

Aug. 9, 1966

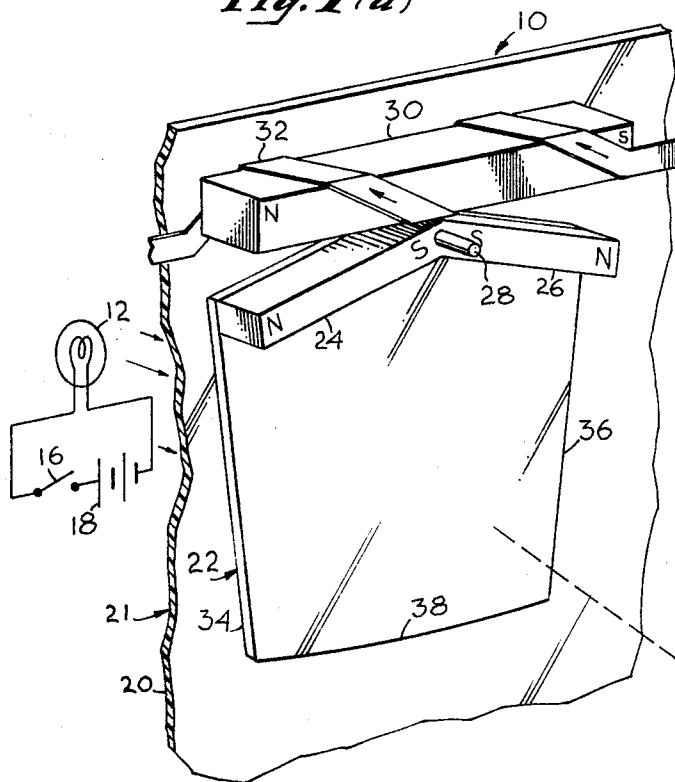
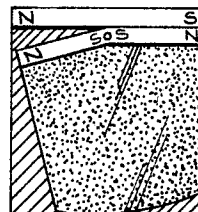
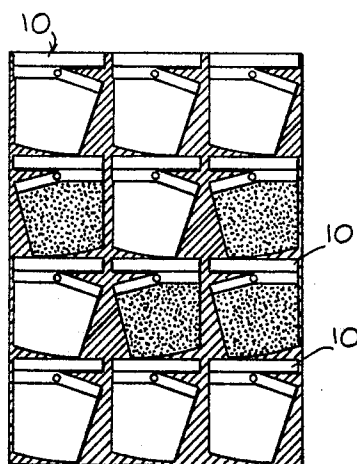
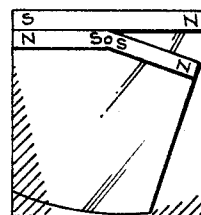
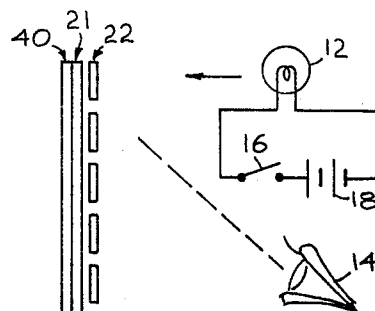
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DISPLAY PANEL HAVING STATIONARY AND MOVABLE POLARIZING ELEMENTS

