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XR 3,621,328
CROSS REFERENCE
SEARCH ROOM

[11] 3,621,328

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[54] INFORMATION DISPLAY SYSTEM

9 Claims, 9 Drawing Figs.

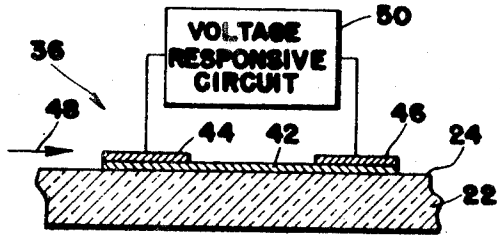
[52] **U.S. Cl.** **315/55,**
310/8, 310/9.1, 310/9.8, 313/108 B, 315/169 TV
[51] **Int. Cl.** **H04n 5/38**
[50] **Field of Search** 315/55,
169; 313/108; 310/8, 8.1, 8.3, 8.7, 9.1, 9.4, 9.8

[56] **References Cited**
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ABSTRACT: An information display system is provided which comprises a body of material serving as both a substrate for thin film components and a medium for the propagation of Rayleigh acoustic waves along its surface. The thin film components include elements responsive to the Rayleigh waves to provide information at selected locations on the surface of the body. These components may be either the control elements or the output elements of the display system.



