

June 4, 1963

D. A. COLE
DISPLAY DEVICE

3,091,876

Filed Sept. 6, 1960

2 Sheets-Sheet 1

Fig. 7.

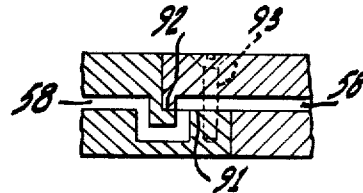
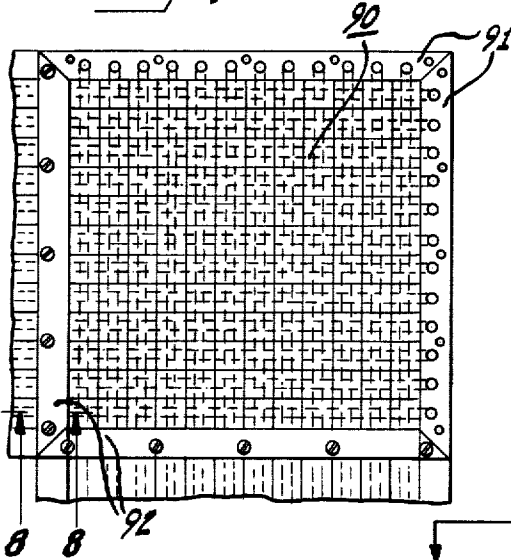


Fig. 8.

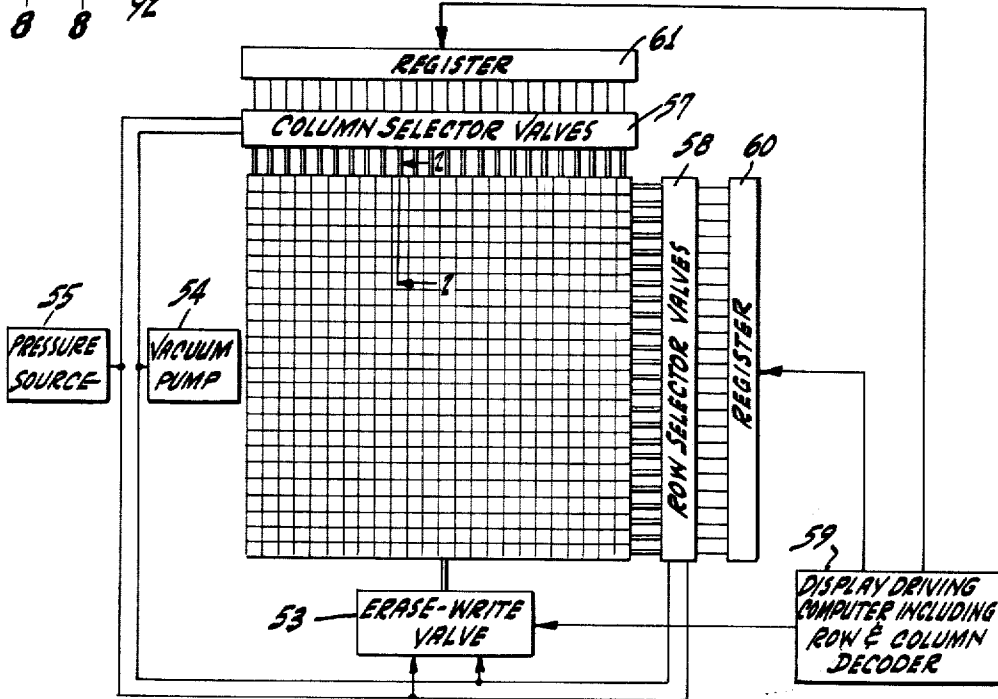


Fig. 1.

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2 Sheets-Sheet 2

Fig. 2.

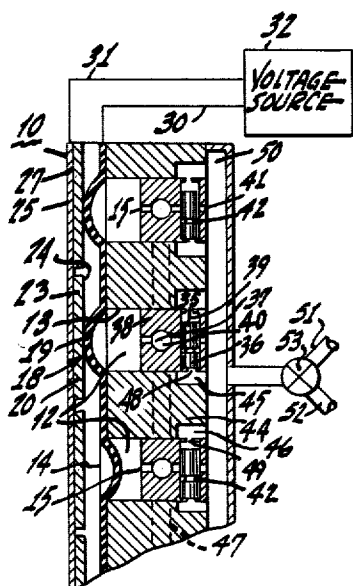


Fig. 5.

