An image-display panel includes a plurality of light-displaying elements, such as electroluminescent capacitors or liquid crystals, disposed in an array of rows and columns. Associated with each light-displaying element is a photoconductor or other light-responsive device for activating the light-displaying elements. A pair of crossed arrays of fiber-optic light pipes have their crossings in juxtaposition with the photosensitive devices, the light pipes including localized light-emitting apertures near the crossings. A system is included for injecting light into the light pipes in a manner to provide systematic sequential scanning of the photosensitive devices by concurrent light emission from the localized apertures of selected light-conductive elements of both of the arrays. Light emitted from a single light-pipe aperture reduces the resistance of the associated photoconductor, but the resistance of the remaining part is sufficient to prevent the light-displaying element from functioning. When light is emitted from both light-pipe apertures associated with the photoconductor at a single display element, the photoconductor resistance is sufficiently reduced that the light-displaying element produces a useful output. In an alternative embodiment, the light pipes are utilized for scanning activation in but one direction, while electrical conductors are used to perform the coordinate scanning function.

10 Claims, 9 Drawing Figures
The present invention pertains generally to the control of scanning in a matrix-type image-display device. More particularly, it provides an image-display panel in which scanning selection within the panel itself is achieved by the use of light-guiding elements such as light pipes.

Since at least as early as the first cathode-ray tube, much effort has been devoted to the ultimate objective of a flat-image-display panel. Some workers have sought to devise cathode-ray tube constructions that result in a rectangular envelope of comparatively narrow depth. Proceeding in a different direction, a great deal of effort has been devoted to attempts to produce a satisfactory matrix-type display panel. These display panels have included matrices of light-control devices such as electroluminescent cells, mechanical shutters, liquid crystals, and injection-luminescent diodes.

Some success has been obtained with the aforementioned approaches. Matrix-accessed displays have been demonstrated that are capable of producing images of simple outlines such as numbers and even of more detailed pictures. However, such approaches have been far from satisfactory for television-type displays.

One reason for the lack of adequate success lies in the high degree of resolution necessary to convey a television image adequately. For a conventional monochrome television picture, it is necessary to reproduce approximately two hundred thousand picture elements over the area of the display surface and to provide a capability of selectively addressing these elements individually within each line either sequentially or in a portion or all of a line at a time. Typical addressing schemes include crossed arrays of conductors, the conductors in one of the arrays corresponding to horizontal lines and the conductors in the other array corresponding to the successively different picture element positions in each such line. It is not surprising that a considerable amount of difficulty has been experienced by reason of the substantial inductance and/or capacitance introduced into the system by such a maze of conductive structures. In an effort to obviate these difficulties, other approaches have sought to include scanning mechanisms directly within the arrays themselves. However, these approaches have also encountered additional problems by reasons of the high switching rates and the significant quantity of energy which must be controlled.

It is a general object of the present invention to provide an image display device which overcomes or at least reduces the aforementioned difficulties and problems.

A related object of the present invention is to provide an image-display device having a new and improved matrix addressing system.

Another object of the present invention is to provide, for use in image-display devices, a matrix addressing system which is compatible with a variety of different kinds of matrix elements.

In accordance with the present invention, an image-display device includes a plurality of elongated light-guiding elements collectively disposed in a predetermined array and individually provided with an input aperture for receiving light and a plurality of localized exit apertures at different locations for permitting localized and directive partial egress of the light, and a plurality of light-responsive elements disposed in a corresponding array so that the light-responsive elements are in juxtaposition with the exit apertures.

The features of the invention which are believed to be novel are set forth with particularity in the appended claims.

The invention, together with further objects and advantages thereof, may best be understood, however, by reference to the following description taken in conjunction with the accompanying drawings, in the several figures of which like reference numerals identify like elements, and in which:

FIG. 1 is a fragmentary perspective view, from the rear and partially broken away, of an image-display device embodying the present invention;

FIG. 2 is a cross-sectional view taken along the line 2—2 in FIG. 1;

FIG. 3 is a fragmentary cross-sectional view taken along the line 3—3 in FIG. 1;

FIG. 4 is a fragmentary rear-elevational view of an alternative embodiment of the present invention;

FIG. 5 is a cross-sectional view taken along the line 5—5 in FIG. 4;

FIG. 6 is a cross-sectional view taken along the line 6—6 in FIG. 4;

FIG. 7 is a fragmentary cross-sectional view taken along the line 7—7 in FIG. 4;

FIG. 8 is a fragmentary cross-sectional view taken along the line 8—8 in FIG. 4; and

FIG. 9 is a block diagram of a system for addressing the display devices of either FIG. 1 or FIG. 4.