Filed Nov. 23, 1962

2 Sheets-Sheet 1

Fig. 1(a)*Fig. 1(b)**Fig. 1(c)**Fig. 1(e)**Fig. 1(d)*

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2 Sheets-Sheet 2

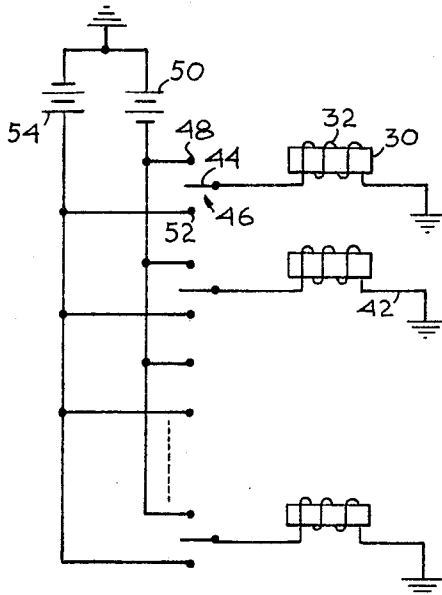


Fig. 2

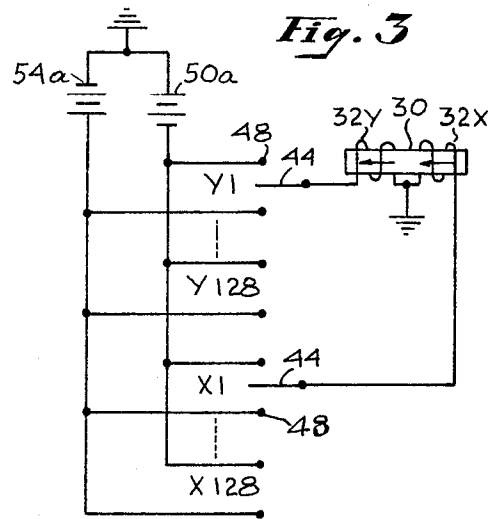


Fig. 3

Fig. 3(a)

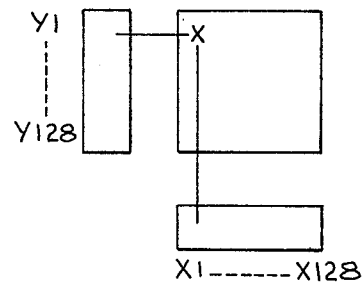
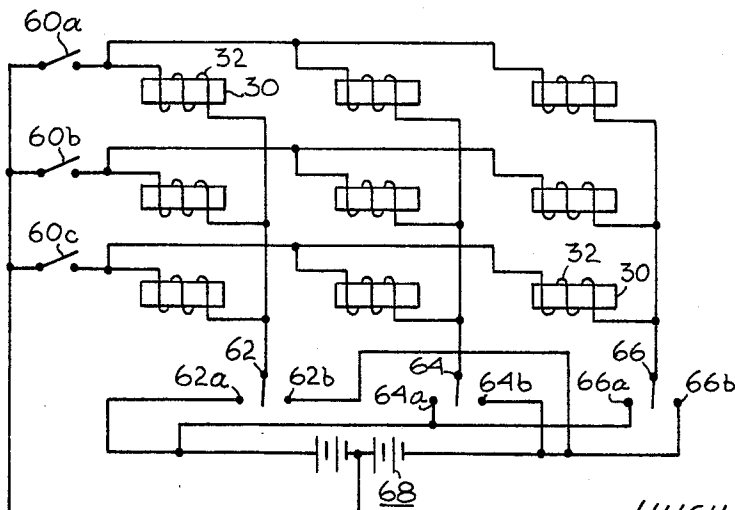


Fig. 4



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DISPLAY PANEL HAVING STATIONARY AND MOVABLE POLARIZING ELEMENTS

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This invention relates generally to display apparatus and more particularly to apparatus for presenting a visual display of electrically represented information.

Visual display apparatus such as a light matrix display generally uses a rectangular organization of a plurality of point light sources, such as electric bulbs. By intelligent selective energization of the bulbs, various light patterns can be generated which are easily recognizable by a viewer. For example, a 5 x 7 light matrix can be employed to suitably represent all of the letters of the alphabet and all of the decimal digits. By contiguously positioning a plurality of 5 x 7 matrices, words, sentences, and complete messages can be displayed. Likewise, more arbitrary light patterns can be developed so as to present pictorial information. Although light matrix displays cannot be switched as rapidly as more sophisticated display devices, such as cathode ray tubes, and are limited to the generation of a finite number of light patterns they are relatively inexpensive, and have accordingly been widely utilized. Light matrix displays are relatively inexpensive because each point light source merely requires an electric bulb and a simple switch with a single electrical energy source sufficing to energize each of the bulbs. Input information designating which bulbs are to be energized can be contained on a recording medium such as punched paper tape, magnetic tape, magnetic cores, or any one of dozens of other memory devices, or alternatively can be provided manually by an operator utilizing a keyboard type structure. Many diverse means are available which are capable of responding to such information to close the appropriate point light source switches.