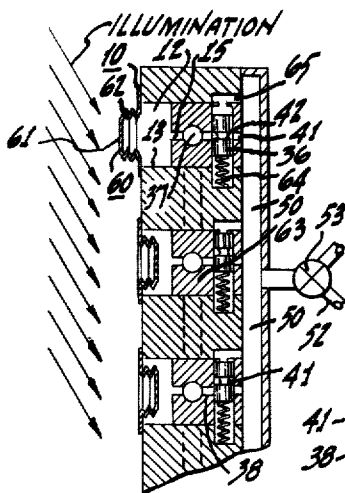
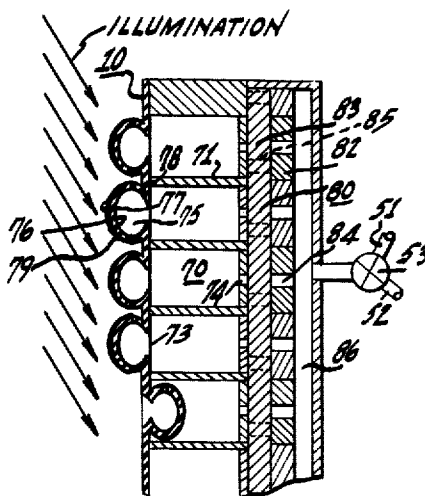


Fig. 3.

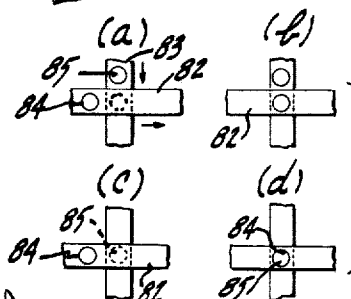
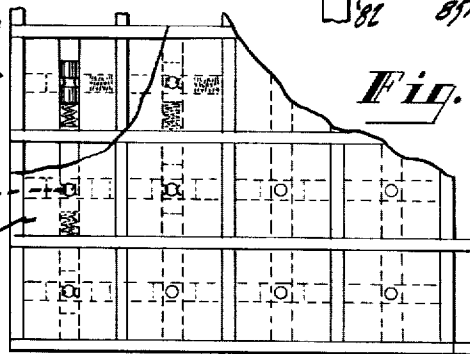


Fig. 6.

Fig. 4.



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3,091,876

DISPLAY DEVICE

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8 Claims. (Cl. 40—28)

This invention relates to a display device, and more particularly to a display device useful for displaying coded information such, for example, as the output information of digital computers.

It is a primary object of this invention to provide an improved display device for converting coded information into visible form.

Another object of this invention is to provide an improved display device as aforesaid which makes use of discrete resolution elements and is capable of selection of elements for information storage and display, and erasure of information from selected elements in accordance with coded information supplied to it.

Another object of this invention is to provide an improved display device as above set forth which is capable of permanent storage of information.

A still further object of this invention is to provide an improved display device as aforesaid which is simple and economical to manufacture and which is highly efficient in use.

Another object of the invention is to provide novel elements for a display device comprising an array of such elements.

In accordance with this invention, there is provided a display device comprising a matrix which contains a plurality of bistable resolution elements each having a tubular-shaped body member and a flexible diaphragm connected to one end of the tubular member in a manner such that the diaphragm can be positioned either within or without the tubular member. Each diaphragm, in one form of the invention, has a highly light reflective front surface which is visible when the diaphragm is positioned outside of its tubular member, but is practically invisible when the diaphragm is positioned within its tubular member.