In the embodiment of FIGS. 1–3, an image-display panel comprises a substrate 10 of a transparent material such as glass. On the surface of the glass faceplate 10 is provided a continuous thin-film transparent conductive electrode 11, of tin oxide, NESA material or the like, and on the surface of electrode 11 is provided a grid-like opaque spacer element 12 subdividing the panel into individual picture-element-sized subdivisions. Disposed in a predetermined array of horizontal rows and vertical columns within the subdivisions or terestices established by spacer 12 are a plurality of light-displaying elements 13, one such element being included for each picture element of the image to be produced. For increased yield in production, it may be desired to include more than one element at each position to provide operative redundancy. As illustrated, display elements 13 are nematic liquid-crystal cells which respond to externally applied electric fields to transmit or reflect light from an external source in an amount proportional to image brightness. Alternatively, elements 13 may be replaced by other suitable light-generating or light-controlling devices. Electroluminescent devices and gas plasma cell exemplify other light producers, while other controllably-reflective or controllably-transmissive devices such as electric particle modulating or mechanical shutters may be employed as the light-displaying elements. Opaque spacer grid 12 is provided with risers 14 extending along the horizontal grid elements on opposite sides of each horizontal row of liquid crystal cells 13, and the liquid crystal materials 13 are confined in the cells by auxiliary glass plates 15 which each extend across an entire horizontal row of liquid crystal cells 13 and fit between
the risers 14 on opaque spacer grid 12. Auxiliary glass substrates 15 are each provided with a conductive coating 16 on the surface facing the liquid crystal cells 13.

On the outer surface of each auxiliary glass plate 15, there is provided a horizontal conductive strip electrode 17, and elements 18 of photocooperative material are provided, one for each cell 13, between strip electrode 17 and another conductive terminal 19 formed as an extension of inner surface electrode 16. A plurality of laterally spaced vertically extending light-guiding elements or light pipes 20, one for each vertical column of light-displaying elements 13, extend in alignment with the photocooperative elements 18 associated with the picture elements of the respective columns. Elements 18 are normally of high impedance but become conductive under the stimulation of light, "light" being defined herein as including visible light or light in either the infra-red or ultra-violet regions of the spectrum. The use of infra-red or ultra-violet light for control can be advantageous in avoiding any problem of segregating the controlled and the controlling light.

While various light-sensitive devices may be employed, e.g., junction diodes or other avalanche-type solid-state elements, devices 18 in this case are photocooperative elements. Although it may be a matter of choice as to which component in a matrix addressing and selection system exhibits non-linearity, it is well understood that proper selection from among the number of different matrix points requires the inclusion of at least one non-linear element in some way associated with each matrix intersection. To that end, the required non-linearity is here insured by the fact that the photocooperative requires both a voltage impressed across it and incident light in order to produce appreciable current. The sharpness of selection of a particular light-displaying element may be enhanced by choosing a photocooperative that exhibits a non-linear response to light. A suitable photocooperative material is vacuum-deposited polycrystalline cadmium selenide.

Light conducted within a given light pipe from a light source 23 is caused to leak or exit from the pipe so as to illuminate each of photocoordinates 18 in the vertical column associated with that pipe. Ordinarily, light is channeled within a light pipe by total internal reflection created by forming the pipe of a material having an index of refraction greater than that of a surrounding material or medium. The surrounding material may simply be air, although the pipe is sheathed or clad with a substance exhibiting an intermediate index of refraction in order to obviate losses where the pipe otherwise would touch some other material or substance. While light pipes 20 may be caused to leak throughout their lengths, it is preferred for increased efficiency to include a plurality of peripheral exit apertures 21 at different spaced locations along the pipes in order to permit localized and directive partial egress of light from the pipes onto the respective different ones of photocoordinates 18 spaced along the length of the pipes. Each light pipe is composed of an inner core clad by an optically-contacting sheath of a material having an index of refraction to the light lower than that of the core.

