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Description

BACKGROUND OF THE INVENTION

(a) Field of the Invention

[0001] The present invention relates to a liquid crystal display and, more particularly, to a liquid crystal display in which a predetermined opening pattern is formed at pixel and common electrodes such that a wide viewing angle is obtained.

(b) Description of the Related Art

[0002] Generally, liquid crystal displays have a structure in which liquid crystal material is sandwiched between two substrates, and an electric field is applied to the liquid crystal material to control the alignment of molecules of the liquid crystal material, ultimately controlling the transmittance of incident light In VA liquid crystal displays, the liquid crystal molecules are aligned normal to the substrates when an electric field is not applied. In case two polarizer films are arranged with their lines (a plurality of which is formed in parallel on each polarizer film) perpendicular to each other, the linearly polarized light passed through the first polarizer film is completely blocked by the second polarizer film in the absence of an electric field. As such a liquid crystal display exhibits a very low brightness in an "off' state of the normally black mode, a relatively higher contrast ratio than that of the conventional TN liquid crystal display can be obtained.

[0003] However, the liquid crystal molecules are irregularly inclined with respect to the substrate in the presence of an electric field such that one or more areas develop where the direction of the long axis of some of the liquid crystal molecules conforms to the polarizing direction of the first or second polarizer film. In such areas, the liquid crystal molecules cannot induce the rotation of the polarizing direction, i.e., polarization, and the light is completely blocked by the polarizer film. Such areas appear as black portions on the screen which cause a reduction in picture quality. These areas are referred to as areas of "texture".

[0004] In order to solve the above problem, several electrode-patterning techniques have been suggested. However, the problem of a slow response speed remains in the resulting LCD.

[0005] Fig. 1 illustrates a schematic view of opening patterns formed at pixel and common electrodes in a prior art liquid crystal display. As shown in Fig. 1, the pixel and common electrodes are formed with opening patterns 1 and 2, respectively. Each of the opening patterns 1 and 2 is formed in a V-shape and is arranged with ends of the V-shapes in proximity to one another so that roughly a diamond shape is formed by the opening patterns 1 and 2. Liquid crystal material is injected between the pixel and common electrodes, and liquid crystal molecules 3 are aligned perpendicular to the electrodes.

[0006] When an electric field is applied to the liquid crystal material, the liquid crystal molecules 3 come to be arranged parallel to the electrodes. However, the response speed of the liquid crystal molecules 3 with respect to the applied electric field is very slow with the formation of the opening patterns 1 and 2 at the pixel and common electrodes. That is, as a result of a fringe field formed due to the opening patterns 1 and 2, the liquid crystal molecules 3 are first arranged perpendicular to the opening patterns 1 and 2 (A state), then aligned to be parallel thereto (B state) due to the inherent tendency of long axes of liquid crystal molecules to align themselves roughly parallel. Because of these two alignment steps, a slow response speed results.

[0007] The slow response speed of liquid crystal molecules causes afterimages when displaying moving pictures on the screen. There is therefore a need to increase the response speed of liquid crystal molecules.

SUMMARY OF THE INVENTION

[0008] It is an object of the present invention to provide a liquid crystal display which has an improved response speed and a wide viewing angle.

[0009] It is another object of the present invention to provide a liquid crystal display which produces improved picture images. These and other objects may be achieved by a liquid crystal display according to claim 1.

[0010] The features of the preamble of claim 1 are known in combination from EP 0884 626.

[0011] The pixel and common electrodes are overlapped with each other such that the first and second opening patterns partition the pixel electrode into several micro-regions. The micro-regions of the pixel electrode are in the shape of polygons where the longest sides are parallel to each other. The micro-regions of the pixel electrode are classified into a first type where the longest sides are arranged in a first direction, and a second type where the longest sides are arranged in a second direction normal to the first direction. The first direction is slanted at a predetermined angle with respect to the long or short sides of the pixel electrode. Alternatively, the first direction may be parallel to one of the long and short sides of the pixel electrode.

[0012] The first and second opening patterns form fringe fields when voltage is applied between the pixel and common electrodes. The orienting direction of the liquid crystal molecules due to the fringe fields corresponds to that of the liquid crystal molecules as a result of a force exerted by the molecules. It is preferable that the liquid crystal molecules are oriented in four directions. The opening width of the first and second opening patterns is preferably in the range of 10-16 μm.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] A more complete appreciation of the invention, and many of the attendant advantages thereof, will be readily apparent as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings in which like reference symbols indicate the same or the similar components, wherein:

Fig. 1 is a schematic view of opening pattern units formed at common and pixel electrodes in a prior art liquid crystal display;
Fig. 2 is a schematic cross sectional view of a liquid crystal display according to a preferred embodiment of the present invention;
Fig. 3A is a schematic view of opening pattern units formed at common and pixel electrodes which are useful to understand the present invention;
Fig. 3B is a schematic view of opening pattern units formed at common and pixel electrodes which are useful to understand the present invention;
Fig. 4A is a schematic view of an opening pattern of a pixel electrode according to a preferred embodiment of the present invention;
Fig. 4B is a schematic view of an opening pattern of a common electrode according to a preferred embodiment of the present invention;
Fig. 4C is a schematic view of the opening patterns of the pixel and common electrodes shown respectively in Figs. 4A and 4B in an overlapped state;
Fig. 5A is a schematic view of an opening pattern of a pixel electrode which does not form part of the present invention but which is used as a comparative example;
Fig. 5B is a schematic view of an opening pattern of a common electrode which does not form part of the present invention but which is used as a comparative example;
Fig. 5C is a schematic view of the opening patterns of the pixel and common electrodes shown respectively in Figs. 5A and 5B in an overlapped state;
Fig. 6A is a schematic view of an opening pattern of a pixel electrode which does not form part of the present invention but which is used as a comparative example ;
Fig. 6B is a schematic view of an opening pattern of a common electrode which does not form part of the present invention but which is used as a comparative example ;
Fig. 6C is a schematic view of the opening patterns of the pixel and common electrodes shown respectively in Figs. 6A and 6B in an overlapped state;
Fig. 7A is a schematic view of an opening pattern of a pixel electrode which does not form part of the present invention but which is used as a comparative example;
Fig. 7B is a schematic view of an opening pattern of a common electrode which does not form part of the present invention;
Fig. 7C is a schematic view of the opening patterns of the pixel and common electrodes shown respectively in Figs. 7A and 7B in an overlapped state;
Fig. 8A is a schematic view of an opening pattern of a pixel electrode which does not form part of the present invention but which is used as a comparative example;
Fig. 8B is a schematic view of an opening pattern of a common electrode which does not form part of the present invention but which is used as a comparative example;
Fig. 8C is a schematic view of the opening patterns of the pixel and common electrodes shown respectively in Figs. 8A and 8B in an overlapped state;
Fig. 9A is a schematic view of an opening pattern of a pixel electrode which does not form part of the present invention but which is used as a comparative example ;
Fig. 9B is a schematic view of an opening pattern of a common electrode which does not form part of the present invention but which is used as a comparative example;
Fig. 9C is a schematic view of the opening patterns of the pixel and common electrodes shown respectively in Figs. 9A and 9B in an overlapped state;
Fig. 10A is a schematic view of an opening pattern of a pixel electrode which does not form part of the present

invention but which is used as a comparative example;

Fig. 10B is a schematic view of an opening pattern of a common electrode which does not form part of the present invention but which is used as a comparative example;

Fig. 10C is a schematic view of the opening patterns of the pixel and common electrodes shown respectively in Figs. 10A and 10B in an overlapped state;

Fig. 11 are schematic views of various types of opening patterns for demonstrating the affect of opening pattern width and spacing on response speed and brightness; Fig. 12A is a graph illustrating light transmissivity levels of test cells applying the opening patterns shown in Fig. 11;

Fig. 12B is a graph comparing the light transmissivity level of a test cell applying a specific opening pattern shown in Fig. 11 to the light transmissivity levels of test cells applying the other opening patterns shown in Fig. 11;

Fig. 13 is a graph illustrating response times as a function of gray scale of test cells applying the opening patterns shown in Fig. 11;

Fig. 14 is a graph illustrating response times as a function of gray scale of actual panels applying specific opening patterns shown in Fig. 11;

Figs. 15A to 15C are photographs of specific opening patterns shown in Fig. 11 at white gray scales;

Figs. 16A and 16B are photographs of specific opening patterns shown in Fig. 11 used to illustrate a change in partitioned regions according to a level of an applied voltage; Figs. 17A and 17B are schematic views used to illustrate the change in intensity of a fringe field according to variations in opening pattern width;

Figs. 18A to 18D are schematic views illustrating orientation states of liquid crystal molecules at a peripheral portion of opening patterns;

Figs. 19 and 20 are schematic views of areas where texture occurs in specific opening patterns shown in Fig. 11; and Figs. 21A to 21C are schematic views of opening patterns where texture improvement techniques have been applied.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] Preferred embodiments of this invention will be explained with reference to the accompanying drawings.

[0015] Fig. 2 is a schematic cross sectional view of a liquid crystal display according to a preferred embodiment of the present invention. As shown in Fig. 2, the liquid crystal display includes lower and upper substrates 10 and 20 arranged substantially in parallel with a predetermined gap therebetween. Liquid crystal material is injected between the lower and upper substrates 10 and 20 to form a liquid crystal layer, the liquid crystal material being comprised of liquid crystal molecules 30. The long axis of liquid crystal molecules 30 is oriented normal to the lower and upper substrates 10 and 20. Both the lower and upper substrates 10 and 20 are formed from a transparent material such as glass.

[0016] The lower substrate 10 is overlaid with a pixel electrode 12 that is connected to a switching element 11 to receive display signals. The pixel electrode 12 is formed from a transparent material such as indium tin oxide (ITO) or indium zinc oxide (IZO), and has an opening pattern (not shown). The switching element 11 is, for example, a thin film transistor, and is connected to a gate line (not shown), which transmits scanning signals, and a data line (not shown), which transmits picture signals. The switching element 11 turns the pixel electrode 12 on and off. A lower polarizer film 14 is adhered to an outer surface of the lower substrate 10. If the pixel electrode 12 is formed from non-transparent material as in the reflection-type liquid crystal display, the lower polarizer film 14 is not needed.

[0017] An inner surface of the upper substrate 20 is sequentially overlaid with a black matrix 21 for preventing the leakage of light, a color filter 22, and a common electrode 23. The common electrode 23 is formed of a transparent material such as ITO or IZO, and has an opening pattern (not shown). A polarizer film 24 is adhered to an outer surface of the upper substrate 20. Alternatively, the black matrix 21 or the color filter 22 may be formed on the lower substrate 10.

[0018] The LCD can be structured to operate in a normally black mode by arranging the lower and upper polarizer films 14 and 24 so that lines formed on the lower polarizer film 14 are perpendicular to lines formed on the upper polarizer film 24, or can be structured to operate in a normally white mode by arranging the lower and upper polarizer films 14 and 24 with their lines parallel to each other. In the following description, only the arrangement producing a normally black mode will be described.

[0019] Fig. 3A shows a schematic view of opening patterns of the pixel and common electrodes 12 and 23 which are useful to understand the present invention. As shown in Fig. 3A, opening patterns 101 and 102 respectively of the pixel and common electrodes 12 and 23 are each formed in a straight line, the opening pattern 101 being substantially parallel to the opening pattern 102. With this structure, the liquid crystal molecules 30 are arranged in parallel as a result of a fringe field generated by the opening patterns 101 and 102. Furthermore, the movement of the liquid crystal molecules 30 into the parallel arrangement is performed in a single step, thereby enabling a rapid response speed.

[0020] However, with the use of the above structure, texture develops over a wide area of the screen. It is also possible for white afterimages to be generated on the screen. The term "white afterimage" refers to a phenomenon in which a portion of the screen, where a dark color has been displayed on a bright background then returned to the color of the bright background, momentarily becomes brighter than the the bright background.

[0021] Fig. 3B shows a schematic view of opening patterns of the pixel and common electrodes 12 and 23 which are useful to understand the present invention. As shown in Fig. 3B, opening patterns 111 and 112 respectively of the pixel and common electrodes 12 and 23 are each formed in a curved shape, with ends of the opening patterns 111 and 112 positioned in close proximity and centers bulging in opposite directions. However, with this structure, the movement of the liquid crystal molecules 30 cannot be completed in a single step, resulting in a slow response speed. In the following preferred embodiments, opening patterns of the pixel and common electrodes 12 and 23 will be described with reference to one pixel area. In a single pixel area, the pixel electrode 12 is substantially rectangular in shape having first and second long sides, respectively corresponding to left and right sides (in the drawings) of the pixel electrode 12; first and second short sides, respectively corresponding to top and bottom sides (in the drawings) of the pixel electrode 12; a first corner formed by ends of the first long side and the first short side; a second corner formed by ends of the first short side and the second long side; a third corner formed by ends of the second long side and the second short side; and a fourth corner formed by ends of the first long side and the second short side. Further, the pixel electrode 12 includes an upper region and a lower region, the upper region corresponding to an upper half (in the drawings) of the pixel electrode 12 and defined by the first long side, the second long side and the first short side, and the lower region corresponding to a lower half (in the drawings) of the pixel electrode 12 and defined by the first long side, the second long side and the second short side.

[0022] As the common electrode 23 is present over the entire surface of the upper substrate 20, a portion of the common electrode 23 roughly corresponding to the pixel electrode 12 in one pixel area will be described. Here, such portions of the common electrode 23 will be indicated by a dotted line and the identifying markers (i.e., upper region and lower region; first long side and second long side; first short side and second short side; and first, second, third and fourth corners) used for ease of explanation of the pixel electrode 12 will also apply to these portions of the common electrode 23 defined by the dotted lines. Fig. 4A shows a schematic view of an opening pattern of the pixel electrode 12 according to a preferred embodiment of the present invention. As shown in Fig. 4A, a middle opening 121 is formed inwardly from the first long side where the upper and lower regions of the pixel electrode 12 meet. The middle opening 121 extends a predetermined distance toward the second long side while being tapered. The first long side is cut at a predetermined angle on both sides of the middle opening 121 such that a wide inlet area of the middle opening 121 is formed. Upper and lower openings 122 and 123 are formed in the upper and lower regions of the pixel electrode 12, respectively, proceeding from the second long side at a predetermined angle respectively toward the first and fourth corners of the pixel electrode 12 in a symmetrical manner.

[0023] Fig. 4B shows a schematic view of an opening pattern of the common electrode 23 according to a preferred embodiment of the present invention. As shown in Fig. 4B, the opening pattern of the common electrode 23 includes middle, upper and lower openings 210, 220 and 230 spaced apart from each at predetermined distances. The middle opening 210 includes a trunk 211 positioned where the upper and lower regions of the common electrode 23 meet and proceeding from the second long side a predetermined distance toward the first long side. First and second branches 212 and 214 are extended at a predetermined angle from the trunk 211 toward the first long side, and first and second sub-branches 213 and 215 extend along the first long side from the first and second branches 212 and 214, respectively, toward the first and second short sides, respectively. The upper opening 220, which is formed in the upper region of the common electrode 23, includes a first body 221 that is formed extended from the second long side to the first short side at a predetermined distance from the second corner and parallel to the first branch 212. A first upper limb 222 extends from an end of the first body 221 along the first short side and until reaching the first long side, and a first lower limb 223 extends from an opposite end of the first body 221 along the second long side toward the second short side. The lower opening 230 includes a second body 231, a second lower limb 232, and a second upper limb 233. The lower opening 230 is arranged in the lower region and is symmetrical to the upper opening 220.

[0024] Fig. 4C shows a schematic view of the opening patterns of the pixel and common electrodes 12 and 23 shown respectively in Figs. 4A and 4B in an overlapped state. As shown in Fig. 4C, the opening patterns of the pixel and common electrodes 12 and 23 divide the pixel electrode 12 into several regions. The openings 121, 122 and 123 of the pixel electrode 12 and the openings 210, 220 and 230 of the common electrode 23 are alternately arranged except where the trunk 211 of the middle opening 210 of the common electrode partially overlaps the middle opening 121 of the pixel electrode 12.

[0025] In this preferred embodiment, the lower and upper polarizer films 14 and 24 are arranged such that their polarizing directions are respectively 0° and 90° (or vice versa) with respect to the first and second short sides of the pixel electrode 12. With such an arrangement, when the liquid crystal molecules 30 are rearranged under the application of an electric field, they are prevented from orienting in the polarizing direction of the polarizer films 14 and 24 so that the problem of texture does not occur. Furthermore, as the liquid crystal molecules 30 are fully oriented in parallel under the influence of the fringe field, the movement of the liquid crystal molecules 30 is completed in one step, resulting in a rapid response speed.

[0026] In addition, the opening portions of the pixel and common electrodes 12 and 23 are arranged generally in two directions normal to each other. Since the opening portions of the pixel and common electrodes 12 and 23 are alternately arranged, the fringe field is applied in four directions at one pixel area. Therefore, wide viewing angles can be obtained in all directions.

