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## (54) Thin film electroluminescent edge emitter structure.

(57) A thin electroluminescent edge emitter structure having an integral beam-shaping lens system includes a common electrode layer disposed on a layer of substrate material. A first dielectric layer is disposed on the common electrode layer, a second dielectric layer is spaced from the first dielectric layer, and a phosphor layer is interposed between the first and second dielectric layers. The phosphor layer has an edge face extending between the first and second dielectric layers. A plurality of control electrodes are disposed on the second dielectric layer, and the common electrode layer, first and second dielectric layers with the phosphor layer interposed therebetween and the plurality of control electrodes define a plurality of pixels. Each of the pixels has a light-emitting face formed from at least the phosphor layer edge face. The plurality of control electrodes and the common electrode are adapted to be connected with an excitation source for applying an excitation signal to selected pixels. The application of an excitation signal to an individual pixel caused the pixel to radiate light energy within the phosphor layer associated with the pixel in in at lease a direction towards the pixel light-emitting face. The light-emitting face of the pixel is shaped to a preselected contour to define an optical lens integral therewith to project the light energy passed therethrough in a preselected direction and form a beam of light energy having a preselected beam pattern.

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# A THIN FILM ELECTROLUMINESCENT EDGE EMITTER STRUCTURE

This invention relates generally to a thin film electroluminescent edge emitter structure arranged to form a linear array of individual light-emitting pixels.

It is well known that an electroluminescent device may be utilized to provide an electronically controlled, high resolution light source. For example, it is well known to utilize electroluminescent devices in various flat panel display systems. One such type of application is disclosed in US-A-4110664. The flat panel display device of the above-identified patent is an electroluminescent bar graph display system which includes, on a unitary substrate, a plurality of discrete, individually controllable adjacent electroluminescent display elements interconnected to a thin film transistor dynamic shift register. Individual stages of the shift register are connected to individual display elements. The electroluminescent display element utilized in such a system is of the type in which one of the electrodes for use with the electroluminescent phosphor is a common light transmissive member. This common electrode is contiguous with the device face and the emissions must pass through this electrode.

The structure of such a display panel may also be seen in US-A-4006383 which discloses an electroluminescent display panel structure in which individual electroluminescent electrodes cover a large area of the panel in order to increase the active display area. The face of the electroluminescent element is the display surface electrode.

Another example of an electronically controlled high resolution light source is disclosed in US-A-4535341 which discloses a thin film electroluminescent line array emitter structure which provides edge emissions which are typically 30 to 40 times brighter than the face emissions of conventional flat panel display light sources. In one embodiment of the invention, the emitter structure includes an integral capacitor in series with each emitter structure pixel. This integral thin film structure dielectric and phosphor composite layer serves as both the light-emitting layer for the edge-emitting device and the dielectric for the capacitor.

Although each of the above-discussed thin film electroluminescent devices provides a high resolution light source, each of these devices is designed to project light energy without particular consideration for the direction in which the light energy is projected and the projected light energy pattern. Thus, if it is desired to utilize one of the above-discussed devices to project a beam of light energy having a specific beam pattern in a specific direction, a separate, optical focusing or beam-shaping lens must be employed. Although a separate lens structure may be utilized with some success, the addition of this lens would be to the size and complexity of each device.

Therefore, there is a need for an improved thin film electroluminescent edge emitter structure having a plurality of light-emitting pixels formed therein in which the light-emitting face of each pixel is shaped to a preselected contour to define an integral optical lens for projecting light energy passed therethrough in a preselected direction and forming the projected light energy into a beam of light energy having a desired beam pattern. Forming an optical lens integral with the light-emitting face of elach pixel in the thin film edge emitter structure does not increase the size and complexity of the structure, and is less expensive to manufacture than a light-projecting assembly which includes a thin film edge emitter structure and a separate focusing lens positioned adjacent to the light-emitting face of each pixel in the array.

## SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided a thin film electroluminescent edge emitter structure having an integral optical lens system which includes a common electrode layer having a first dielectric layer disposed thereon. A second dielectric layer is spaced from the first dielectric layer; and a phosphor layer is interposed between the first and second dielectric layers. A plurality of control electrodes are disposed on the second dielectric layer. The common electrode layer, first and second dielectric layers with the phosphor layer interposed therebetween and the plurality of control electrodes define a plurality of light-emitting pixels. The common electrode layer, first and second dielectric layers, phosphor layer and plurality of control electrodes each have an edge face. The edge faces of the various layers and control electrodes are in substantial alignment with each other, and form the light-emitting faces of the plurality of pixels.

The plurality of control electrodes and the common electrode layer are adapted to be connected with an excitation device for applying an excitation signal to selected pixels. The application of an excitation signal to an individual pixel causes the phosphor layer associated with the pixel to radiate light energy in at least a direction towards the pixel light-emitting face. The light-emitting face of the individual pixel is shaped to a preselected contour to define an optical lens integral with the pixel to refract the light energy passed therethrough. Depending upon the specific contour of the integral optical lens, the refracted light energy is projected in a preselected direction and formed into a beam of light energy having a preselected beam pattern.

Further in accordance with the present invention, there is provided a thin film electroluminescent edge emitter structure having an integral optical lens system and operable to produce a preselected color image which includes a common electrode layer with a first dielectric layer disposed thereon. A second dielectric layer is spaced from the first dielectric layer, and a phosphor layer is interposed between the first and second dielectric layer. The phosphor layer is divided into a plurality of phosphor zones each formed from a preselected composition of light-radiating materials, and each zone extends between the first and second dielectric layers. A plurality of control electrodes are disposed on the second dielectric layer with one control electrode in alignment with one phosphor zone. The common electrode layer, first and second dielectric layers with the plurality of phosphor zones interposed therebetween and the plurality of control electrodes define a plurality of light-emitting pixels. The comnon electrode layer, first and second dielectric layers, phosphor zones in the phosphor layer and the plurality of control electrodes each have an edge face. The edge faces of the various layers, phosphor zones and control electrodes are in substantial alignment with each other, and form the light-emitting faces of the plurality of pixels.

The plurality of control electrodes and the common electrode layer are adapted to be connected with an excitation source for applying an excitation signal to selected pixels. The application of an excitation signal to an individual pixel causes the phosphor zone associated with the pixel to radiate light energy in at least a direction towards the pixel light-emitting face. The color of the radiated light energy is dependent upon the composition of the light-radiating materials in the phosphor zone. The light-emitting face of the individual pixel is shaped to a preselected contour to define an optical lens integral with the pixel for projecting the colored light energy passed therethrough into an overlapping relationship with the colored light energy projected by predetermined other ones of the pixels.

The colored light energy projected by the individual pixel and the predetermined other ones of the pixels into an overlapping relationship is blended at the area of the overlap to form a resultant light image having a color dependent upon the colors of the light energy projected by the individual pixel and the predetermined other ones of the pixels.

Still further in accordance with the present invention, there is provided a thin film electroluminescent edge emitter structure having an integral beam shaping lens system which includes a common electrode layer and a plurality of control electrodes spaced therefrom. A layer of dielectric material is interposed between the common electrode layer and the plurality of control electrodes. A phosphor layer having an edge face extending in a direction between the common electrode layer and the plurality of control electrodes is also interposed between the common elect:rode layer and the plurality of control electrodes. The common electrode layer, layer of dielectric material, phosphor layer and plurality of control electrodes form a generally laminar arrangement and are disposed on a layer of substrate material. The common electrode layer, layer of dielectric material, phosphor layer and plurality of control electrodes define a plurality of pixels each having a light-emitting face formed from at least the phosphor layer edge face.

