrode disposed on the transparent substrate most distant from the viewer. By so electrically disposing the contact, the switching element is made to be invisible to the viewer.

The switching elements 50-66 are adapted not to conduct electrical impulses below a certain preselected threshold voltage. Thus, the switching elements are adapted to prevent stray electrical impulses and electronic "noise" transmitted through the X-Y address lines of the matrix from prematurely or inadvertently activating the discrete pixel associated therewith. The switching elements 50-66 may be either discrete, large area devices manually mounted, as by plug and socket connection, to each large area pixel, or said elements may be thin film devices depo-

sited directly onto the glass substrate of each large area pixel.

In one preferred embodiment, the switching element includes a pair of discrete diodes (156-158) operatively disposed in anode-to-cathode relationship so as to function as a two-diode, three terminal switch which is electrically connected and mechanically affixed to an electrode of said large area pixel. One distinguishing feature of the two-diode switch configuration is the need to provide two X or row address lines per row of large area pixels. This configuration will be discussed in greater detail hereinbelow with reference to Figure 4.

In a second and more preferred embodiment, the switching element employed in conjunction with and in order to address each large area pixel in the X-Y matrix of the display 10 is a discrete transistor 120. Since the transistor is a three terminal device, it is adapted to electrically communicate with both the X and Y address lines, as well as with one electrode of the large area pixel 134. This of course eliminates the need for the second X or row address line for every row of pixels which is required in the two diode switch embodiment. This configuration will be described in greater detail with reference to Figure 3 hereinbelow.

Turning now to Figure 2, illustrated therein is a socket arrangement 100 operatively associated with each of said crossover points 70-86 and each opening of the X-Y matrix on the support structure 18 (of Figure 1). Since each socket arrangement 100 is substantially identical to every other socket, only one such socket need be illustrated and described. This socket arrangement 100 is adapted to accommodate and electrically interconnect the switching element associated with each large area pixel with each picture element. As can be seen in Figure 2, each socket arrangement is an electrical communication with both the X address line 102 by means of conductive lead 104, and the Y address line 106 by means of conductive lead 108. Thus, in the preferred embodiment wherein the switching element is a transistor, the first and second terminals thereof are adapted to engage and seat in the socket 100 for electrical communication with the X and Y address lines respectively ; while the third terminal thereof is adapted to be placed in electrical communication with one electrode of the large area pixel (the other pixel electrode is connected to ground). In order to make the macroscopically sized display easy to construct and service (as may become necessary when a pixel malfunctions) each of the socket arrangements 100 includes pin connectors or are adapted to engage pin connectors protruding from the switching element. This is illustrated in Figure 2 by means of plated-through holes 110 which are placed in electrical communication with the X address line 102 via lead 104, and plated-through holes 112 which are placed in electrical communication with the Y address line 106 via lead 108. The plated-through holes 110-112 are adapted to engage pin connectors protruding from the switching elements, thereby ensuring good electrical contact with the X and Y address lines, while additionally securing each large area pixel to the support structure 18. The reader should appreciate that while the socket is shown as part of the arrangement, said arrangement could be provided with pins without departing from the spirit or scope of the instant invention.

Referring now to Figure 3, illustrated therein, in schematic form, is the manner in which the terminals of a transistor 120 are electrically connected to, respectively, the first pixel electrode 132 of a single large area pixel 134 and the X and Y address lines 124 and 128 of the matrix array. It can be noted from even a cursory perusal of Figure 3 that the first terminal 122 of the transistor 120 is coupled to the X address line 124, the second terminal 126 of the transistor 120 is coupled to the Y address line 128, and the third terminal 130 of the transistor 120 is coupled to the first pixel electrode 132 of the large area pixel 134. The second pixel electrode 136 of the large area pixel 134 is then coupled to a common potential such as ground by lead 138. Disposed between the first pixel electrode 132 and the second pixel electrode 136 of the large area display element is a layer of a liquid crystal material 140 which is responsive to the application of an electrical charge thereto. By applying an electrical potential to both the X and Y address leads, it is possible to achieve a desired optical effect at the large area pixel, i.e., change the liquid crystal material from a non-transmissive to a transmissive condition. By simultaneously addressing a number of such large area pixels, it is possible to generate a large area video or still image for mass viewing.