Apertures 21 are formed in the cladding at each position directly opposite one of photocoordinates 18, each of the apertures preferably being filled with an insert of a material having an index of refraction of about the same as that of the core in order to facilitate egress of the light through the aperture. If desired, light loss in pipes 20 may be compensated by progressively changing the effective light output from successive apertures, as by forming them to have progressively larger diameters or higher transmissivities.

For the purpose of feeding light sequentially to successive light pipes 20 in order to provide line-by-line scanning of the array, light source 23 in its most elementary form may simply be composed of a series of incandescent lamps, gas-discharge cells, or other light generators energized sequentially through a rotary switch. As one alternative, light pipes 20 may be twisted so that their light-receiving free ends are disposed in a circle; an intense light beam from a source such as a laser may then be reflected from a rotating mirror so as repetitively to scan the circular array represented by the input end of the pipes. In some applications, it might also be advantageous that light source 23 take the form of a small cathode-ray tube. With the controlling light pipes arranged at their outer ends in the form of a circle as previously described, the use of a circular scan on the screen of the cathode-ray tube, imaged on the input light-pipe ends, would cause the pipes to be successively illuminated in turn. Such a circular scan approach requires no fly-back arrangements for the cathode-ray tube, thus simplifying its deflection circuitry. In any event, care is taken so that the light affecting each photocoordinate 18 is that from its associated aperture 21. To that end, as previously mentioned, the back side of the panel when in use is encased by a light-tight cover, or its entire rear surface is coated with a light-opaque layer 22 of black epoxy resin or the like.

To achieve row selection, an energizing source is connected to establish an electric field sequentially between horizontal strip electrodes 17 and inner surface electrode 16. To obtain sequential or line-by-line scanning as in a conventional television display, selective connection to strips 17 may in the simplest version be by means of a rotary switch or commutator.

Activation of any given one of the light-displaying elements 13 occurs whenever light is being emitted from the one of apertures 21 associated with that display element and its associated photocoordinate 18 at the same time that the one of strips 17 connected to that photocoordinate is connected to the energy supply source. In the absence of photocoordinate illumination, the resistance presented by any photocoordinate is sufficiently high to prevent activation of its associated light-displaying element even though the full potential of the energy supply source may be impressed across the series combination of the display element and its photocoordinate. On the other hand, while the resistance of each photocoordinate will be lowered whenever it is illuminated, its associated display element will not be activated unless, at the same time, the associated one of strips 17 is connected to the energy source. Consequently, any desired combination of cells 13 may be activated by selecting the appropriate combinations of strips 17 and light pipes 20. At the same time, either the light intensity supplied from pipes 20 or the level of energy supplied to the display cells by strips 17 may be adjusted to control or modulate the intensity of light.
emitted by the diodes. In the manner, the contrast or gray scale within the image may be defined. The light may control the resistance of the photoconductor, and thus the output of the light-display device, by its intensity, its spatial distribution on the photoconductor, its spectral distribution, or a combination of any of these three variables.

A number of other refinements and modifications may be incorporated into the structure as thus far described. However, attention will first be directed toward the basic structure of the embodiment of FIGS. 4-8 to which those same changes also are applicable in whole or in part. This second embodiment differs primarily in that light pipes are employed for selection in both the vertical and horizontal directions and the active light-producing device in this case is an electroluminescent cell. Thus, a display panel 40 includes a transparent substrate 41 over one major surface of which are distributed a plurality of light-displaying electroluminescent cells 42 disposed in a predetermined array of rows and columns. Each of cells 42 is composed of a layer 42 of an electroluminescent material, such as zinc sulfide doped with copper and chlorine, sandwiched between a pair of electrodes 44 and 45. Electrodes 45, which are affixed to transparent substrate 41, are of a material such as tin oxide so as to be transparent to light developed by layers 43 in response to potentials applied across electrodes 44 and 45. In this instance, a thicker electrode 46 is affixed to each electrode 44 to permit attachment of a connecting lead 47 without injury to the material of layer 43.