The plurality of control electrodes and the common electrode layer are adapted to be connected with an excitation source for applying an excitation signal to selected pixels. The application of an excitation signal to a selected pixel causes the pixel to radiate light energy within a portion of the phosphor layer associated with the pixel in at least a direction towards the pixel light-emitting face. The pixel light-emitting face is shaped to a preselected contour to define an optical lens integral with the pixel for projecting the light energy passed therethrough in a preselected direction and forming the projected light energy into a beam of light energy having a preselected beam pattern.

In order to make the invention clearly understood reference will now be made to the accompanying drawings which are given by way of example and in which:

Fig. 1A is a perspective view of a thin film electroluminescent edge emitter structure of the prior art, illustrating the planar light-emitting face of the structure;

Fig. 1B is a top view of a portion of the prior art thin film edge emitter structure of Fig. 1A, illustrating the extremities of the beam formed as the structure is operated to project a beam of light energy;

Fig. 2 is a perspective view of one embodiment of the thin film electroluminescent edge emitter structure of the present invention, illustrating the light-emitting face of each pixel in the structure shaped to a preselected contour to form an optical lens integral with the pixel;

Fig. 3 is a top view of a portion of the thin film edge emitter structure of Fig. 2, illustrating the contour of the light energy-projecting lens integral with each pixel in the structure;

Fig. 4 is a view similar to Fig. 3, illustrating the contour of an alternate embodiment light energy-projecting lens integral with each pixel;

Fig. 5 is a view similar to Fig. 3, illustrating the contour of another alternate embodiment light energy-projecting lens integral with each pixel;

Fig. 6 is a view similar to Fig. 3, illustrating the contour of still another alternate embodiment light energy-projecting lens integral with each pixel;

Fig. 7 is a top view of a portion of three light-emitting pixels positioned in side-by-side relationship, each pixel having a light-emitting face shaped to a preselected contour to project light energy passed therethrough into an overlapping relationship with the light energy projected by the other pixels;

Fig. 8 is a view similar to Fig. 2, and is a perspective view of an alternate embodiment of the thin film electroluminescent edge emitter structure of the present invention, illustrating a pair of adjacent pixels each having a serrated light-emitting face;

Fig. 9 is a top view of a portion of an individual pixel of Fig. 8, illustrating the waveguide effect on light energy passed through the serrated light-emitting face of the pixel; and

Fig. 10 is a view in side elevation of an alternate embodiment of the thin film electroluminescent edge emitter structure of the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, and particularly to Figs. 1A and 1B, there is illustrated an example of a thin film electroluminescent (TFEL) edge emitter structure of the prior art which may be utilized as a solid state, electronically controlled high resolution light source. Both the construction and operation of this prior art TFEL edge emitter structure are disclosed in U.S. Patent No. 4,535,341 to Kun et al., which is assigned to the assignee of the present invention.

Referring first to Fig. 1A, the prior art thin film electroluminescent (TFEL) edge emitter structure is generally indicated by the reference numeral 10. TFEL edge emitter structure 10 includes a common electrode layer 12, a first dielectric layer 14, a second dielectric layer 16, a phosphor layer 18 interposed between first and second dielectric layers 14, 16 and an excitation electrode layer 20. The generally laminar structure formed from common electrode layer 12, first and second dielectric layers 14, 16 with phosphor layer 18 interposed therebetween and excitation electrode layer 20 is disposed on a layer 21 of substrate material. An excitation source 22 is in electrical communication with the common electrode layer 12 and the excitation electrode layer 20 to provide the signal necessary to excite electroluminescent phosphor layer 18. The edge face of the TFEL structure, as at 24, is the light-emitting face or emission source. The back of the structure, that is, the edge opposite the light-emitting face, as at 26, may be mirrored with a suitable non-conducting reflector 28. It should be pointed out that although first and second dielectric layers 14, 16 are illustrated in Fig. 1A as unitary layers, each dielectric layer may in fact consist of a plurality of sublayers. In addition, the sublayers may be formed from different dielectric materials, and those skilled in the art may select the sublayer material utilized depending on the dielectric properties desired.

Although not specifically illustrated in Fig. 1A, at least one of the electrode layers, for example, excitation electrode layer 20, may be separated into a plurality of control electrodes to define, in combination with the remaining components of the structure, a plurality of individual light-emitting pixels. However, if excitation electrode layer 20 is separated into a plurality of control electrodes, an excitation source must be connected between the common electrode layer and each of the control electtrodes to provide an excitation signal to the plurality of pixels formed.

The TFEL edge emitter structure 10 illustrated in Figs. 1A and 1B forms an individual pixel 30 which has a planar light-emitting face 24. Thus, the light energy radiated within phosphor layer 18 upon the application of an excitation signal across electrodes 12, 20 is refracted at planar light-emitting face 24 and projected in a naturally diverging beam pattern to form a constantly expanding beam of light energy whose boundaries are designated by the numerals 32 in Fig. 1B. Stated in another manner, since phosphor layer 18 has a higher index of refraction than the medium adjacent to light-emitting face 24 (i.e. air), and light-emitting face 24 is planar in configuration, the light energy generated within phosphor layer 18 is refracted at planar light-emitting face 24 and projected through the air medium to form a beam pattern which diverges naturally in a direction Y parallel with the width of pixel 30.

As described, the use of a TFEL edge emitter structure having a planar light-emitting face as a high resolution light source may not be desired in applications which require the high resolution light source to project light energy in a preselected direction and form a beam of light energy having a tightly controlled converging, collimated or diverging beam pattern.

In accordance with the present invention, there is illustrated in Fig. 2 a thin film electroluminescent edge emitter structure generally designed by the numeral 40 operable to project radiated light energy in a desired direction and form a beam of light energy having a preselected beam pattern. As seen in Fig. 2, thin film electroluminescent (TFEL) edge emitter structure 40 includes a common electrode layer 42 disposed on a layer of substrate material 44. A first dielectric layer 46 is disposed on common electrode layer 42, and a second dielectric layer 48 is spaced from first dielectric layer 46. A phosphor layer 50 is interposed between first and second dielectric layers 46, 48, and a pair of control or excitation electrodes 52 are disposed on second dielectric layer 48.

As seen in Fig. 2. common electrode layer 42, first and second dielectric layers 46, 48 with phosphor layer 50 interposed therebetween, and the pair of control electrodes 52 form a pair of light-emitting pixels 54 in which the common electrode layer 42 and the first and second dielectric layers 46, 48 with phosphor layer 50 interposed therebetween are common to both pixels. Thus, the pair of control electrodes 52 define, in combination with the remaining components of the structure, the pair of pixels 54 illustrated. Although only a pair of light-emitting pixels 54 are illustrated in Fig. 2, it should be understood that the actual number of individual light-emitting pixels 54 which may be formed in a TFEL structure such as TFEL structure 40 will be dependent upon the structure's overall length and the total number of control electrodes actually formed in the layer of control electrode material. In addition, it should be pointed out that although first and second dielectric layers 46, 48 are illustrated in Fig. 2 as unitary layers, each dielectric layer may in fact consist of a plurality of sublayers. The sublayers may be formed from different dielectric materials, and those skilled in the art may select the sublayer material utilized depending upon the dielectric properties desired.

The control electrode 52 of each light-emitting pixel 54 and electrode layer 42 common to the pair of pixels are adapted to be connected with an excitation source 56. As known in the art, excitation source 56 is in electrical communication with common electrode layer 42 and the pair of control electrodes 52 to provide the excitation signal necessary to excite the electroluminescent phosphor layer 50 common to the pair of pixels. Upon the application of an excitation signal to an individual pixel 54 control electrode 52 and common electrode layer 42, the portion of the phosphor layer 50 associated with the individual pixel radiates light energy. As with the TFEL edge emitter structure 10 of the prior art, the rear face 58 of each pixel 54 is coated with a layer of non-metallic reflective coating 60. The layer of reflective coating 60 is operable to reflect a great portion of the light present at the rear face 58 of an individual pixel 54 in a general direction towards the light-emitting end portion 62 of the pixel.