[0027] Fig. 5A shows a schematic view of an opening pattern of the pixel electrode 12 which does not form part of the present invention. As shown in Fig. 5A, the opening pattern of the pixel electrode 12 is a V-shaped opening130. The V-shaped opening 130 has a vertex in proximity to the second long side and positioned where the upper region meets the lower region of the pixel electrode 12, and opens toward the first long side of the pixel electrode 12. That is, an upper half 131 of the opening 130 extends at a predetermined angle from the vertex of the opening 130 toward the first long side of the pixel electrode 12 such that the upper half 131 is positioned wholly in the upper region of the pixel electrode 12, and a lower half 132 of the opening 130 extends at a predetermined angle from the vertex of the opening 130 toward the first long side of the pixel electrode 12 such that the lower half 132 is positioned wholly in the lower region of the pixel electrode 12. Further, the second and third corners of the pixel electrode 12 are cut away to form a curved shape. Fig. 5B shows a schematic view of an opening pattern of the common electrode 23 which does not form part of the present invention. As shown in Fig. 5B, the opening pattern of the common electrode 23 includes a right opening 240 and a left opening 250. The right opening 240 includes a base 241 formed along and extending past the first long side of the common electrode 23, and which tapers from a middle portion along the first long side toward the first and second short sides. The base 241 of the right opening 240 also includes a projection 242 extending a predetermined distance from the base 241 toward the second long side and tapered in the same direction. A portion of the projection 242 adjacent to the base 241 is formed at a predetermined slant. The left opening 250 includes a body 251 formed along the second long side of the common electrode 23, an upper limb 252 extended at a predetermined angle from one end of the body 251 toward and continuing past the first corner of the common electrode 23, and a lower limb 253 extended at a predetermined angle from the other end of the body 251 toward and continuing past the fourth corner of the common electrode 23. Centers of both the right and left openings 240 and 250 are positioned where the upper and lower regions of the common electrode 23 meet.

[0028] Fig. 5C shows a schematic view of the opening patterns of the pixel and common electrodes 12 and 23 shown respectively in Figs. 5A and 5B in an overlapped state. As shown in Fig. 5C, the opening patterns of the pixel and common electrodes 12 and 23 divide the pixel electrode 12 into several regions. The V-shaped opening 130 of the pixel electrode 12 is placed between the right and left openings 240 and 250 of the common electrode 23. The upper and lower parts 131 and 132 of the V-shaped opening 130 proceed in parallel to the lower and upper limbs 252 and 253 of the left opening 250, respectively, as well as to the portion of the projection 242 adjacent to the base 241 of the right opening portion 240. An end of the projection 242 overlaps the vertex of the V-shaped opening portion 130. With the configuration as described above, the lower and upper polarizer films 14 and 24 are arranged such that their polarizing directions are the same as in the preferred embodiment.

[0029] Fig. 6A shows a schematic view of an opening pattern of the pixel electrode 12 which does not form part of the present invention. As shown in Fig. 6A, the opening pattern of the pixel electrode 12 includes an upper opening 141 formed in the upper region of the pixel electrode 12, and a lower opening 142 formed in the lower region of the pixel electrode. If the pixel electrode 12 is divided into three areas of equal length, that is, first to third areas, with the first area having as its one side the first short side, the third area having as its one side the second short side, and the second area being formed between the first and third areas, the upper opening 141 is positioned where the first and second areas meet, and the lower opening 142 is positioned where the second and third areas meet. The upper opening 141 extends from the first long side to the second long side of the pixel electrode 12 in the horizontal direction, and areas of the pixel electrode 12 corresponding to where the upper opening 141 is positioned along the first long side are cut away to form a curved shape. Similarly, the lower opening 142 extends from the second long side to the first long side of the pixel electrode 12 in the horizontal direction, and areas of the pixel electrode 12 corresponding to where the lower opening 142 is positioned along the second long side are cut away to form a curved shape. In addition, second and third corners of the pixel electrode 12 are cut such that they are rounded. Fig. 6B shows a schematic view of an opening pattern of the common electrode 23 which is not part of the present invention. As shown in Fig. 6B, the opening pattern of the common electrode 23 is a zigzag-shaped opening 260. The zigzag-shaped opening 260 includes an upper part 261 proceeding from the first corner of the common electrode 23 at a predetermined slant toward and meeting the second long side of the common electrode 23, a middle part 262 extended at a predetermined slant from an end of the upper part 261 where the same meets the second long side toward and meeting the first long side of the common electrode 23, and a lower part 263 extended at a predetermined slant from an end of the middle part 262 where the same meets the first long side toward and meeting the third corner of the common electrode 23. If the common electrode 23 is divided into three areas of equal length, that is, first to third areas, with the first area having as its one side the first short side, the third area having as its one side the second short side, and the second area being formed between the first and third areas, the upper and middle parts 261 and 262 converge where the first and second areas meet, and the middle and lower parts 262 and 263 converge where the second and third areas meet.

[0030] Fig. 6C shows a schematic view of the opening patterns of the pixel and common electrodes 12 and 23 shown respectively in Figs. 6A and 6B in an overlapped state. As shown in Fig. 6C, the opening patterns of the pixel and common electrodes 12 and 23 divide the pixel electrode 12 into several regions. The portion where the upper and middle parts 261 and 262 of the opening 260 of the common electrode 23 meet overlaps an end of the upper opening portion 141 of the pixel electrode 12 adjacent to the second long side, and the portion where the middle and lower parts 262 and 263 of the opening 260 of the common electrode 23 meet overlaps an end of the lower opening portion 142 of the pixel electrode 12 adjacent to the first long side.

[0031] With the configuration as described above, the lower and upper polarizer films 14 and 24 are arranged such that their polarizing directions are the same as in the preferred embodiment. Fig. 7A shows a schematic view of an opening pattern of the pixel electrode 12 which does not form part of the present invention. As shown in Fig. 7A, the opening pattern of the pixel electrode 12 includes an upper opening 151 formed parallel to the first and second short sides in the upper region of the pixel electrode 12, and a lower opening 152 also formed parallel to the first and second short sides in the lower region of the pixel electrode 12. If the pixel electrode 12 is divided into three areas of equal length, that is, first to third areas, with the first area having as its one side the first short side, the third area having as its one side the second short side, and the second area being formed between the first and third areas, the upper opening 151 is positioned where the first and second areas meet, and the lower opening portion 152 positioned where the second and third areas meet. The upper and lower openings 151 and 152 extend from a position in proximity to the first long side to a position in proximity to the second long side. Fig. 7B shows a schematic view of an opening pattern of the common electrode 23 which does not form part of the present invention. As shown in Fig. 7B, the opening pattern of the common electrode 23 includes first, second and third X-shaped openings 270, 280 and 290 spaced apart from each other at a predetermined distance along the length of the common electrode 23. A center area of each of the X-shaped openings 270, 280 or 290 is cut away to form an enlarged area approximately rectangular in shape. One line forming the "X" of the first X-shaped opening 270 extends from the first corner to the second long side of the common electrode 23 and its other line extends from the second corner to the first long side of the common electrode 23; one line forming the "X" of the second X-shaped opening 280 extends from the first long side to the second long side of the common electrode 23 and its other line extends from the second long side to the first long side of the common electrode 23; and one line forming the "X" of the third X-shaped opening 290 extends from the second long side to the fourth corner of the common electrode 23 and its other line extends from the first long side to the third corner of the common electrode 23.

[0032] Fig. 7C shows a schematic view of the opening patterns of the pixel and common electrodes 12 and 23 shown respectively in Figs. 7A and 7B in an overlapped state. As shown in Fig. 7C, the opening patterns of the pixel and common electrodes 12 and 23 are alternately arranged, and divide the pixel electrode 12 into several regions.

[0033] With the configuration as described above, the lower and upper polarizer films 14 and 24 are arranged such that their polarizing directions are respectively 45° and 135° (or vice versa) with respect to the first and second short sides of the pixel electrode 12. Fig. 8A shows a schematic view of an opening pattern of the pixel electrode 12 which does not form part of the present invention. As shown in Fig. 8A, the opening pattern of the pixel electrode 12 includes an upper opening 160 formed in the upper region of the pixel electrode 12, and a lower opening 170 formed in the lower region of the pixel electrode 12. The upper opening 160 is T-shaped. That is, the upper opening 160 has a base 161 (the top of the "T") formed at a predetermined distance from where the upper and lower regions of the pixel electrode 12 meet, the base 161 extending from approximately the first long side to the second long side of the pixel electrode 12. The upper opening 160 also has a protrusion 162 extending substantially from a center of the base 161 in a direction toward the first short side of the pixel electrode 12, thereby bisecting the upper region of the pixel electrode 12 into left and right sub-areas. The lower opening 170 is formed parallel to the base 161 of the upper opening 160 and extends across the pixel electrode 12 approximately and at predetermined distances from the first long side to the second long side of the pixel electrode 12 such that the lower opening 170 bisects the lower region of the pixel electrode 12 into upper and lower sub-areas. Fig. 8B shows a schematic view of an opening pattern of the common electrode 23 which is not part of the present invention. As shown in Fig. 8B, the opening pattern of the common electrode 23 includes two upper openings 310 and 320, a middle opening 330, and a lower opening 340. The two upper openings 310 and 320 are spaced apart from each other at a predetermined distance in the upper region of the common electrode 23, and are parallel to each other and to the first and second long sides of the common electrode 23. The middle and lower openings 330 and 340 are spaced apart from each other at a predetermined distance in the lower region of the common electrode 23, and are parallel to each other and to the first and second short sides of the common electrode 23. Both end portions of the middle and lower openings 330 and 340 are enlarged in roughly a triangular shape, and the triangle-shaped end portions of the middle and lower opening portions 330 and 340 proceed over the first and second long sides of the common electrode 23.

[0034] Fig. 8C shows a schematic view of the opening patterns of the pixel and common electrodes 12 and 23 shown respectively in Figs. 8A and 8B in an overlapped state. As shown in Fig. 8C, the opening patterns of the pixel and common electrodes 12 and 23 divide the pixel electrode 12 into several regions. That is, ends of the upper opening portions 310 and 320 of the common electrode 23 farthest from the first short side of the common electrode 23 overlap the base 161 of the T-shaped opening 160 of the pixel electrode 12. Accordingly, the upper openings 310 and 320 of the common electrode 23, and the protrusion 162 of the T-shaped opening 160 of the pixel electrode 12 divide an area of the pixel electrode 12 defined by the base 161 of the T-shaped opening 160, the first and second long sides of the pixel electrode 12, and the first short side of the pixel electrode 12 into four sub-areas. The middle and lower openings 330 and 340 of the common electrode 23, and the lower opening 170 of the pixel electrode 12 divide an area of the pixel electrode 12 defined by the base 161 of the T-shaped opening 160, the first and second long sides of the pixel electrode 12, and the second short side of the pixel electrode 12 into four sub-areas.

[0035] With the configuration as described above, the lower and upper polarizer films 14 and 24 are arranged such that their polarizing directions are the same as in the arrangement of figures 7A-7C. Accordingly, the orienting direction of the liquid crystal molecules 30 becomes 45° with respect to the polarizing direction of the polarizer films 14 and 24 so that the response speed is rapid and the occurrence of texture is decreased, resulting in enhanced picture quality. The opening portions of the pixel and common electrodes 12 and 23 proceed generally in two directions normal to each other. Furthermore, as the opening portions of the pixel and common electrodes 12 and 23 are alternately arranged, the fringe field in one pixel area is applied in all directions. Fig. 9A shows a schematic view of an opening pattern of the pixel electrode 12 which does not form part of the present invention. As shown in Fig. 9A, the opening pattern of the pixel electrode 12 is a single linear opening 180 parallel to the first and second short sides of the pixel electrode 12. If the pixel electrode 12 is divided into three areas of equal length, that is, first to third areas, with the first area having as its one side the first short side, the third area having as its one side the second short side, and the second area being formed between the first and third areas, the linear opening 180 is positioned where the second and third areas meet.

[0036] Fig. 9B shows a schematic view of an opening pattern of the common electrode 23 which does not form part of the present invention. As shown in Fig. 9B, the opening pattern of the common electrode 23 includes an upper opening 350 formed in the upper region of the common electrode 23 and a lower opening 360 formed in the lower region of the common electrode. The upper opening 350 includes a base 351, a trunk 352, and two branches 353 and 354. The base 351 of the upper opening 350 is formed roughly in a triangular shape and positioned extending over and past the first short side of the common electrode 23. The trunk 352 is linearly extended from an apex of the base 351 in a direction toward the second short side of the common electrode 23. The branches 353 and 354 are branched from a distal end of the trunk 352 toward and extending over the first and second long sides of the common electrode 23, each of the branches 353 and 354 forming an obtuse angle with respect to the trunk 352. The lower opening 360 linearly proceeds in a direction parallel to the first and short sides of the common electrode 23. Both ends of the lower opening 360 are enlarged in roughly a triangular shape and extend over the first and second long sides of the common electrode 23.

[0037] Fig. 9C shows a schematic view of the pixel and common electrodes 12 and 23 shown respectively in Figs. 9A and 9B in an overlapped state. As shown in Fig. 9C, the branches 353 and 354 of the upper opening 350 of the common electrode 23 roughly divide the pixel electrode 12 into upper and lower areas. The trunk 352 of the upper opening 350 of the common electrode 23 bisects the upper area of the pixel electrode 12 into two sub-areas, one sub-area having as its one side the second long side of the pixel electrode 12 and the other sub-area having as its one side the first long side of the pixel electrode 12. The lower opening 360 of the common electrode 23, and the linear opening 180 of the pixel electrode 12 trisect the lower area of the pixel electrode 12 into upper, middle and lower sub-areas.

[0038] With the configuration as described above, the lower and upper polarizer films 14 and 24 are arranged such that their polarizing directions are the same as in the arrangement of figures 7A-7C. With this structure, effects similar to those obtained in that arrangement are realized.

[0039] Fig. 10A shows a schematic view of an opening pattern of the pixel electrode 12 which does not form part of the present invention. As shown in Fig. 10A, the pixel electrode 12 is formed of four oval-shaped portions sequentially interconnected in the longitudinal direction.

[0040] Fig. 10B shows a schematic view of an opening pattern of the common electrode 23 which does not form part of the present invention. As shown in Fig. 10B, the opening pattern of the common electrode 23 includes four diamond-shaped openings 370, and left and right openings 380 and 390 surrounding the diamond-shaped openings 370. The diamond-shaped openings 370 are arranged over a longitudinal center of the common electrode 23 and are spaced apart from each other at a predetermined distance. Inner sides of the left and right openings 380 and 390 facing the diamond-shaped openings 370 substantially form cycloids such that four partial ovals result, each oval surrounding one of the diamond-shaped openings 370.

[0041] Fig. 10C shows a schematic view of the pixel electrode 12 and the common electrode 23 shown respectively in Figs. 10A and 10B in an overlapped state. As shown in Fig. 10C, each diamond-shaped opening 370 of the common electrode 23 is placed at the center of the corresponding oval-shaped portion of the pixel electrode 12. Also, the left and right openings 380 and 390 of the common electrode 23 surround the pixel electrode 12 at a predetermined distance.

[0042] With the configuration as described above, the lower and upper polarizer films 14 and 24 are arranged such that their polarizing directions are the same as in the preferred embodiment. The opening patterns of the pixel and common electrodes 12 and 23 according to the preferred embodiment were designed with the intent of maximally satisfying the following conditions, the conditions being particular to opening patterns of the type for obtaining the partitioned orientation of the liquid crystal molecules 30.

[0043] First, in order to obtain a maximum viewing angle, it is preferable that four partitioned regions for orienting the liquid crystal molecules 30 are present within one pixel area.

[0044] Second, to obtain a stable partitioned orientation, disclination or texture should not be generated outside of the partitioned regions. Disclination occurs when the long axes of liquid crystal molecules are oriented in various directions in a confined area, particularly when the long axes are inclined toward one another. Therefore, it is preferable that the opening patterns of the pixel and common electrodes 12 and 23 are alternately arranged, and the end portions of the opening patterns are adjacent to each other. That is, when viewed from above, the opening patterns of the pixel and common electrodes 12 and 23 are preferably structured in the form of closed polygons. Furthermore, since disinclination is prone to occur when the opening patterns are structured having acute angles, it is preferable that the opening patterns are formed including only obtuse angles. A stable partitioned orientation of liquid crystal molecules also enhances brightness. At areas where the orientation of the liquid crystal molecules 30 is dispersed, the leakage of light occurs in an off state, and dark portions are generated in an on state. Also, this dispersion of the orientation of liquid crystal molecules causes the generation of afterimages when the liquid crystal molecules are rearranged.

[0045] Third, in order to obtain a high level of brightness, the following conditions should be satisfied. The angle made by the two directors of the liquid crystal molecules 30 at adjacent partitioned regions is preferably about 90°. When the angle of the director is established in this manner, disclination occurs only at the narrowest areas. The brightness is highest when the angle between the light transmission axis of the polarizer film and the director for liquid crystal molecules is 45°. It is preferable that twisting or bending of the opening patterns of the pixel and common electrodes 12 and 23 is minimized as much as possible.