Associated with each cell 42 is a light-responsive photosensitive element 49. Preferably, each of photoconductors 49 is formed into a pair of separated photosensitive areas 50 and 51 joined by a narrow neck 52, which may be of the same material. On the other hand, the material of connecting neck 52 may be simply ohmic. Generally disposed between photoconductors 50, 51 and substrate 41, and also overlying “open” areas of the substrate surface, is a light-opaque layer 53 that shields the photoconductors from ambient or stray light transmitted through the substrate. As before, and as shown only in FIG. 6, the back side of panel 40 also is light shielded by a layer 56 of opaque epoxy resin or other suitable encapsulant.

Electrically bridging a small portion of each of the electrodes 45 in each row of cells 42 is a respective conductive strip 54. In this case, strips 54 are spaced across substrate 41 so as to run in a horizontal direction. Another set of horizontally-oriented conductive ribbons 55 serves to electrically interconnect all photoconductive areas 51 in each horizontal row. Like layer 53, ribbons 55 are light opaque. In operation, an a.c. or d.c. energizing potential may be continually maintained, during each image-display frame, between strips 54 and ribbons 55. Display cells 42 may then be activated at any time upon the occurrence of simultaneous illumination of both associated areas 50 and 51. Areas 50 to respond to column selection while areas 51 respond to row selection. Each pair of areas is effectively connected electrically in series, the resistance of that series combination being sufficiently high to prevent activation of the associated display cell 42 except when both of areas 50 and 51 are illuminated.

For activating selection, display panel 40 includes a first series of spaced parallel light guides, such as fiber-optic elements 58 each extending in a horizontal direction. A second series of spaced parallel light guides, such as fiber-optic elements 59 extend orthogonally to light pipes 58, pipes 58 and 59 being in close mutual juxtaposition so as to constitute a rectangular-coordinate matrix. As shown in FIGS. 5 and 7, each light pipe 59 undulates over pipes 58 and the latter, in turn, undulate over successive ones of photoconductor areas 51, so that the entire light-pipe matrix lies snugly against the panel assembly and so that the light pipes are closely adjacent to the photoconductor areas. It may be noted that the one of horizontal light-pipes 58 that should appear in the background has been omitted from FIG. 6 for clarity of illustration. Similarly, the one of light-pipes 59 that might be shown in the background in FIG. 8 has been omitted.

Thus, each individual one of light pipes 59 overlies the photoconductor areas 50 associated with a vertical column of cells 42. Analogously, each individual one of light pipes 58 overlies the photoconductive areas 51 associated with a horizontal row of cells 42. As in the previous embodiment, light pipes 58 and 59 preferably are constructed so that light is channeled down the pipes by means of total internal reflection except where the light pipes pass adjacent to the photoconductor areas. Also as before, at each photoconductor area, the light pipe may include an insert having a meshing index of refraction so as to permit egress of the light at that point. Other techniques may be employed in either embodiment, such as forming a lens at each point where light output is required. One simple approach is to expose the pipe core material at the location of each aperture or desired point of egress and roughen the external surface of the pipe; as a result, light is scattered out from the roughened surface rather than being reflected specularly down the pipe. While not capable of being adequately shown in the drawings, the later is contemplated for purposes of illustration in the embodiment of FIGS. 4-8.

As will be apparent from what has already been explained, selection of any given one of cells 42 is accomplished by feeding light into the pair of light pipes 58 and 59 that cross or intersect near the cell so that light emerging from the respective apertures illuminates the respective areas of the associated photoconductor elements 49. Accordingly, another selectively actuated plural light source, like light source 23 in FIG. 1, is included for delivering light to vertical light pipes 59.

Use of two separated photconductor areas electrically in series and each illuminated by a single light guide, instead of a single photoconductor area illuminated by both light guides, gives better control with linear photoconductor materials. If a single-area arrangement were used, the photoconductor resistance would be decreased partially by one light guide and further by the other light guide. With the two areas separated but electrically in series, even if the resistance of one photoconductor area is decreased by a factor of 1 million because of the light from the light guide, the other photoconductor, if it remains dark, has the same high resistance. Thus a change of a factor of 1 million in one of the two photoconductors may reduce
the series resistance of the pair by a factor of only two. This nonlinearity is most helpful in effecting selection of a single display element from an array containing several hundred thousand elements. This spatial non-linearity can be further enhanced if the photoductor material itself exhibits non-linear response to light.