Although light matrix display devices have proved to be admirably suited for many applications, certain inherent disadvantages of this type of display apparatus have become readily apparent. In the normal utilization of a light matrix display, each of the individual lights is energized and de-energized very frequently, consequently shortening the life which could otherwise be expected from the bulb under the optimum or continually energized condition. Because of the relatively short life of the individual lights, the overall reliability of the entire apparatus leaves something to be desired. Moreover, this relatively poor reliability necessitates preventive maintenance thereby making the light matrix display somewhat expensive to operate.

Cathode ray devices suffer from the detriment that they cannot be operated under conditions of high ambient light.

An object of the present invention is to provide an improved display device which is considerably more reliable than conventional display devices.

An additional object of the present invention is to provide an improved light type of display device which can be satisfactorily operated under conditions of high ambient light.

Still another object of the present invention is the provision of a light type of display device which is inexpensive.

Yet another object of the present invention is the provision of a light type of display device in which the display can be altered rapidly.

Another object of the present invention is the provision of a novel, and useful display device.

The above and other objects of this invention may be achieved in display apparatus utilizing a plurality of light switches in conjunction with a single source of illumination. Each of the light switches is capable of defining two states; namely a light transmitting and non-transmitting state. By arranging the light switches in a matrix and positioning the illumination source adjacent thereto, light displays can be generated by selectively controlling the state of each switch.

In a first embodiment of the invention, each of the light switches comprises first and second optically polarizing elements adapted to be rotated with respect to each other. When the first switch element is in a first position with respect to the second element, light from the illumination source is transmitted through the elements. When the first element is however, rotated to a second position with respect to the second element, the elements are cross polarized thereby being effectively opaque so as to prevent light from the illumination source from passing therethrough. The disclosed embodiment recognizes the advantage of disposing all of the second switch elements in the matrix contiguously so as to form a sheet with the first element being disposed adjacent one surface thereof and the illumination source adjacent the opposite surface thereof.

In a second embodiment of the invention, reflective apparatus is utilized to permit the positioning of the illumination source on the same side of the optically polarizing sheet as a viewer. A mirror is positioned adjacent one side of the optically polarizing material which may be birefringent or circular polarizing material. The first switch elements are positioned between the illumination source and the optically polarizing sheet.

In each of the embodiments, novel electromechanical switch means are utilized to pivot the first switch element with respect to the second. The electromechanical switch means include a pair of permanent magnets secured to the pivotally mounted first switch element. A magnetizable member having a wire wound around it is positioned adjacent the permanent magnet so that a current in one direction through the wire will attract one of the permanent magnets so as to pivot the first element into a first position while a current in the opposite direction through the wire will attract the other of the permanent magnets thereby pivoting the first switch element into a second position.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which:

FIGURE 1a is a fragmentary perspective view of one of the light switches showing its utilization in the first embodiment of the invention;

FIGURE 1b is a front fragmentary view illustrating the light switch in a first state or opaque condition;

FIGURE 1c is a front fragmentary view illustrating the light switch in a second state or light transmitting condition;

FIGURE 1d is a side view of a second embodiment of the invention showing how reflective means can be employed to permit the positioning of the illumination source on the same side of the optically polarizing sheet as the viewer;

FIGURE 1e is a drawing of the light switches disposed in a rectangular matrix in accordance with this invention; FIGURE 2 is a schematic diagram illustrating the man-

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ner in which the wires associated with each of the light switches can be connected to electrical energy sources;

FIGURE 3 is a schematic diagram illustrating the manner in which the wire associated with each of the light switches can be wound to implement the coincident current selection scheme illustrated in FIGURE 3a;

FIGURE 3a schematically illustrates how the light switches can be employed in a coincident current type selection system;

And FIGURE 4 is a schematic diagram illustrating another selecting scheme for the embodiment of the invention.

