

June 6, 1972

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3,667,830

DISPLAY SYSTEM UTILIZING A SELECTIVELY DEFORMABLE
LIGHT-REFLECTING ELEMENT

Filed April 8, 1970

3 Sheets-Sheet 1

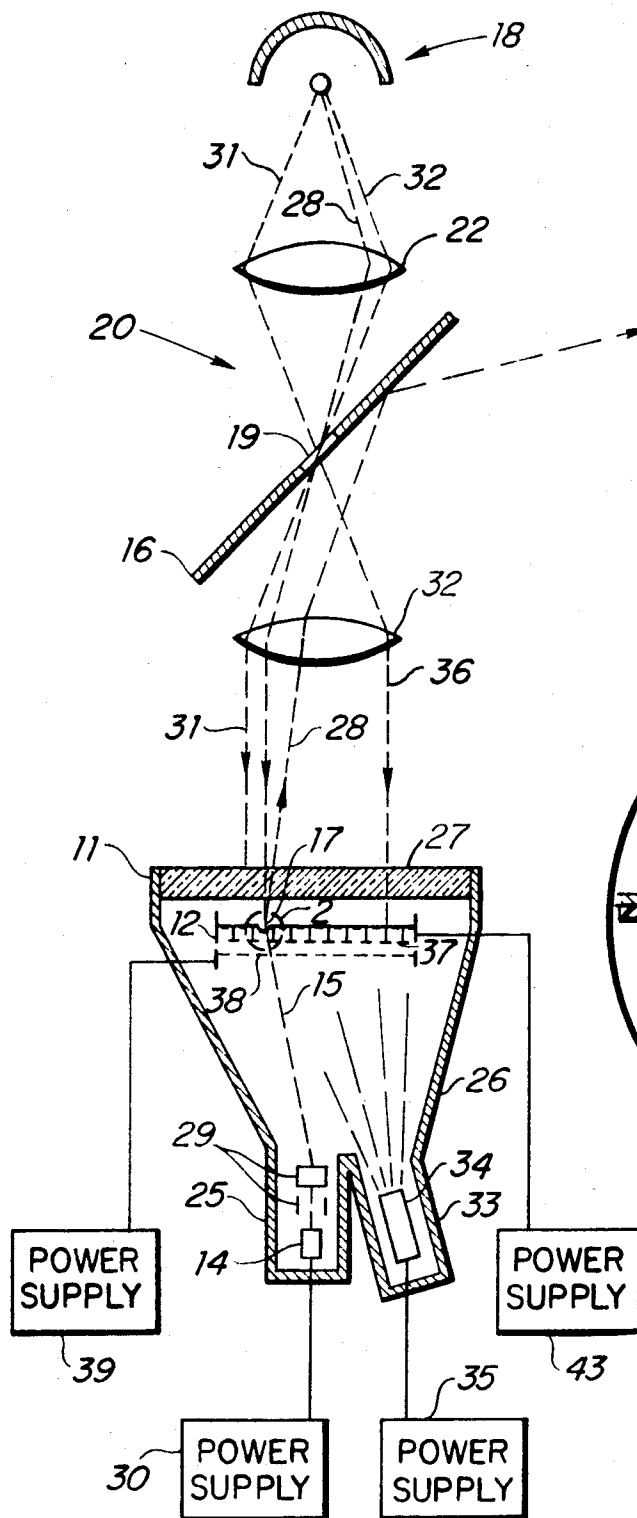


FIG. 1

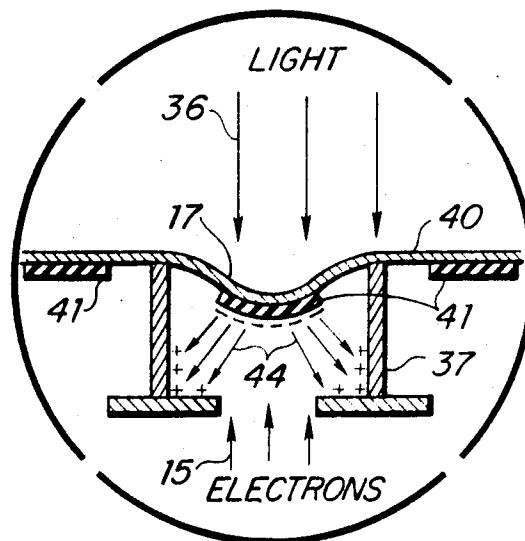


FIG. 2

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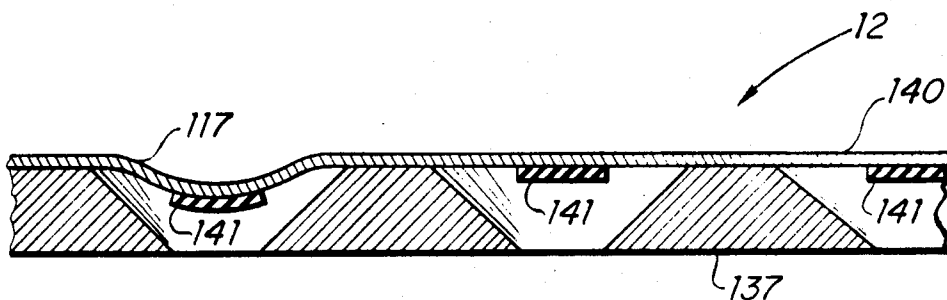