The resolution elements are arranged in rows and columns. Associated with each resolution element and located adjacent the end of the tubular member opposite to the diaphragm thereof is a pair of pneumatically actuated valves, one valve being considered a row valve and the other being considered a column valve. The valves are normally biased to a closed position. Every valve in a particular row is actuated when that row is selected; and every valve in a particular column is actuated when that column is selected. Located behind the valve assemblies is a manifold to which a vacuum pump and pressure source are connected. When the output of a computer, for example, is impressed on the register, a particular row and column selector valve will be actuated. The row and column selector valve will, in turn, actuate all the row valves of the resolution elements in the selected row and all the column valves of the resolution elements in the selected column. There will therefore be one element with both the row and column valves in an open position. If a pressure is then present in the manifold, the pressure will pass through the open valves to the selected resolution element, thereby forcing the flexible diaphragm thereof out past the end of the resolution element's tubular member to the "on" position. In this position, the reflective surface of the diaphragm reflects incident light to provide a visible "bright spot" on the surface of the array. Alternatively, if a vacuum is created in the manifold, atmospheric pressure will force the flexible diaphragm in the opposite

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direction into the element's tubular member to the "off" position where the reflective surface of the diaphragm cannot be seen. Then, the "hole" left by the retracted diaphragm at the forward end of its tubular member absorbs the incident light to show a substantially "black spot." In the absence of either of the actions described above, the diaphragm remains indefinitely in the position to which it was last actuated, thus providing "memory" as to whether it is "on" or "off."

In another form of the invention, the bistable, flexible diaphragms may be made of electrically conductive material and an individual electroluminescent panel positioned adjacent the diaphragm of each of the resolution elements. The electroluminescent panels are connected to a viewing surface which is coated with a transparent conductive coating connected to a source of voltage. The diaphragms of all the resolution elements of the panel are also connected to the same source of voltage. Therefore when a particular resolution element's diaphragm is forced out past the end of its tubular member by selection of its row and column, the diaphragm will make contact with one surface of the electroluminescent panel, thereby applying a voltage across its associated panel to cause it to emit light. By the same process as set forth above, a second row and column can be actuated, thereby causing a second resolution element to emit light. This process can be repeated until the desired configuration on the surface of the display device is obtained. The configuration on the surface of the display device can be erased by creating a vacuum in the manifold, thereby forcing the projected diaphragms back into the openings in their respective resolution element tubular members. This, in turn, will remove the voltage across the electroluminescent panel, thereby darkening the panel adjacent the particular resolution element erased. As in the previously described embodiment, this embodiment also has the memory feature by permitting the diaphragms to remain in the state to which they were last moved.

The novel features of this invention, both as to its organization and method of operation, as well as additional objects and advantages thereof, will be understood more fully when read in connection with the accompanying drawings in which

FIGURE 1 is a block diagram of an information handling system employing a display device according to the present invention,

FIGURE 2 is a fragmentary, enlarged, cross-sectional view taken along a plane corresponding to the line 2—2 of FIG. 1 and showing one form of display device according to the present invention,

FIGURE 3 is a view similar to FIG. 2 but showing another form of display device according to the present invention,

FIGURE 4 is a fragmentary, rear elevational view of the display device shown in FIG. 3, certain of the parts being omitted to more clearly show the display selecting means,

FIGURE 5 is a view similar to FIGS. 2 and 3 but showing still another form of display device according to the present invention,

FIGURE 6 is a fragmentary elevational view of individual column and row selecting means of the form of the invention shown in FIG. 5, the selecting means being shown in four different positions,

FIGURE 7 is a front elevational view of a modular display panel employing a plurality of individual viewing elements in accordance with the present invention, and

FIGURE 8 is a fragmentary, cross-sectional view taken along the line 8—8 of FIG. 7 and showing the inter-

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connection between a pair of the modular display units of the matrix of FIG. 7.

Referring, first, more particularly to FIG. 2 of the drawings, a display device 10 is shown having a plurality of bistable resolution elements 12. Each resolution element 12 comprises a tubular member 13 which could be of any desired shape, the member having a preferably circular opening 14 at one end thereof and a preferably circular opening 15 of smaller diameter in the opposite end thereof. Positioned in front of and adjacent each opening 14 and communicating therewith is light producing means 18 which includes a flexible diaphragm 19 and an electroluminescent panel 20. The diaphragm 19 is in the form of a flexible, dimpled or dished membrane composed of electrically conducting material such as conductive, synthetic rubber or conductive flexible plastic. A single diaphragm for all the resolution elements 12 of a display panel 10 can also be molded from a single piece of flexible material with dimples formed therein to correspond to the openings 14 in the resolution elements 12, each dimple thereby forming an individual diaphragm 19. In this case, the membrane is bonded to the surface of supporting bodies 44, to be hereinafter described, positioned between the resolution elements 12.