Referring now to Figure 4, illustrated therein, in schematic form, is the manner in which the anode and the cathode of the two diode switch configuration of the instant invention are electrically interconnected with the pair of X or row address lines 152-154 and the first pixel electrode 160 of the large area picture element. As can be noted from Figure 4, the row address lines 152 and 154, have a pair of series connected diodes 156 and 158 coupled between the address lines 152 and 154. A common node 157 is formed therebetween. The common node 157 is then electrically coupled to the first pixel electrode 160. The large area pixel 150 further includes the second pixel electrode 162 coupled to the Y address line 164. Operatively disposed between the first pixel electrode 160 and the second pixel electrode 162 is a layer of liquid crystal material 166. A more complete teaching of the two-diode switch configuration is disclosed in commonly assigned U.S. Patent No. 4,868,616 to Johnson, et al for "ELECTRONIC MATRIX ARRAY", the disclosure of which is incorporated herein by reference.

Referring now to Figure 5, which is a cross sec-

tional view taken along lien 5-5 of Figure 1, there is illustrated therein a final feature of the large area liquid crystal display of the instant invention, which feature is the inclusion of generally "v" shaped, elongated lenses (also known as "butterfly" lenses) 82 between each adjacent row and column of macroscopically sized, discrete liquid crystal pixels, such as 34 and 36. As alluded to hereinabove, it is the function of such lenses to slightly distort light emanating from the edges of the adjacent macroscopically sized, discrete liquid crystal pixels so that the interstitial spaces of the support structure formed therebetween are obscured by the distorted light. Of course, the amount of the distortion must be very slight so as to not deleteriously effect the qualify of the image generated on the large area display 10. It is to be noted that if the interstitial spacing between each macroscopically sized, discrete liquid crystal pixel can be kept sufficiently small, i.e., less than.3 mm for every meter distant the viewing audience is located, then such lenses will not be necessary.

While for purposes of illustration and explanation, several forms of this invention have been disclosed, other forms thereof may become apparent to those skilled in the art upon reference to this disclosure and, therefore, this invention is to be limited only by the scope of the appended claims.

Claims

1. A large area liquid crystal display (10) comprising :
   a substantially rectangular support structure (18) adapted for viewing by a plurality of people, said structure defining an X-Y matrix substantially parallel rows and columns, and the space between each two adjacent rows and each two adjacent columns defining a macroscopically sized opening ;
   discrete macroscopically sized pixels, (32, 34, 36, 38, 40, 42, 44, 46, 48) each pixel adapted to present a large image area to viewers of the information displayed thereupon and including liquid crystal display material operatively disposed between the electrodes thereof, the size of said pixels being sufficiently large so as to be manually manipulatable and the shape of the pixels conforming generally to the shape of the opening ;
   A pixel being operatively disposed in each one of the openings in the X-Y matrix of said support structure ; and
   discrete, non-thin film switching elements (50, 52, 54, 56, 58, 60, 62, 64, 66) electrically connected to the pixels for simultaneously addressing specific pixels in the rows and columns of the matrix.

2. A display as in Claim 1, wherein the size of each rectangularly shaped pixel is substantially the same as the size of the opening in the matrix of the support structure.

3. A display as in Claim 1, wherein each pixel is substantially rectangular.

4. A display as in Claim 1, wherein the depth dimension of the pixel is small as compared to the length or width dimensions of the pixel.

5. A display as in Claim 3, wherein each pixel has an image surface area of between at least one and 50 or more centimeter on a side.

6. A display as in Claim 1 further including a plurality of spaced, electrically conductive X address lines (26, 28, 30) and a plurality of spaced, electrically conductive y address lines (20, 22, & 24).

7. A display as in Claim 6 wherein the discrete switching elements are transistors and wherein each discrete transistor includes first, second, and third terminals ; the first terminal electrically connected to an X address line, the second terminal electrically connected to a Y address line, and the third terminal electrically connected o a pixel electrode associated with X and Y address lines.

8. A display as in Claim 7, wherein each opening of said support structure further includes means for receiving the first and second terminals of one of the discrete transistors and electrically connecting said terminals to the respective X and Y address lines.

9. A display as in Claim 8, wherein each of said discrete large area pixels further includes means for receiving the third terminal of one of the discrete transistors and electrically connecting said third terminal to one pixel electrode.

10. A display as in Claim 9, wherein the second electrode of each pixel is electrically connected to ground.

11. A display as in Claim 6 wherein the discrete switching elements are diodes and wherein the diodes associated with each pixel are connected in anode to cathode relationship ; the cathode of the first diode electrically connected to a first X address line, the anode of the second diode electrically connected to an adjacent X address line, and the first pixel electrode electrically connected to the common node between the first and second diodes.

12. A display as in Claim 11, wherein each opening of said support structure further includes means for electrically connecting the cathode of the first diode to the first X address line and the anode of the second diode to the adjacent X address line.