FIG. 3

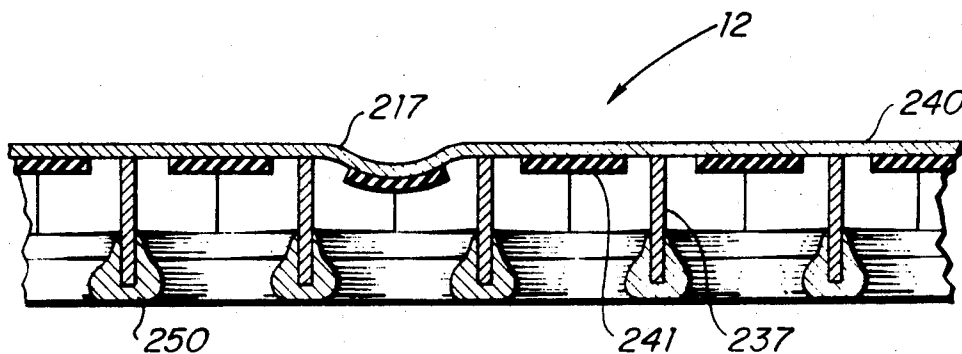


FIG. 4

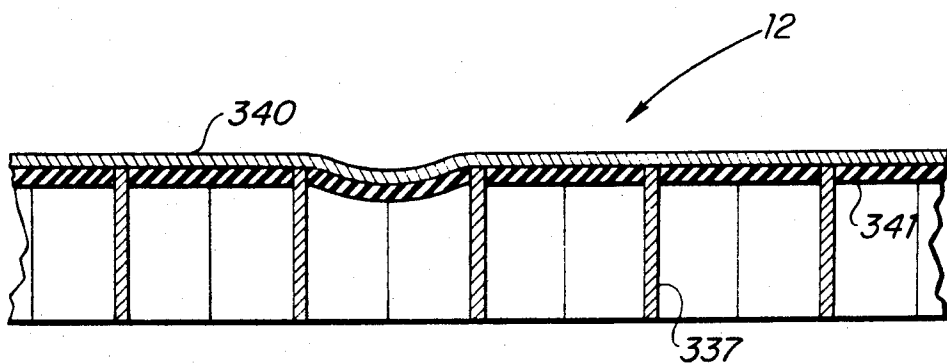


FIG. 5

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3 Sheets-Sheet 3

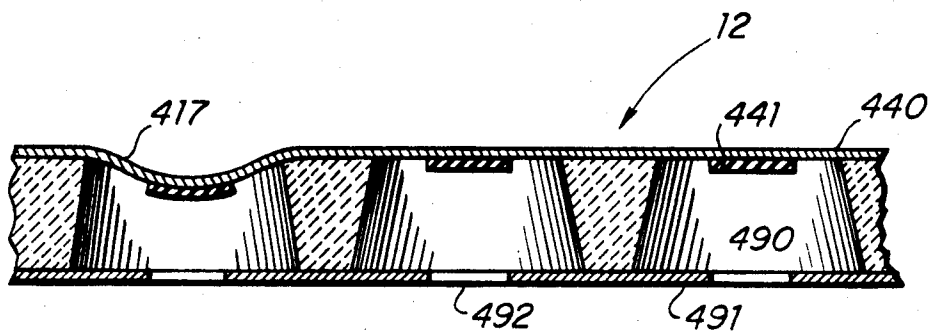


FIG. 6

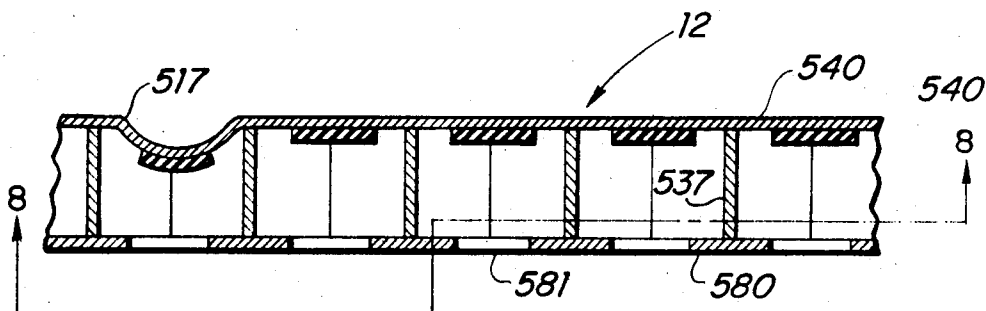


FIG. 7

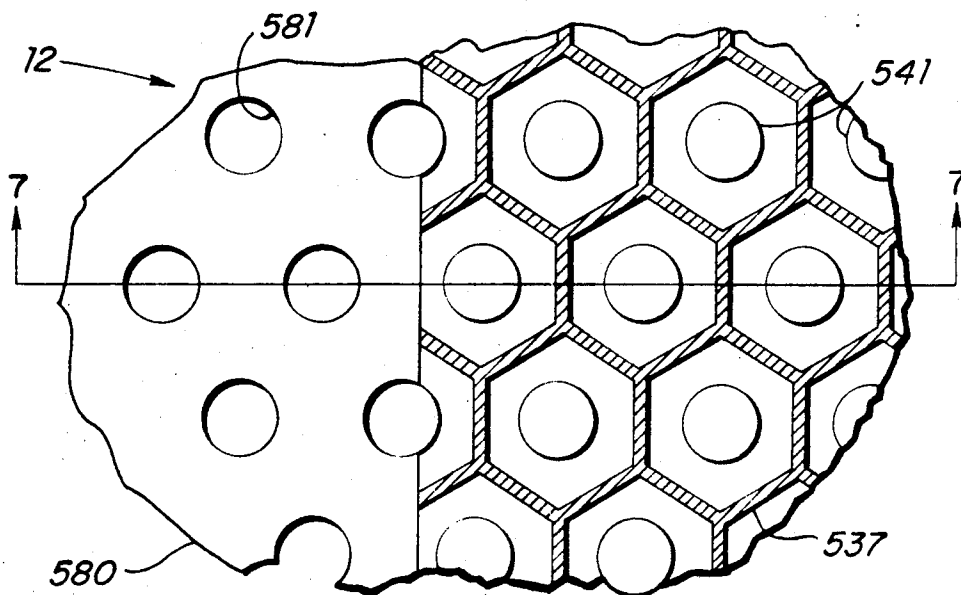


FIG. 8

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DISPLAY SYSTEM UTILIZING A SELECTIVELY DEFORMABLE LIGHT-REFLECTING ELEMENT

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Int. Cl. H01j 29/12

U.S. Cl. 350—161

8 Claims

ABSTRACT OF THE DISCLOSURE

A large scale display system utilizing a deformable metal film light-reflecting surface or light valve is disclosed. A light valve is assembled consisting of a very thin metal film mounted on a support grid. An area of dielectric material is placed on the lower surface of the film within each grid opening. This assembly is placed in a cathode ray tube so that an electron beam may be caused to impinge upon the dielectric areas. In one embodiment, a conventional optical system is used to direct collimated light against the upper surface of the metal film. Light reflected from distorted portions of the metal film is transmitted to a display screen, while light reflected from undistorted portions of the metal film does not reach the screen. When the electron beam impinges upon the dielectric areas, the areas are attracted by electrostatic attraction forces toward the adjacent grid members. This causes surface distortions or dimples in the metal film. A spot of light appears on the display screen at locations corresponding to the dimple locations. Where the dielectric areas are very small and closely spaced, an image corresponding to the areas scanned by the electron beam will appear on the display screen.

BACKGROUND OF THE INVENTION

The invention herein described was made in the course of or under a contract with the Department of the Air Force.

Many different techniques have been used to visually display images produced by a data processing device onto a large area screen. In general, it has been found that light images generated by the phosphor layer of a cathode ray tube are of insufficient brightness when considerably magnified and projected onto a large screen. Attempts have been made to utilize the light and/or electrostatic charge images generated in a cathode ray tube for large screen display systems by interposing optical systems which serve to amplify the available light for use in the display system.