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FIG.1

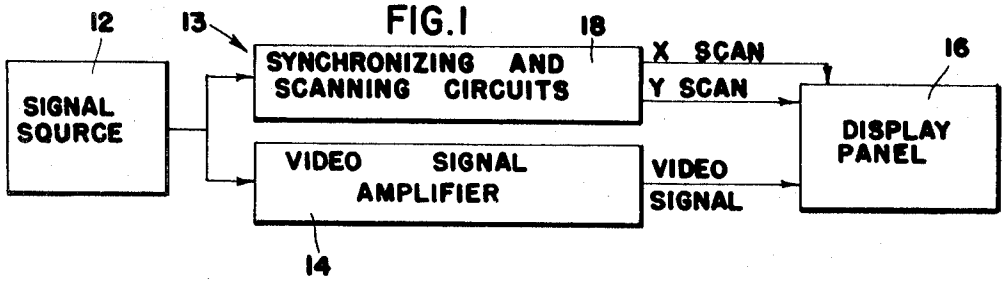


FIG.2

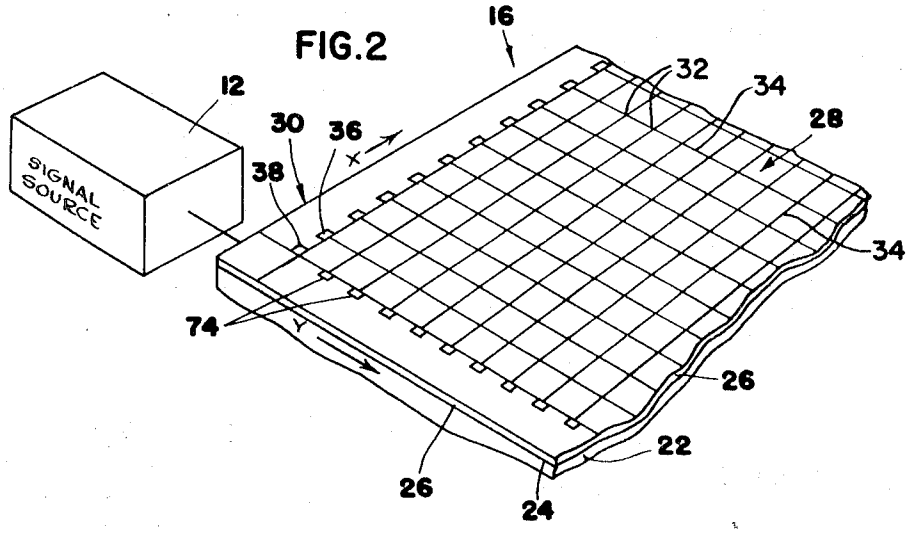


FIG.3

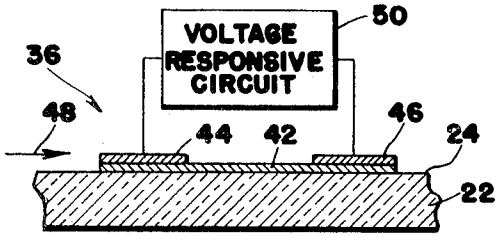


FIG.4

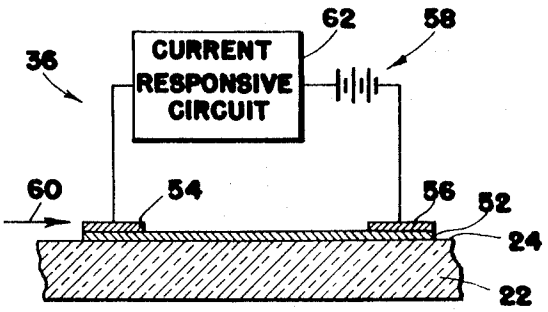
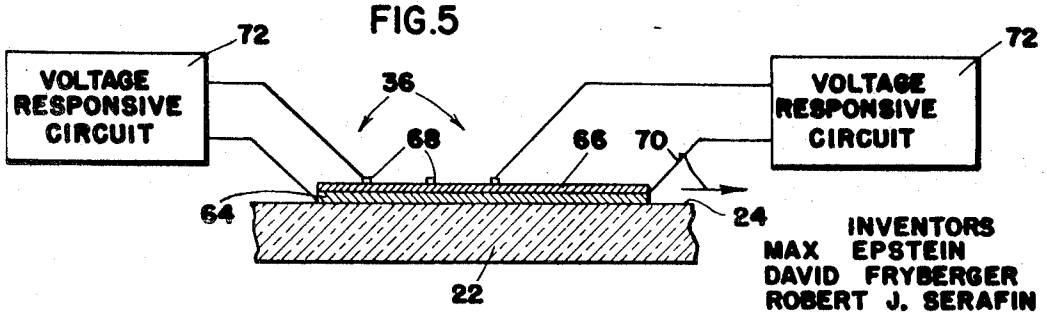