The light-emitting end portion 62 of each pixel 54 has an outer or light-emitting face 64 shaped to a preselected contour. For example, the light-emitting face 64 of each pixel 54 illustrated in Fig. 2 is shaped to a concave contour viewed from the body portion 66 of the pixel. The light-emitting face 64 of each pixel 54 is formed from the edge faces 68, 70 of first and second dielectric layers 46, 48, the edge faces 72, 73 of common and control electrodes 42, 52, and the edge face 74 of phosphor layer 50. The edge face 74 of phosphor layer 50 extends between the edge faces 68, 70 of first and second dielectric layers 46, 48. As will be explained later in greater detail, the light-emitting face 64 of each pixel 54 forms an optical lens integral with the pixel for projecting the light energy exiting the pixel face in a desired direction and forming a beam of light energy having a preselected beam pattern.

As previously described, the application of an excitation signal delivered from excitation source 56 to the phosphor layer 50 of each pixel 54 causes the phosphor layer associated with each pixel to radiate light energy. The light energy radiated within the phosphor layer 50 associated with an individual pixel 54 passes through the phosphor layer in a direction towards the individual pixel light-emitting face 64. Since the index of refraction of phosphor is approximately 2.4, and the index of refraction of the medium external to light-emitting face 64 is, for example 1.0 for an air medium, it is seen that light energy passing from the interior of an individual pixel phosphor layer 50 to the external medium surrounding the pixel will be refracted at pixel light-emitting face 64.

Since the light-emitting face 64 of each individual pixel 54 has a preselected contour (concave contour in Fig. 2), each light-emitting face defines an optical lens integral with the pixel. By varying the contour of an individual pixel light-emitting face, the light energy refracted at the light-emitting face may be projected in a desired direction and shaped into a beam of light energy having a preselected beam pattern. In addition, each pixel light-emitting face 64, and particularly the edge face 74 of each pixel phosphor layer 50, is substantially perpendicular to the phosphor layer itself and the first and second faces 76, 78 defined by common and control electrodes 42, 52. As a result, the light energy refracted by each pixel integral lens will be oriented in a direction parallel with the width Y of the pair of pixels.

Now referring to Figs. 3 through 6, there are illustrated various alternate embodiments of portions of the pair of pixels 54 previously described with reference to Fig. 2. Each of the pixels illustrated in Figs. 3 through 6 has an end portion which includes a light-emitting face shaped to a preselected contour to control both the direction of the light energy projected by the pixel and the beam pattern of the light energy.

Referring first to Fig. 3, there is illustrated a top view of portions of the pair of light-emitting pixels 54 of Fig. 2. Each of the pixels 54 has a body portion 66 with an end portion 62 formed therein. The end portion 62 of each pixel includes an outer or light-emitting face 64 shaped to define an integral optical lens having a concave contour viewed from body portion 66. The length of radius R, which determines the radius of curvature of the integral optical lens defined by light-emitting face 64, may be varied depending upon whether it is desired to project a beam of light energy having a converging, diverging or collimated beam pattern. Thus, by controlling the length of radius R, the light energy beam pattern may be correspondingly controlled. This allows the beam pattern to be shaped for a specific application. As previously described with reference to Fig. 2, since the light energy refracted at light-emitting face 64 travels in a direction substantially perpendicular to light-emitting face 64, the converging, diverging or collimated beam of light energy is oriented parallel to the width Y of the pair of pixels.

Now referring to Fig. 4, there is illustrated a top view of the pair of pixels 54 of Fig. 3. As seen in Fig. 4, varying the radius of curvature of each pixel light-emitting face 64 between $R'$ and $R''$ results in a corresponding change in the contour of each light-emitting face. Thus, by selecting a desired radius of curvature for the concave light-emitting face 64 of each pixel 54, the light energy projected at the light-emitting face may have a converging beam pattern with a controlled rate of convergence, a diverging beam pattern with a controlled rate of divergence, or a collimated beam pattern.

Now referring to Fig. 5, there is illustrated a top view of the pair of pixels 54 previously described with reference to Fig. 2. Although each pixel 54 illustrated in Fig. 5 has an end portion 80 which is configured differently than the end portion 62 of each pixel illustrated in Figs. 2 through 4, the outer or light-emitting face of each end portion 80 is also shaped to a contour for projecting a light energy in a preselected direction and forming a beam of light energy having either a converging diverging or collimated beam pattern.

As seen in Fig. 5, the end portion 80 of each pixel 54 includes an outwardly expanding conical first portion 82 formed from a pair of side faces 84 positioned in divergent relationship with each other. Each of the side faces 84 has an end portion 86 connected to and integral with an adjacent end portion 88 of pixel body portion 66. Each of the side faces 84 also includes an end portion 90, and a light-emitting face 92, which forms an integral optical lens, extends between and is connected with the side faces 84 at end portions 90. Each light-emitting face 92 has a concave contour viewed from the associated pixel body portion 66. As previously described, the radius of curvature of each concave light-emitting face 92 may be varied as required to project light energy in a desired direction and form a beam of light energy having either a converging, diverging or collimated beam pattern.

Now referring to Fig. 6, there is illustrated a top view of the pair of pixels 54 previously described. However, as seen in Fig. 6, each of the pixels 54 has an end portion 94 which includes an integral, convex light-emitting face 96 operable to project a beam of light energy having a diverging beam pattern. Each pixel 54 illustrated in Fig. 6 has the same layered configuration as the pixels illustrated in Figs. 2 through 5, with the exception that the light-emitting face 96 of each pixel 54 in Fig. 6 has a convex contour viewed from the associated pixel body portion 66. As with the concave light-emitting faces illustrated in Figs. 2 through 5, the radius of curvature R of each convex light-emitting face 96 may be varied to produce a projected beam of light energy having a diverging beam pattern and a controlled rate of divergence.

Now referring to Fig. 7, there is illustrated a top plan view of portions of three light-emitting pixels such as light-emitting pixels 54 positioned in side-by-side relationship on substrate 44. Each pixel 54 illustrated in Fig. 7 has the same layered configuration as the pixels illustrated in Figs. 2 through 6. As seen in Fig. 7, each individual pixel 54 has a body portion 66 with an end portion 98 extending therefrom. Each end portion 98 has an integral, lens-defining light-emitting face 100 shaped to a convex contour viewed from body portion 66. By angularly spacing the convex, light-emitting faces 100 of the pair of outer pixels 54 from the dotted lines 101 which represent the inside faces of the outer pixels end portions by a preselected angle $\theta$, the beams of light energy projected by the outer pixels 54 are projected into overlapping relationship with the beam of light energy projected by the center pixel. Stated in another manner, with the light-emitting faces 100 of the pair of outer pixels 54 angularly spaced from their respective body portions 66 as illustrated in Fig. 7, the three pixels 54 positioned in side-by-side relationship project three beams of light energy into overlapping relationship at a plane designated schematically by the numeral 102. The three beams of light energy are blended at the area of the overlap to form a resultant linear light image at plane 102 extending between points 104 and 106.

The light-radiating phosphor layer of each pixel 54 in the trio of pixels is composed of a different, preselected composition of light-radiating materials. The color of the light energy radiated by each pixel is dependent on the specific composition of the materials in the phosphor layer, and therefore selecting the specific composition of light-radiating materials in the phosphor layer of a particular pixel to control the color of the light energy radiated by each pixel may be readily accomplished. If, for example, the phosphor layer common to the trio of pixels is divided into a first zone formed from a first preselected composition of light-radiating materials, a second zone formed from a second composition of light-radiating materials, and a third zone formed from a third preselected composition of light-radiating materials, and each zone is associated with a single pixel, then three beams of light energy at a first, second and third preselected color,respectively, will be projected into overlapping relationship at plane 102. The three colored beams of light energy will be blended at the area of the overlap to form a linear light image having a resultant color dependent on the colors of the first, second and third beams of light energy. Thus, if the first zone is a red phosphor (ZnS:Sm), the second zone is a green phosphor (ZnS:Tb) and the third zone is a blue phosphor (SrS:Ce), it is seen that the linear image formed at plane 102 will have a resultant color which is a blend of the colors red, green and blue. By varying the magnitude of the excitation signal across the control and common electrode of one or more pixels, the colored light energy radiated by the phosphor zone(s) associated with the pixel(s) may be varied in intensity. Thus, the individual beam(s) of light energy projected will also vary in intensity. It can be seen that by varying the intensity of a preselected combination of beams of light energy projected into overlapping relationship, a resultant light image may be formed having a desired color.