One known display system uses an electron beam generating device and an oil surface or film. A modulating signal is supplied to the electron beam which scans the oil surface. As the electron beam passes over the oil film the thickness of the film is altered by an amount dependent upon the magnitude of the electron beam which, in turn, is controlled by the modulating signal. As the film thickness varies the optical path length through the film varies, thus altering the phase of a light beam incident upon the film and imparting the modulation information to the reflected light beam. However, efficient electron emission is not maintained for very long because vapors from the oil poison the cathode and shorten its life. Some systems using oil films and layers are further limited by the requirement that the tube surface carrying the oil film be maintained very level, to prevent the oil from running off. This severely limits portability of the system and adversely affects use of the systems in ships or aircraft and is a severe constraint on overall system design.

Bulky vacuum pumps must be employed to remove the vapors and maintain a vacuum within the system. At-

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tempts have been made to bring the oil film outside the cathode ray tube to overcome the problems when the oil vaporizes. Typical of these systems is that described in U.S. Pat. No. 3,385,927. While several of the above problems are overcome in this system, the oil is likely to become contaminated when it is exposed to the atmosphere. Further, it is difficult to transfer the high resolution electron beam image from within the tube to the oil layer on an outer surface of the tube.

Another technique which overcomes some of the problems associated with the oil film type modulator uses a plurality of individual reflecting elements. Each reflecting element has associated with it a transducer to which the modulation information is supplied. The transducer movement controls the position of the reflecting element. It is apparent that this arrangement provides localized operation if the various transducers and reflecting elements are isolated. The resolution of such a system is limited by the size of the individual reflecting elements and transducers. Typical of such a system is that disclosed in U.S. Pat. No. 2,681,423. However, such a system is extremely expensive to fabricate and manufacturing the individual reflecting elements in a size sufficiently small to give good image resolution is very difficult.

