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(54) **Transverse electric-field type liquid crystal display device, process of manufacturing the same, and scan-exposing device**

Flüssigkristallanzeige mit transversalem elektrischen Feld, deren Herstellungsverfahren und Vorrichtung zur Abtastbelichtung

Dispositif d'affichage à cristal liquide avec champs électrique transversal, son procédé de fabrication et dispositif d'exposition par balayage

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a liquid crystal display device of transverse electric-field type which is available at a relatively low cost and which permits high-quality displaying of images on a wide screen with a wide field of view -or a large angle of visibility. The present invention is further concerned with a process of manufacturing such a liquid crystal display device, and a scan-exposing device used in the process of manufacture.

Discussion of Related Art

[0002] JP-A-2000-066240 (Laid-open Publication of Japanese Patent Application) discloses a halftone exposure technique effective to reduce the required number of steps in a photomasking process in the manufacture of a liquid crystal display device of active matrix type. The halftone exposure technique disclosed in this publication uses a slit-type photomask 70 which has slits 73 formed in its local portions, as shown in Fig. 1. The locally formed slots 73 serve to adjust an average amount of exposure of an active matrix substrate 9 to a light generated by an exposing device, for forming a first pattern of a resist on a portion of the substrate 9 which corresponds to a channel portion of a thin-film transistor. The first pattern of resist has a positive resist portion 6 having a relatively large thickness and a positive resist portion 7 having a smaller thickness than that of the positive resist portion 6. Then, an etching operation is performed on the substrate 9 so that only those portions of semiconductor layers 10, 11, a barrier metal layer 12 and a low-resistance metal layer 13 which underlie the positive resist portions 6, 7 of the first resist pattern are left, whereby the semiconductor layers 10, 11 are formed into semiconductor elements. The thickness of the positive resist portions 6, 7 are then reduced by an ashing operation, so that the positive resist portion 7 in the area corresponding to the channel portion of the thin-film transistor element is removed, with a result of formation of a second resist pattern which consists of only the positive resist portions 6. The channel portion of the thin-film transistor element is formed by etching using the second resist pattern. According to the halftone exposure technique disclosed in JP-A-2000-066240 described above, a single photomasking step permits formation of the semiconductor layers into the semiconductor elements, and formation of the channel portion of the thin-film transistor element. Accordingly, the halftone exposure technique makes it possible to reduce the required number of the photomasks, and considerably lower the cost of manufacture of the active matrix substrate, as compared with the conventional photomasking technique. The halftone exposure technique of JP-A-200-066240 is shown in Fig. 22.

[0003] Where the halftone exposure technique as disclosed in JP-A-2000-066240 is used to form the channel portion of the thin-film transistor element, however, the formed channel portion of the thin-film transistor element tends to have a relatively large amount of variation in its dimensional accuracy, leading to instability factors in mass production of a product including the thin-film transistor elements. Further, a variation in the amount of overlapping between a gate electrode and source and drain electrodes causes a display variation in the halftone area, giving rise to a problem of reduction in the yield ratio of the active matrix substrate.

SUMMARY OF THE INVENTION

[0004] It is therefore a first object of the present invention to provide a process which permits economical high-yield manufacture of a liquid crystal display device of transverse electric-field type which has a considerably large size and a considerably wide field of view. A second object of the invention is to provide such a liquid crystal display device. A third object of the invention is to provide a scan-exposing device used in the process of manufacture according to the present invention.

[0005] The object is attained by a method according to claim 1. Further developments of the invention are specified in the dependent claims, respectively.