[0046] Finally, in order to obtain a rapid response speed of the liquid crystal molecules 30, it is preferable again that the opening patterns of the pixel and common electrodes 12 and 23 are not twisted or bent too much. That is, it is preferable that the opening patterns of the pixel and common electrodes 12 and 23 linearly face each other. The effect of an opening width of the opening patterns and a spacing interval between the openings on light transmission and response speed will now be described.

[0047] In order to investigate such an interrelation, nine panels, each with different opening patterns were made and tested. Fig. 11 shows schematic views of nine different opening patterns A - J for demonstrating the affect of opening pattern width and spacing on response speed and brightness. In the drawing, the opening patterns of the common electrode are indicated by diagonal lines, and the opening patterns of the pixel electrode are indicated by solid lines.

[0048] As shown in Fig. 11, the B, C and D opening patterns are identical and the E, F and G opening patterns are identical. However, these opening patterns differ in opening width and spacing. The I and J opening patterns differ in the number of openings used, effectively having different opening spacings. The A opening pattern has a shape similar to that of the B, C and D opening patterns except for the formation at a center area of the A opening pattern. As a result, the A opening pattern is different in opening spacing from the B, C and D opening patterns. The opening width and the opening spacing of each opening pattern are listed in Table 1. Fig. 12A is a graph illustrating light transmissivity levels of test cells applying the A through J opening patterns, and Fig. 12B is a graph comparing the light transmissivity level of a test cell applying the B opening pattern to the light transmissivity levels of test cells applying the A through J opening patterns. As shown in the graphs, the light transmissivity level of the test cell applying the G opening pattern is the highest, exceeding 13%. If the light transmissivity levels of the test cells are ranked from highest to lowest according to which opening pattern is used, the following ranking results: G, E, I, B, D, A, C, F, and J. Fig. 13 is a graph illustrating response times as a function of gray scale of test cells applying the A through J opening patterns. Although only sixty-nine (69) gray scales are used in actual application, the experiment was performed with one hundred and ten (110) gray scales. As shown in the graph, response times of the test cells applying the B, C, D, and J opening patterns were relatively fast over the whole range of gray scales. For the test cells applying the other opening patterns, the response times were relatively slow. In the case of the test cells applying the A and I opening patterns, the slow response times were due to the movement of texture, and in the case of the test cells applying the E, F, and G opening patterns, the slow response times can be attributed to the two-step movement of liquid crystal molecules.

[0049] The A through J opening patterns shown in Fig. 11 were applied to actual panels and the panels were tested. Testing was performed on a total of four panels for each opening pattern. The results are listed in Table 2.

[0050] The results of the experiment performed with the actual panels were similar to the results when using the test cells. However, there were some differences as follows. First, the actual panel in which the I opening pattern was applied exhibited a higher response speed than the test cell applying the same opening pattern. Also, better results with regard to brightness were obtained with the actual panel applying the J opening pattern than when the test cell was used. Specifically, the brightness of the test cell applying the J opening pattern was 75% of the cell applying the B opening pattern, whereas this was increased to 90% when the J opening pattern was applied to the actual panel.

[0051] When the actual panels were used, white afterimages were generated with the application of the C, I, and J opening patterns. The degree of white-afterimage generation was so high with the application of the C opening pattern that picture quality was impaired beyond a level that could be corrected. However, the generation of white afterimages was low enough when the I and J opening patterns were applied so that with some improvement, the panels could be used.

[0052] On the basis of the above results, the opening patterns to select depending on what the intended area of improvement is are as follows. If the improvement of brightness and the minimization of white afterimages are what are desired, it is preferable to use the B, D, E, and I opening patterns. However, if an improvement in response speed while keeping the brightness at a normal level is desired, the B, D, and I opening patterns are preferred. Finally, if what is needed is solely an improvement in response speed (without concerning brightness), the D and J opening patterns are preferred.

[0053] In order to further examine the interrelation between the response speed and the opening width of the opening patterns, the differences in the optical characteristics of panels applying the B, C, and D opening patterns, which have the same shape but different opening widths, will now be described.

[0054] Fig. 14 is a graph illustrating response times as a function of gray scale of actual panels applying the B, C, and D opening patterns. As shown in the graph, the response times of the panels applying the opening patterns exhibited the following relation (based on the type of opening pattern) when 20 to 40 gray scales were used: D<B<C. It is evident, therefore, that the larger the width of the opening pattern the faster the response time.

[0055] Roughly between 40 and 45 gray scales, the response time of the panel applying the C opening pattern is shorter than that of the panel applying B opening pattern, and after 45 gray scales, the response time of the panel applying the C opening pattern is shorter than that of the panel applying the D opening pattern. However, such a change in the response time of the panel applying the C opening pattern is not actually taking place, but instead is given the appearance of change as a result of the generation of white afterimages. That is, the response waveform is distorted due to the white afterimages so that the response time seems to be shorter than it actually is. Accordingly, the conclusion originally reached that the larger the width of the opening pattern the faster the response speed remains valid.

[0056] With the use 60 gray scales or more, the response speed slows considerably due to the occurrence of texture. In conclusion, the panel applying the D opening pattern, which has the greatest width, exhibits the most stable characteristics. Figs. 15A to 15C are photographs of the C, B and D opening patterns, respectively, at white gray scales. As seen from the photographs, the C opening pattern with poor texture stability displays the lowest level of brightness, with the B and D opening patterns exhibiting similarly higher levels of brightness. The D opening pattern exhibits a low opening ratio due to its significant width, but displays good texture stability such that panels applying this opening pattern have a high brightness. Texture stability is determined by the intensity of the fringe field and the width of the opening pattern.

[0057] The boundary areas between adjacent partitioned regions in the C, B and D opening patterns are formed differently. That is, two clearly distinguishable textures are present in most of the boundary areas of the C opening pattern, and with the B opening pattern, the boundary areas are again distinguishable but not as clearly as with the C opening pattern. The boundary areas of the D opening pattern, on the other hand, are not clearly formed and are faint in many portions.

[0058] Figs. 16A and 16B are photographs of the C and D opening patterns applied to test cells in which a change in the partitioned regions according to a level of an applied voltage is shown.

[0059] In the C opening pattern, two clearly distinguishable textures are present in the boundary areas when the applied voltage reaches 3.5V, and becomes clearer with further increases in the applied voltage. However, in the D opening pattern, the boundary areas are somewhat clearly distinguishable only when the applied voltage reaches 5V. Such distinguishable boundary areas are a result of the non-uniform orientation of the liquid crystal molecules. To better describe such a phenomenon, the intensity of the fringe field as a function of the widths of the opening patterns will be examined.

[0060] Figs. 17A and 17B are schematic views used to illustrate the change in intensity of a fringe field according to variations in opening pattern width.

[0061] As the width of the opening pattern becomes larger, the horizontal component of the fringe field experiences corresponding increases. The horizontal component of the fringe field plays an important role in determining the orienting direction of liquid crystal molecules. Therefore, opening patterns with a large width are preferred in forming partitioned regions. In contrast, the larger the width of the opening pattern the weaker the intensity of the vertical component of the electric field working at the center of the opening pattern.

[0062] Figs. 18A to 18D are schematic views illustrating orienting states of liquid crystal molecules at a peripheral portion of the opening patterns. When the width of the opening pattern is relatively small, the liquid crystal molecules are horizontally oriented to some degree even at the center area of the opening pattern. That is, they are slightly inclined when the applied voltage is low, but completely oriented in the horizontal direction when the applied voltage is high. This is due to the vertical component of the electric field being strong even at the center area of the opening pattern. As a result, the leakage of light occurs and the boundary area between the partitioned regions is formed by two separate lines. Furthermore, in case the orienting direction of the liquid crystal molecules is changed by 180°, elasticity becomes greater due to the small width of the opening pattern. In contrast, as the horizontal component of the fringe field is weak, the fringe field is not strong enough to overcome the elasticity, thereby resulting in the orienting direction of the liquid crystal molecules at the boundary areas becoming non-uniform between the partitioned regions. Such a non-uniform orientation of the liquid crystal molecules occurs even in micro regions of the pixel.

[0063] When the width of the opening pattern is relatively large, the long axes of the liquid crystal molecules are perpendicular to the electrodes at the center area of the opening pattern. As the applied voltage is increased, the liquid crystal molecules are slightly inclined, but the degree of inclination is less than when the opening pattern has a small width. Therefore, only a minimal amount of light leakage occurs and the boundary area between adjacent partitioned regions is shaped with a dark line.

[0064] As described previously, the greater the width of the opening pattern the more rapid the response speed , and as stated above, a greater width of the opening pattern leads to more uniform micro regions of the pixel. When the width of the opening pattern is great, although the opening ratio is low, the orientation of the liquid crystal molecules is uniform such that a satisfactory degree of brightness is obtained. According to the above experimental results, it is preferable that the opening width of the opening pattern is in the range of 13 ± 3 μm, and the cell gap is in the range of about 4-6 μm.

[0065] The affect of opening spacing on the optical characteristics of the opening patterns will now be described. The I and J opening patterns have the same total widths but effectively different spacings. According to the experimental results with respect to the test cells, the optical characteristics of the I and J opening patterns are significantly different. However, when actual panels apply these opening patterns, the resulting optical characteristics of the I and J opening patterns do not vary by such a degree. It is viewed that this is a result of the such factors as the difference in the type of alignment layer used, whether a protective insulating layer is used, the difference in the waveforms of the applied voltage, etc. However, when the speeds of moving picture images are compared in the actual panels, they are more rapid with the J opening pattern than with the I opening pattern. This can be easily demonstrated by observing the motion of a dark rectangle on a gray background. The only difference in response speed occurs by variations in the gray scales.

[0066] As with the opening width of the opening pattern, when the spacing between the opening portions of the opening pattern becomes smaller, the opening ratio is significantly reduced but the brightness does not undergo much change. This is due to texture. That is, when the distance between the opening portions is increased, the control of texture becomes difficult, whereas such control is easily performed when the opening spacing is small. Therefore, when the distance between the opening portions is small, the opening ratio is reduced but the control of texture is easy, thereby enabling the compensation of brightness. The exception is with the I opening pattern in which even though the distance between the opening portions is large, a high brightness results because texture control is easily performed. In brief, a smaller distance between the opening portions results in an improvement of the response speed at various gray scales. Even though the brightness is prone to deteriorate due to the decrease in the opening ratio, this can be compensated for to some degree by controlling texture.

[0067] There exists a direct correlation between texture and response speed. Moving texture reduces response speed. When a high voltage is applied, the response speed is reduced in most of the opening patterns. This is due to the generation of texture. Therefore, if texture can be suitably controlled, picture quality as well as response speed can be improved. Techniques of inhibiting the occurrence of texture will now be described.

[0068] Figs. 19 and 20 show schematic views of portions where texture occurs in the B and J opening patterns, respectively. The opening pattern shown in Fig. 19 is nearly identical to that shown in Fig. 4C. However, in the opening pattern of Fig. 19, second and third openings 122 and 123 of the pixel electrode 12 begin from the first long side of the pixel electrode 12 and extend toward the second long side of the pixel electrode 12 nearly reaching the same, whereas in the opening pattern of Fig. 4C, the second and third openings 122 and 123 are structured in the opposite manner. Furthermore, portions of the second long side of the pixel electrode 12 adjacent to ends of the second and third openings 122 and 123 of the opening pattern of Fig. 19 are protruded externally to prevent the interconnection of the partitioned regions of the pixel electrode 12 from deteriorating due to the opening portions 122 and 123.

[0069] Portions where texture occurs mainly correspond to areas where ends of the opening portions of the common electrode 23 and ends of the opening portions of the pixel electrode 12 meet. When the upper and lower substrates are appropriately arranged, the occurrence of texture is low, whereas when the substrates are inappropriately arranged, half moon-shaped textures, which do not cause the generation of white afterimages, occur. In order to inhibit such texture occurrence, the width of the ends of the opening portions of the common electrode 23 may be enlarged. Through such enlargement, the allowable range of error in arrangement can be increased. The opening pattern shown in Fig. 20 is similar to that shown in Fig. 8C, but differs in the number of openings extending across the pixel electrode from the first long side to the second long side. Furthermore, the openings of the pixel electrode 12 are such that they are open where they begin at the first long side of the pixel electrode 12 and extend across toward, but not reaching, the second long side of the pixel electrode 12. Portions of the second long side of the pixel electrode 12 adjacent to ends of these openings are protruded externally.

[0070] The occurrence of texture is concentrated at areas "a" corresponding to ends of openings of the common electrode 23 proceeding across from the first long side to the second long side of the common electrode 23. Furthermore, texture occurs also along the second short side of the pixel electrode 12, or area "b", which is deformed outwardly to enable a connection with the source electrode, as well as at area "c" at an end of an opening of the pixel electrode 12.

[0071] Such texture can be inhibited in the following way. In the case of area a, a width of the ends of the openings of the common electrode 23 are increased. In the case of area b, the openings of the common electrode 23 are structured to overlap part of area b. For this purpose, it is necessary to control the width and spacing of the opening portions. When the spacing is decreased, the opening ratio is reduced but the response speed is enhanced. In the case of area c, the end of the opening of the pixel electrode 12 extended from the first short side is formed having sharp edges.

[0072] Figs. 21A to 21C illustrate opening patterns where the above-described texture improving techniques have been applied.

[0073] In the above description, a structure in which the opening patterns are formed at both the pixel and common electrodes 12 and 23 is disclosed. However, it is also possible to form the opening patterns, together with the protrusions, only at the pixel electrode 12. In this case, the protrusions are formed using a gate insulating layer or a protective layer. In the formation of the protrusions, care should be taken to avoid the formation of parasitic capacitance between electrical lines. The openings and the protrusions can be arranged as illustrated in Fig. 21.

[0074] Alternatively, the opening patterns may be formed only in the pixel electrode 12 while forming the protrusions in the common electrode 23. In this case, the openings and the protrusions can be arranged also as illustrated in Fig. 21.

[0075] As described above, the inventive liquid crystal display obtains a wide viewing angle, and exhibits stable orientation of the liquid crystal molecules and a rapid response speed.

[0076] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the scope of each element identified by way of example by such reference signs.

TABLE 1

	Openning Width (μm)	Openning Spacing (μm)
A	10	33.5
B	10	22.5
C	7	25.5
D	13	19.6
E		24
F		21
G		27
I	10	Narrow Spacing:29 Wide Spacing:32
J	10	Narrow Spacing:10 Wide Spacing:16

TABLE 2

PTN	T(%)	Ton(ms)	Toff (ms)	Ttotal (ms)	White after image	T(%)	Ton(ms)	Toff (ms)	Ttotal (ms)	White after image
A	5.50	21.53	20.38	41.73	medium	5.12	18.56	13.99	32.55	week
	5.44	19.14	20.18	39.32	strong	4.27	14.69	15.15	29.84	week
B	5.23	18.16	20.28	38.44	very week	4.79	12.36	14.5	26.86	X
	4.88	18.79	20.42	39.21	very week	4.56	12.64	15.48	28.12	X
C	4.96	18.8	21.6	40.4	strong	4.07	9.6	14.8	24.4	strong
						4.19	8.98	14.3	23.28	strong
D	4.88	24.36	21.2	40.0	X	4.75	12.8	14.8	27.6	X
						4.79	13.36	13.47	26.83	X

(continued)

PTN	T(%)	Ton(ms)	Toff (ms)	Ttotal (ms)	White after image	T(%)	Ton(ms)	Toff (ms)	Ttotal (ms)	White after image
E	5.52	22.2	21.69	46.05	very week	5.34	44.1	14.28	58.39	X
	5.58	23.67	20.0	42.2	very week					
F	4.79	20.8	21.63	45.2	X	4.34	70.79	14.89	85.68	X
	5.58	20.8	19.2	40.0	X					
I	5.51	15.0	21.6	42.4	week	4.99	10.4	13.0	23.4	very week
						4.77	12.6	15.4	28	X
J	4.76		20.8	35.8	week	4.49	7.6	12.4	20.0	week
						3.96	9.6	15.4	25.0	week

Claims

1. A liquid crystal display, comprising:

a first insulating substrate (10) on which a pixel electrode (12) is formed;
a second insulating substrate (20) on which a common electrode (23) is formed; and
a liquid crystal (30) positioned between the first and second insulating substrates (10, 20), wherein:

the pixel electrode (12) includes a first opening pattern (121, 122, 123) and the common electrode (23) includes a second opening pattern (210, 220, 230),
the pixel electrode (12) comprises first and second long sides substantially parallel to each other and first and second short sides substantially parallel to each other and substantially perpendicular to the first and second long sides;
the second opening pattern (210, 220, 230) includes upper (220), lower (230) and middle (210) openings,
characterized in that
the middle opening (210) of the second opening pattern including a trunk (211) substantially parallel to the first and second short sides of the pixel electrode (12), first (212) and second (214) branches extending at a predetermined angle from the trunk (211) respectively to the first and second short sides of the pixel electrode, and first (213) and second (215) sub-branches respectively extending from ends of the first (212) and second (214) branches toward said first and second short sides, respectively, and along the second long side of the pixel electrode (12);
the upper (220) and lower (230) openings of the second opening pattern include a first body (221) and a second body (231), respectively,
the upper opening (220) of the second opening pattern including a first upper limb (222) extending from the first body (221) along the first short side of the pixel electrode (12) and oblique to the first body (221), the first body (221) further including a first lower limb (223) extending therefrom along the first long side of the pixel electrode (12) and oblique to the first body (221);
the lower opening (230) of the second opening pattern including a second lower limb (232) extending from the second body (231) along the second short side of the pixel electrode (12) and oblique to the second body (231), the second body (221) further including a second upper limb (233) extending therefrom along the first long side of the pixel electrode (12) and oblique to the second body (231).