FIG.5



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FIG.6

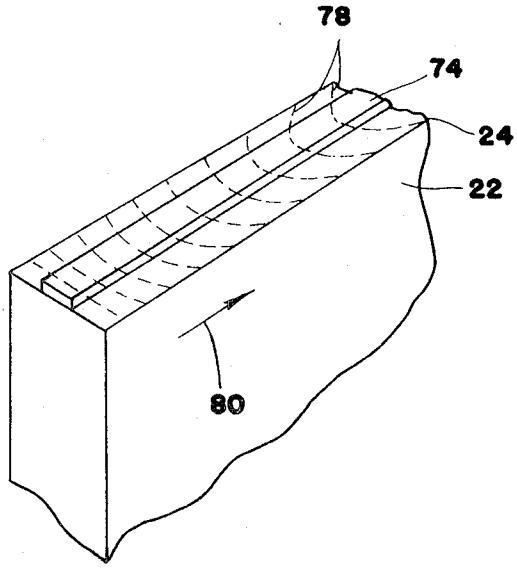


FIG.7

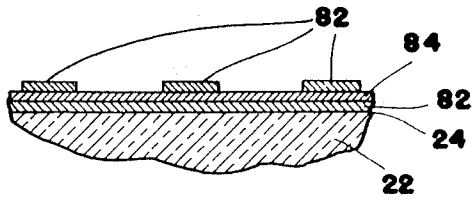


FIG.8

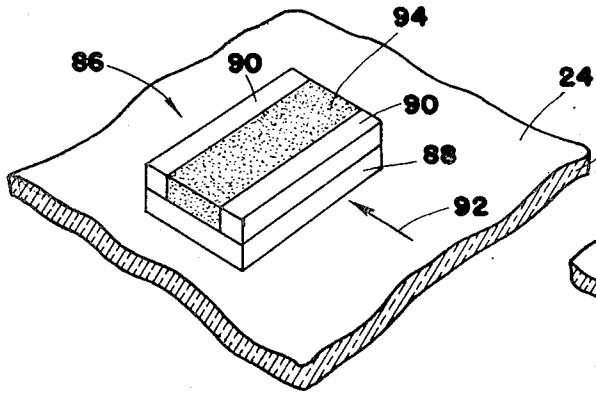
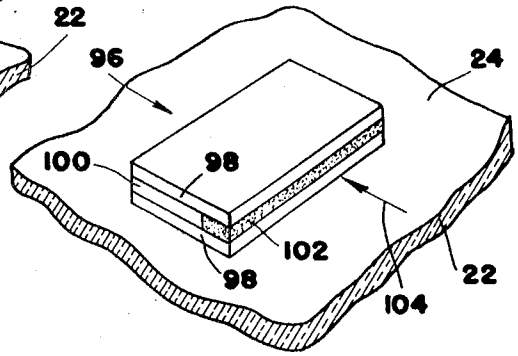


FIG.9



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INFORMATION DISPLAY SYSTEM

This invention relates to information display systems and, more particularly to a panel display device adapted for the synchronous display of video information using thin film components.

In recent years interest has grown in the development of flat or panel display systems to replace conventional vacuum tube or cathode-ray tube display systems for a variety of commercial and military uses. Among the advantages of such systems are compactness, ruggedness and light weight. Additionally, problems of parallax in observation are minimized in a flat display system since all characters or elements of the display are produced in a single plane. Because evacuated tubes are not required, as in cathode-ray or vacuum tube displays, a potential cost saving over such devices also exists.

One type of panel display system which has been developed utilizes electroluminescent phosphors, materials that luminesce when under the influence of an externally applied electric field. Such systems often are constructed of two sheets of conductive material, at least one of which is transparent, which are placed on opposite sides of a dielectric plastic or ceramic sheet impregnated with a phosphor. An electrical signal applied to the conductive sheets causes an electric field to be applied to the phosphor causing it to luminesce. Illumination of selected areas of a surface of such an electrically actuated system has been provided by dividing each of the two conducting sheets into a set of parallel strips electrically insulated from one another, with each set of strips being perpendicular to one another to form an orthogonal grid. External switching means are provided to establish a potential difference between two selected conducting strips, one in each set, so that the phosphor disposed at the selected position of crossover is excited to illuminate that position.

In another approach a sheet of piezoelectric material and a sheet of an electroluminescent material are placed next to one another. Electrodes above and below the piezoelectric sheet on one edge thereof are used to produce a bulk elastic wave in the sheet which propagates through and across the sheet along with an accompanying electric field which causes the overlying electroluminescent sheet to luminesce along the wave front. A second orthogonal set of electrodes may be used to produce a second elastic wave and electric field propagating through the piezoelectric sheet orthogonally to the first wave and field. The two electric fields add where the waves intersect to produce a spot of light at that point brighter than the illumination produced by the intersecting waves separately. The pattern of illuminated spots thus produced is regulated by the time relationship between the activation of the two of electrodes, which is determined by external timing and switching means.

Both of these types of flat display devices have presented disadvantages. An electrically actuated device requires a large number of external electrical interconnections and switching arrangements for controlling the selective illumination of specified areas of the display. This of course contributes to high cost and lack of reliability. The piezoelectric sheet device presents the same disadvantages. Additional problems exist in the latter type of device due to multiple propagation paths of the bulk elastic wave in the piezoelectric sheet and reflections of the wave which may cause such phenomena as ghost images.