From the following description, it will be evident that either of the diaphragms illustrated in FIGS. 3 or 5 may be substituted for the diaphragms 19, or vice versa.

Adjacent the diaphragm and forming the other part of the light-producing means 18 for each resolution element 12 is the electroluminescent panel 20. The panel 20 is provided with a layer of electroluminescent material 23, such as any of a number of well-known phosphors, one surface thereof being sprayed with a layer 24 of opaque conducting material, such as silver paint. The panel 20 is oriented so that the layer 24 is adjacent the diaphragm 19. A plate 25 of glass or the like, which is approximately the same size as the display panel 10, forms a viewing surface for the panel 10 and also a substrate for the layer 23. One surface of the plate 25 is coated with a film 27 of transparent conductive material, such as tin fluoride or finely sprayed silver paint. Alternatively, the plate could be made of conducting glass. The individual electroluminescent panels 18 are secured against the surface of the plate coated with the film 27. The conductive diaphragms 19 are connected to a terminal lead 30 and the transparent conductive film 27 to a terminal lead 31. These terminal leads 30 and 31 connect the conductive diaphragms 19 and the conductive film 27 to a source of voltage 32 for energizing the various individual electroluminescent panel elements when their respective diaphragms make contact therewith. The source of voltage 32 can be any voltage supply suitable for use with the particular electroluminescent phosphor material 23 employed.

Located adjacent the openings 15 in the resolution elements 12 is means for selecting one of said resolution elements 12 to be actuated. The selecting means may consist of a double valve assembly 35 positioned behind each resolution element 12, one of said valves being a row valve 36 and the second being a column valve 37. Each valve assembly 35 is formed with a preferably square shaped member 38 with two openings 39 and 40 therethrough which are in planes substantially perpendicular to each other and in which the respective valves 36 and 37 are positioned. There is also an opening 41 through the center of the member 38 which communicates with the opening 15 in the resolution element 12 and a vacuum-pressure manifold to be hereinafter described. The row valve 36 and column valve 37 are preferably cylindrical shaped with a central groove 42 around the outer periphery thereof. The valves 36 and 37 are so formed that, when they are in the open position, the grooves 42 therein are aligned with the openings 41 and 15. When the valves 36 or 37 are in the closed position, the grooves 42 thereof and openings 41 and 15 are mis-

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aligned. When both valves 36 and 37 of a particular resolution element are in the open position and their grooves 42 are in alignment with the openings 41 and 15, a pressure or vacuum created in the manifold, to be hereinafter described, can communicate with the opening in the resolution member 12.

Positioned between each row of resolution elements 12 is a supporting member 44 of electrical insulating material formed with a pair of longitudinally extending grooves or passages 45 and 46 in opposed surfaces thereof and with a plurality of transversely extending openings 47 therethrough. When the supporting member 44 is assembled between two rows of resolution elements 12, the grooves 45 thereof will communicate with the bottom opening 48 in each of the row valve housings so that, when a vacuum is created in the groove 45, a vacuum will be created under each of the valves 36. The groove 46, on the other hand, will communicate with the top openings 49 in each of the row valve housings of the resolution elements 12 in the row below the supporting member 44. Therefore, when a pressure is created in the groove 46, a pressure will be applied to the tops of all the valves in the row communicating with the groove 46. This same arrangement is provided for each row of resolution elements 12. The plurality of openings 47 in the supporting member 44 are so positioned that one opening 47 communicates with the left side opening of each column valve housing in the column immediately to the right thereof and a second opening 47 communicates with the right side opening in each valve housing in the column immediately to the left thereof. Therefore, in a manner similar to that utilized in opening and closing the row valves the column valves can be actuated to open or closed position. It will be understood from the above that, by applying a pressure or creating a vacuum in a certain groove 45 or 46 or certain opening 47, all the valves in a particular row or column can be opened or closed. The valves in the same row or in the same column have the same orthogonal relationship with respect to each other.