2. The liquid crystal display of claim 1, wherein the first body (221) extends from the first short side of the pixel electrode (12) to the first long side of the pixel electrode (12).

3. The liquid crystal (30) display of claim 1, wherein the first body (221) extends from the first short side of the pixel electrode (12) to the first long side of the pixel electrode (12), wherein the first short side is shorter than the first long side.

4. The liquid crystal display of claim 1, wherein the second lower limb (232) is substantially parallel to the first upper limb (222).

5. The liquid crystal display of claim 1, wherein the first (121, 122, 123) and second (210, 220, 230) opening patterns are formed in a pixel area, and at least one of the first (121, 122, 123) and second (210, 220, 230) opening patterns is separated from the first (121, 122, 123) and second (210, 220, 230) opening patterns of an adjacent pixel area.

6. The liquid crystal display of claim 1, wherein the upper (221, 222, 223) and lower (231, 232, 233) openings are symmetrical to each other.

7. The liquid crystal display of claim 1, wherein the trunk (211), first and second branches (212, 214), and first and second sub-branches (213, 215) are formed in a pixel area and are separated from first and second opening patterns of an adjacent pixel area.

8. The liquid crystal display of claim 7, wherein the first opening pattern (121, 122, 123) includes a middle opening (122) extending substantially parallel to and overlapping, at least in part, the trunk (211) of the second opening pattern (210, 220, 230).

Patentansprüche

1. Eine Flüssigkristallanzeige, die Folgendes umfasst:

ein erstes Isoliersubstrat (10), auf dem eine Pixelelektrode (12) geformt ist;
ein zweites Isoliersubstrat (20), auf dem eine gemeinsame Elektrode (23) geformt ist; und
einen Flüssigkristall (30), positioniert zwischen dem ersten und dem zweiten Isoliersubstrat (10, 20), worin:

die Pixelelektrode (12) ein erstes Öffnungsmuster (121, 122, 123) einschließt und die gemeinsame Elektrode (23) ein zweites Öffnungsmuster (210, 220, 230) einschließt,
die Pixelelektrode (12) erste und zweite lange Seiten umfasst, die im Wesentlichen zueinander parallel sind, und erste und zweite kurze Seiten, die im Wesentlichen zueinander parallel und im Wesentlichen senkrecht zu den ersten und zweiten langen Seiten sind;
das zweite Öffnungsmuster (210, 220, 230) obere (220), untere (230) und mittlere (210) Öffnungen einschließt,
dadurch gekennzeichnet, dass
die mittlere Öffnung (210) des zweiten Öffnungsmusters einen Stamm (211) einschließt, der im Wesentlichen parallel zu den ersten und zweiten kurzen Seiten der Pixelelektrode (12) ist, wobei sich erste (212) und zweite (214) Zweige in einem vordefinierten Winkel vom Stamm (211) zu den ersten bzw. zweiten kurzen Seiten der Pixelelektrode erstrecken und wobei erste (213) und zweite (215) Unterverzweigungen sich jeweils von Enden der ersten (212) bzw. zweiten (214) Zweige zu den ersten bzw. zweiten kurzen Seiten und entlang der zweiten langen Seite der Pixelelektrode (12) erstrecken;
die oberen (220) und unteren (230) Öffnungen des zweiten Öffnungsmusters einen ersten Körper (221) bzw. einen zweiten Körper (231) einschließen;
die obere Öffnung (220) des zweiten Öffnungsmusters einen ersten oberen Schenkel (222) einschließt, der sich vom ersten Körper (221) entlang der ersten kurzen Seite der Pixelelektrode (12) und schräg zum ersten Körper (221) erstreckt, wobei der erste Körper (221) weiter einen ersten unteren Schenkel (223) einschließt, der sich davon entlang der ersten langen Seite der Pixelelektrode (12) und schräg zum ersten Körper (221) erstreckt;
die untere Öffnung (230) des zweiten Öffnungsmusters einen zweiten unteren Schenkel (232) einschließt, der sich entlang der zweiten kurzen Seite der Pixelelektrode (12) und schräg zum zweiten Körper (231) vom zweiten Körper (231) erstreckt, wobei der zweite Körper (231) weiter einen zweiten oberen Schenlek (233) einschließt, der sich davon entlang der ersten langen Seite der Pixelelektrode (12) und schräg zum zweiten Körper (231) erstreckt.

2. Die Flüssigkristallanzeige gemäß Anspruch 1, wobei sich der erste Körper (221) von der ersten kurzen Seite der

Pixelelektrode (12) zur ersten langen Seite der Pixelelektrode (12) erstreckt.

3. Die Flüssigkristallanzeige (30) gemäß Anspruch 1, wobei sich der erste Körper (221) von der ersten kurzen Seite der Pixelelektrode (12) zur ersten langen Seite der Pixelelektrode (12) erstreckt, wobei die erste kurze Seite kürzer ist als die erste lange Seite.

4. Die Flüssigkristallanzeige gemäß Anspruch 1, wobei der zweite untere Schenkel (232) im Wesentlichen parallel zum ersten oberen Schenkel (222) ist.

5. Die Flüssigkristallanzeige gemäß Anspruch 1, wobei das erste (121, 122, 123) und das zweite (210, 220, 230) Öffnungsmuster in einem Pixelbereich geformt sind und mindestens eines des ersten (121, 122, 123) und des zweiten (210, 220, 230) Öffnungsmusters von den ersten (121, 122, 123) und zweiten (210, 220, 230) Öffnungsmustern eines angrenzenden Pixelbereichs getrennt ist.

6. Die Flüssigkristallanzeige gemäß Anspruch 1, wobei die oberen (221, 222, 223) und unteren (231, 232, 233) Öffnungen zueinander symmetrisch sind.

7. Die Flüssigkristallanzeige gemäß Anspruch 1, wobei der Stamm (211) erste und zweite Zweige (212, 214) und erste und zweite Unterverzweigungen (213, 215) in einem Pixelbereich geformt sind und von ersten und zweiten Öffnungsmustern eines benachbarten Pixelbereichs getrennt sind.

8. Die Flüssigkristallanzeige gemäß Anspruch 7, wobei das erste Öffnungsmuster (121, 122, 123) eine mittlere Öffnung (121) einschließt, die sich im Wesentlichen parallel zu dem Stamm (ββ) (211) des zweiten Öffnungsmusters (210, 220, 230) erstreckt und ihn zumindest teilweise überlappt.

Revendications

1. Dispositif d'affichage à cristaux liquides, comprenant:

une première couche d'isolation (10) sur laquelle est formé un électrode (12) de pixel ;
une deuxième couche d'isolation (20) sur laquelle est formé un électrode (23) commun ; et
un cristal liquide (30) positionné entre les première et deuxième couches d'isolation (10, 20),
dans lequel
l'électrode de pixel (12) inclut un premier modèle d'ouverture (121, 122, 123) et l'électrode commun (23) inclut un deuxième modèle d'ouverture (210, 220, 230),
l'électrode de pixel (12) comprend des premiers et deuxièmes côtés longs essentiellement parallèles l'un à l'autre, et des premiers et deuxièmes côtés courts essentiellement parallèles l'un à l'autre et essentiellement orthogonales aux premiers et deuxièmes côtés longs;
le deuxième modèle d'ouverture (210, 220, 230) inclut des ouvertures supérieure (220), inférieure (230) et intermédiaire (210),
caractérisé en ce que
l'ouverture intermédiaire (210) du deuxième modèle d'ouverture inclut un tronc (211) essentiellement parallèle aux premiers et deuxièmes côtés courts de l'électrode de pixel (12), une première (212) et une deuxième (214) branches s'étendant à un angle prédéterminé du tronc (211) respectivement aux premiers et deuxièmes côtés courts de l'électrode de pixel, et une première (213) et deuxième (215) sous-branches s'étendant respectivement des extrémités de la première (212) et la deuxième (214) branches vers lesdits premiers et deuxièmes côtés courts, respectivement, et le long du deuxième côté long de l'électrode de pixel (12) ;
les ouvertures supérieure (220) et inférieure (230) du deuxième modèle d'ouverture incluent un premier corps (221) et un deuxième corps (231), respectivement,
l'ouverture supérieure (220) du deuxième modèle d'ouverture incluant un premier membre supérieur (222) s'étendant du premier corps (221) le long du premier côté court de l'électrode de pixel (12) et oblique au premier corps (221), le premier corps (221) incluant en outre un premier membre inférieur (223) s'étendant à partir de celui-ci le long du premier côté long de l'électrode de pixel (12) et oblique au premier corps (221) ;
l'ouverture inférieure (230) du deuxième modèle d'ouverture incluant un deuxième membre inférieur (232) s'étendant du deuxième corps (231) le long du deuxième petit côté de l'électrode de pixel (12) et oblique au deuxième corps (231), le deuxième corps (221) incluant en outre un deuxième membre supérieur (233) s'étendant de celui-ci le long du premier côté long de l'électrode de pixel (12) et oblique au deuxième corps (231).

2. Dispositif d'affichage à cristaux liquides selon la revendication 1, dans lequel le premier corps (221) s'étend du premier côté court de l'électrode de pixel (12) au premier côté long de l'électrode de pixel (12).

3. Dispositif d'affichage à cristaux liquides (30) selon la revendication 1, dans lequel le premier corps (221) s'étend du premier côté court de l'électrode de pixel (12) au premier côté long de l'électrode de pixel (12), dans lequel le premier côté court est plus court du premier côté long.

4. Dispositif d'affichage à cristaux liquides selon la revendication 1, dans lequel le deuxième membre inférieur (232) est essentiellement parallèle au premier membre supérieur (222).

5. Dispositif d'affichage à cristaux liquides selon la revendication 1, dans lequel les premiers (121, 122, 123) et deuxièmes (210, 220, 230) modèles d'ouverture sont formés dans une zone de pixel, et au moins l'un des premiers (121, 122, 123) et deuxièmes (210, 220, 230) modèles d'ouverture est séparé des premiers (121, 122, 123) et deuxièmes (210, 220, 230) modèles d'ouverture d'une zone adjacente de pixel.

6. Dispositif d'affichage à cristaux liquides selon la revendication 1, dans lequel les ouvertures supérieures (221, 222, 223) et inférieures (231, 232, 233) sont symétriques l'une par rapport à l'autre.

7. Dispositif d'affichage à cristaux liquides selon la revendication 1, dans lequel le tronc (211), les première et deuxième branches (212, 214) et les premières et deuxième sous-branches (213, 215) sont formés dans une zone de pixel et sont séparés des premiers et deuxièmes modèles d'ouverture d'une zone de pixel adjacente.

8. Dispositif d'affichage à cristaux liquides selon la revendication 7, dans lequel le premier modèle d'ouverture (121, 122, 123) inclut une ouverture intermédiaire (121) s'étendant essentiellement parallèlement à, et se superposant, au moins en partie, au tronc (211) du deuxième modèle d'ouverture (210, 220, 230).