Thus, there is a continuing need for large screen display systems which will enable an image from a cathode ray tube system to be projected with sufficient brightness and resolution onto a large display surface.

SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to provide a display system overcoming the above-noted problems.

Another object of this invention is to provide a deformable metal film light valve suitable for use in large screen display systems.

Another object of this invention is to provide a large screen display system having an extended useful life span.

Still another object of this invention is to provide a large screen display system of improved resolution.

Yet another object of this invention is to provide a deformable metal film light valve for large screen display systems which is simple and economical to fabricate.

A further object of this invention is to provide a deformable metal film light valve for large screen display systems capable of extended use within a cathode ray tube without contamination of the system.

A still further object of this invention is to provide improved process for forming deformable metal film light valves.

The above objects, and others, are accomplished in accordance with this invention by providing a display system which incorporates a variable reflectance element or light valve within a cathode ray tube to control the reflection of light from a surface of the element to a large display screen in accordance with an electron beam scan on the opposite surface of the element. The light valve comprises a very thin film of metal supported on a grid. The side of the film not in contact with the grid is adapted to reflect light impinging thereon. A layer of dielectric material is placed on the film within each of the openings in the grid. When an electron beam scans across the grid side of the reflecting element, dielectric areas struck by the electron beam are electrostatically charged. The dielectric is attracted downward towards the grid element by the resulting electrostatic attraction forces. Each attracted dielectric area or spot causes a small deformation or dimple to form in the metal film at that spot. When light from a conventional Schlieren optical system is directed against the reflective surface of the element, only light which strikes the deformed areas reaches the screen. Thus, a light image is formed on the display screen corresponding to the dimpled image formed in the metal film

by the electron beam. A flood gun may be provided within the cathode ray tube to remove the charge placed on the dielectric spots by the electron beam ray gun. Also, a charged grid may be placed adjacent the dielectric layer side of the light valve to absorb secondary electrons emitted by the grid and dielectric areas in response to the electron bombardment.

Any suitable optical system may be used with the tube. Either the light reflected by undistorted areas or by distorted areas may be transmitted to the screen. Thus, the electron beam image may be presented in either a dark-on-light or light-on-dark mode.

Any suitable reflective film and grid arrangement may be used. Several preferred embodiments of the light valve are described in the following detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Details of the invention will be further understood upon reference to the drawings which show various preferred embodiments of the present invention.

In the drawings:

FIG. 1 shows a schematic representation of a display apparatus embodying the present invention;

FIG. 2 shows an enlarged fragmentary portion of the apparatus shown in FIG. 1;

FIG. 3 shows a vertical section through a portion of a deformable metal film light valve according to this invention;

FIGS. 4 through 7 show vertical sections through portions of several alternative embodiments of deformable metal film light valves; and

FIG. 8 shows a plan view of the light valve of FIG. 7, partially in section, taken along line 8-8 in FIG. 7.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIG. 1, there is seen an assembly including an evacuated tube 11 within which a deformable metal film light valve 12 is supported. While light valve 12 is shown horizontal in FIG. 1, it is, of course, operable in any other orientation. An electron beam source 14 within tube 11 generates and directs an electron beam 15 toward one surface of the light valve 12. Electron beam 15 scans the light valve 12 and is intensity modulated in accordance with the intelligence supplied. The surface of the deformable metal film light valve 12 is distorted by the accumulated charges produced by the electron beam, forming, effectively, an optical perturbation as indicated at 17. Light rays from a light source 18 are directed by a suitable optical system 20 against the upper surface of light valve 12. Light rays reaching undisturbed portions of the light valve 12 are reflected back to the light source and do not reach projection screen 21. The light rays which strike disturbed portion 17 of light valve 12 are projected on screen 21 as a light area. In this manner, the pattern of light formed on screen 21 is modulated in accordance with the intelligence supplied, providing a visual display of light images on a dark background in accordance therewith.

More specifically, the evacuated tube 11 includes a neck portion 25 and a generally frusto-conical portion 26. The larger end of frusto-conical portion 26 is closed with a plate 27, which in the illustrated embodiment, is preferably optically flat so as to prevent the distortion of parallel light rays passing therethrough. Electron gun 14, which is of conventional construction, is located in neck portion 25. Electron gun 14 includes a cathode, grid, and accelerating and focussing anodes, as is conventional. Electron gun 14 is connected to a conventional power supply 30. The kinetic energy or velocity of the electrons in the electron beam 15 is changed to permit writing of intelligence, as described hereinafter, by selecting the potential of the cathode within electron gun 14 with respect to the light valve 12. Positioned within neck portion 25 is a pair of beam deflection plates 29. Deflec-

tion plates 31 are supplied with deflection potentials to select the point upon light valve 12 which beam 15 impinges, in a conventional manner. If desired, magnetic rather than electrostatic deflection means may be used.