The particular manner in which light is selectively fed to the different ones of the light pipes in either of the above-discussed embodiments is not of the essence of the present invention. To fully understand the concepts of the display panels disclosed, it is only necessary to consider light source 23 in FIG. 1 or the corresponding source in FIG. 6 as including individual lamps for injecting light into each respective light pipe and with those lamps having individual switches for selectively controlling their energization. Nevertheless, numerous schemes are known that may be employed for selectively activating the different picture elements distributed across the display panels. One such known system suitable for television image display is depicted in FIG. 9 wherein television signal variously develops a composite program signal. The signal is fed to a diode and synchronizing-signal separator 66. The latter produces a video signal representative of the picture content to be displayed together with respective horizontal and vertical synchronizing signals.

The system of FIG. 9 is represented for its application to control either the display panel of FIG. 1 or panel 40 of FIG. 4. Vertical synchronizing pulses from the separator portion of stage 66 are fed to a timing clock 67 and to a gate 68 which also receives control pulses from clock 67. Gate 68 feeds actuating pulses to a vertical shift register 69 which is coupled to a plurality of light or voltage sources 70 that are sequentially energized in repetitive cycles to provide row selection in a display matrix 71. The horizontal synchronizing pulses from stage 66 are fed to a timing clock 73 and also to a gate 74 that receives a timing pulse from clock 73. Gate 74 feeds successive timing pulses to a horizontal shift register 75 which in turn sequentially actuates individual ones of a plurality of light sources 76 in a repetitive cycle. Light sources 76 are coupled to matrix 71 to provide vertical column selection.

When panel 40 of FIGS. 4-8 is employed as matrix 71 in FIG. 9, block 70 in FIG. 9 is, of course, a plurality of light sources individually coupled respectively to the different ones of light pipes 58. Light sources 76, then, are coupled individually to the respective different ones of light pipes 59. On the other hand, when the display panel of FIGS. 1-3 is employed as matrix 71, block 70 constitutes a plurality of voltage sources and those sources preferably are individually connected to respective different ones of strips 17. At the same time, light sources 76 are coupled individually to respective different light pipes 20. Thus, strips 17 are preferably employed to achieve horizontal row selection, while light pipes 20 are sequentially obtained to vertical column or picture element selection. In a conventional television system, the scanning of the vertical columns is at a rate of 4.5 megahertz while horizontal row or line selection is achieved at a scanning rate of only 15,750 hertz. For this reason, it is preferable to employ the electrical scanning accomplished by strips 17 at the much lower line-scanning rate. Consequently, the faster-response characteristics available with light

scanning control are employed to effect the faster of the two scanning operations.

Finally, the video signal detected by stage 66 is in this case applied in parallel to all of light sources 76. In principle, the video signals could instead be used to modulate the intensity of light or voltage sources 70; however, applying the modulation to the vertical light pipes may take advantage of the lag in response or the persistence of the photoconductors, which will tend to retain the photoconductivity produced by activating light for a period longer than the duration of a single TV element.

The nature of operation of the addressing system as shown in FIG. 9 is well understood in the art. Each successive timing pulse from one of the gates steps its shift register throughout its sequence of steps so as to successively energize the different rows or columns in the display. The timing clocks serve to control the repetition rates of the timing pulses from the gates during each frame, and the synchronizing pulses act to reset both the clocks and the shift registers at the end of each line and during the normal retrace between frames.

Of course, FIG. 9 represents but one of a variety of useful addressing systems. For example, the picture elements may instead be addressed a row at a time. In that case, as is now well known, register 75 is modified to include a bank of storage elements for the video signals corresponding to the array of picture element positions, and the entire content of the bank then is "dumped" into the columns simultaneously.

Returning now to the display panels themselves, it is to be observed that, in FIG. 4, both arrays of light pipes are allowed to "leak" light at each intersection. At the intersection of two of the light pipes, the illuminated photoconductor has a much lower impedance than that of any other photoconductor in the array not so illuminated. Consequently, that intersection is selected by a low-power pattern of light. On the other hand, the supply of the much higher-level power needed to energize the light-display elements is obtained from the conductive strips and ribbons for which no switches are required between themselves and the source of power.