Positioned adjacent the valve assembly 35 is actuating means 50 which is illustrated in FIG. 2 as a vacuum-pressure manifold. Communicating with the manifold 50 by means of conduits 51 and 52, connected to a valve 53, are a vacuum pump 54 and a pressure source 55 illustrated schematically in FIG. 1. When the valve 53 is in a first position, a pressure is created in the manifold by means of the pressure source 55, the pressure being utilized to actuate the diaphragm 19 of a selected resolution element 12. When the valve 53 is in a second position, a vacuum is created in the manifold which is used to erase information placed on the panel 22. The vacuum pressure manifold 50 in FIG. 2 is illustrated schematically by the erase-write valve 53 in FIG. 1.

To operate the display device 10, as shown in FIG. 2, the diaphragm 19 of each resolution element must initially be positioned in a first stable state. In this first stable state, the diaphragms 19 are located within the opening 14 in the tubular member 13 so that the diaphragm 19 will not be in contact with the electroluminescent panel 18. The diaphragms are placed in the first stable state as follows: A particular valve in the column selector 57 and a particular valve in the row selector 58 are opened (FIG. 1). This allows the vacuum pump 54 and pressure source 55 to create, through the grooves 45 and 46, pressure on one side and vacuum on the other side of all the row valves 36 of the selected row, thereby aligning the grooves 42 in the valves 36 with the openings 41. A similar condition is created about each of the column valves 37. Next, the valve 53 is turned to the erase position, thereby creating a vacuum in the manifold 50 by means of the vacuum pump 54. The vacuum in the manifold 50 will, in turn, create a vacuum in the tubular member 13 of the resolution element with both the row 36 and column 37 valves open. Due to the

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vacuum created, the ambient air will force the diaphragm 19 into the opening 14, thereby disengaging the diaphragm 19 from contact with the electroluminescent panel 20. The diaphragm 19 is then positioned in the first stable state. The process of selecting different rows and columns to be actuated may be continued until all the diaphragms 19 are in the first stable state. It will be understood that all of the diaphragms 19 can be returned to the first stable state simultaneously by casing all rows and columns to be selected simultaneously.

The valve 53 is then turned to the write position which will connect the pressure source 55 to the manifold 50. As illustrated in FIG. 1, a display driving computer 59 communicates a signal to the row register 60 and the column register 61 which may be a plurality of independent bistable switches. The row register 60 and column register 61 will open corresponding row and column valves in the column selector 57 and row selector 58 which will, in turn, allow a pressure and vacuum to be created on different sides of the valves in the selected row and column. As set forth above, there will be one resolution element in which both the row and column valves are open. The pressure created in the manifold 50 will then be able to communicate through the openings 41 and 15 to the opening in the tubular member 13. The pressure created in the tubular member 13 will force the diaphragm out through the opening 14 past the edge of the tubular member 13. The diaphragm 19 is then considered to be in the second of its two stable states. As shown in FIG. 2, when the diaphragm 19 is in the second stable state, it is in contact with the opaque conducting layer 24 of the electroluminescent panel 22. A second set of row and column valves can then be opened and the process repeated until the selected diaphragms are in the second stable state. It will be understood that, should it be desired to actuate more than one diaphragm in a given row to the second stable state, all such diaphragms may be actuated simultaneously by selecting the desired row and all columns in which the desired elements lie. Similarly, one may simultaneously actuate all elements in a rectangular area by simultaneously selecting the rows and columns which define that area.

A voltage from the voltage source 32 is then applied to the transparent conductive layer 27 and the diaphragm 19, thereby causing the electroluminescent panels 20 adjacent the resolution elements 12 whose diaphragms 19 are in the second stable state to luminesce. Inasmuch as the diaphragms 19 are always in one or the other of their two stable states, if the pressure or vacuum behind a particular valve is released, the diaphragm associated therewith will remain in the same position until a different pressure or vacuum force is applied to change its state.