As described the various light-emitting pixels illustrated in Figs. 2 through 7 each include a substrate layer, a common electrode layer disposed on the substrate layer, a first dielectric layer disposed on the common electrode layer, a second dielectric layer spaced from the first dielectric layer, a phosphor layer interposed between the first and second dielectric layers, and a plurality of control electrodes disposed on the second dielectric layer. The control electrodes define, in conjunction with the dielectric, phosphor and common electrode layers, a plurality of individual light-emitting pixels. Each pixel has an end portion with an outer or a light-emitting face shaped to a preselected contour to define an integral optical lens. Since the phosphor layer of each pixel has an edge face which forms a portion of the lens, light energy radiated within a pixel phosphor layer and passed in a direction towards the edge face is refracted by the defined lens. Depending upon the contour of the integral lens, a beam of light energy may be projected by each pixel having either a diverging, collimated or converging beam pattern. If desired, a plurality of pixels positioned in side-by-side relationship may each have an integral, convex lens formed thereon and oriented to provide that the beams of light energy projected by the plurality of pixels are projected into overlapping relationship with each other. By properly selecting the composition of light-generating materials in each pixel phosphor layer, the beam of light energy projected by each pixel may have a desired color. The light beams projected by a plurality of pixels may be projected into overlapping relationship and blended at the area of the overlap to produce a resultant light image having a color dependent upon the colors of the projected individual beams.

Now referring to Fig. 8, there is illustrated an alternate embodiment of the thin film electroluminescent edge emitter structure of the present invention. As seen in Fig. 8, TFEL edge emitter structure 110 has a construction similar to TFEL edge emitter structure 40 of Fig. 2, and includes a first dielectric layer 112 disposed on a common electrode layer 113. Common electrode layer 113 is, in turn, disposed on substrate layer 114. A second dielectric layer 116 is spaced from first dielectric layer 112, and a layer of phosphor material 118 is interposed therebetween. A pair of control electrodes 120 are disposed on second dielectric layer 116 to define, in conjunction with first and second dielectric layers 112, 116, phosphor layer 118 and common electrode layer 113, a pair of light emitting pixels 122. The common and control electrodes of each pixel 122 are adapted to be connected to an excitation source 124 operable to provide a selected excitation signal to the phosphor layer of each pixel. As previously described for the TFEL edge emitter structure of Fig. 2, the application of an excitation signal to the phosphor layer of each pixel 122 excites the associated phosphor layer to radiate light energy in all directions within the phosphor layer. A portion of the light energy radiated in a direction towards the rear face 125 of each pixel 122 and is reflected by a non-metallic reflective coating 126 in a direction towards the end portion 128 of each pixel. The light energy radiated within the phosphor layer 118 of a particular pixel and passed in a direction towards end portion 128 is refracted at light-emitting face 130 formed in the end portion 128 of the pixel.

As seen in Fig. 8 and particularly in Fig. 9, the light-emitting face 130 of each pixel has a generally serrated contour. Specifically, light-emitting face 130 is formed from a plurality of rectangular protuberances 132 separated from each other by a plurality of recesses 134. As with the light-emitting faces of the pixels described in Figs. 2 through 7, the light-emitting face 130 of each pixel 122 defines an optical lens integral with the pixel to project the light energy passed therethrough in a preselected direction and form a beam of light energy having a preselected light pattern. Since the optical lens formed by light-emitting face 130 has a serrated contour, the plurality of protuberances 132 forming the serration act as waveguides to control the rate of divergence of the light energy projected by the pixel.

Referring now to Fig. 10, there is illustrated a side elevational view of an alternate embodiment of the thin film electroluminescent edge emitter structure 40 described herein with reference to Figs. 2 and 3. The edge emitter structure 40′ illustrated in Fig. 10 is identical to the edge emitter structure 40 described with reference to Figs. 2 and 3 except for the fact that edge emitter structure 40′ includes only one layer of dielectric material. The edge emitter structure having only one dielectric layer therein is designated by the numeral 40′ in Fig. 10 to differentiate it from structure 40 shown in Figs. 2 and 3 which includes a pair of dielectric layers. It should be understood that although edge emitter structure 40′ is referred to herein as an alternate embodiment of structure 40, any of the structures illustrated in Figs. 2 through 9 may also be formed to include a single dielectric layer rather than the pair of dielectric layers as previously described herein.

As seen in Fig. 10, TFEL edge emitter structure 40′ includes a common electrode layer 42 disposed on a layer of substrate material 44. A layer of dielectric material 46 is disposed on common electrode layer 42. It should be understood that although dielectric layer 46 of structure 40′ is illustrated in Fig. 10 as a unitary layer, the dielectric layer may consist of a plurality of sublayers. In addition, the sublayers may be formed from different dielectric materials, and those skilled in the art may select the sublayer material utilized depending upon the dielectric properties desired.

Phosphor layer 50 is disposed on dielectric layer 46, and the plurality of control electrodes 52 (one shown) are disposed directly on the phosphor layer. As described, common electrode layer 42, dielectric layer 46, phosphor layer 50 and the plurality of control electrodes 52 form a generally laminar arrangement on substrate 44. Although not specifically illustrated in Fig. 10, it is apparent that the positioning of the various layers forming structure 40′ may be rearranged so that phosphor layer 50 is disposed directly on common electrode layer 42. If this is the case, then dielectric layer 46 will be interposed between the phosphor layer and the plurality of control electrodes.

As with TFEL edge emitter structure 40 of Figs. 2 and 3, TFEL structure 40′ defines a predetermined number of individual light-emitting pixels 54, the actual number of pixels defined dependent upon the overall length of structure 40′ and the total number of control electrodes actually formed in the layer of control electrode material. In addition, the control electrode 52 and common electrode layer 42 of each light-emitting pixel 54 in structure 40′ are also adapted to be connected with an excitation source for providing the excitation signal necessary to excite the electroluminescent phosphor layer of the pixel and cause the phosphor layer associated with the pixel to radiate light energy. Each pixel 54 in structure 40′ includes a rear face 58 which is coated with a layer of non-metallic coating 60, and the coating is operable to reflect a great portion of the light present at rear face 58 of an individual pixel 54 in a general direction towards the light-emitting end portion 62 of the pixel.

The light-emitting end portion 62 of each pixel 54 has an outer or light-emitting face 64 shaped to a preselected contour. The light-emitting face 64 of each pixel 54 is formed from the edge face 68 of dielectric layer 46, the edge faces 72,73 of common and control electrodes 42,52, and the edge face 74 of phosphor layer 50. The edge face 74 of phosphor layer 50 extends between the edge faces 68,73 of the dielectric layer and control electrodes, respectively. As previously described with reference to Figs. 2 and 3, the light emitting face 64 of each pixel 54 forms an optical lens integral with the pixel for projecting the light energy exiting the pixel face in a desired direction and forming a beam of light energy having a preselected beam pattern.

From the above, it will be appreciated that the TFEL edge emitter structure 40 illustrated in Figs. 2 and 3 and the TFEL edge emitter structure 40′ illustrated in Fig. 10 operate identically, and the only structural difference between the two is that structure 40′ includes only one layer of dielectric material. It will be further appreciated that, although not specifically described herein, the TFEL edge emitter structures illustrated in Figs. 4 through 9 may also be formed including only a single layer of dielectric material.