FIG. 1

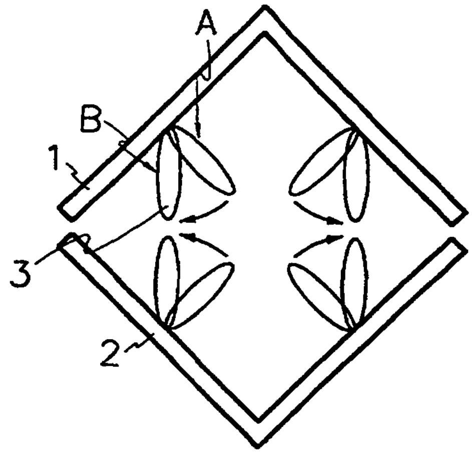


FIG. 2

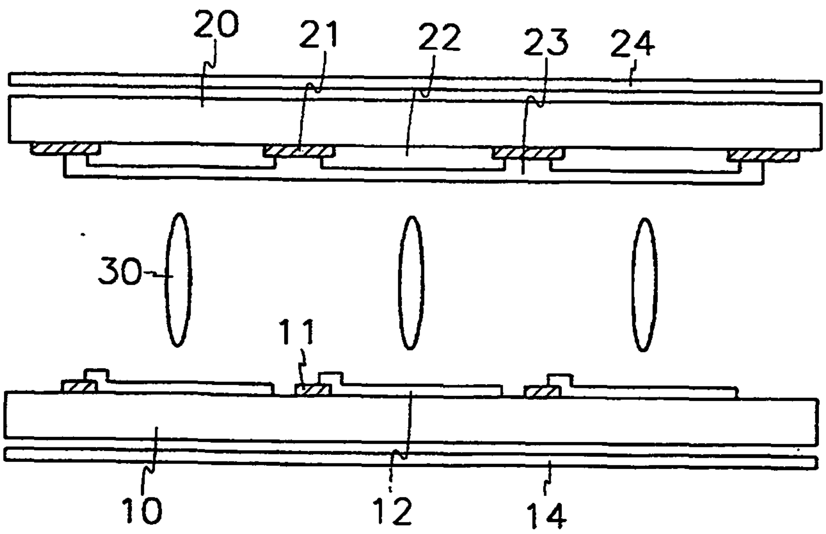


FIG. 3A

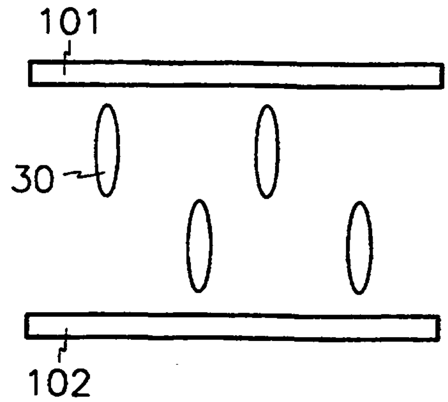


FIG. 3B

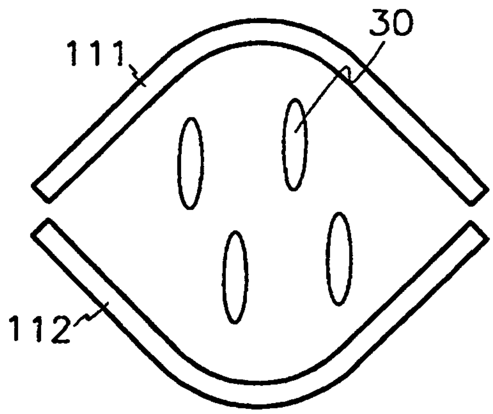


FIG. 4A

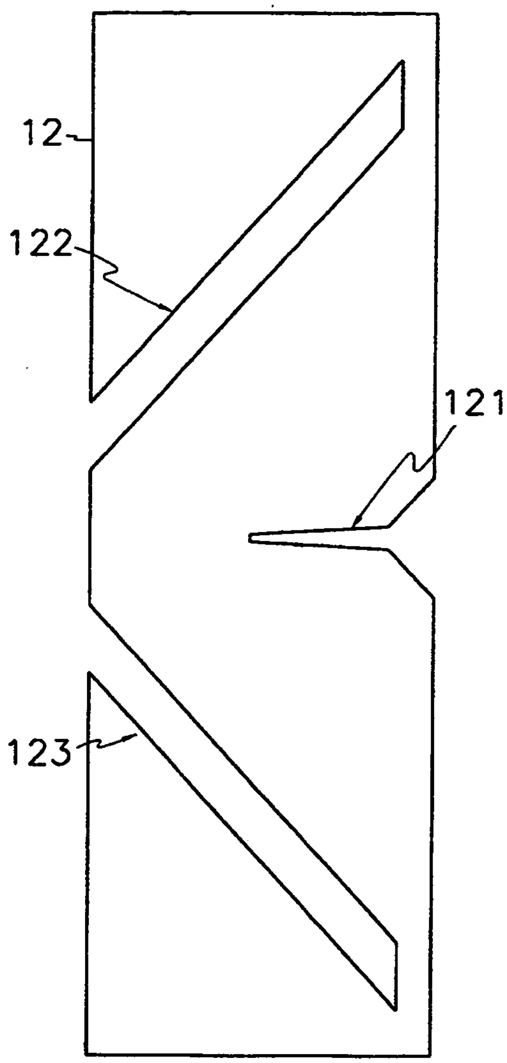


FIG. 4B

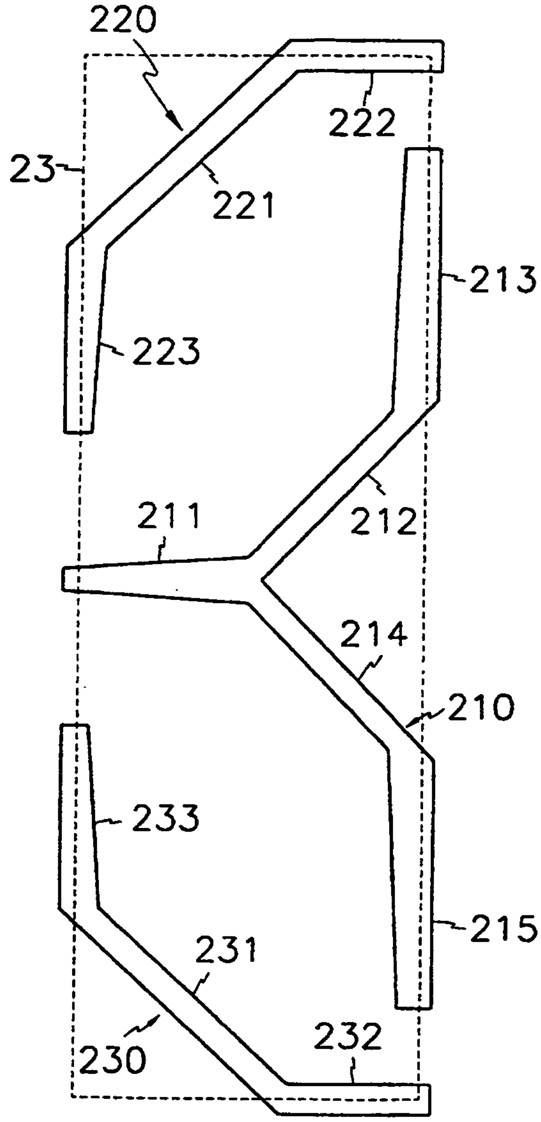


FIG. 4C

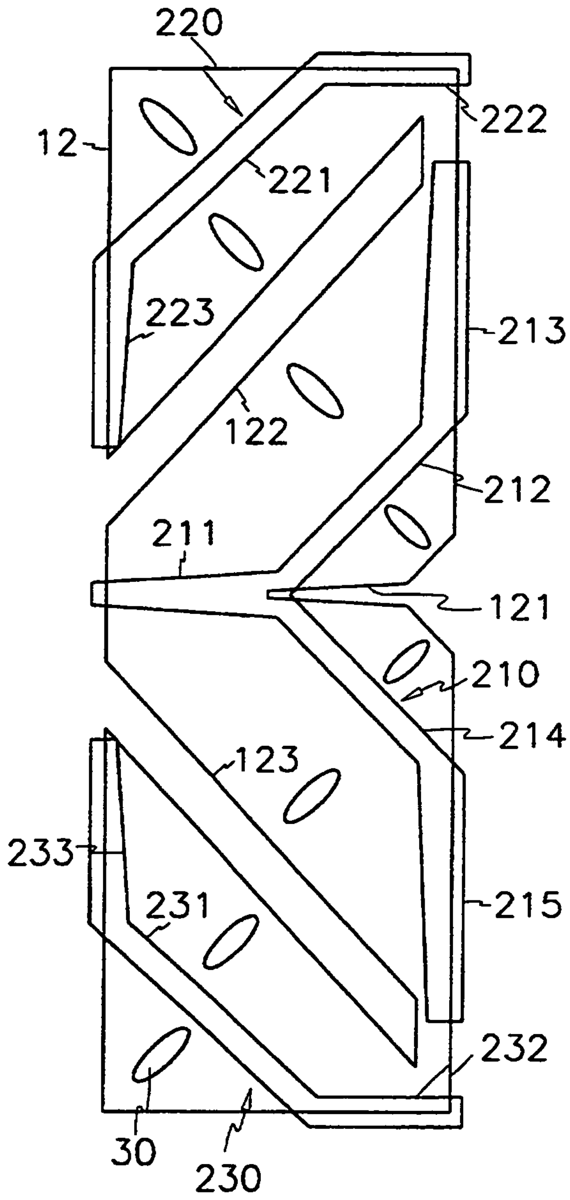

220
12
221
222
223
213
122
212
211
121
210
214
123
233
231
215
232
30
230

FIG. 5A

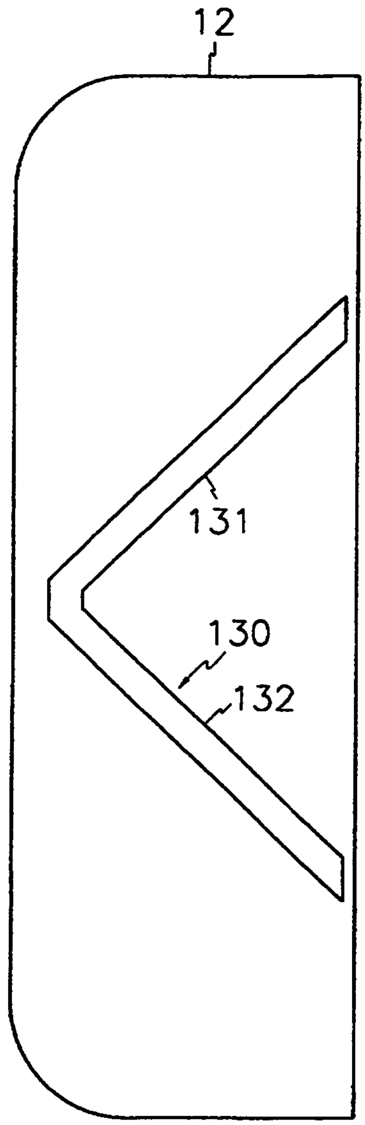


FIG. 5B

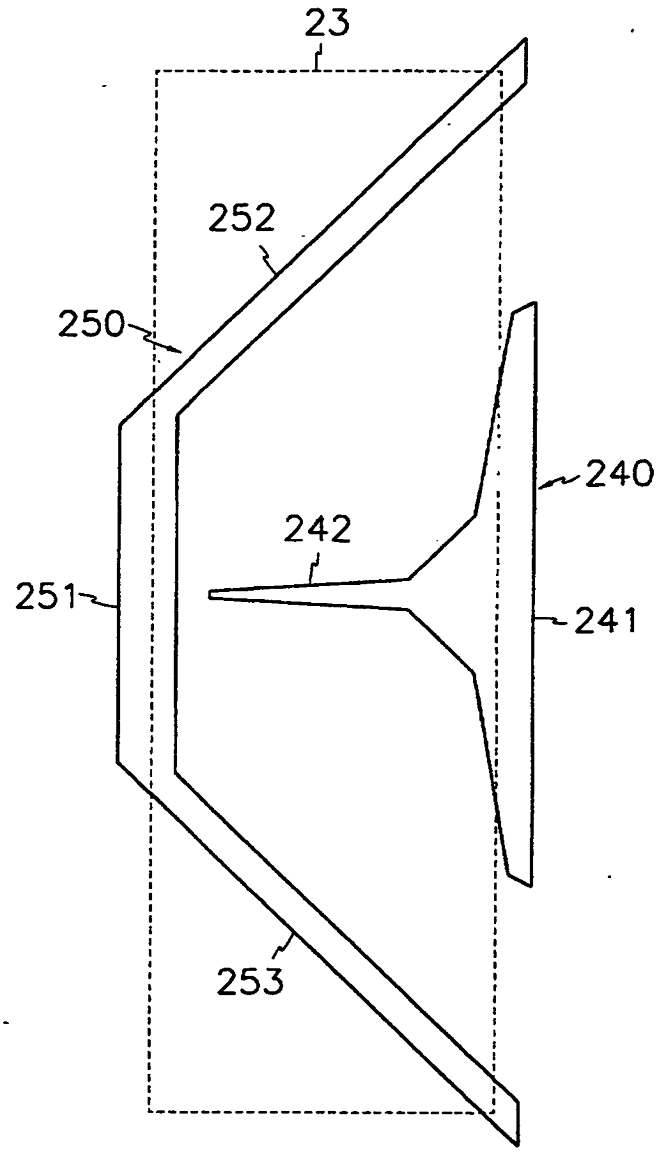


FIG. 5C

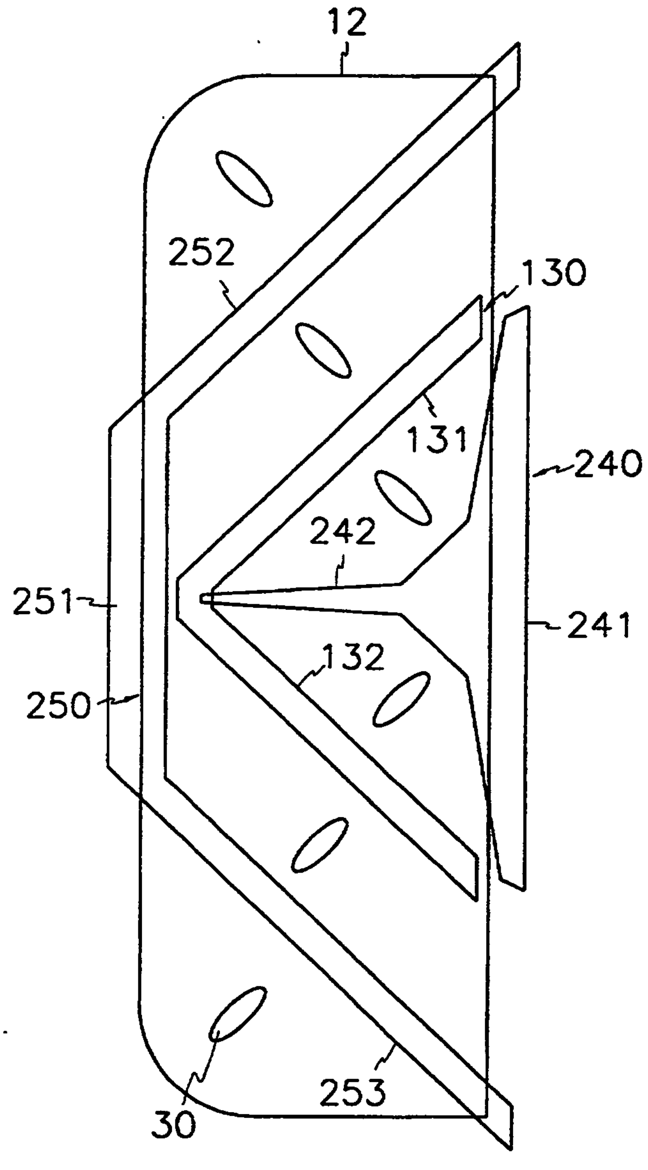