Attention is now called to FIGURE 1a wherein the details of one of the plurality of light switches utilized in the first embodiment of the invention are illustrated. Each light switch 10 serves the function of either transmitting the light from illumination source 12 therethrough to the eye of viewer 14, or of preventing the illumination from passing therethrough. Source 12 can be serially connected to control switch 16 and an electrical energy source 18.

The light switch 10 comprises a pair of optically polarizing elements 20 and 22. When the switch 10 is incorporated in a matrix with a plurality of other like switches, the element 20 can comprise merely a unit area on a large sheet 21 of optically polarizing material which is common to all of the switches.

Secured to the element 22 are a pair of permanent magnets 24 and 26 which are joined with their like poles in abutting relationship. For example, note that in FIGURE 1a the south poles of the permanent magnets 24 and 26 are in abutting relationship. A pivot pin 28 extends through the magnets 24 and 26 and the element 22 in a manner so as to permit them to pivot thereabout. The pin 28 is terminally supported on element 20. Secured to element 20 immediately above the pivot pin 28 is a bar 30 formed of magnetically soft material. Conductor 32 is wound about bar 30 in a manner so that a current therethrough in the direction of the arrows will establish a magnetic field in bar 30 such that the right hand end becomes a south pole and the left hand end becomes a north pole. Due to magnetic remanence, the bar 30 will retain this magnetic orientation even after the current through conductor 32 ceases. With the magnetic flux in a bar 30 so oriented, the north pole of permanent magnet 26 will be attracted to the south pole of bar 30 resulting in the element 22 pivoting to the position illustrated in FIGURE 1b. If the elements 20 and 22 are properly chosen, they can be substantially cross polarized when element 22 assumes the position shown in FIGURE 1b thereby rendering the combined elements substantially opaque so as to prevent the light from source 12 from reaching eye of viewer 14.

On the other hand, if a current opposite in direction to the current shown in FIGURE 1a is made to flow through conductor 32, the left hand end of bar 30 will become a south pole and the right hand end a north pole. Consequently, permanent magnet 26 will be repelled and permanent magnet 24 will be attracted toward bar 30 so that the element 22 assumes the position shown in FIGURE 1c. In this position, the planes of polarization of elements 20 and 22 are not cross polarized and thereby permit substantial illumination from source 12 to be transmitted through the combined elements.

By properly controlling each of a plurality of light switches 10 organized in a rectangular matrix, such as shown in FIGURE 1e, light patterns or visual displays observable by viewer 14 can be formed by the contrast between the light and dark areas, corresponding to the two states the light switches can assume. The contrast ratio between the light and dark areas depends upon the quality of the polarizing elements 20 and 22, and the angle through which the element 22 is rotated with respect to the element 20 with high quality elements, i.e., very low transmission of light polarized perpendicularly to the

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polarization plane of the element, the contrast ratio is high even for very small angles of rotation.

If the bar 30 is formed of soft iron having a fairly high magnetic permeability and small but significant remnant flux, an extremely short pulse of electric current through conductor 32 will suffice to cause a rapid reversal of the magnetic polarity of the bar 30. It will be appreciated that once the magnetic state of the bar 30 is switched, the current through conductor 32 is no longer necessary to maintain the new magnetic state thereby relieving the means utilized to address or energize the particular conductor 32 to perform other tasks, as for example, orienting the magnetic flux in other bars 30 associated with other light switches. The speed of mechanical rotation of the element 22 need only be great enough so as to permit it to assume its new position before a subsequent updating cycle. For example, at U.S. television rates, the requirements are that the magnetic bar 30 be switched in the picture element time of approximately .25 microsecond, while the mechanical response of the element 22 need only be accomplished in the frame time of .033 second.

The shape of element 22 should be carefully noted. The top surfaces thereof coincide with the top surfaces of magnets 24 and 26 and define an obtuse angle of nearly 180° therebetween. It will be appreciated that the size of this angle depends upon the number of degrees the element 22 need be rotated in order to achieve the desired contrast ratio. The sides 34 and 36 of element 22 depend from the top surfaces thereof and converge remote from the top surfaces. The side surfaces 34 and 36 terminate in an arcuate surface 38. The particular shape of the pivotable element 22 has been chosen to maximize the controlled area of optical transmission under the constraint that the shape of the associated element 20 or unit area on the large optically polarizing sheet 21 must not exceed the boundaries of a rectangle. The rectangular shape constraint has been chosen since it allows a large number of like switches to be arranged in a rectangular matrix or array which may be addressed in a convenient orthogonal fashion.