The second neck portion 33 is provided to house a second electron gun 34 of the "flood" type. Flood gun 34 is energized by a suitable power supply 35. Flood gun 34 is provided to permit quick erasure of charge patterns formed on light valve 12 by light beam 15. In operation, erasure can be quickly accomplished by turning on the flood gun 34 with high beam current, or the image can be made to gradually fade by turning on the flood gun 34 with low beam current. The flood gun 34 showers the lower surface of light valve 12 with electrons, the result being the elimination of the original selective charge pattern. Alternatively, the flood gun 34 may be eliminated and the writing electron beam gun 14 may be utilized to erase previous charge patterns before the formation of new charge patterns. These techniques for erasing existing charge patterns are described in further detail in co-pending U.S. application Ser. No. 644,837, filed June 9, 1967 (assigned to the assignee of this application), and in an article by H. A. Pohl, in the "Journal of Applied Physics," vol. 32, page 1784 (1961).

In operation, the upper surface of light valve 12 is illuminated by light from light source 18. The light from source 18 passes through a projection lens 22 having its focal point coincident with the focal point of a collimating lens 23 which provides parallel light rays for illumination of the upper surface of the light valve 12. Lenses 22 and 23 are mounted on a common axis. Positioned at the coincident focal point of these lenses 22 and 23 is an aperture 19 in a first-surface reflecting mirror 16, the planar surface of which forms an angle of approximately 45° with the common axes of the lenses 22 and 23. A projection screen 21 is positioned to receive the light reflected from the mirror for display thereon. In order to describe the operation of the optical system in conjunction with light valve 12, three typical light rays are illustrated. These rays are designated as 28, 31, and 32. These rays which emanate from light source 18 pass through the lens 22, the aperture 19, and the lens 23. The rays are collimated and projected upon the upper surface of light valve 12 generally perpendicular to the surface thereof. The rays 31 and 32 are reflected by the reflecting surface of light valve 12 back along their incident path. These rays 31 and 32 are thus "trapped" within the optical system and will return through the mirror aperture 19. Ray 28 also reaches the surface of light valve 12 on a path substantially perpendicular to that surface. However, since this ray is reflected from a distorted area on surface of light valve 12, it returns to lens 23 along a different path than the incident ray. This reflected ray is then reflected by mirror 16 to screen 21 where it appears as a bright dot. In this manner those portions of the surface of light valve 12 which have been distorted in response to the writing electron beam produce illuminated areas on screen 21, thereby providing a visual display of the electrical intelligence supplied. While this optical system is highly effective when used in conjunction with light valve 12, any other suitable system, such as conventional bar-grating system may be used, if desired. Other conventional optical systems which permit the simultaneous formation of images on plural screens, or copying on photosensitive material of the image, may be used if desired.

Basically, deformable metal film light valve 12 comprises a thin metal film supported on a grid or mesh 37. If desired, a grid 38 may be located within cathode ray tube 11 between light valve 12 and the electron beam source 14. Grid 38 may be maintained at any desired potential by means of conventional power supply 39. Grid 38 may be utilized to collect secondary electrons and/or to vary the velocity of electrons passed from electron beam source 14 to light valve 12, as desired.

The manner in which light valve 12 operates will be further understood upon reference to FIG. 2, which shows an enlarged fragmentary view of the area indicated at 2 in FIG. 1. As seen in FIG. 2, the light valve includes a thin metal film 40 supported on a mesh 37 may be formed in various ways, as further described below. Preferably, mesh 37 includes, in addition to a portion extending at right angles to metal film 40, a portion extending generally parallel to, and spaced from, film 40. Within each opening in mesh or grid 37, a thin layer or spot 41 of a dielectric material is formed on the surface of metal film 40. When electron beam 15 from write gun 14 strikes the surface of dielectric material 41, an electrostatic charge is formed on the surface of the dielectric material. The mesh 37 is maintained at a selected potential, opposite in sign to the electrostatic potential on dielectric spot 41, by conventional power supply 43. Electrostatic attraction forces, indicated by arrows 44, attract dielectric spot 41 toward the grid 37. This causes a minute deflection of the upper surface of metal film 40. Light reflected from the distorted surface reaches screen 21 as a bright dot. The image is thus formed on the screen 21 from a plurality of such light dots.

This system will have extremely high image resolution where the cell spacing of mesh 37 is very small. While any suitable cell size may be used, it is preferred that the individual cells have a diameter from about 15 to about 100 microns. Also, this system has very high image brightness since reflection efficiency is high.

Any suitable conductive film may be used for the distortable film 40. Desirably, the material will be ductile but capable of many flexings. It is also desirable that the material have good light reflecting characteristics. While any suitable film thickness may be used, in general, best results are obtained where the film has a thickness of from about 5×10^{-2} micron up to about 0.5 micron. Substantially thinner films lack mechanical strength, while substantially thicker films do not have the desirable flexure characteristics at reasonable potentials. Typical conductive materials include silver, aluminum, copper and nickel.