FIG. 6A

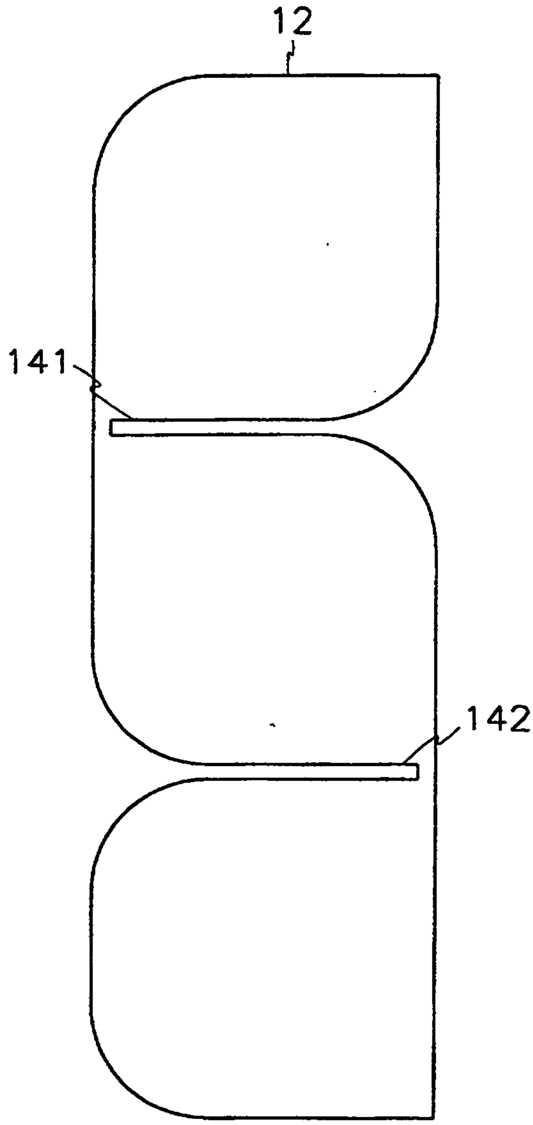


FIG. 6B

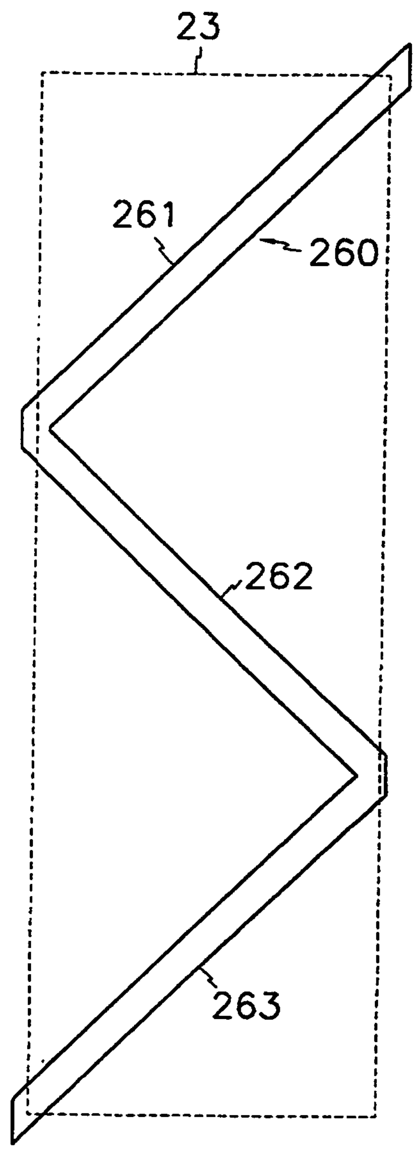


FIG. 6C

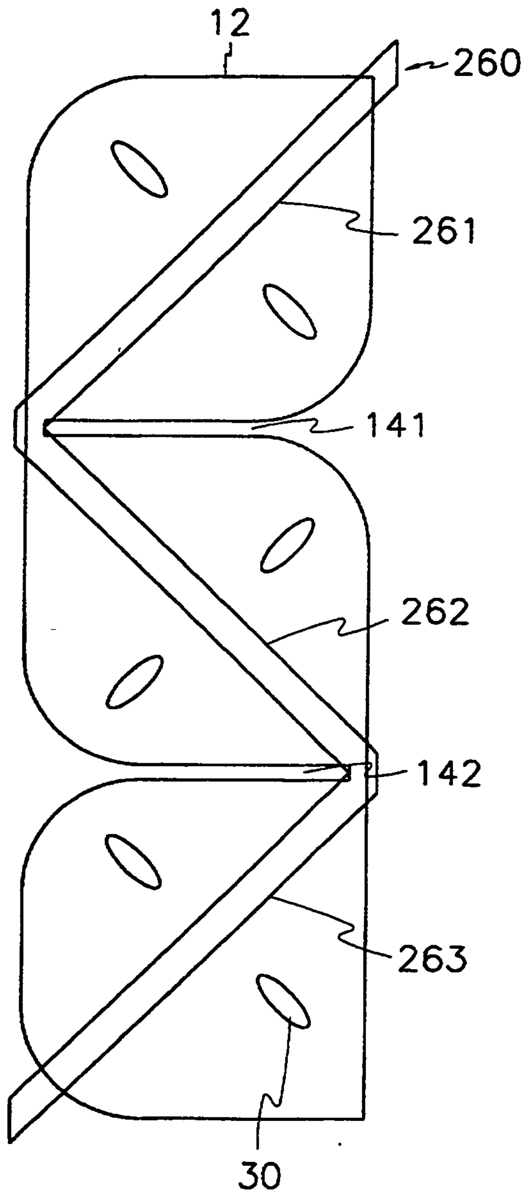


FIG. 7A

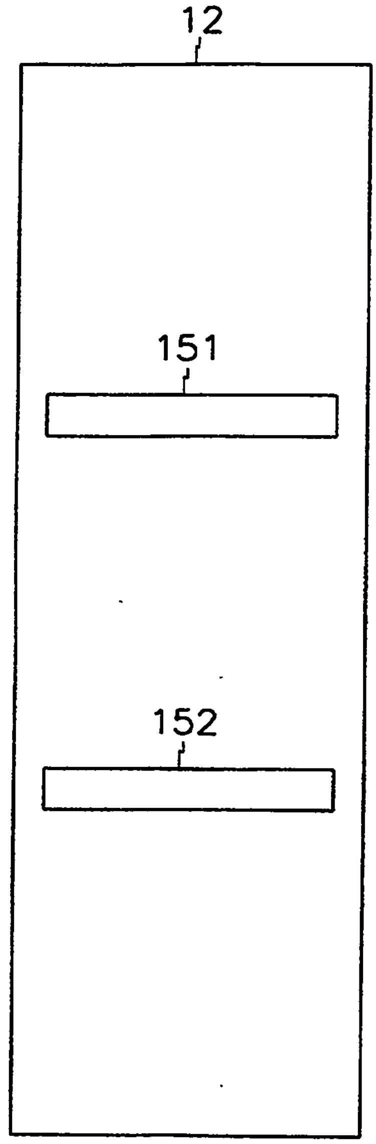


FIG. 7B

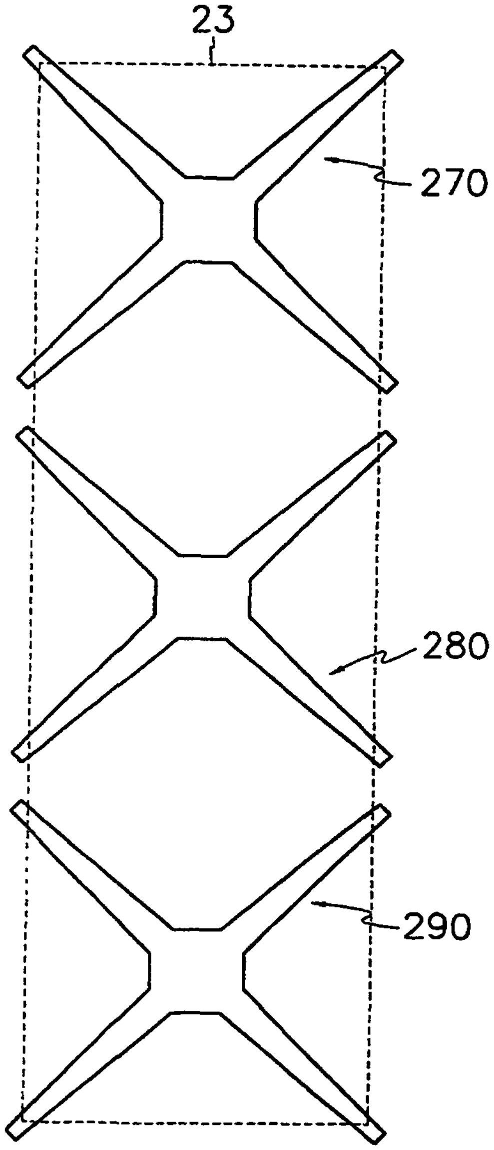


FIG. 7C

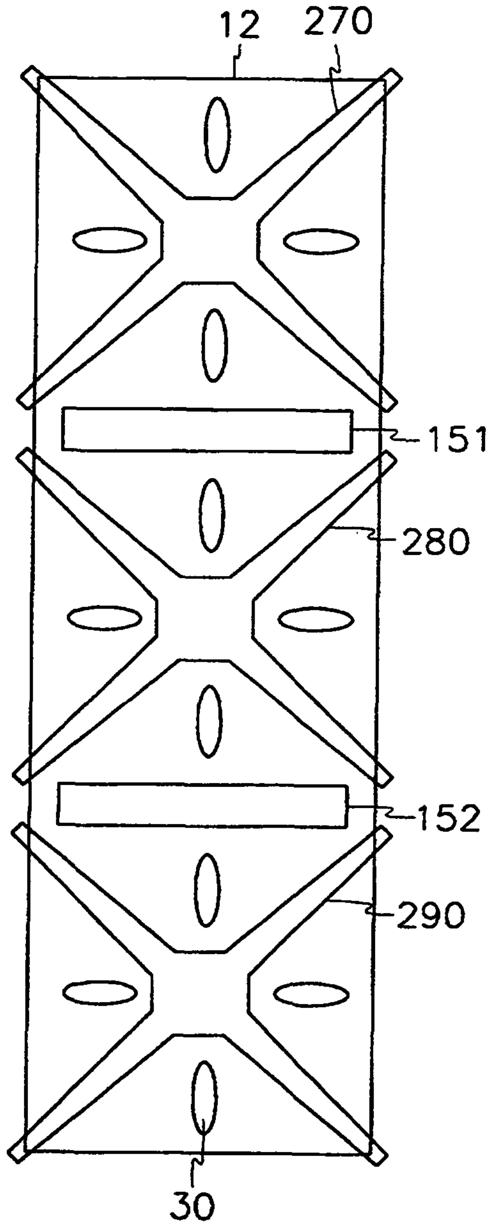


FIG. 8A

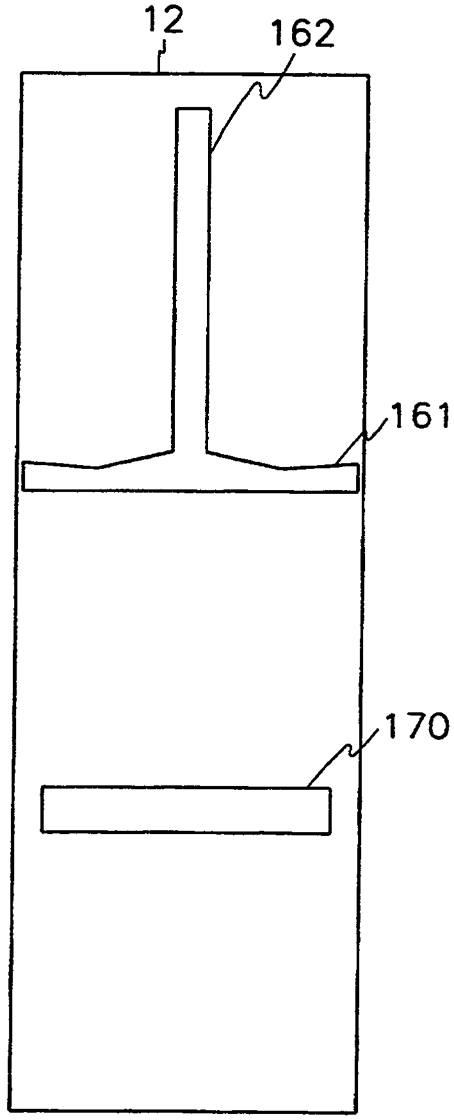


FIG. 8B

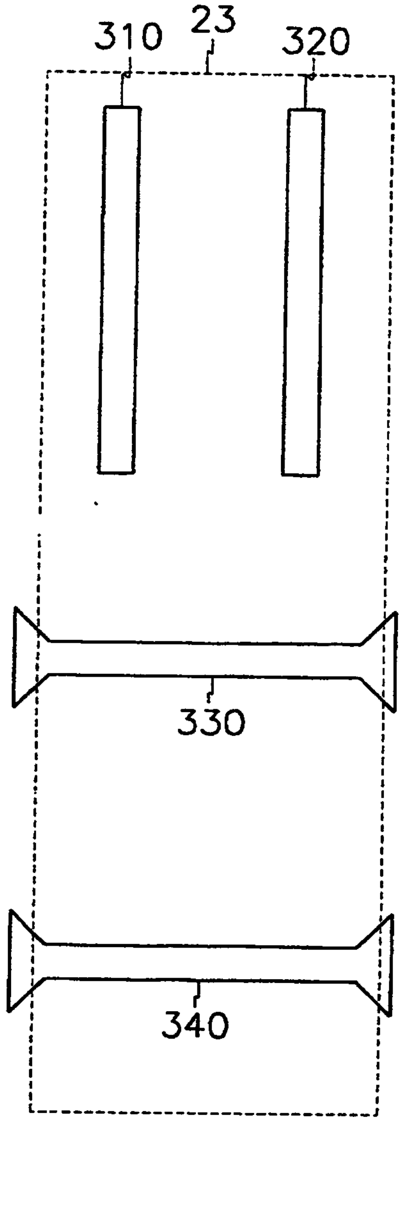


FIG. 8C

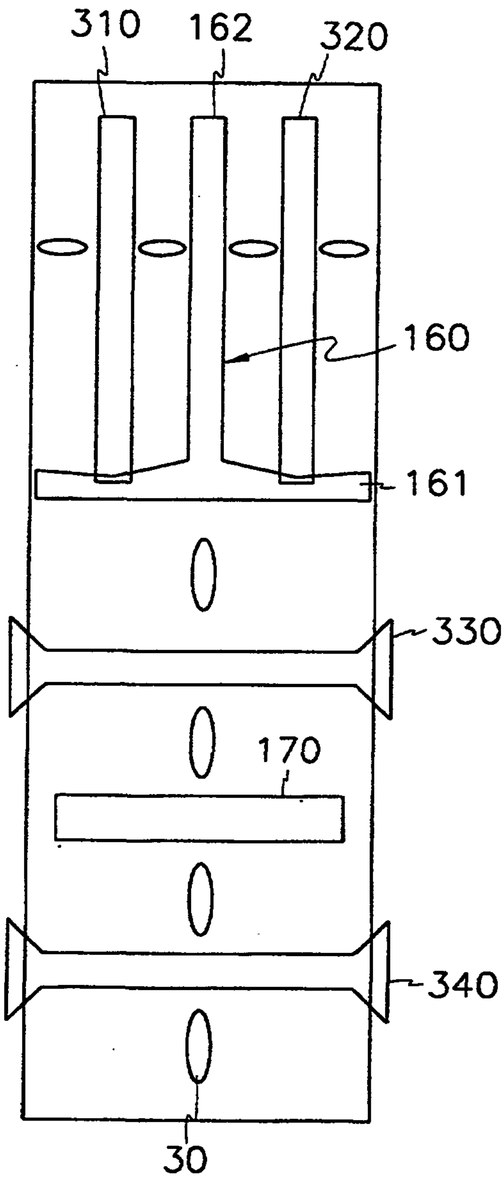


FIG. 9A

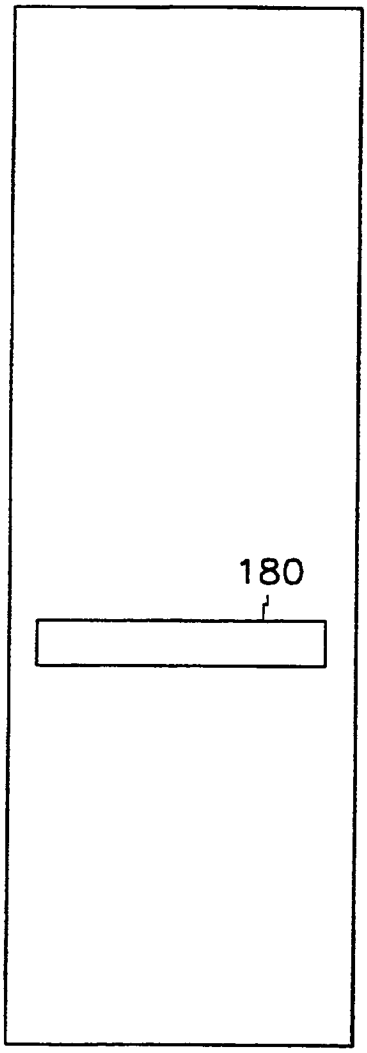


FIG. 9B

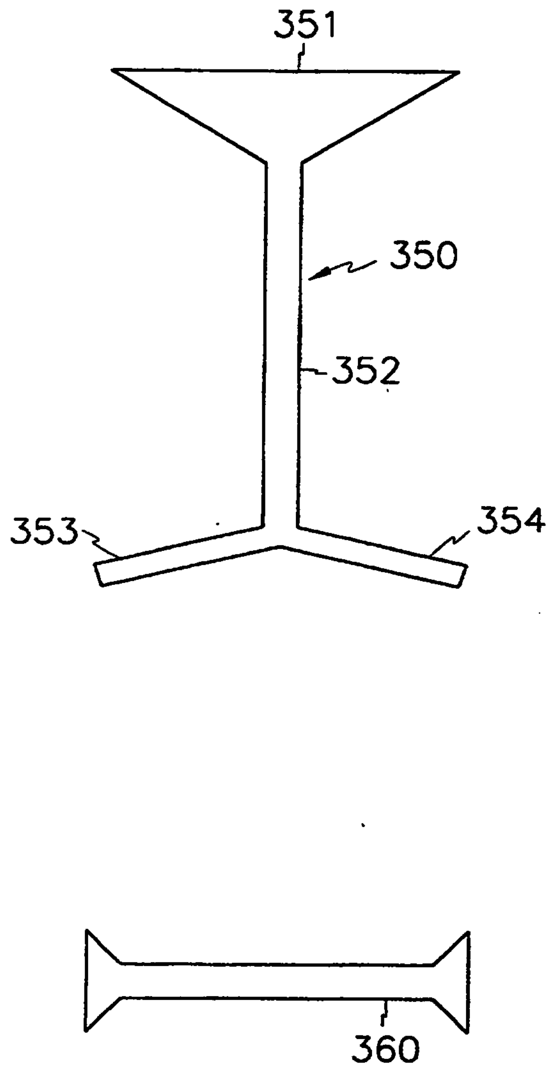


FIG. 9C