## Claims

1. A thin film electroluminescent edge emitter structure having an integral beam-shaping lens system, comprising:
a common electrode layer (42);
a first dielectric layer (46) disposed on said com-

mon electrode layer (42);

a second dielectric layer (48) spaced from said first dielectric layer (46);

a phosphor layer (5) interposed between said first and second dielectric layers (46,48), said phosphor layer (50) having an edge face extending between said first and second dielectric layers;

a plurality of control electrodes (52) disposed on said second dielectric layer;

said common electrode layer (42), first (46) and second (48) dielectric layers with said phosphor layer (50) interposed therebetween and said plurality of control electrodes defining a plurality of pixels (54), each of said pixels (54) having a light-emitting face (64) formed at least from said phosphor layer edge face;

said plurality of control electrodes (52) and said common electrode layer (42) being adapted to be connected with an excitation means (56) for applying an excitation signal to selected pixels, the application of said excitation signal to an individual pixel causing said pixel to radiate light energy within said phosphor layer (50) associated with said pixel in at least a direction towards said pixel light-emitting face (64); and

said light-emitting face (64) of said pixel being shaped to a preselected contour to define an optical lens integral therewith for projecting said light energy passed therethrough in a preselected direction and forming said light energy into a beam of light energy having a preselected beam pattern.

2. A thin film electroluminescent edge emitter structure as claimed in claim 1, characterised in that each of said pixels has a first and a second face generally defined by said common and control electrodes, respectively, and:

each said pixel light-emitting face is substantially perpendicular to said first and second faces.

3. A thin film electroluminescent edge emitter structure as claimed in claim 2, characterised in that said light emitting face is positioned relative to said first and second faces to provide that said beam of light energy is orientated in a plane substantially parallel with said first and second faces.

4. A thin film electroluminescent edge emitter structure as claimed in claim 1, 2 or 3, characterised in that said light-emitting face is shaped to a preselected contour to provide that said optical lens defined thereby refracts said light energy to form a beam of light energy having a converging or a diverging pattern.

5. A thin film electroluminescent edge emitter structure ad claimed in claim 4, characterised in that said light-emitting face has a concave contour.

6. A thin electroluminescent edge emitter structure as claimed in claim 4, characterised in that said light-emitting face has a convex contour.

7. A thin film electroluminescent edge emitter structure as claimed in claim 4, characterised in that said light-emitting face has a generally serrated contour.

8. A thin film electroluminescent edge emitter structure as claimed in any one of claims 1 to 7, characterised in that one of said electrodes is disposed on a layer of substrate material.

9. A thin film electroluminescent edge emitter structure as claimed in claim 1, characterised in that the phosphor layer is divided into a plurality of zones each formed from a preselected composition of light-radiating materials; the plurality of control electrodes being disposed on said second dielectric layer with one said control electrode in alignment with one said phosphor zone; said common electrode layer, first and second dielectric layers with said plurality of control electrodes defining said plurality of pixels, each said pixel having a light-emitting face formed from at least said edge face of said zone associated with said pixel; said plurality of control electrodes and said common electrode layer adapted to be connected with an excitation means for applying an excitation signal to selected pixels, the application of said excitation signal to an individual pixel causing said pixel to radiate light energy of a preselected colour within said phosphor zone associated with said pixel in at least a direction towards said pixel light-emitting face, said colour of said light energy being dependent upon said preselected composition of light-radiating materials forming said phosphor zone; and said light-emitting face of said individual pixel being shaped to a preselected contour to define an optical lens integral therewith for projecting said coloured light energy passed therethrough into an an overlapping relationship with the coloured light energy projected by predetermined other ones of said pixels.

10. A thin film electroluminescent edge emitter structure as claimed in claim 9, characterised in that said coloured light energy projected by a plurality of pixels into an overlapping relationship is blended at the area of said overlap to form a resultant light image having a colour dependent upon the colour of said light energy projected by each of said pixels.

11. A thin film electroluminescent edge emitter structure as claimed in claim 9 or 10, characterised in that said phosphor layer includes a first zone formed from a first preselected composition of light-radiating materials, a second zone formed from a second preselected composition of light radiating materials and a third zone formed from a third preselected composition of light-radiating materials, said first, second and third phosphor zones being associated with first, second and third pixels, respectively; and said first, second and third pixels each having a light-emitting face shaped to a

preselected contour to project light energy at a first, second and third preselected colour, respectively, into an overlapping relationship for blending at the area of said overlap to form a linear light image having a resultant colour determined by said first, second and third preselected colours.

12. A thin film electroluminescent edge emitter structure as claimed in claim 11, characterised in that said first, second and third colours are selected from a group consisting of the colours red, blue and green.

13. A thin film electroluminescent edge emitter structure as claimed in any one of claims 9 to 12, characterised by means for varying the magnitude of said excitation signal applied to selected ones of said plurality of pixels for varying the intensity of said coloured light energy radiated by said selected ones of said pixels.

14. A thin film electroluminescent edge emitter structure as claimed in any one of claims 9 to 13, characterised in that said light-emitting face of each of said plurality of pixels has a convex contour to define an integral, convex optical lens.

15. A thin film electroluminescent edge emitter structure having an integral beam-shaping lens system, comprising:
a common electrode layer;
a plurality of control electrodes spaced from said electrode layer;
a layer of dielectric material interposed between said common electrode layer and said plurality of control electrodes; a phosphor layer having an edge face extending in a direction between said common electrode layer and said plurality of control electrodes interposed between said common electrode layer and said plurality of control electrodes; said common electrode layer, layer of dielectric material, phosphor layer and said plurality of control electrodes formed in a generally laminar arrangement and disposed on a layer of substrate material; said common electrode layer, layer of dielectric material, phosphor layer and plurality of control electrodes defining a plurality of pixels each having a light-emitting face formed at least from said phosphor layer edge face; said plurality of control electrodes and said common elect:rode layer adapted to be connected with excitation means for applying an excitation signal to selected pixels, said application of said excitation signal to a selected pixel causing said pixel to radiate light energy within a portion of said phosphor layer associated with said pixel in at least a direction towards said pixel light-emitting face; and said pixel light-emitting face being shaped to a preselected contour to define an optical lens integral therewith for projecting said light energy passed therethrough in a preselected direction and forming said light energy into a beam of light energy having a preselected beam pattern.

16. A thin film electroluminescent edge emitter structure as claimed in claim 15, in which: said layer of dielectric material is disposed on said phosphor layer ; and said plurality of control electrodes are disposed on said layer of dielectric material.

17. A thin film electroluminescent edge emitter structure as claimed in claim 16 or 16 characterised in that said layer of dielectric material is formed from a plurality of dielectric sublayers each formed from a preselected dielectric material.

18. A thin film electroluminescent edge emitter structure as claimed in claim 15 characterised in that said phosphor layer is disposed on said layer of dielectric material; and said plurality of control electrodes are disposed on said phosphor layer.

19. A thin film electroluminescent edge emitter structure as claimed in claim 22, characterised in that said layer cf dielectric material is formed from a plurality of dielectric material.