Any suitable dielectric material may be used for dielectric layer or spots 41. Preferably, the dielectric material will be resistant to high voltage breakdown at the voltages to be used in the system, will not out-gas in the high vacuum environment, will have high secondary electron emission characteristics and will have thermal expansion characteristics reasonably matching those of the metal film. Typical dielectric materials include silicon dioxide, caesium oxide and directly formed oxides such as a beryllium copper treated to oxidize the surface. While the dielectric material 41 may, if desired, cover the entire surface of metal film within grid 37, it is preferable that the dielectric material only cover about one-half of the area within grid 37. The dielectric material may have any suitable thickness. Preferably, the thickness is from about one micron to about one-half the overall thickness of the grid system. If the dielectric material is much thinner than one micron, voltage breakdown problems may occur. If the dielectric material has the thickness substantially greater than one-half the grid thickness, the electrostatic force field between the dielectric material and the grid will be primarily horizontal so that the forces will not cause substantial deflection of the surface of metal film 41.

The dielectric layer may be formed in any suitable manner. Where the opening in the grid is smaller than the exposed film surface within the individual grid cell, it is generally preferred that the dielectric layer be coated by a line-of-sight coating process, such as conventional cathode sputtering or vacuum evaporation, so that the dielectric spot area will be less than the metal film area within the cell. Some materials such as beryllium copper foil may be simply oxidized in air to form a submicron area of dielectric oxide. The oxidized area may be limited by any suitable masking technique.

Any suitable grid material and configuration may be

used, as desired. In general, an overall grid thickness of from about 5 to about 25 microns is preferred. The best results are also obtained where the cell size (the distance from the center of one cell to the center of the adjacent cell) is from about three to about four times the thickness of the grid. These proportions tend to give the best force vectors between the grid walls and the dielectric material while maintaining high resolution. The grid may have various shapes and thicknesses as discussed below. In general, if the grid walls are excessively thin they will be fragile and subject to vibration damage. Thicker walls tend to help heat dissipation, but may decrease resolution where they decrease the number of cells per unit area. Any suitable material may be used for the grid. Preferably, the material will have good heat dissipation characteristics and, where the grid is made by an etching technique, should be an easily etched material. Typical grid materials include copper, silver, nickel and gold. Various configurations of the grid, film and dielectric may be selected depending upon the characteristics desired. Typical embodiments are shown in FIGS. 3 through 8.

Referring now to FIG. 3, there is seen a section through a portion of a deformable metal film light valve 12. In this embodiment, the thin deformable metal film 140 is supported on a grid 137. Spots of dielectric material 141 are located within each cell in grid 137. In this embodiment, each cell has a generally frusto-conical shape with the larger end adjacent the film 140. This embodiment is highly effective in providing sufficient distortion of film 140 as shown at 117 with reasonably low potentials on dielectric areas 141. As can be seen, electrostatic force vectors between areas 141 and the adjacent cell walls have a substantial vertical component. Also, the grid 137 has a substantial cross-section which will result in excellent heat dissipation characteristics. While this configuration may be manufactured by any suitable technique, the following process is preferred.

A layer of photo-resist material is coated on one surface of the metal sheet 137. The photo-resist is then exposed to actinic radiation in a pattern which results in hardened areas where grid members are to remain and which is still soft in the cell area. The soft material is then washed away and the plate is treated with an etchant which etches away the metal sheet material from the cells. After the etching step is complete, forming the generally frusto-conical cells, the hardened photo-resist is washed away with a solvent and a thin metal film 140 is bonded to the surface of sheet 137 which had been coated with the photo-resist. The bonding of film 140 to sheet 137 may be accomplished by any suitable technique, such as spot welding. The cell walls slope as shown in FIG. 3. While the angle of undercut may be selected in accordance with desired characteristics, in general about a 45° undercut is suitable. Next, dielectric layers or spots 141 are deposited by any suitable technique, such as cathode sputtering or vacuum deposition. Using these techniques, the individual spots of dielectric material 141 will have a surface shape corresponding to the shape of the openings in grid 137. Dielectric material will also deposit on the under surface of the grid members. This material may be removed by any conventional dissolving or abrading technique. In some instances, however, this material may be left on the grid members if it does not adversely affect operation of the apparatus. Thus, it can be seen that the embodiment shown in FIG. 3 may be easily and economically produced utilizing well-known processes in the art.