Accordingly, the panel completely separates the function of display-element selection from that of the supply of power to the display elements.

On the other hand, the panel of FIG. 1 does utilize one of the selection elements, strips 17, as a powersupply element as well. However, the switching necessary in the electrical circuits associated with that element may be at the much lower line scanning rate as indicated in the discussion of FIG. 9. By thus using low-power light as a selection element in at least one scanning direction, the invention avoids many problems that occur in purely electrical switching matrices wherein it is necessary to propagate short, fast-rise power pulses along relatively high-impedance, high-shunt-capacitance electrodes deposited on the surface of a display device.

It may appear from viewing the drawings, in which the many different elements are greatly enlarged for clarity as compared with actual sizes in a television environment, that for transmission mode operation the portion of the display obscured by the light pipes would be excessive. This is not the case. Assuming a display size of 20 inches by 15 inches and with 500 resolution
elements in both the horizontal and vertical directions, each horizontal element is 40 mils wide and each vertical element is 30 mils high. The total area, then, is 1,200 square mils per element. With light pipes employed that are 3 mils in diameter, each resolution element thus has only 210 mils obscured, and that is only eighteen percent of the total area.

Either of the illustrated panels may be modified to enable color reproduction. For each row of display devices and their associated photoconductive control elements, each horizontally-oriented selection element would then in fact be composed of three parallel rows with one designated for each primary color. An alternative approach for color is to arrange a triad of the light-display elements (e.g., 13 or 42) at each array intersection. The crossed arrays thus select different ones of the triads. At the same time, video modulation is applied in parallel to all the array elements of each particular color.

The simplest type of light-display element contemplated is one which emits or controls light, throughout the fullest extent required by the video signal, instantaneously on being stimulated by action of the crossed arrays. When the rise time of actuation for the display element is greater than the display time of each picture element (0.12 microsecond for conventional television), operation of the selector mechanism without some form of buffer storage results in loss of horizontal definition. Where the display element is one which will itself store a control impulse but takes some time to react to it, this is not necessarily a disadvantage as long as the signal on each element either decays away or switches off before the next frame. A decay time that is a substantial portion of a frame period can be advantageous in producing additional output. In any event, non-linearity, in the light-display element, in the photosensitive control device or by means of some other element interposed between the controlled and the controlling devices, is essential in order to produce adequate contrast on the basis of coincidence of vertical and horizontal selection.

Storage may be desired, for example, when utilizing solid-state photosensitive devices that do not react sufficiently fast to the light illumination to permit full application of the simultaneously applied video signal. One such solid-state device is a photosensitive insulated-gate field-effect transistor. Its gate is transparent, as a result of which applied radiation increases the conductivity of its conduction channel. Conduction through that channel is obtained only when the illumination is applied in addition to the application of a signal to the gate electrode. Thus, the operating light-display power is applied through the drain-source terminals of the transistor, the video signal is applied to the gate electrodes and light pipes are utilized to illuminate the gate.

In some applications, it may become desirable to use both electrical and light energy to exercise control in a particular direction. An electrical potential may prime a light-responsive or light-display element with light illumination being employed to trigger that element into conduction past the knee of its response curve. A preconditioning voltage may be obtained from either a separate series of electrodes or from a potential existing on one of the already-described strips or ribbons.

Such a combination of voltage and light control in some cases may also afford an increased non-linearity characteristic. Moreover, the dual-stimulus approach may be advantageous with slower-acting photoconductors in order to prime the photoconductor into an excited condition so that its response to the onset of the light will be faster. Such an electrical stimulus applied ahead of the light pulse may be easily incorporated by applying it to an entire row or column at a time. With a shift-register accessing approach of the kind generally illustrated in Fig. 9, it is not particularly difficult to include the additional programming necessary for such variations.