In order to prevent light from illumination source 12 from passing around the edge of element 22 when it is in the opaque condition as shown in FIGURE 1b, portions of the element 20 or unit area on the large optically polarizing sheet 21 are painted in some manner to render them opaque. The painted portions are indicated by the cross hatched areas in FIGURES 1b, 1c and 1e.

Although magnets 24 and 26 and element 22 are illustrated as being pivotally supported on pivot pin 28, an alternative arrangement is to provide sufficient magnetic attraction between the element 22 and bar 30 to overcome the weight of the element and the permanent magnets 24 and 26, so that the element 22 swings freely about its junction. This alternative arrangement has the advantage of simplifying the construction of the light switch 10 and eliminating the possibility of mechanical failure due to wear or breakage at the pivot point.

Attention is now called to FIGURE 1d which is a side view of an embodiment of the invention. The embodiment in FIGURE 1d permits the source of illumination 12, energized by electrical energy source 18 through switch 16, to be placed on the same side of the optically polarizing sheet 21 as the viewer 14. In this embodiment, a mirror or other reflective surface 40 is disposed immediately adjacent one surface of the optically polarizing sheet 21 which can be formed of some birefringent or circular polarizing material. Elements 22 which can be mounted on the sheet 21 in the same manner as discussed in conjunction with the embodiment shown in FIGURES 1a through 1c, are disposed adjacent the surface of the sheet 21 opposite to the surface adjacent reflective surface 40. It would be appreciated that in a first rotational state of the element 22, the illumination from source 12 will be unable to pass through the element

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22 and sheet 21 to reflective surface 40. In a second state, or in a transmitting condition of the element 22, the illumination from source 12 will pass through the element 22 and sheet 21 so as to be reflected back again thereby being apparent to the viewer 14.

Attention is now called to FIGURE 2 wherein an elementary system for selectively controlling the magnetic flux orientation in bars 30 is illustrated. Assume for example, a display device constructed according to the invention utilizing 16,384 light switches 10 is arranged in a rectangular matrix of 128 x 128. In order to selectively orient the flux in each of the 16,384 bars 30, the terminals of conductors 32 wound thereon are respectively grounded and connected to the movable contact 44 of a single pole double throw switch 46. A first fixed contact 48 of the switch 46 is connected to a negative potential source 50 while a second fixed contact 52 is connected to a positive potential source 54. It will be appreciated that when the movable contact 44 engages fixed contact 48, the right hand end of bar 30 will become a north pole while if the movable contact 44 engages fixed contact 52, the right hand end of bar 30 will become a south pole. It can be seen, therefore, that by selectively positioning each of the 16,384 switches 46, as for example, by some relay means or some manual procedure, the magnetic flux orientation in each associated bar 30 and consequently its associated polarizing element 22 is selectively controlled.

Whereas the system shown in FIGURE 2 requires the utilization of 16,384 single pole double throw switches 46, FIGURES 3 and 3a illustrate how 256 single pole double throw switches 46 can be utilized to control the same 16,384 light switches 10. Again, the 16,384 light switches 10 can be arranged in a rectangular matrix 56 of 128 x 128. Such a matrix may be considered as having 128 horizontal rows and 128 vertical columns. Any light switch 10 in the matrix 56 can be uniquely identified by designating a particular row and a particular column. If, for example, each of the single pole double throw switches 46 associated with a horizontal row is given a designation of $y_1, y_2, \dots, y_{128}$, and each of the switches associated with the vertical columns is designated as $x_1, x_2, \dots, x_{128}$, then any light switch in the matrix 56 can be uniquely identified by designating one of the y switches and one of the x switches.