If it is desired to return some of the diaphragms to the first stable state while allowing other diaphragms to remain in the second stable state, the valve 53 can again be changed to the erase position, thereby creating a vacuum in the manifold 50. By selecting particular rows and columns at the intersections of which the certain resolution elements 12 of interest are located, their diaphragms 19 can be returned to the first stable state while allowing the other resolution elements 12 to remain in the second stable state.

FIG. 3 shows another embodiment of the display panel 10, as illustrated in FIG. 2, with a different type of light producing means and actuating means.

The light producing means in FIG. 3 is provided with a diaphragm 60 having a somewhat bulging, flexible member 61 connected to the tubular member 13 by means of a bellows 62. The surface of the member 61 is light-reflective and the surface of the bellows 62 is light absorptive. Therefore, when a vacuum is created in the manifold 50, and the valves 36 and 37 associated with a particular resolution element are opened, the flexible member 61 will be forced into the opening in the tubular

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member 13 by means of the ambient air. When illumination, such as ordinary light, is projected at an appropriate angle onto the viewing surface of display panel 10, the light will be absorbed by the light-absorbent surface of the bellows 62, thereby leaving a dark spot at the actuated resolution element 12. On the other hand, if pressure is created in the manifold 50 and the tubular member 13, the diaphragm 60 will be forced out of the tubular member 13 through the opening 14. In this position, illumination projected on the viewing surface of the display panel 10 will be reflected by the light reflective surface of the diaphragm 61, thereby showing a bright spot in front of the actuated resolution element. By selecting different combinations of resolution elements 12 to be actuated, different patterns will be shown on the viewing screen.

The actuating means 63 is similar to the actuating means 35 illustrated in FIG. 2 except that the piston-type members 36 are biased in a closed position by means of springs 64. Other similar biasing means can be used. When a pressure is created in the communicating means 65 adjacent each row and each column of resolution elements 12, the valves 36 are forced, against the action of the spring 57, into an open position in which the groove 42 is aligned with the opening 15 in the resolution element 12.

FIG. 4 is a rear view of the panel with the write-erase manifold 50 removed in order to more clearly illustrate the valve members 38 and the respective, central openings 41 therethrough.

Referring, now, more particularly to FIG. 5 of the drawings, another embodiment of the display panel 10 is illustrated having a plurality of bistable resolution elements 70. Each resolution element 70 is formed in the shape of a tubular member 71 which is preferably square in cross section and has a circular opening 73 in one end thereof and a circular opening 74 of smaller diameter in the opposite end thereof. Communicating with the opening 73 is a bulbous, flexible diaphragm 75 having an inner surface 76 and an outer surface 77. A portion of the outer surface 77 adjacent the tubular member 71 is preferably coated with a light-absorbing material 78, the remainder of the outer surface 77 being coated with a light-reflective material 79. The flexible diaphragm 75 can be formed of ordinary vulcanized rubber or similar material. For long life, it may be desirable to lubricate the rubber diaphragm with a silicone oil or other such lubricant which does not attack rubber. The diaphragm 75 of each resolution element 70 may be molded separately, or the diaphragm 75 for all the resolution elements 70 may be molded from one piece of material.

Located adjacent the opening 74 in each resolution element 70 are means 80 for selecting the resolution elements to be actuated. The selecting means 80 consist of a separate, elongated rod 82 behind each row and a separate, elongated rod 83 behind each column of resolution elements 70. Each row rod 82 is formed with a plurality of openings 84 therethrough, and each column rod 83 is formed with a plurality of openings 84 therethrough. When the rods 82 and 83 are actuated by means of pressure exerted on the ends of the rods, the openings 84 and 85 will align with the openings 74 in the resolution elements 70.