An alternative embodiment of the light valve 12 is shown in FIG. 4. In this embodiment, a commercially obtainable fine hexagonal "honey-comb" metal grid 237 is bonded to a thin metal film 240. While any bonding technique may be used, it is preferred that simultaneous spot welding be used. In this technique, a large electrode is placed in contact with the upper surface of metal film 240 with a second electrode in contact with the lower end of the grid 237. The electrodes are operated at the

desired welding potential to simultaneously weld all intersections between metal film 240 and grid 237. Next, the beads 250 are formed on the lower extremity of all of the grid webs. Beads 250 may be formed by any suitable technique. Typically, the material may be electro-plated onto the grid webs, or the material may be vacuum evaporated from a source maintained at a shallow angle to the plane of the grid, or the grid may be dipped into a molten solder bath and then pressed against a cold plate to expand the beads transversely. After beads 250 are formed, dielectric layers 240 may be formed by a technique such as cathode sputtering or vacuum evaporation. Using such a technique, each spot 241 will have a transverse area equal to the area between adjacent beads 250. Again, the dielectric material which is deposited upon the lower surface of beads 250 may be removed or left in place, as desired. This embodiment has advantages of permitting relatively close cell spacing since the cell walls are relatively narrow, to improve image resolution. The beads, which extend partially parallel to film 240 result in electrostatic attraction force vectors between the grid 237 and the dielectric areas 240 which have a substantial vertical component. This permits substantial deflection of film 240 as indicated at 217 with reasonably low potentials. Also, the area of the individual spot 241 may be easily selected by selecting the quantity of material to be incorporated into beads 250. In general, it is desirable that the spot 241 be substantially less than the surface of film 241 within the cell since most of the deflection of film 240 occurs in the area between spot 241 and the cell walls. The dielectric material 241 inherently tends to reinforce the film 240 in the coated areas decreasing the deflection therein.

FIG. 5 shows a further embodiment of the light valve 12. This is a relatively simple embodiment in which a commercially available hexagonal "honey-comb" grid 337 is bonded to a metal film 340, as discussed above. In this embodiment, the layer 341 is formed entirely across the surface of film 340 within each cell. While layer 341 may be formed by cathode sputtering, vacuum evaporation, etc., as discussed above, it may also be formed by any direct coating process. For example, a layer of glass frit may be coated onto the surface and the assembly may be heated to fuse the frit, forming a continuous layer. While this embodiment is simple and economical to fabricate, it has disadvantages in that the continuous layer 341 will tend to reinforce metal film 340 and decrease the amount of deflection produced by a given electrostatic potential difference. Also, the electrostatic force vectors between the 341 and the walls of grid 337 will be substantially horizontal so that there will be less vertical force applied to cause deflection of metal film 340.

FIG. 6 shows a slightly more complex embodiment of light valve 12 which has certain advantages. In this embodiment, the deflectable metal film 440 is supported on a grid 490 of a dielectric material. The opposite surface of grid 490 supports a perforated metal layer 491. While this structure may be produced by any suitable technique, the following process is preferred. A sheet of dielectric material 490 is coated on one side with the metal film 440 and on the other side with metal layer 491 by any suitable process, such as electroless plating. Then, by the photo-resist techniques described above or any other suitable technique, perforations 492 are etched out of layer 491 using an etching solution which does not attack dielectric material 491. Then, an etchant is applied which attacks only dielectric material 490. The etching process is continued until the configuration shown in FIG. 6 is achieved. Finally, the dielectric spots 441 are produced by any suitable technique, such as cathode sputtering or vacuum evaporation.

Since film 440 and metal layer 491 are electrically isolated, they may be maintained at different potentials. This capability may have several advantages. For example, it will be possible to maintain a potential difference

between dielectric material 441 and metal layer 491 which is so great that if the same potential difference were maintained between layer 440 and the surface of spot 441 voltage breakdown through dielectric material 441 would occur. Also, since layer 491 extends substantially parallel to metal film 440, the electrostatic attraction force vectors between dielectric spots 441 and layer 491 will be substantially perpendicular to the surface of 440 so that sufficient deflection of metal layer 441, as shown at 417, will occur with a relatively low potential difference.

Another embodiment of light valve 12 is shown in FIGS. 7 and 8. FIG. 8 is a plan view, partially in section, of the light valve 12 shown in FIG. 7. In this embodiment, a metal hexagonal "honeycomb" grid is secured to a metal film 540 by any suitable technique as discussed above. Then, a metal sheet 580 having perforations 581 corresponding to the locations of the cells within grid 537 is secured to the opposite surface of grid 537. Finally, dielectric layers or spots 541 are formed within each cell by any suitable technique. While this embodiment requires considerable care that the perforations 541 align with the cells within grid 537, this embodiment has certain advantages. The size of the dielectric spots 541 may be easily selected merely by selecting the size of perforations 581. Also, the electrostatic force vectors between spots 541 and sheet 580 may be selected according to the extent to which sheet 580 extends parallel to metal film 540.

Although the deformable metal film light valves of this invention may be made by any suitable method, the following examples describe in detail several preferred processes which simply and economically produce light valves having optimum operating characteristics.