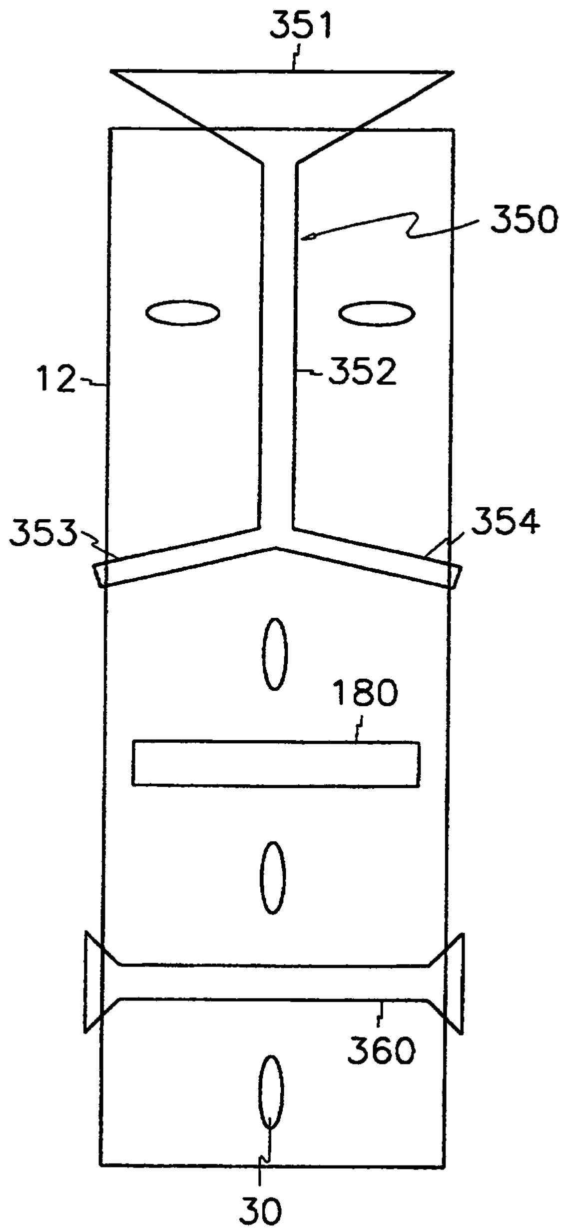


FIG. 10A

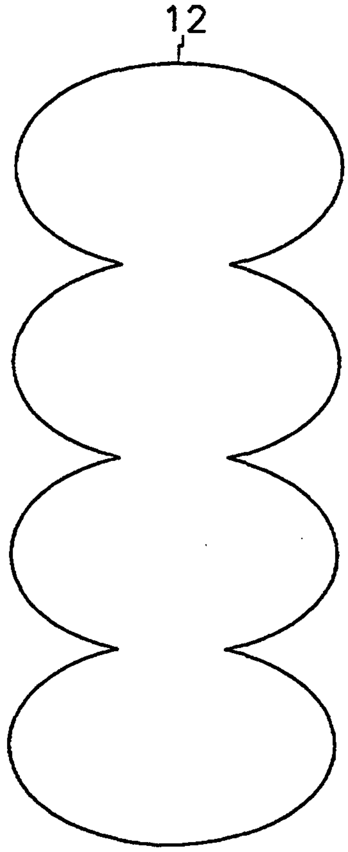


FIG.10A

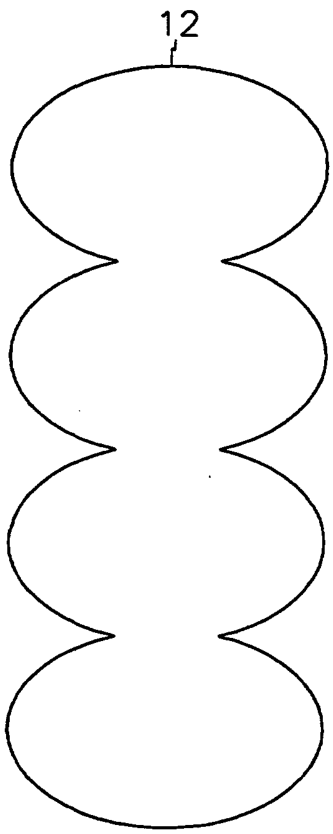


FIG.10B

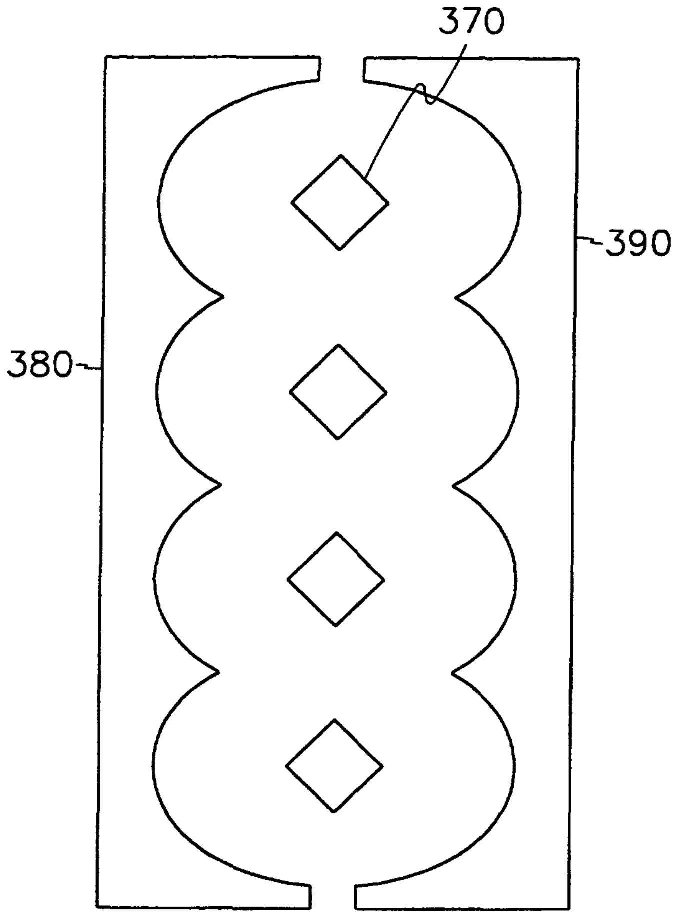


FIG.10C

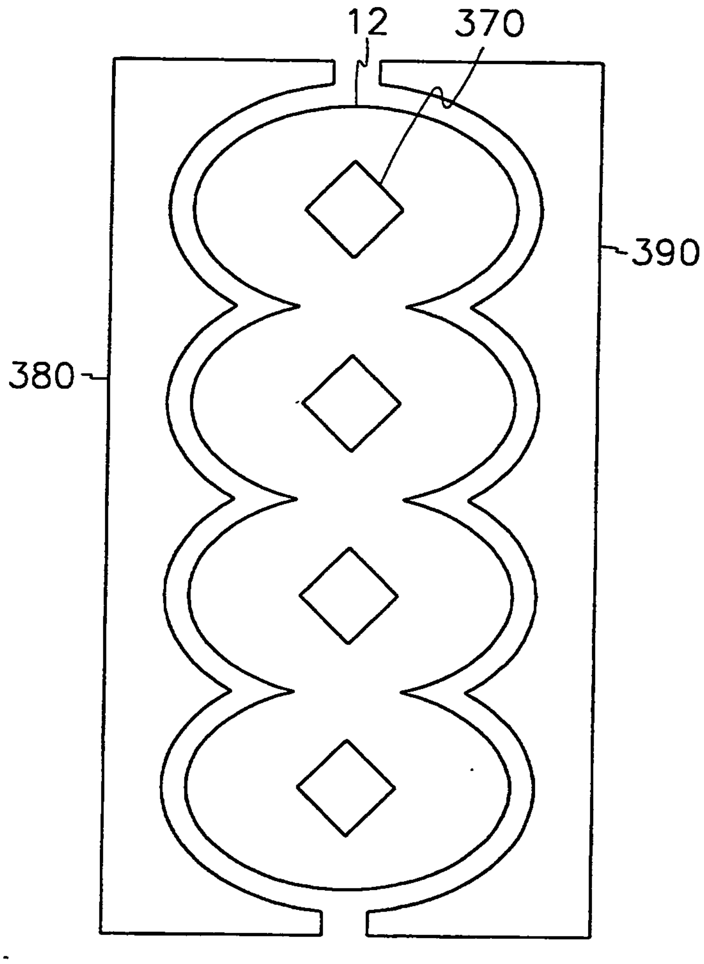


FIG. 11

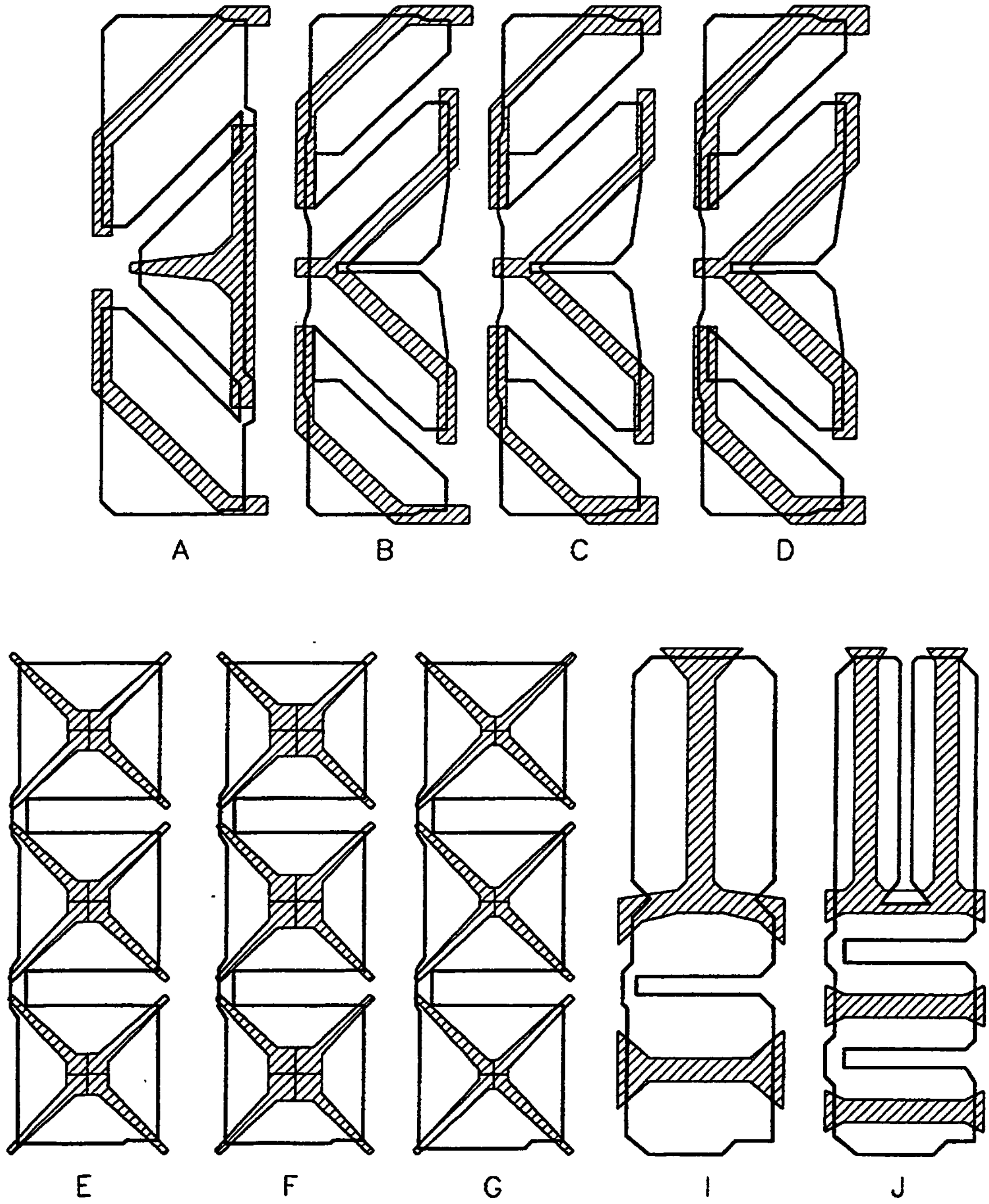


FIG. 12A

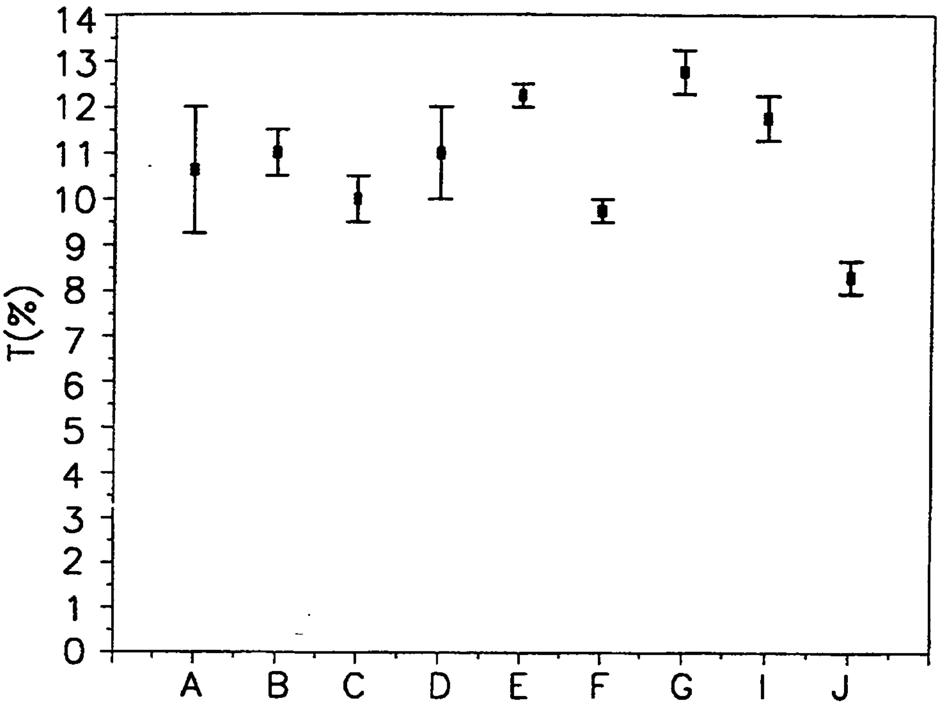


FIG. 12B

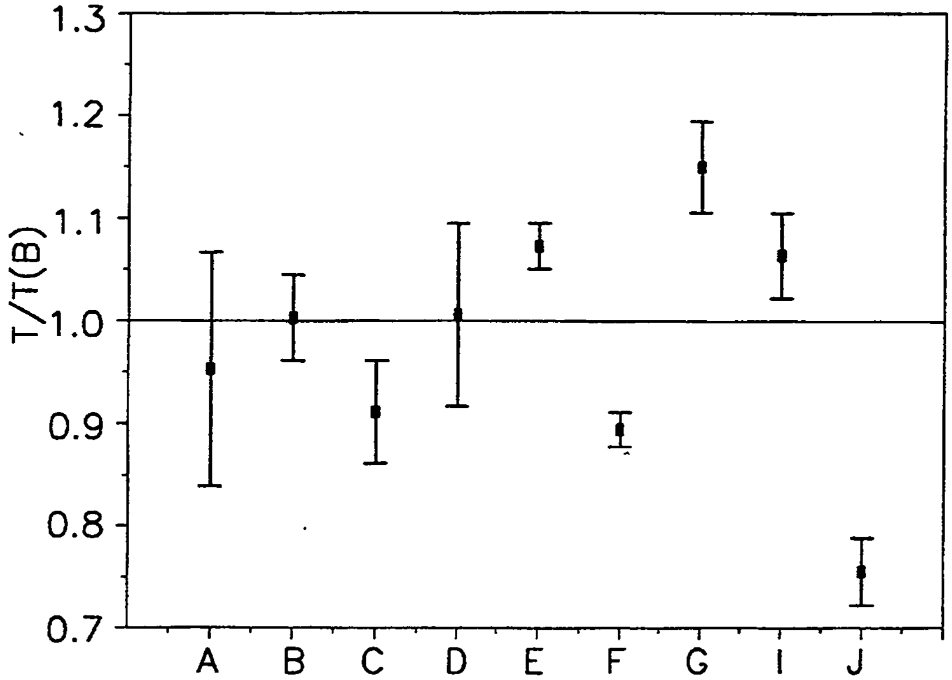


FIG. 13

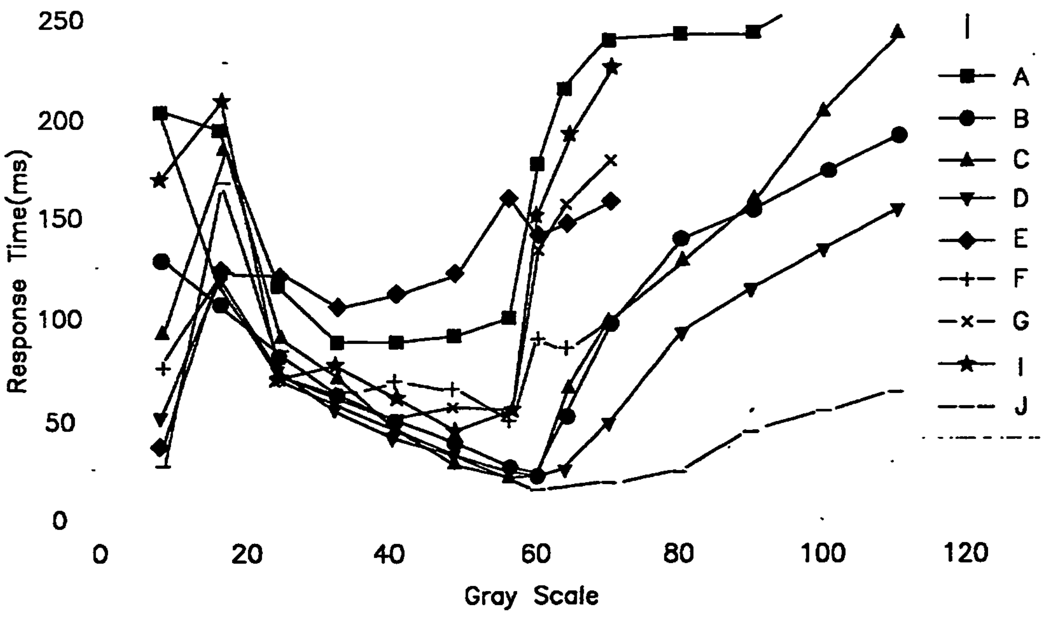


FIG. 14

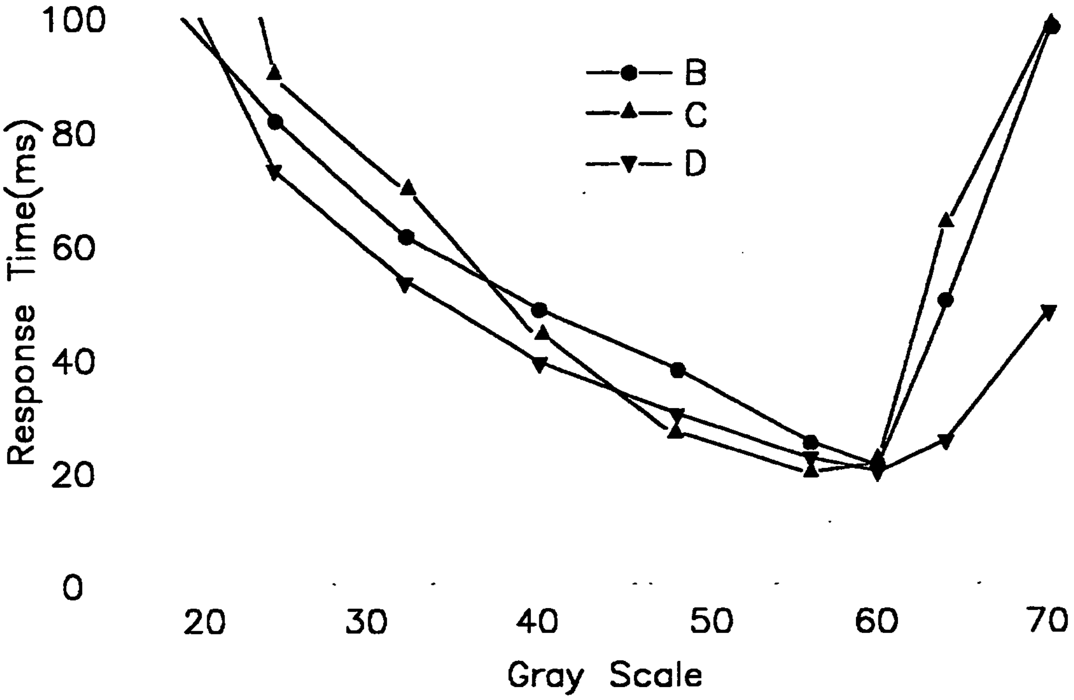
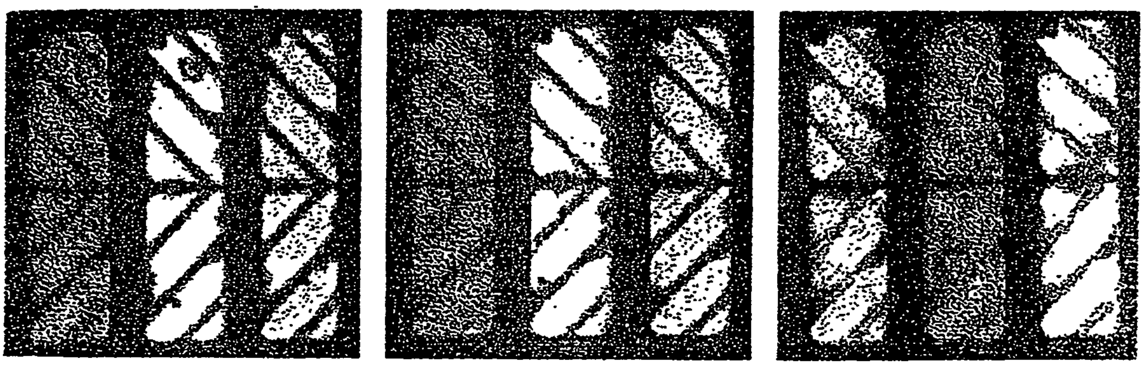
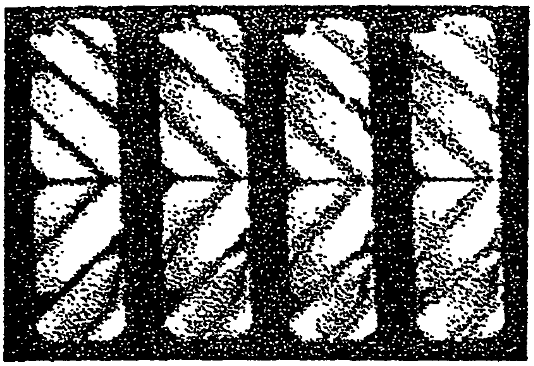