Accordingly a need exists for improved panel display systems which will produce high quality images without undue complexity in their fabrication or operation.

It is, therefore, an important object of the present invention to provide an improved panel display system.

Another object of the invention is to provide a flat display system utilizing thin film layers deposited on an inexpensive supporting substrate.

Another object of the invention is to provide a flat display system utilizing components actuated by sonic surface waves on a substrate.

Yet another object of the invention is to provide a panel display system adapted for rapid scanning so as to provide a means of displaying video information.

A further object of the invention is to provide a flat display system which requires relatively few external connections and switching arrangements.

A still further object of the invention is to provide a compact flat display system which is economical in construction and has increased reliability.

Yet another object of the invention is to provide a flat panel display system which will produce high-quality images free of ghosts and other noise or distortion.

Other objects and advantages of the invention will become apparent from the following description when taken in connection with the accompanying drawings in which:

FIG. 1 is a schematic diagram of a video information display system;

FIG. 2 is a partially diagrammatic perspective view of a display system showing various features of the invention;

FIG. 3 is a sectional view of a portion of an acoustic delay line which may form part of the scanning means of the display system of FIG. 2;

FIG. 4 is a sectional view of a portion of another form of acoustic delay line which may form part of the scanning means of the display system;

FIG. 5 is a sectional view of a portion of still another form of acoustic delay line which may form part of the scanning means of the display system;

FIG. 6 is a perspective view of an acoustic wave guide which may form part of the scanning means of the display system;

FIG. 7 is a sectional view of one form of output means which may form a part of the display system;

FIG. 8 is an enlarged perspective view of a portion of the device showing another form of output means for the display system; and

FIG. 9 is an enlarged perspective view of a portion of the device showing an example of still another form of output means for the display system.

Generally an information display system in accordance with the present invention comprises a body of material which is adapted to serve as a medium for the transmission of surface acoustic waves along a surface thereof, which surface also is adapted for and serves as a substrate on which are deposited thin film components of the device. The system includes means for indicating information at each of an array of selected locations on the display surface. As used herein the term "information indicating means" includes both control means for scanning the array of locations on a display panel and producing energy at the locations as well as output means for converting such energy to a recognizable form such as visible light.

It is an important feature of the invention that all of the information indicating means may be formed of thin film electronic, acoustic and luminescent elements so that the full advantages of a flat display panel may be realized through the complete or partial elimination of external switching elements and the like. It is also an important feature that acoustic elements are included which utilize Rayleigh acoustic waves which travel essentially on the surface of the body and only penetrate the material on the order of one wavelength. Such waves have minimal dispersion and energy losses through reflection of the waves in the body and are easily accessible to transducers. Moreover, problems of multiple path transmissions and ghosts arising from bulk acoustic waves are eliminated.

As shown in FIG. 1 an information display system adapted for the display of video information includes a signal source 12 which may be a television receiver or a video tape recorder and may be remotely located from the display system itself. The signal source provides a signal to control circuits 13 which include a video signal amplifier 14 which provides modulating information to a display panel 16. The signal source 12 also provides a signal to synchronizing and scanning circuits 18 which coordinate the application of the modulating energy to the display panel. A variety of scanning patterns may be provided by circuitry well known in the art, a common pattern being a raster in which vertically disposed horizontal

or x direction lines are successively or alternately scanned until the entire display panel is scanned in the y direction. In a conventional cathode-ray display device the scanning and synchronizing circuits comprise circuitry outside of the type which control electromagnetic fields within the tube. These fields serve to direct an electron beam in accordance with the desired scanning pattern, the electron beam intensity being modulated by the video signal. The electron beam actuates fluorescent elements at the face of the tube to provide a display. An important feature of the present invention is that, not only are the output means which produce the display formed of thin films deposited on a substrate, but also all or a desired portion of the control circuits, particularly the synchronizing and scanning means are formed of such thin films deposited on the same substrate. Additionally certain of the elements of the system may utilize transducers responsive to Rayleigh acoustic surface waves on the substrate, which waves constitute a particularly useful means of transmitting energy.