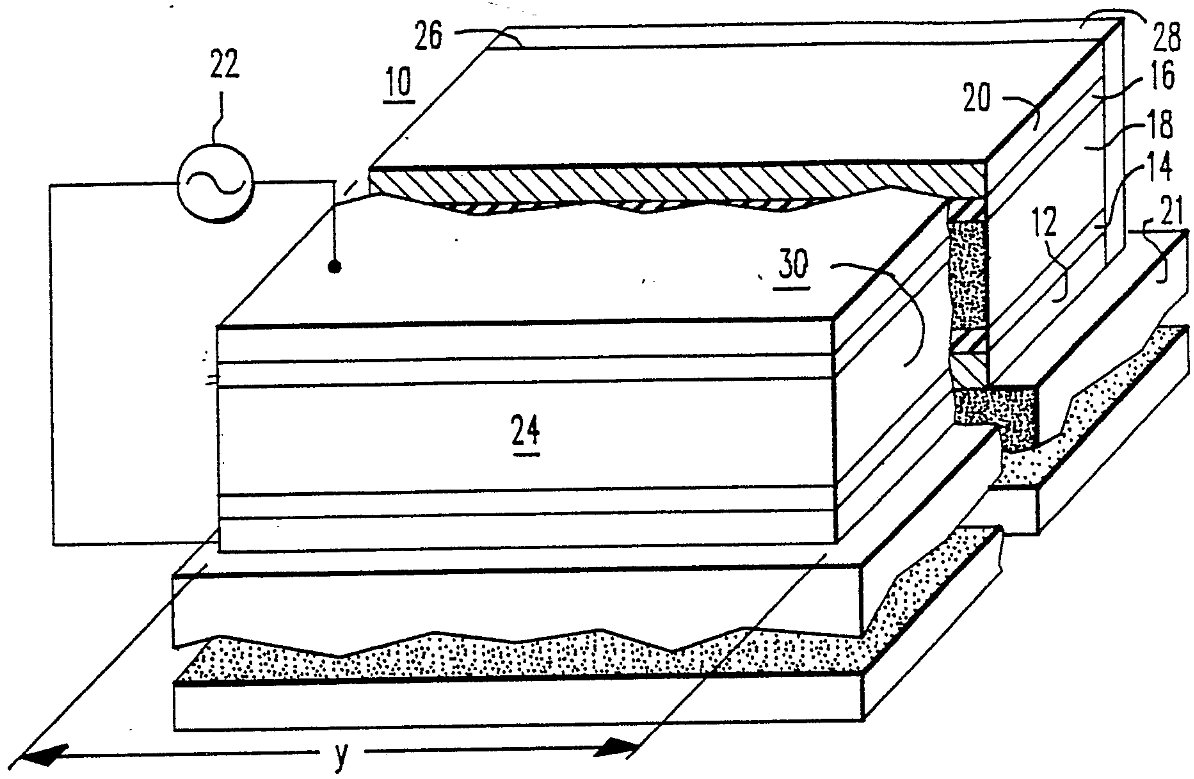


FIG. 1A
PRIOR ART

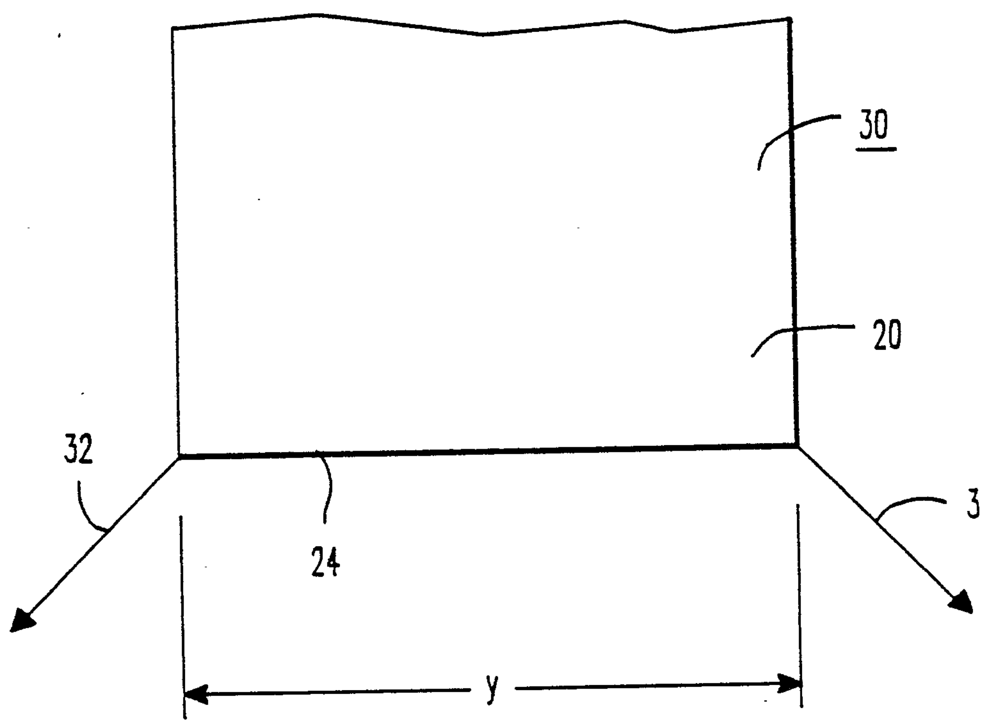


FIG. 1B
PRIOR ART

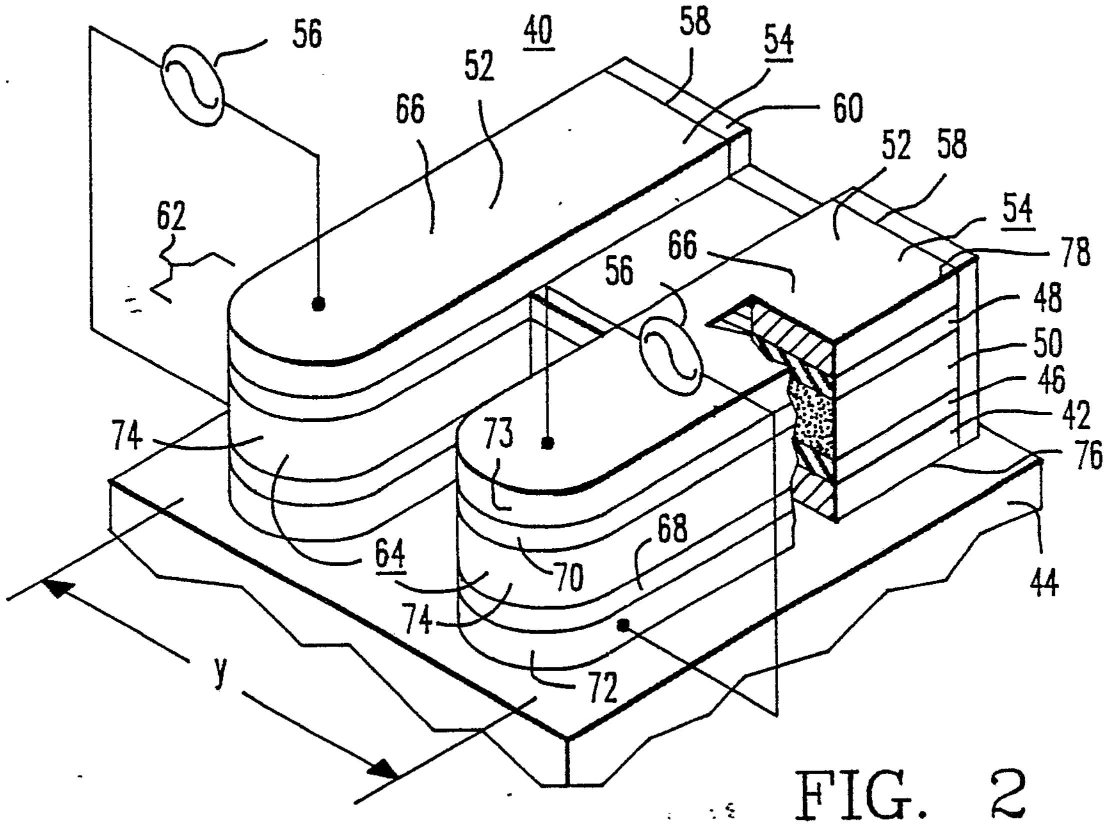
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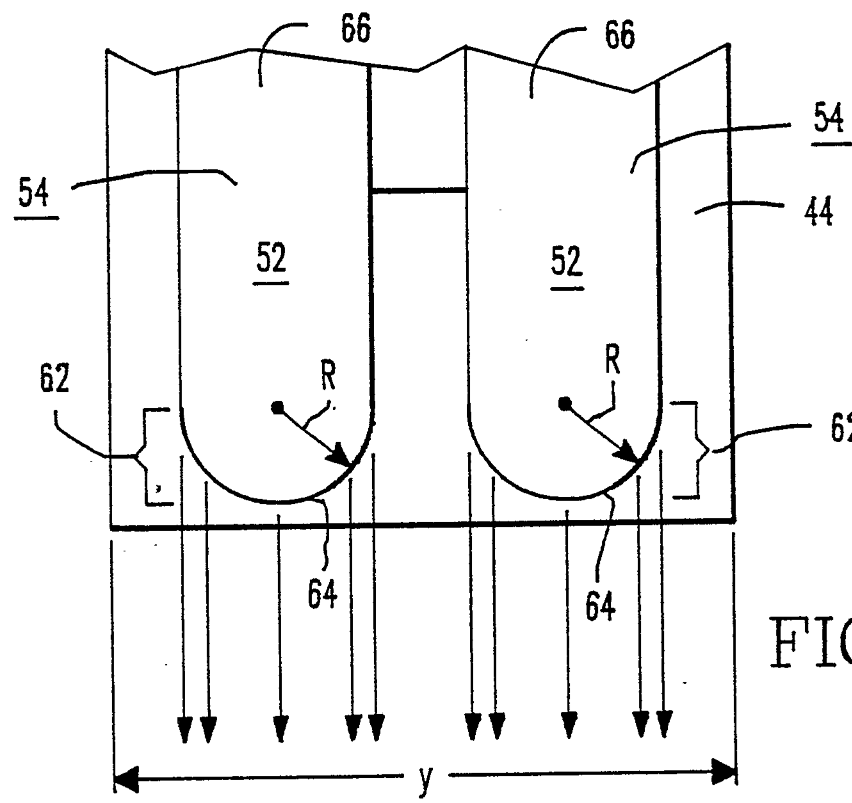
FIG. 2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44
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62
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64
y