FIG. 15

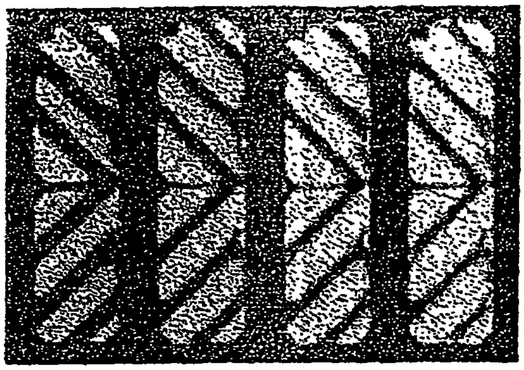


(A) C Pattern(width:7um) (B) B Pattern(width:10um) (C) D Pattern(width:13um)

FIG.16



(A) C Pattern:3V-> 3.5V -> 4V -> 5V



(B) D Pattern:3V-> 3.5V-> 4V-> 5V

FIG. 17A

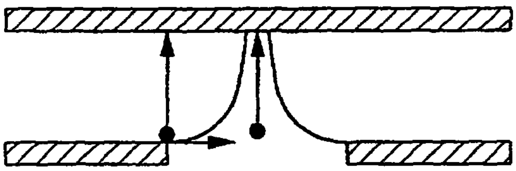


FIG. 17B

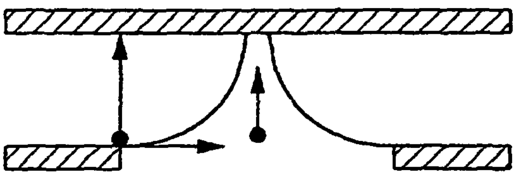
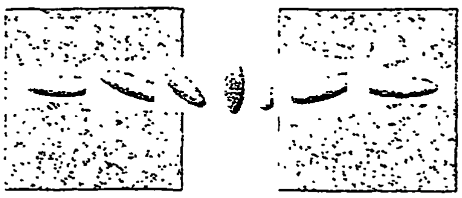
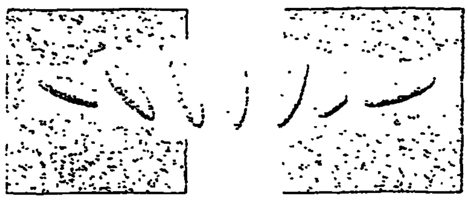


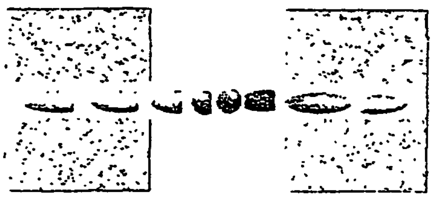
FIG.18



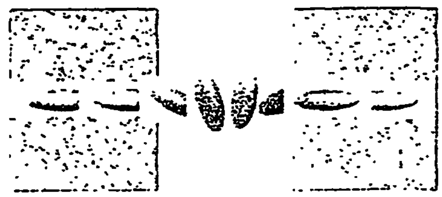
(A) Small Width, Low Voltage



(A) Small Width, High Voltage



(C) Large Width, Low Voltage



(D) Large Width, High Voltage

FIG. 19

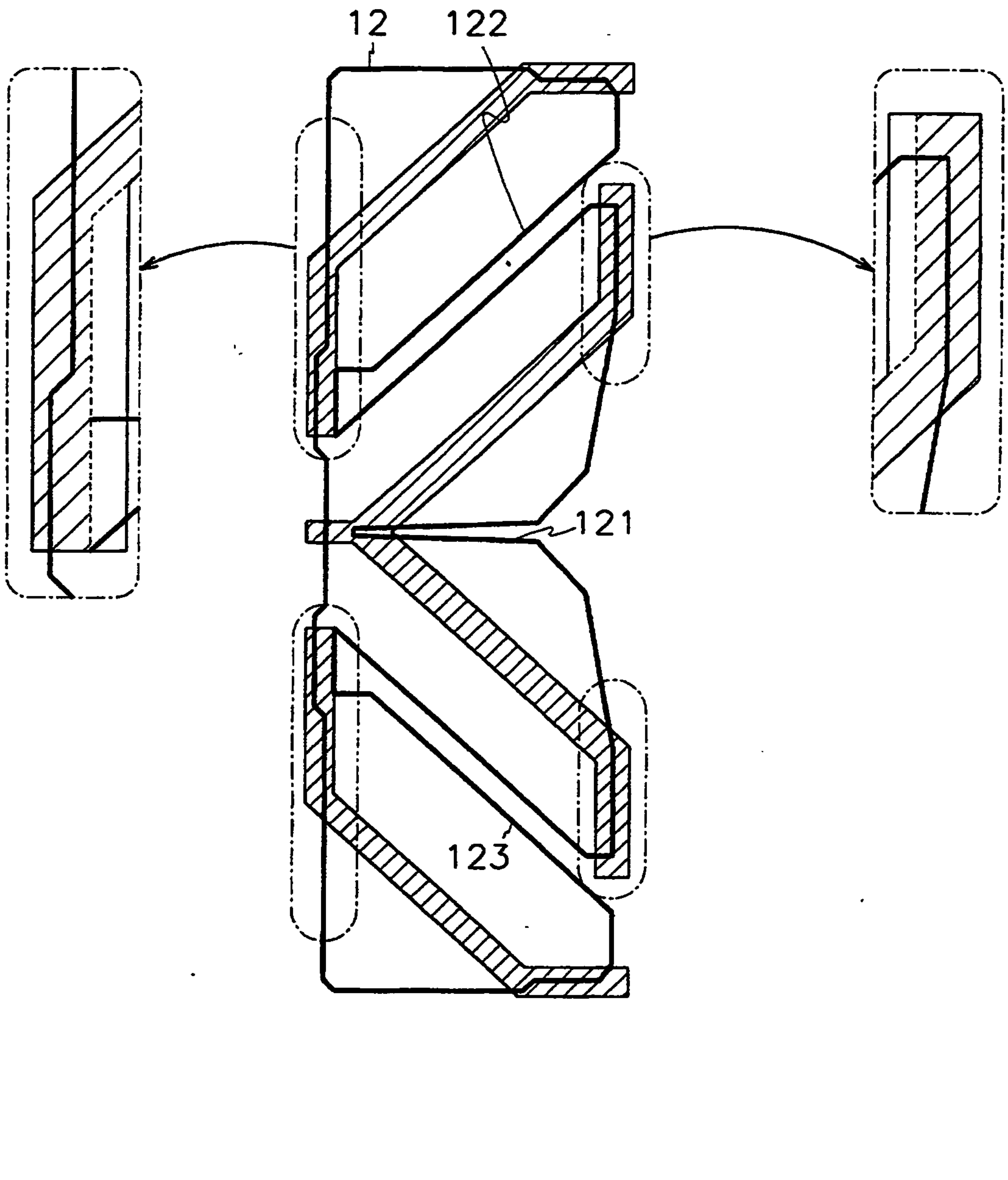


FIG. 20

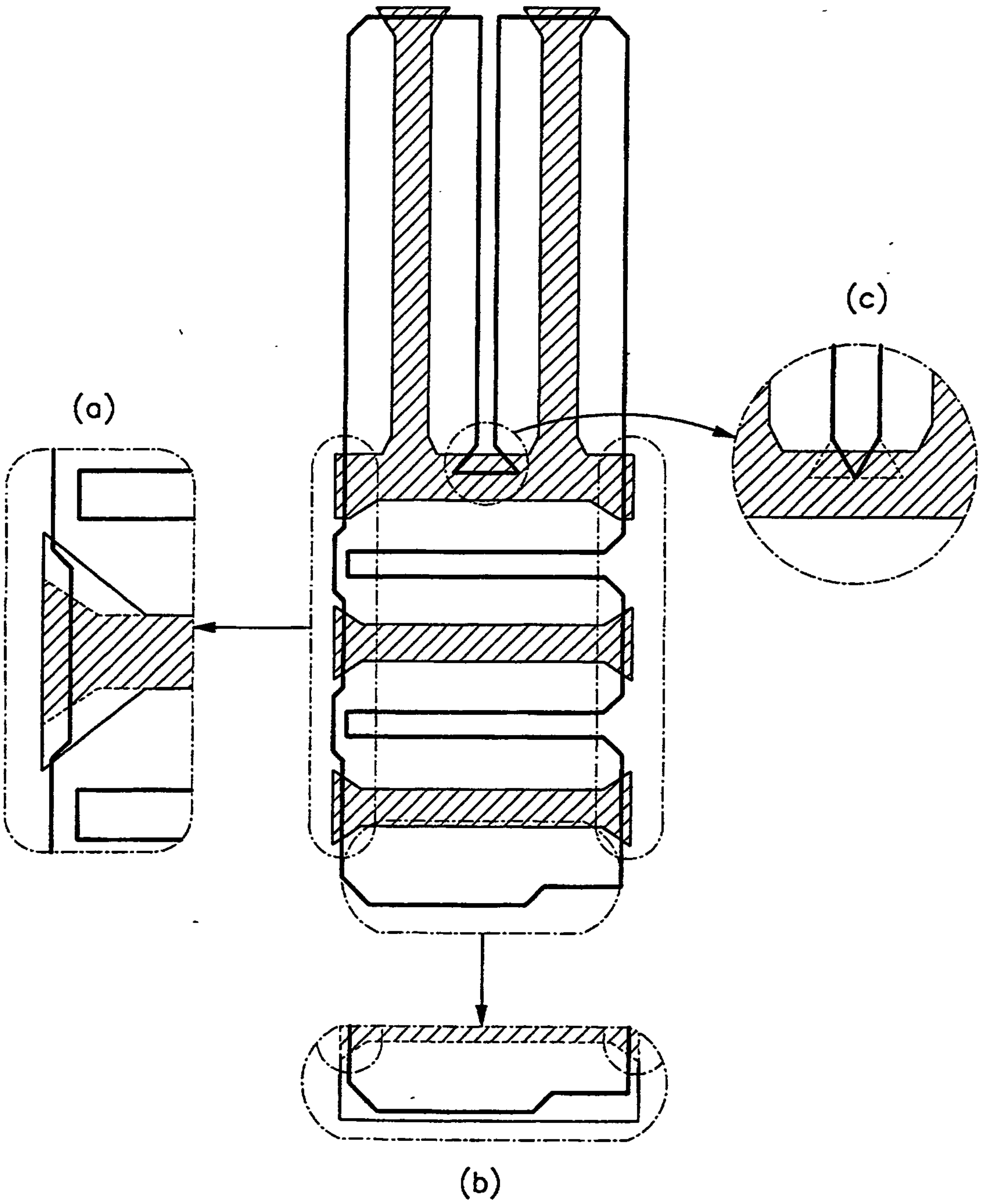


FIG. 21A

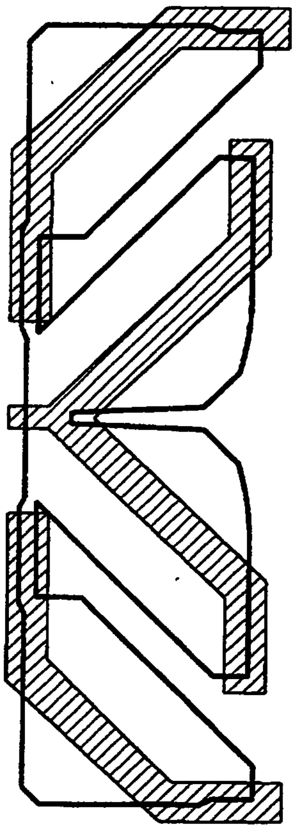


FIG. 21B

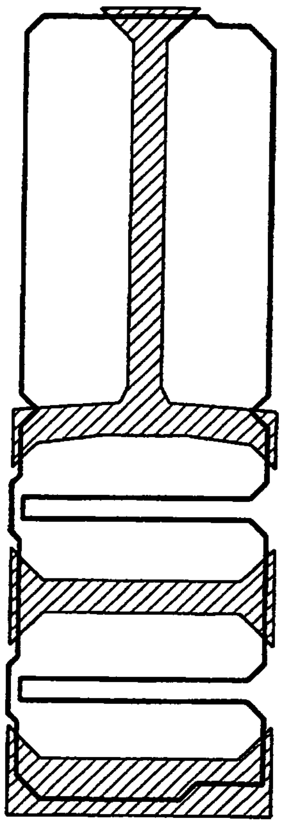
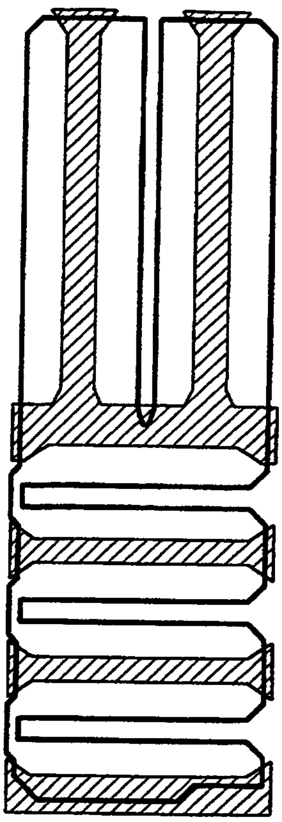


FIG. 21C



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 0884626 A **[0010]**

专利名称(译)	液晶显示器		
公开(公告)号	EP1091238B1	公开(公告)日	2012-09-26
申请号	EP2000110292	申请日	2000-05-23
[标]申请(专利权)人(译)	三星电子株式会社		
申请(专利权)人(译)	SAMSUNG ELECTRONICS CO. , LTD.		
当前申请(专利权)人(译)	三星DISPLAY CO. , LTD.		
[标]发明人	SONG JANG KUN RYU JAE JIN		
发明人	SONG, JANG-KUN RYU, JAE-JIN		
IPC分类号	G02F1/1343 G02F1/1333 G02F1/139 G02F1/13 G02F1/1337 G02F1/1335 G02F1/136		
CPC分类号	G02F1/134309 G02F1/133707 G02F1/134336 G02F1/1393 G02F2001/13373 G02F2001/133742 G02F2001/134318 G02F2001/134345 G02F2001/134372 G02F2201/123		
优先权	1019990042216 1999-10-01 KR		
其他公开文献	EP1091238A2 EP1091238A3		
外部链接	Espacenet		

摘要(译)

液晶显示器包括具有顶表面和底表面的第一绝缘基板。像素电极形成在第一绝缘基板的顶表面上。像素电极（12）在每个像素区域具有第一开口图案（122,121,123）。具有第一开口图案的像素电极的形状基本上为矩形，具有第一和第二长边，以及第一和第二短边。像素电极被划分为由第一和第二长边和第一短边限定的上部区域，以及由第一和第二长边以及第二短边限定的下部区域。具有顶表面和底表面的第二绝缘基板平行于第一绝缘基板布置，与第一绝缘基板相距预定距离，使得第二绝缘基板的底表面面对第一绝缘基板的顶表面。公共电极（23）形成在第二绝缘基板的底表面上。公共电极在每个像素区域具有第二开口图案（220,210,230），其对应于像素电极的每个像素区域。在接触像素和公共电极的同时，液晶层夹在第一和第二基板之间。第一开口图案和第二开口图案均具有多个开口，第一开口图案和第二开口图案的开口彼此平行地交替布置。

FIG. 1

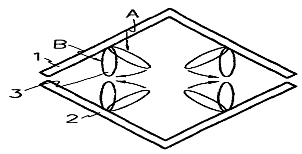

FIG. 2