More specifically, as shown in FIG. 2, a display system in accordance with the present invention very generally comprises a body 22 with a flat surface 24. The body 22 is adapted to serve as a medium for the transmission of Rayleigh acoustic waves along the surface 24 and also is adapted to serve as a substrate for the deposit of thin films on the upper surface 24. Above the upper surface 16 is a thin film zone 26 in which the various thin film components of the system are deposited.

The supporting body is preferably made of a relatively inexpensive material and one which has relatively low acoustic absorption qualities so that surface sound waves therein are not appreciably attenuated. As illustrated, the supporting body is of glass, although some metals or fused nonpiezoelectric quartz might also be utilized in some applications.

For clarity in illustration the vertical dimension of the thin film zone 26 in FIG. 2 has been exaggerated relative to the remaining dimensions.

The panel is divided into a display portion 28 on which the display is produced and a control portion 30 on which are deposited thin film control circuits for the display, particularly means for providing scanning of the display portion in accordance with the desired scanning pattern. The circuits in the control portion of the panel generally correspond functionally to the control circuits 13 of the generalized display system illustrated in FIG. 1 and are suitably connected to a signal source 12. However, some portions of the control circuits such as the video signal amplifier may be formed of conventional components rather than thin film components, if desired.

The display portion of the panel is provided with a plurality of transducers 32 at selected locations on the panel, which convert energy delivered to the location into a recognizable form such as light. As illustrated a conventional rectangular matrix of such transducers is provided at the intersection of the illustrated grid lines 34.

A variety of scanning means and output means may be provided, all of which comprise thin films deposited on the body 22. Although several such means are illustrated and will be discussed below, no unnecessary limitation is to be implied therefrom. The use of transducers responsive to Rayleigh surface waves in the substrate is a preferred form of the invention; however, these elements may be combined with thin film electrical elements without departing from the invention.

One means of scanning the display panel in a single direction, say the x direction, as illustrated in FIG. 2, comprises applying a pulse of energy in the form of a Rayleigh acoustic wave to the supporting body 22 adjacent the upper left hand corner of the body. This wave may be produced by sound generating means 38 formed of thin films, as for example, a piezoelectric transducer adapted to produce Rayleigh acoustic waves along the upper surface 26 in response to a suitable electrical signal applied thereto by the signal source. Such sound generators are devices well known in the art and will not be described herein in detail. It is, however, an important advantage of the invention that such generators and their electrical connections so the signal source may be formed of thin films deposited on the substrate. As the wave travels in the x direction it is detected successively by spaced acoustic taps 36 which convert the acoustic energy to electrical energy. Three forms of such taps are illustrated and will be described in detail below. The Rayleigh wave generating means and the taps comprise an acoustic delay line by means of which scanning in the x direction is accomplished.

FIGS. 3, 4 and 5 illustrate three forms of acoustic delay line taps 36 which may be utilized. FIG. 3 represents a piezoelectric-type tap. In the illustrated embodiment, a delay line is formed of the supporting body 22, which comprises a propagation medium, and a series of strips of piezoelectric film material 42 deposited on the propagation surface. The thickness of the piezoelectric films is less than 0.1 of the wavelength of the acoustic wave travelling along the medium. Over each strip of such film, two film conductors 44 and 46 are deposited at opposite edges with a gap therebetween. As a Rayleigh wave passes each tap, the distortion of the piezoelectric film caused by strain in the direction of propagation creates a component of electric field in the same direction, that is in the direction of propagation shown by the arrow 48. Each conductor is an equipotential surface. The difference in potential between electrodes 44 and 46 may be measured by making an electrical connection from each electrode to a voltage responsive circuit 50, for example. This circuit is illustrated schematically and is preferably also formed of thin films. This piezoelectric tap has the advantage of generating its own voltage without the aid of a magnetic field or other outside energy source. Each tap consists of a piezoelectric film 42 and two film conductors 44 and 46 applied to the propagation surface perpendicular to the direction of wave propagation.