[0006] In the process of manufacturing a liquid crystal display device of transverse electric-field type, the halftone exposing step is implemented to form (i) the first positive resist portions which have the first thickness and which cover the portions of the semiconductor layer which correspond to the thin-film transistor elements, (ii) the resist-free areas covering the portions of the semiconductor layer which correspond to the first connecting portion provided to form the first static-electricity protective. transistor elements connecting the common electrodes and the scanning lines, the second connecting portion provided to form the second static-electricity protective transistor elements connecting the common electrodes and the image-signal wires, and the third connecting portion connecting the external scanning-line driver circuit and the scanning-line terminal portions, and (iii) the second positive resist portions which have a second thickness smaller than the first thickness and which cover the other portions of the semiconductor layer. Accordingly, the portions of the semiconductor layer corresponding to the first, second and third connecting portions are first removed by subjecting the substrate with the semiconductor layer to an etching operation, and then the second resist portions having the second thickness are removed by subjecting the first and second positive resist portions to an ashing operation, for example, so that the semiconductor layers are formed into semiconductor elements.

[0007] While the concept of the present invention is similar to that disclosed in the above-identified publication JP-A-2000-066240 in that both of these concepts utilize the halftone exposure technique to reduce the requir3d number of the photomask. However, the portions of the semiconductor layer on which the seconde positive resist portions having the second thickness smaller than the first thickness are formed according to the present invention are different from those according to the technique in JP-A-2000-066240.

[0008] In the process according to the present invention the halftone exposing step can be implemented without using a special photomask as used in the process disclosed in JP-A-2000-066240. While the conventional mass production of the liquid crystal display device using the halftone exposure requires the use of a photomask having a high degree of dimensional accuracy, the process according to the second or third preferred form of the process of the invention does not require the use of such a photomask to implement the halftone exposure, and therefore increases the freedom in the design of the photomask to be used, resulting in a considerable reduction in the cost of manufacture of the photomask.

[0009] Preferably, the first positive resist portions having the first thickness are formed with the fully light-shielding area of the photomask preventing the ultraviolet radiation from exposing the portions of the semiconductor layer which correspond to the thin-film transistor elements, and the second positive resist portions having the second thickness smaller than the first thickness are formed with the fully light-transmitting area of the photomask permitting the ultraviolet radiation to expose the other portions of the semiconductor layer, while at the same time the resist-free areas are formed by exposing portions of the photoresist covering the portions of the semiconductor layer corresponding to the first, second and third connecting portions, to the respective spot lights of the condensed ultraviolet radiation. This process permits efficient formation of the first and second positive resist portions having the respective first and second thickness values and the resist-free areas, resulting in a significant improvement in the efficiency of manufacture of the liquid crystal display device.

[0010] In the preferred form, the width of the third connecting portion is made larger than those of the first and second connecting portions, so that the contact resistance at the third connecting portion connecting the external scanning-line driver circuit and the scanning-line terminal portions can be lowered to minimize a variation in the horizontal stripes on the screen of the display device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The above and other objects, features, advantages and technical and industrial significance of the present invention will be better understood by reading the following detailed description of presently preferred embodiments of the invention, when considered in connection with the accompanying drawings, in which:

Fig. 1 is an elevational view in cross section showing a halftone photomask and a photoresist layer after development, in the prior art;
Fig. 2 is an elevational view in cross section showing a halftone photomask and a photoresist layer after development, according to a first embodiment of the present invention;
Fig. 3 is a flow chart illustrating a photomasking process according to the first embodiment;
Fig. 4 is a flow chart illustrating a photomasking process according to a second embodiment of the present invention;
Fig. 5 is a circuit diagram depicting a static-electricity protective transistor element according to the present invention;
Fig. 6 is a circuit diagram depicting a static-electricity protective transistor element according to the invention;
Fig. 7 is a plan view of a static-electricity protective transistor element according to the present invention;
Fig. 8 is a plan view of a static-electricity protective transistor element according to the present invention;
Fig. 9 is a plan view of a static-electricity protective transistor element according to the present invention;
Fig. 10 is a plan view of a static-electricity protective transistor element according to the present invention;
Fig. 11A through Fig. 11F are elevational views in cross section of an active matrix substrate, explaining a halftone exposing step according to the first embodiments
Figs. 12A, 12B and 12C are elevational views in cross section showing a combination exposure process and a photoresist layer after the development, according to a second embodiment of the invention
Fig. 13 is a plan view of a static-electricity protective transistor element formed in the combination exposing step according to the second embodiment;
Fig. 14 is a plan view of a static-electricity protective transistor element also formed according to the second embodiment;
Fig. 15A through Fig. 15E are elevational views in cross section of an active matrix substrate, explaining the halftone

exposing step according to the second embodiment;