EXAMPLE I

A copper sheet having a thickness of about 20 microns is coated on one surface with a layer of KPR-1, a photo-resist composition available from Eastman Kodak Co., to a thickness of about 5 microns. The photo-resist is exposed to a mask pattern with ultraviolet light, the mask leaving spaced round "dots" unexposed, each dot having a diameter of about 20 microns and the spacing between centers of adjacent dots being about 60 microns. The composite is washed with trichlorethylene to remove the unexposed photo-resist, leaving the surface of the copper exposed in the "dot" areas. The composite is then treated with concentrated nitric acid for a time sufficient to produce the frusto-conical cells shown in FIG. 3. The hardened photo-resist is removed by working with Amerace Formula 676, a solvent mixture available from the Amerace Corporation. An aluminum film having a thickness of about 0.1 micron is then bonded to the surface of the perforated copper sheet by spot welding between wide electrodes in contact with the film and perforated sheet. The light valve is then coated with silicon dioxide by conventional vacuum evaporation to a thickness of about 5 microns. The light valve is then ready for installation in a cathode ray tube for use.

EXAMPLE II

A beryllium-copper film having a thickness of about 2 microns is placed in contact with a stainless steel "honeycomb" mesh or grid having a thickness of about 25 microns and a cell spacing of about 100 microns. The cells having generally hexagonal cross-sections. This assembly is placed between the electrodes of a spot welding machine and sufficient current is passed therethrough to bond the film to the grid. The composite is then placed on a turntable in a vacuum chamber with the grid extending upwardly. Copper is vacuum evaporated in a conventional manner from a source at an angle of about 20° above the plane of the mesh upper surface while the turntable is rotated. The resulting deposition produces inwardly extending copper "beads" on the cell walls, as shown in FIG. 4. Then silicon dioxide is vacuum evaporated onto the assembly from a source located perpendicular to the

grid. If desired, the silicon dioxide deposited on the beads may be removed by gentle abrasion of the beaded surface. The light valve is then ready for installation in a cathode ray tube and use.

EXAMPLE III

A 15 micron sheet of Mylar (polyethylene terephthalate, available from E. I. du Pont de Nemours & Co.) mounted in a supporting frame is coated on one side with a 0.05 micron layer of platinum, by a conventional cathode sputtering process. A pattern of 15 micron "dots," spaced (center-to-center) 50 microns, is formed on the opposite surface by the photo-resist technique described in Example I. A 30 micron layer of copper is then formed on that surface by cathode sputtering. The composite is then treated with trichlorethylene which dissolves the photo-resist dots and strips away the copper layer coated thereover. The composite is then treated with hydrofluoric acid which dissolves the Mylar without attacking the metal layers. After the cells are formed, the composite is dried. A layer of caesium oxide is vacuum evaporated onto the cells to a thickness of about 10 microns, producing the configuration shown in FIG. 6. The caesium oxide deposited on the outer surface of the cell walls may be removed, if desired. The light valve is then ready for installation in a cathode ray tube. This tube is preferably continually vacuum pumped during operation, because of the tendency for the Mylar layer to out-gas slightly. Without such pumping, cathode life will be limited.

Although specific components, arrangements and proportions have been described in the above examples and descriptions of preferred embodiments, other suitable materials, components, arrangements, etc., may be used with similar results, as indicated above. In addition, other materials may be included in the dielectric layers, support grids, and deflectable metal films to enhance or otherwise modify their properties.

Other modifications and ramifications of the present invention will occur to those skilled in the art upon reading the present disclosure. These are intended to be included within the scope of this invention as defined in the following claims.

I claim:

1. A deformable metal film light valve comprising:

- (a) a thin metal film having a reflective first surface, and a second surface;
- (b) a grid in supporting contact with said second surface;
- (c) a layer of dielectric material on at least part of said second surface within the grid interstices.
- (d) means for applying a selected potential to said grid; and

(e) means for forming an electrostatic charge, opposite in sign to said potential, at selected spots on said layer of dielectric material.

2. The light valve according to claim 1 wherein said film has a thickness of up to about 5 microns, said grid has a thickness of from about 5 to about 25 microns and the grid cell size is from about 15 to about 100 microns.

3. The light valve according to claim 1 wherein film has a thickness of from about 0.005 to about 0.1 micron.

4. The light valve according to claim 1 wherein said grid comprises a sheet of conductive material having a plurality of open cells in the form of truncated cones with their bases at the film.

5. The light valve according to claim 1 wherein said grid comprises an expanded metal mesh with approximately hexagonal cells therein, the cell walls extending substantially perpendicular to said film.

6. The light valve according to claim 5 wherein said grid includes a conductive bead on said walls away from said film.

7. The light valve according to claim 1 wherein said grid comprises an electrically insulating material having a metal layer on the surface thereof away from said film, said metal layer having apertures in alignment with the grid cells.

8. The light valve according to claim 1 wherein the area of the film surface within each grid cell is greater than the area of the cell aperture in the plane of the surface of the grid opposite to the surface in supporting contact with said second surface of said metal film, and the area of the dielectric layer on the film within each cell is approximately equal to said cell aperture area.

References Cited

UNITED STATES PATENTS

2,681,423	6/1954	Auphan	313—91
2,510,846	6/1950	Wikkenhouser	350—161
2,910,532	10/1959	Auphan	350—161
3,306,160	2/1967	Dinhobel et al.	350—161
3,479,109	11/1969	Preston, Jr.	350—161

OTHER REFERENCES

R.C.A. Technical Note No. 775, 1968.

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