A second embodiment of tapping means has been designated the piezoresistive tap. FIG. 4 shows a typical piezoresistive tap on a delay line. The delay line 14 comprises a propagation medium having a deposited film of piezoresistive material 52 on the propagation surface 24 of the substrate 22. Electrodes 54 and 56 are deposited on opposite edges of film 52 leaving a gap. In operation, a constant voltage is applied across electrodes 54 and 56 by bias means 58. As a wave passes in the direction of arrow 60 the strain causes the resistivity of the piezoresistive material 52 to vary and the variation may be sensed as a change in current through electrodes 54 and 56 by means of current responsive circuit 62. Thus, the operation of the piezoresistive tap is similar to the piezoelectric tap with the exception of the need for a bias voltage.

A third embodiment of tapping means is shown in FIG. 5. The principle involved is again the piezoelectric effect as in FIG. 3. FIG. 5 is a longitudinal section of a delay line formed of a medium having a conducting film 64 deposited on the propagation surface 24. A film of piezoelectric material 66 is deposited over and in contact with the film 64. One or more thin film electrodes 68 are deposited on the piezoelectric film in parallel configuration. The electrical connections are made across common electrode 64 and one or more of electrodes 68. The voltage generated by the shear component of a wave traveling in the direction of arrow 70 straining the piezoelectric film 66, which shear component moves electrodes 68 vertically, is then detected or utilized by known means indicated diagrammatically as voltage-responsive circuits 72. The piezoelectric film is as in FIG. 3 very thin, less than 0.1 of the wavelength of the acoustic wave propagated along the surface 24.

In either the embodiment of FIG. 3 or FIG. 5, the piezoelectric film 42 or 66 may be continuous or interrupted between individual taps. The same is true in FIG. 4 for the electrode 52. In any case, the piezoelectric film is not the propagating medium but is substantially less than a wavelength in thickness and is deposited over the propagating surface either directly or with the electrode 52 intervening.

In the embodiments of FIGS. 3 and 5, the strips of conductive material such as 44, 46 or 64 may be deposited directly on the propagation surface with the piezoelectric layer overlying the conductive strips except at the external connections to the conductive strips. In the embodiment of FIG. 5, the common conductive layer such as 64 would then overlie the piezoelectric layer 66. Similarly the conductive strips 54 and 56 in FIG. 4 may underlie the piezoresistive film 52. In any of these arrangements, however, the various layers of conductive and wave-responsive material are all considered to be "on" the propagation surface and are mechanically supported thereby.

In all of these acoustic delay lines problems of reflecting signals which would distort subsequent signals may readily be eliminated. A liquid or grease film may be applied to the surface 24 beyond the last tap to attenuate the wave without reflection.

Returning now to the scanning process generally and FIG. 2 it will be apparent that scanning for the orthogonal y direction could be provided by a number of means. For example, a single sound generator 38 could produce waves proceeding in one direction to provide scanning in that direction while synchronism for the other direction could be provided by a plurality of active electronic devices 74 sequentially activating the output means in each vertically spaced horizontal line on the display area. Such devices may be and preferably are thin electronic components of a variety of conventional types. Such devices are well known and need not be described in detail. The important feature is that, like the acoustic elements and the output elements to be described below, they may be deposited on the common substrate surface 24.