FIG. 6 illustrates four different positions into which the row rods 82 and the column rods 83 can be shifted to dispose their respective openings 84 and 85 adjacent a particular element. In FIG. 6(a), neither the row rod 82 nor the column rod 83 has been actuated. Therefore, neither of the openings 84 and 85 is aligned with the opening 74. If the rod 82 is moved to the right, as shown by the horizontal arrow in FIG. 6(a), to the position of FIG. 6(b), the row opening 84 becomes aligned with the opening 74 in the resolution element 70 but the column rod 83, which has not been actuated, remains in its initial position, as shown in FIG. 6(b). Now, sup-

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pose the column rod 83 is moved downwardly, as shown by the vertical arrow of FIG. 6(a). In this case, the opening 85 thereof becomes aligned with the opening 74; but since the row rod 82 was not actuated, its opening 84 remains out of alignment with the opening 74, as shown in FIG. 6(c). If, now, both of the rods 82 and 83 adjacent a particular resolution element 70 have been actuated to move in the directions of their respectively associated arrows of FIG. 6(a), their openings 84 and 85 will become aligned with the opening 74, thereby allowing the pressure or vacuum created in the manifold, to be hereinafter described, to be applied to the tubular opening in the resolution element 70. Positioned behind the selecting means 80 is a write-erase manifold 86 which is similar to the manifold 50 described in connection with FIG. 2. As set forth above, a pressure source 55 and vacuum pump 54 are connected to the manifold 86. Therefore, when the row opening 84 and column opening 85 both are aligned with the opening 74 in the resolution element 70, a vacuum created in the manifold 86 will create a vacuum in the tubular opening in the selected resolution element 70. The ambient air will force the bulbous diaphragm 75 into its first stable state, to its "off" position, within the tubular shaped member 13 through the opening 73. In this position, illumination, such as ordinary light, which strikes the outer surface 77 of diaphragm 75 will be absorbed by the portion 78 of the surface 77 which is light-absorbing. If a pressure is created in a tubular member, the diaphragm 75 will be forced out through the opening 73 to its second stable state. In this position, illumination will strike the light-reflective portion 79 of the surface 77. In the second stable state, the diaphragm is considered in the "on" position.

FIG. 7 illustrates an assembly of modular resolution elements 70 connected together to form a modular panel 90. Each modular unit may comprise either a single resolution element or a group of several rows and columns of such elements, as desired. Each modular resolution element includes passages, such as those described above, through which pressure variations can be applied to its actuating means. The marginal areas of the panel 90 are formed with mating lips 91 and 92 to provide a lap joint. Communicating means, such as the communicating means 58 shown in FIG. 3, can be provided to terminate at the surfaces of these lips so that the communicating means 58 of one panel 90 can be connected to the communicating means 58 of another adjacent panel 90. The lips 91 and 92 are engaged and held together by means of screws 93. An assembly of panels 90, joined in this or any other suitable manner, provides the display device.

From the foregoing description, it will be apparent that I have provided an improved display device which has increased efficiency over previously known display devices. While I have illustrated and described three particular types of display panels, it will, no doubt, be apparent to those skilled in the art that various changes may be made in the particular forms described, and that other forms are possible all within the spirit of the present invention. Hence, I desire that the foregoing shall be taken merely as illustrative and not in a limiting sense.

What is claimed is:

1. In a display device, the combination of a resolution element comprising a tubular member having a pair of openings therein, light producing means including an electroluminescent panel and a diaphragm, said diaphragm comprising a flexible membrane connected across one of said pair of openings, said membrane including electrically conductive material, and actuating means communicating with the other of said openings, said actuating means being capable of conditioning said diaphragm in either one of two different stable states in one of which said membrane contacts said electroluminescent panel for rendering said panel light producing.

2. A display device comprising a plurality of bistable

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resolution elements aligned in rows and columns, each of said elements comprising a tubular member having a pair of openings therein, light producing means including a flexible diaphragm connected across one of said openings, actuating means communicating with the other of said openings, said actuating means being capable of conditioning said diaphragm into one or the other of two, different, stable states, two means corresponding, respectively, to said columns of resolution elements and to said rows of resolution elements for selecting at least one of said resolution elements to place the diaphragm corresponding to said selected element into one of its said stable states, and means for rendering said light producing means operative to make the diaphragm of said selected resolution element visible when it is in said one of its stable states.