In order to implement the system schematically illustrated in FIGURE 3a, each of the bars 30 will have wound thereon, a pair of conductors designated as 32y and 32x. Utilizing as an example, the bar 30 situated in the matrix 56 in column 1 and row 1, winding 32y will be connected to the moveable contact 44 of switch x_1 . Assume moveable contact 44 of switch y_1 is urged into engagement with fixed contact 48 thereby driving a current through winding 32y. If the magnitude of the potential source 50a is properly chosen, the current driven through winding 32y will be insufficient to overcome the remnant flux in bar 30. Accordingly, the flux orientation in bar 30 will not change and the permanent magnets and polarizing element 22 associated therewith will not pivot. Likewise, if moveable contact 44 of switch x_1 moves into engagement with its contact 48, a current insufficient in magnitude to switch bar 30 will be driven through winding 32x. When however, contacts 44 of both switches x_1 and y_1 simultaneously move into engagement with contact 48, currents are driven through both winding 32x and 32y aiding each other to thereby establish a magnetic field adequate to switch the magnetic orientation of bar 30 and pivot the permanent magnets 24 and 26 and polarizing element 22. This technique for selecting a unique light switch 10 out of the matrix 56 is properly called a coincident current technique because it requires the coincidence of currents in windings 32y and 32x to switch the magnetic orientation in bar 30.

It has been seen therefore, how 256 single pole double throw switches (128y switches) and (128x switches) can

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be utilized to control 16,384 light switches 10. Again, each of these 256 single pole double throw switches can be controlled manually or by some type of relay means. In a practical embodiment of the invention, some type of recording media, such as punched paper tape or magnetic tape, can be utilized to store the information for selectively controlling each of the 256 single pole double throw switches shown in FIGURE 3.

FIGURE 4 is a circuit diagram of another switching system which can be used for selectively applying current of a desired direction to the windings 32 or the bars 30. By way of illustration a 3 x 3 array is shown. The bars and their windings are disposed in columns and rows. One end of each of the windings 30 on a row of bars is connected to one of the three row switches 60A, 60B, 60C. Three single pole double throw switches respectively 62, 64, 66, hereafter called column switches, are employed, one for each column of bars. The other end of each winding 30 in a column of bars not connected to a row switch is connected to the column switch associated with that column.

Each column switch has one contact respectively 62a, 64a, 66a, connected to one terminal of the center tapped power supply 68, and the other contact respectively 62b, 64b, 66b, connected to the other terminal of the center tapped power supply 68. The row switches 60a, 60b, 60c, are all connected to the center tap of the center tapped power supply 68.

The method of selecting a light switch and for determining whether it should be light or dark or alternatively expressed, the method of selecting a coil 32 and determining the direction of current flow therethrough should be apparent. Such selection is made by closing the one of the row switches 60a, 60b, 60c and to which one end of the desired coil winding is connected, and by closing the one of the column switches 62, 64, 66, to which the other end of the desired coil winding is connected, to one or the other of the contacts a or b in accordance with the direction of current flow desired. Also, the arrangement shown in FIGURE 4 permits selecting an entire row simultaneously, by first setting the switches 62, 64, 66 to provide the direction of current flow desired for the coil selected in that column, and then by closing the row switch for the selected row.

From the foregoing, it should be appreciated that applicant has herein provided an inexpensive and highly reliable display device capable of visually presenting electrically represented information. The extraordinarily high reliability arises from the fact that there need only be one source of illumination used which need not be frequently switched on and off but which can remain continually energized so long as the display apparatus is in use. Additionally, it should be appreciated that the display apparatus provided herein provides a storage feature inasmuch as the magnetic flux orientation in bars 30 remains unchanged in the absence of input information. More particularly this feature permits the utilization of very short addressing or selecting pulses which need merely orient the flux in the bar 30. Once the flux is properly oriented in the bar 30 its hysteresis characteristics maintain this orientation so that the polarizing element 22 associated therewith will maintain its position indefinitely in the absence of an opposite current through the conductor 32 wound about its associated bar 30.