FIG. 3

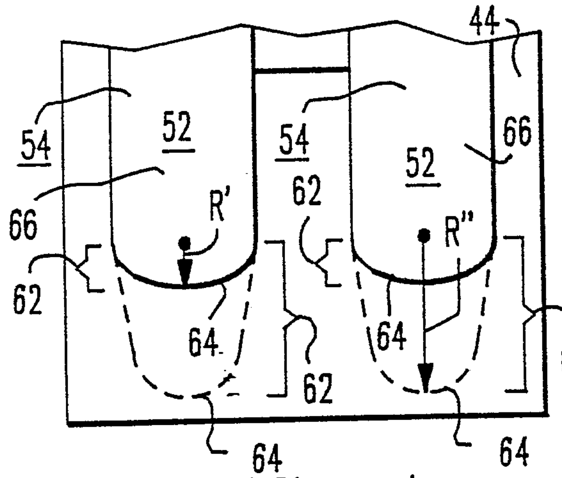



FIG. 4

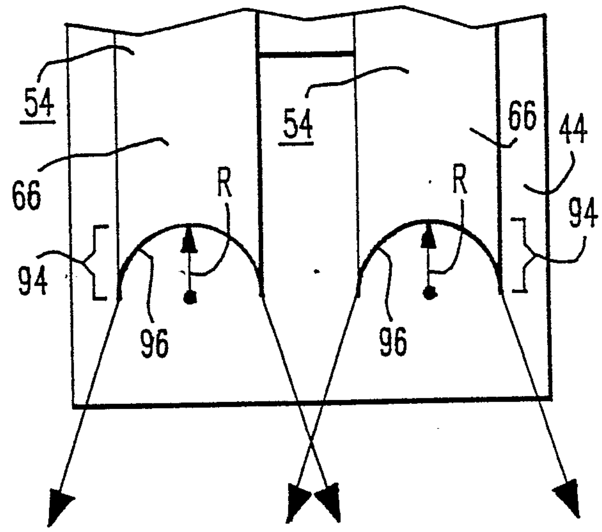



FIG. 6

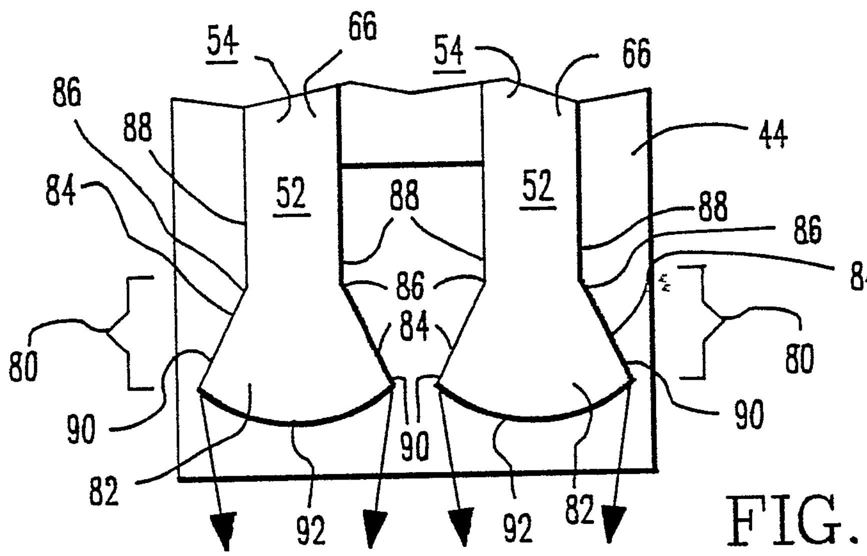



FIG. 5

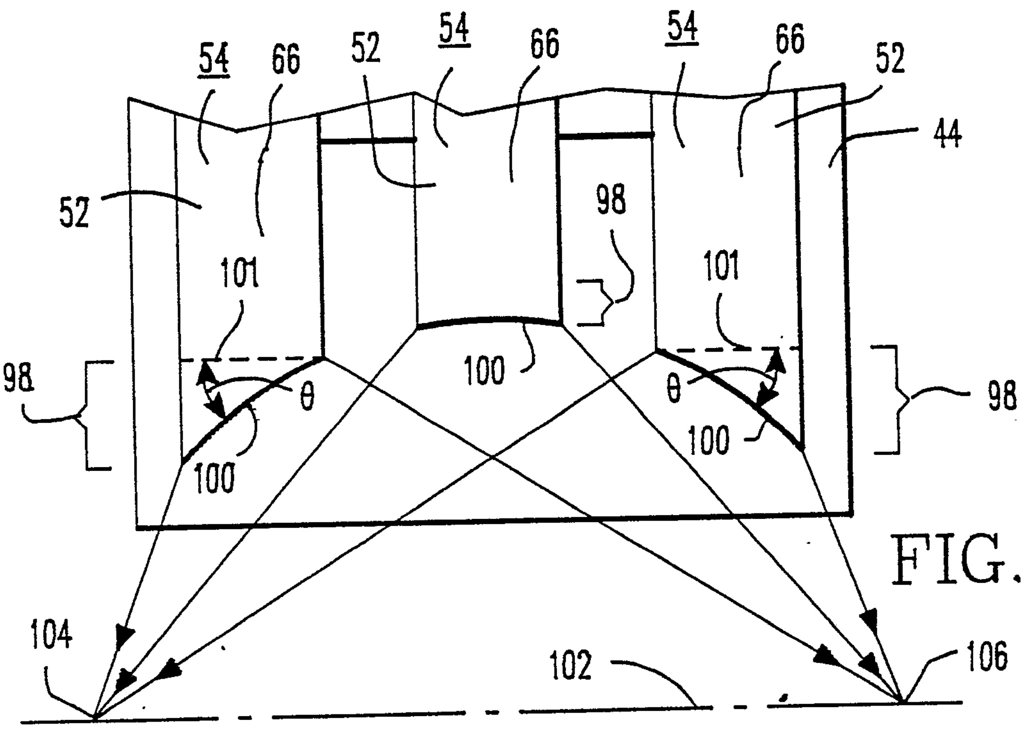
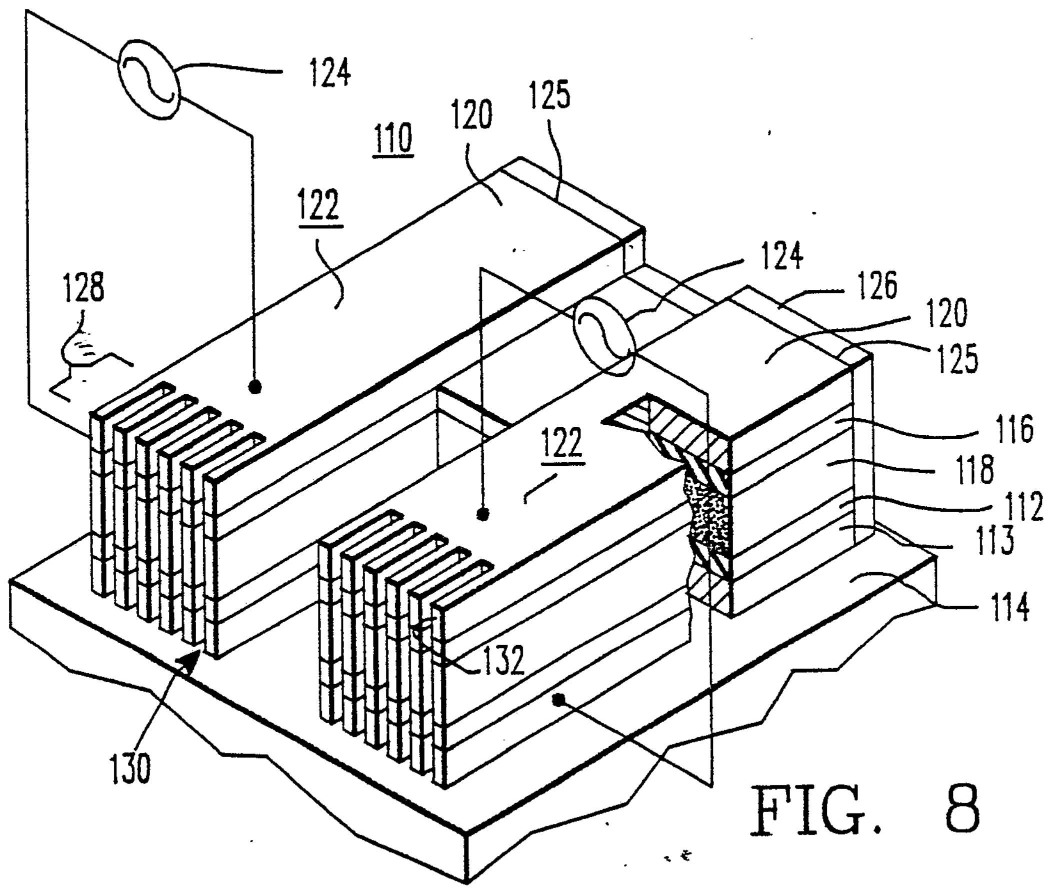