13. A display as in Claim 1 wherein one of either each of the openings of the support structure or each of the switching elements includes connector pin means and the other of either each of the openings or each of the switching elements includes connector socket means, said socket means adapted to receive said pin means in electrical engagement.

14. A display as in Claim 13 wherein the pixels and the transistors are sized and configured to be manually electrically interconnected within the opening in said support structure.

15. A display as in Claim 1 wherein the support structure provides an interstitial network into which said macroscopically-sized pixels are adapted to be housed ; and lens means operatively disposed between said pixels so as cover said interstices, whereby light from the peripheral edges of the pixels covered the interstitial network.

FIG - 1

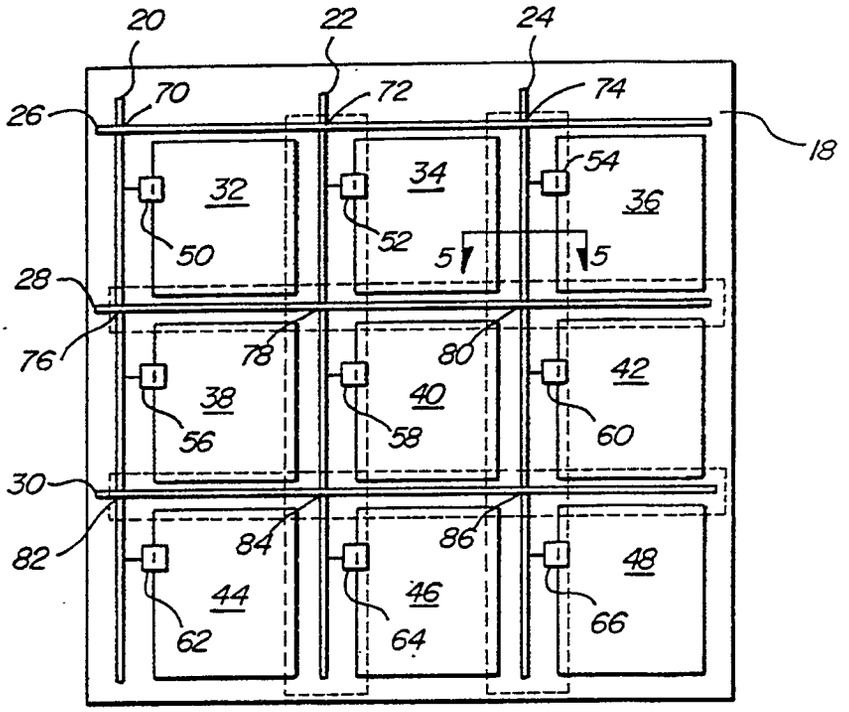

FIG - 2

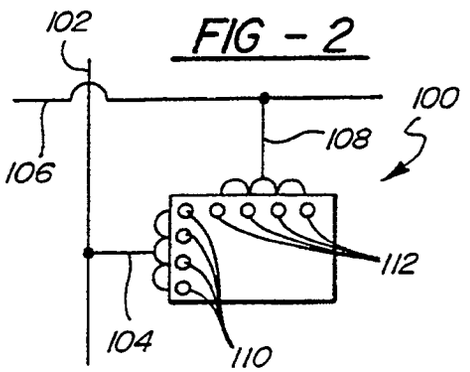

FIG - 4

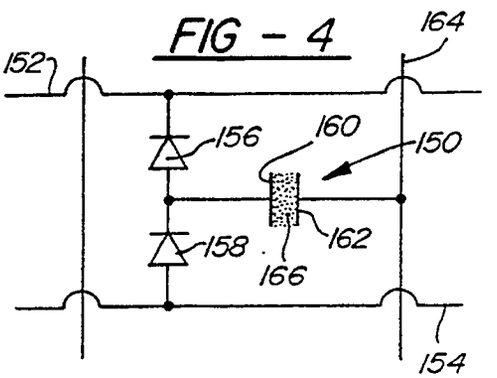

FIG - 3

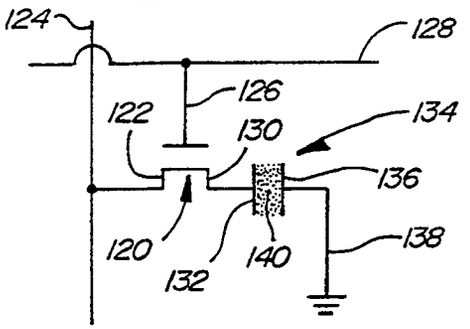

FIG - 5