Another method of scanning would be to utilize an additional delay line extending in the y direction with the input pulses of the second delay line being delayed relative to the first delay line. The additional delay line could be formed of acoustic taps such as any of those illustrated in FIGS. 3, 4 and 5. In order to prevent interference between waves in two such delay lines it is necessary to guide the waves in their respective directions. This may be accomplished as illustrated in FIG. 6, in which a narrow strip 74 of material is deposited on the surface 24 of the substrate 22. The strip 74 is formed of a material in which the velocity of the acoustic wave is slower than the corresponding velocity in the substrate. As a result wave fronts 78 of a wave traveling in the direction of the arrow 80 will be distorted as illustrated and the wave will follow the strip 74 which functions as a wave guide. The energy in the wave decays exponentially away from the guide boundaries.

Regardless of which method of scanning is used the energy produced thereby is applied to output means in the display portion 28 of the panel. When the energy produced by the scanning is electrical the form of output means shown in FIG. 7 may be appropriate. This output means comprises a plurality of thin film conductive strips 82 arranged in two sets at right angles with one another on the substrate surface 24. Between the upper and lower strips as disposed a thin film layer 84 of a phosphor and dielectric material, which produced a spot of light at the intersection of two conductors when actuated. The arrangement is similar to conventional crossed conductor arrays for displays; however, the use of thin films for all of the parts of the output means permits compactness and promotes reliability. The phosphor layer of course need not be continuous since only that disposed at the crossover points of two conductors functions in the display.

It is also possible to scan the panel by producing wave fronts proceeding in orthogonal directions and intersecting at points on the display panel where an output is desired. Separate thin film transducers are provided at each of the points on the panel where a display is desired. The transducers convert the acoustic energy to a desired from such as light. Preferably the response of such transducers is nonlinear so that light is produced only at the intersection of the wave fronts. FIGS. 8 and 9 illustrate two transducers suitable for use with this scanning approach.

In FIG. 8 a transducer 86 is shown which utilizes the piezoelectric effect. A thin film 88 of a piezoelectric material is deposited on the sound propagation surface 24 of the substrate 22. On the piezoelectric film are deposited two film conductors 90 spaced from one another in the direction of propagation of the acoustic wave shown by the arrow 92 and as illustrated, perpendicular thereto. Between the two conductors 90 is deposited a thin film 94 of a phosphor and dielectric. As a surface wave in the surface 24 passes the piezoelectric film 88 its compressional component causes a distortion in the piezoelectric film due to strain in that direction. This results in a component of electrical field in the direction of propagation and a potential difference between the two conductors 90. The voltage applied to the phosphor film 94 between the conductors causes it to luminesce.

In FIG. 9 another transducer 96 utilizing the piezoelectric effect is shown, in this case one which is actuated by the shear component of the Rayleigh wave on the surface 24. In this transducer two thin film conductors 98 are deposited one above the other on the surface 24. Between a portion of the conductors is deposited a thin film 100 of a piezoelectric material and between the remaining portions of the conductors is deposited a thin film dielectric-phosphor layer 102. The shear component of a Rayleigh wave in the surface 24 proceeding in the direction of arrow 104 causes vertical strain in the piezoelectric film 100 and a voltage difference between the conductors 98 which is applied to the phosphor film 102 and causes it to luminesce.

In both the embodiment of FIG. 8 and that of FIG. 9 the piezoelectric film may be a continuous film or may be formed of discrete segments. It is preferably substantially less in thickness than a wavelength of the sound wave and does not serve as the propagation medium for the sound wave, that function being performed by the supporting body 22. Furthermore, in none of the embodiments is it required that a particular film layer be in direct contact with the propagation surface 24. The deposited layers are so thin that the sonic surface wave causes the necessary disturbance, i.e., movement of the conductive film 90 or strain of the piezoelectric films 88 and 100, even if one or more other films are positioned between such film and the surface 24. In this connection a film is considered to be "deposited on" the surface if it is mechanically supported thereby, albeit indirectly. Additionally, it is not necessary that the phosphor films be the topmost film, as indeed is not the case in the embodiment of FIG. 9 so long as the overlying layers are thin enough to transmit light therethrough.