FIG. 7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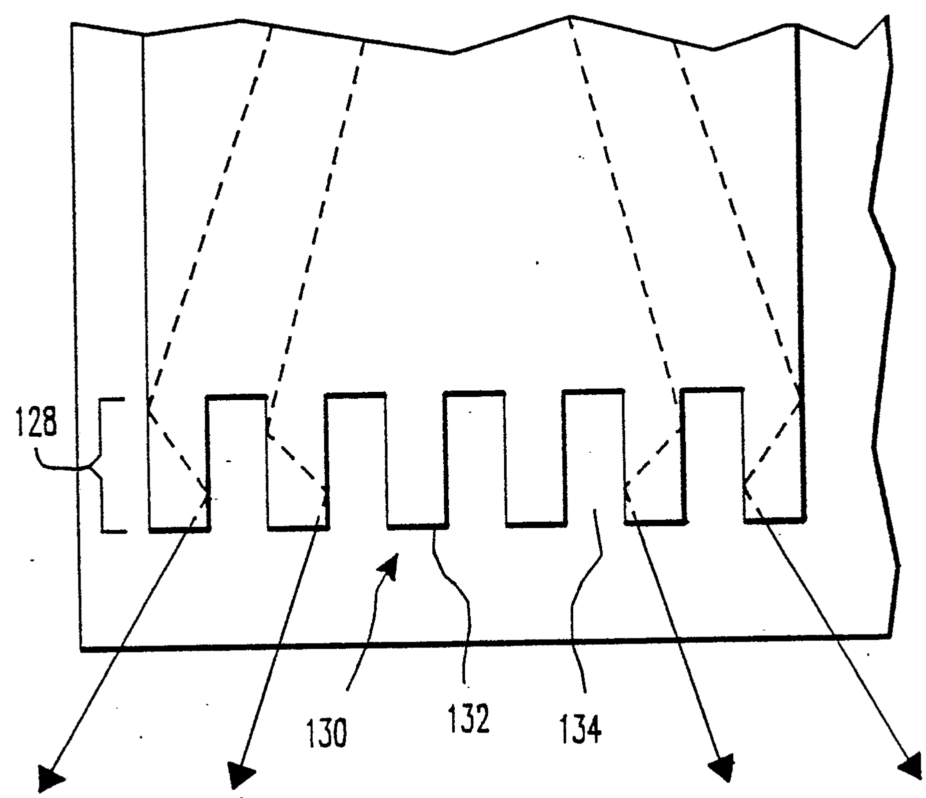
130

FIG. 8

FIG. 9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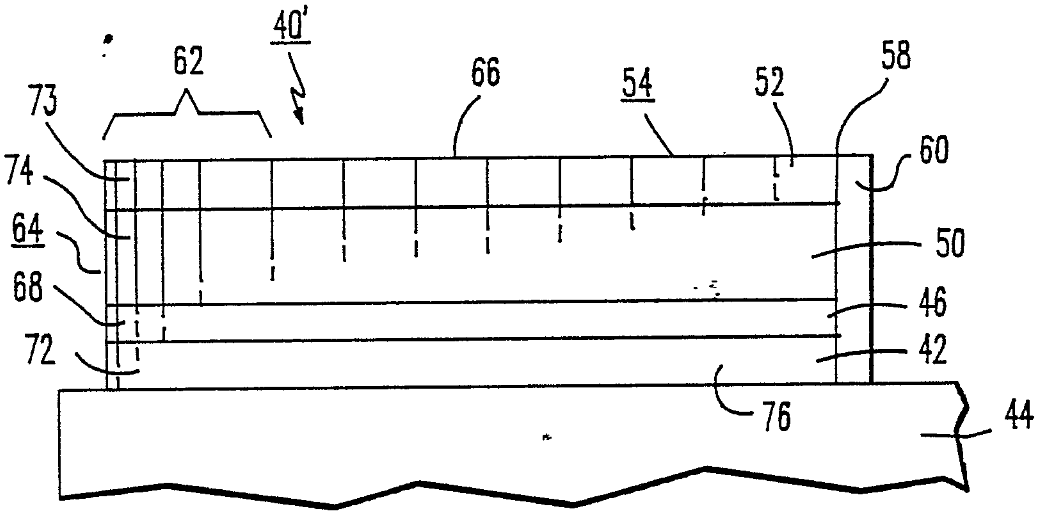


FIG. 10