Display apparatus constructed in accordance with the present invention provides displays of surprisingly good clarity and contrast at a relatively low expense. To this point it has been assumed that the source of illumination 12 provides white light, which the illustrated light switch 10 will transmit when in the state shown in FIGURE 1c. The recognition that many transparent materials, such as cellophane, exhibit optical polarization characteristics as a function of wave length, has provided a still further embodiment of the invention which permits the production of brightly colored displays. Such an embodiment

is formed by utilizing cellophane material as the pivotal element 22 in each light switch 10 and sandwiching all of the pivotable elements 22 between two large sheets of cross polarizing material.

The foregoing embodiment of the invention is considered as illustrative of the principles of the invention and it should be understood that there is no intention to limit the scope of the invention to the specific details illustrated herein.

I claim:

1. Apparatus for presenting a visual display of electrically represented information, comprising a source of light, a plurality of light switches disposed adjacent said source, each light switch being capable of defining a light transmitting and not transmitting state, each light switch including a first and a second element of optically polarizing material spaced opposite each other, and means for controlling said switches in response to said electrically represented information to permit light from said source to be transmitted through selected ones of said switches to thereby form a display, each means for controlling a light switch including a member of magnetizable material, means for selectively establishing first and second magnetic states in said member, first and second permanent magnets secured to said first element of optically polarizing material, and means pivotally mounting said first and second permanent magnets adjacent to said magnetizable member whereby the establishment of said first magnetic state in said magnetizable member attracts said first permanent magnet thereto, thereby pivoting said first element to a first rotational position and the establishment of said second magnetic state in said member attracts said second permanent magnet thereto, thereby pivoting said first element to a second rotational position.

2. The apparatus of claim 1 wherein the second elements of all said switches comprise contiguous portions of a sheet of optically polarizing material.

3. Display apparatus for presenting visually recognizable light patterns in response to electrically represented information comprising, a sheet of optically polarizing material, a source of light disposed adjacent one surface of said sheet; a matrix of flat optically polarizing elements pivotally mounted in a common plane parallel to and adjacent an opposite surface of said sheet, each of said elements selectively pivotable between first and second positions; and means for selectively pivoting said elements in response to said electrically represented information.

4. The apparatus of claim 3 wherein said means for pivoting said elements includes a member of magnetizable material, means for selectively establishing first and second magnetic states in said member, first and second permanent magnets secured to said pivotably mounted elements, and means for supporting said permanent magnets adjacent to said magnetizable member whereby the establishment of said first magnetic state in said member attracts said first permanent magnet thereto thereby piv-

oting said pivotably mounted element to a first rotational position and the establishment of said second magnetic state in said member attracts said second permanent magnet thereto, thereby pivoting said pivotably mounted element to a second rotational position.

5. Display apparatus for presenting visually recognizable light patterns in response to electrically represented information comprising a sheet of optically polarizing material, a sheet of reflective material disposed parallel to and adjacent a first surface of said sheet of polarizing material, a matrix of flat optically polarizing elements pivotally mounted in a common plane parallel to and adjacent an opposite surface of said sheet of polarizing material, each of said elements selectively pivotable between first and second positions; a source of light disposed adjacent said common plane of elements remote from said sheet of polarizing material, and means for selectively pivoting said elements in response to said electrically represented information.

6. The apparatus of claim 5 wherein said means for pivoting said elements includes a member of magnetizable material; means for selectively establishing first and second magnetic states in said member, first and second permanent magnets secured to said pivotally mounted elements, and means for supporting said permanent magnets adjacent to said magnetizable member whereby the establishment of said first magnetic state in said member attracts said first permanent magnet thereto, thereby pivoting said pivotally mounted element to a first rotational position and the establishment of said second magnetic state in said member attracts said second permanent magnet thereto, thereby pivoting said pivotally mounted element to a second rotational position.

7. Display apparatus for presenting visually recognizable colored light patterns in response to electrically represented information comprising first and second sheets of cross polarized material, a matrix of flat optically polarizing elements pivotally mounted in a common plane parallel to and between said first and second sheets, each of said elements being formed of a material exhibiting optical polarization as a function of wave length, means for mounting said elements for pivotal movement between first and second positions, and means for selectively pivoting said elements in response to said electrically represented information.

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