From the foregoing it may be seen that the use of such thin films for the transducing means in panel display devices has the advantage that the relative vertical positions thereof may be varied as is convenient. The use of such films for transducers as well as for other parts of the system such as the control elements and sound generators has the additional advantage that the sound transmission characteristics of the surface 24 are not appreciably affected if the aggregate thickness of the films is small relative to a wavelength of the sound utilized. In practice the various film thicknesses, especially that of the piezoelectric films, is preferably less than or of the order of one tenth of the sound wavelength. Such films are easily formed by conventional vacuum deposition techniques. A cost advantage may arise from the fact that the entire display assembly may be fabricated by a series of such depositions in a single vacuum chamber.

Since the actuating sound wave travels on the surface of the supporting body 24, the problems of multiple paths such as result from reflection at the top and bottom surface of a film are eliminated. In addition such surface waves are nondispersive and may easily be damped without reflection outside of the display area. Finally the thickness of the supporting body, from the acoustic standpoint, need only be about 5 wavelengths, any additional thickness serving to provide mechanical strength.

Various changes and modifications may be made in the above described display device without departing from the present invention. For example, the transducer pattern, and the geometric form of each could be varied greatly and a wide variety of materials could be used for all of the thin film components, all of which would fall within the spirit and scope of the present invention, various features of which are set forth in the accompanying claims.

We claim:

1. An information display system comprising a body of material adapted to serve as a medium for the transmission of acoustic waves and having a surface adapted for the deposit of thin films thereon, and means for providing an indication of information at each of an array of selected locations on said surface, said information-providing means including means for propagating Rayleigh acoustic waves in said body along said surface and transducers responsive to said Rayleigh acoustic waves in said body along said surface formed of thin films on said surface for converting the energy of said waves into a recognizable form.

2. An information display system according to claim 1 wherein all of said information providing means are formed of thin films on said surface.

3. An information display system according to claim 1 wherein said information providing means comprises control means for providing acoustic energy at selected ones of said locations on said surface.

4. An information display system according to claim 3 wherein said control means includes transducers responsive to Rayleigh acoustic waves in said body along said surface and formed on thin films on said surface.

5. An information display system comprising a body of material adapted to serve as a medium for the transmission of acoustic waves and having a surface adapted from the deposit of thin films thereon, and means for providing an indication of information at each of an array of selected locations on said surface, said information providing means comprising control means for providing acoustic energy at selected ones of said locations on said surface and output means at each of said locations for converting said acoustic energy into a recognizable form, said control means including an acoustic delay line extending in one direction with input means formed of thin films on said surface for generating Rayleigh acoustic waves along said surface and tapping means formed of thin films on said surface for detecting said Rayleigh acoustic waves at selected positions along said delay line, whereby said array of locations is scanned in said one direction.

6. An information display system according to claim 5 wherein said control means includes active electronic elements formed of thin films on said surface for providing synchronous scanning of said array of locations in a direction orthogonal to the direction of said acoustic delay line.

7. An information display system according to claim 6 wherein said control means includes an additional delay line extending in a direction orthogonal with said acoustic delay line, said additional delay line comprising thin films on said surface.

8. An information display system according to claim 7 wherein said additional delay line comprises input means formed of thin films for generating Rayleigh acoustic waves along said surface and tapping means formed of thin films on said surface for detecting said Rayleigh acoustic waves at selected positions along said delay line, whereby said array of locations is scanned in said orthogonal direction.

9. An information display system accordingly to claim 7 including delay means for delaying the input of said additional delay line relative to the input of said acoustic delay line, said delay means being formed of thin films on said surface.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,621,328 Dated November 16, 1971

Inventor(s) Max Epstein, et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 48 after "two" insert --sets--
Column 3, line 4 cancel "type" and substitute --tube--
Column 5, line 57 cancel "produced" and substitute --produces--; line 71 cancel "from" and substitute --form--
Column 7, line 34 cancel "from" and substitute --for--

Signed and sealed this 13th day of June 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334