It may be desired in some cases that one of the photo-conductor areas 50 and 51 (FIG. 4) be of a material different than that of the other or for a combination of two materials to be employed in either area. In order to obtain full response to short-light pulse intervals. One such material may exhibit a fast response even though its response characteristic is linear. That material may then be connected electrically in series with a non-linear device having storage for the energy passed by the other material. While the non-linear material may exhibit a response that otherwise would be too slow, the stimulus from the fast-acting material in this case is applied long enough for the full effect of the non-linearity of the second material to be utilized. Accordingly, such a combination of two different materials can advantageously be employed to provide both the speed and the non-linearity desired in a television matrix selector.

As thus far discussed, all of the light entering a single light pipe is distributed to all of the leaks or exit apertures. In order to direct the light in a given pipe to a single aperture, that aperture may be produced with the use of a pulse of sound energy to create a moving change in the index of refraction of the light pipe or the surrounding material. The compressions and rarefactions involved in a sound wave produce corresponding changes in the index of refraction. With the indices of refraction of the pipe and its surrounding material suitably chosen, a moving sound pulse thus produces a moving "leak".

While particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made therein without departing from the invention in its broader aspects. The aim of the appended claims, therefore, is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

We claim:
1. An image-display device comprising:
   a display panel including a plurality of light-responsive elements disposed in a predetermined array;
   and a matrix of light guides in close juxtaposition with said panel arranged in rows and columns so as to define guide intersections adjacent said light-responsive elements, each light guide being provided with a plurality of exit apertures one disposed adjacent each light-responsive element for permitting light to escape therefrom transverse to the axis of the associated light guide to excite said light-responsive elements.

2. An image-display device comprising:
   a display panel including a plurality of light-displaying elements disposed in a predetermined array;
means including a corresponding plurality of light-responsive elements for controlling the energization of said light-displaying elements;
and means including a matrix of light guides provided with a corresponding plurality of localized light-emitting apertures, each in juxtaposition with one of said light-responsive elements, for selectively irradiating individual ones of said light-responsive elements in accordance with a predetermined pattern.

3. An image-display device as defined in claim 2, in which said light-responsive elements exhibit significant non-linearity of response to incident illumination.

4. An image-display device as defined in claim 2, in which said light-responsive elements effectively exhibit storage of the effects of the irradiation from said apertures.

5. An image-display device as defined in claim 2, in which a power source is included for effecting operation of said light-displaying elements, and said light-responsive elements control the application of power from said source to said light-displaying elements.

6. An image-display device as defined in claim 2, which further includes a source of composite video signals having picture information and synchronizing information and in which said matrix means responds to said synchronizing information for selecting said light-responsive elements and said light-displaying elements respond to said video signals for displaying light in correspondence therewith.

7. An image-display device comprising:
   a matrix of light-displaying elements disposed in a predetermined pattern throughout an image-display field;
   means, including photosensitive devices respectively associated with said light-displaying elements, responsive to light for activating individual ones of said light-displaying elements;
a pair of crossed arrays of light-conductive elements with their crossings respectively in juxtaposition with said photosensitive devices, said light-conductive elements being provided with localized light-emitting apertures near said crossings;
and means for injecting light into said light-conductive elements to provide selective scanning of said photosensitive devices by concurrent emission of light from localized apertures of selected light-conductive elements of both of said arrays.

8. An image-display device as defined in claim 7, in which said photosensitive devices are each separate into a pair of photoconductors individually responsive to light-conductive elements in respective ones of said arrays and electrically connected in series.

9. An image-display device comprising:
a matrix of light-displaying elements disposed in a predetermined pattern throughout an image-display field;
means, including photosensitive devices respectively associated with said light-displaying elements, responsive to light for modifying the actuation condition of individual ones of said light-displaying elements;
a pair of crossed arrays of scanning-control elements with their crossings respectively in juxtaposition with said photosensitive devices, at least one of said arrays being composed of light-conductive elements provided with localized light-emitting apertures at said crossings;
means for selectively injecting light into said light-conductive elements to provide energization of said photosensitive devices by emission of light quanta from said localized apertures;
and means for selectively energizing the scanning-control elements of the other of said arrays to provide selective modification of the activation condition of individual ones of said light-displaying elements, said elements individually being activated when said condition is concurrently modified by both of said arrays.

10. An image-display device as defined in claim 9, in which said other of said arrays is composed of electrically-conductive elements.