3. A display device comprising a plurality of bistable resolution elements aligned in rows and columns, each of said elements comprising a tubular member having a pair of openings therein, light producing means including a flexible diaphragm connected across one of said openings, actuating means communicating with the other of said openings, said actuating means being capable of conditioning said diaphragm into one or the other of two, different, stable states, means for selecting at least one of said resolution elements comprising a separate rod behind each said row and each said column of said elements, each of said rods having a plurality of openings therethrough, means for actuating at least one of said row rods and at least one of said column rods for aligning openings therein corresponding to a selected resolution element, and pneumatic means included in said actuating means for communicating with said other of said pair of openings in said tubular member through the aligned openings in said row rod and said column rod.

4. A display device comprising a plurality of bistable resolution elements aligned in rows and columns, each of said elements comprising a tubular member having a pair of openings therein, light producing means including a flexible diaphragm connected across one of said openings, actuating means communicating with the other of said openings, said actuating means being capable of conditioning said diaphragm into one or the other of two, different, stable states, means for selecting one of said resolution elements comprising a separate communicating means adjacent each row and column of said resolution elements, each said communicating means having associated therewith a plurality of row valves and column valves, one of said row valves and one of said column valves being positioned adjacent the other of said openings in each said tubular members, means associated with each of said valves for biasing the valve into closed position, means for operating all of said valves associated with one of said column communicating means and one of said row communicating means so as to open said row valve and said column valve associated with a selected resolution element, and means for rendering said light producing means operative to make the diaphragm of said selected resolution element visible when it is in one of said stable states.

5. A display device comprising a plurality of bistable resolution elements aligned in rows and columns, each of said elements comprising a tubular member having a pair of openings therein, light producing means including a flexible diaphragm connected across one of said openings, actuating means communicating with the other of said openings, said actuating means being capable of conditioning said diaphragm into one or the other of two, different, stable states, means for selecting one of said resolution elements comprising a pair of communicating means adjacent each row and each column of said resolution elements comprising a pair of communicating means having associated therewith a plurality of row valves and column valves, one of said row valves and one of said column valves being positioned adjacent said

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other opening in each said tubular member, each of said valves being positioned between its associated pair of communicating means, means for operating all of said valves associated with a selected one of said column communicating means and a selected one of said row communicating means so as to open the row and column valves associated with a selected resolution element, and means for rendering said light producing means operative to make the diaphragm of said selected resolution element visible when it is in one of said stable states.

6. In a display device, a plurality of resolution elements arranged in rows and columns each comprising a tubular member having a pair of openings therein, light producing means including a diaphragm connected across one of said pair of openings, a pair of communicating means adjacent each row and each column of said resolution elements, each said pair of communicating means having associated therewith a plurality of row valves and column valves, one of said row valves and one of said column valves being positioned adjacent the other of said pair of openings in each said tubular member, each said valve being positioned between its associated pair of communicating means, means for creating a pressure in one of said communicating means, and means for creating a vacuum in the other of said communicating means in order to force said selected row and column valves into an open position.

7. In a display device, a bistable resolution element comprising a tubular member having a pair of openings therein, a conductive diaphragm connected across one of said openings, actuating means communicating with the other of said openings, said actuating means being capable of conditioning said diaphragm in one or another of two stable states, an electroluminescent panel having an electroluminescent layer with coating of conductive material on opposite surfaces thereof, the material of one

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of said elements included a movable member capable of being positioned adjacent said diaphragm so that when said diaphragm is in one of said stable states it is in contact with the coating on the surface of said electroluminescent panel adjacent to said diaphragm, and means for connecting a source of voltage to said diaphragm and said transparent conducting coating, said transparent coating being furthest from said diaphragm.

8. A display device comprising a matrix having a plurality of orthogonally arranged resolution elements, each of said coatings being transparent said panel being positioned so as to assume one or the other of bistable "on" and "off" states and having a viewing surface adapted to reflect incident light when said member is in its said "on" state to thereby provide a visible display, said surface being substantially obscured from view when said member is in its said "off" state to thereby render said member incapable of providing said display, and pneumatically operable means including a plurality of orthogonally arranged valves each associated with a correspondingly arranged one of said resolution elements for shifting said members to one or the other of their said states, said pneumatically operable means also including means for simultaneously actuating all of said valves having the same orthogonal relationship with respect to each other.

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