Fig. 16 is a plan view of an active matrix substrate of transverse electric-field type produced in the halftone exposing step according to the second embodiment;

Fig. 17 is a plan view of a scan-exposing device used to effect a halftone exposing step according to a third embodiment of the present invention;

Fig. 18 is a plan view of a scan-exposing device used to effect a halftone exposing step according to a fourth embodiment of the invention;

Fig. 19 is a flow chart illustrating a feedback control used to effect the halftone exposing step of the present invention;

Fig. 20 is a view showing an optical principle of a white light interferomter used according to the present invention, for measuring steps between positive resists having a first and a second thickness and an areas not coated with a positive resist;

Fig. 21 is a plane view of an active matrix substrate of transverse electric-field type produced in the halftone exposing step according to the second embodiment;

Fig. 22 is a flow chart illustrating a photomasking process utilizing a conventional halftone exposing step;

Fig. 23 is an elevational view in cross section showing a scan-exposing device used to effect a halftone exposing step according to a fifth embodiment of the present invention; and

Fig. 24 is an elevational view in cross section of a scan-exposing step used to effect a halftone exposing step according to a sixth embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] A first embodiment of this invention will be described. In the first embodiment, a halftone photomask 60 as shown in the cross sectional view of Fig. 1 is used in a halftone exposing step. The halftone photomask 60 includes a photomask substrate 1 (quartz glass), and a photomask metal 62 and a semi-light-transmitting portion 64 which are formed on the substrate 1. The photomask metal 62 provides the halftone photomask 60 with a fully light-shielding area (fully light-blocking area), while a portion of the semi-light-transmitting portion 64 which is not held in contact with the photomask metal 62 provides the halftone photomask 60 with a semi-light-transmitting area. The halftone photomask 60 has a fully light-transmitting area 65 in which the semi-light-transmitting portion 64 is not formed.

[0013] There will next be described the halftone exposing step. Figs. 11A through 11B are cross sectional views of an active matrix substrate, for explaining the halftone exposing step. Fig. 11A shows a resist pattern formed on the active matrix substrate 9, by using the halftone photomask 60 described above. This resist pattern includes a positive resist portion 6 which has a predetermined first thickness and which is prevented by the fully light-shielding area of the halftone photomask 60 from being exposed to a ultraviolet radiation. This positive resist portion 6 covers a portion of the active matrix substrate 9 at which a thin-film transistor element 58 is formed so as to be superposed on a gate electrode 55. The resist pattern further has a resist-free area 8 which is not provided with any positive resist portion and which corresponds to the fully light-transmitting area 65 of the halftone photomask 60 that permits full transmission of the ultraviolet radiation therethrough. This resist-free area 8 covers a portion of the active matrix substrate 9 at which there is formed a third connecting portion in the form of a contact hole 59 which connects an external scanning-line driver circuit (not shown) and a scanning-line terminal portion 19 through a junction electrode 21. The resist pattern formed in the step shown in Fig. 11A further has other resist-free areas covering a first connecting portion and a connecting portion in the form of contact holes 18 (shown in Fig. 7) for forming static-electricity protective transistor elements 42 (shown in Fig. 7). As also shown in Fig. 11A, the resist pattern further includes a positive resist portion 7 which has a second thickness smaller than the first thickness of the positive resist portion 6 and which is the portion other than the positive resist portion 6 and the resist-free area 8.

[0014] Then, the active matrix substrate 9 is subjected to an etching operation, so as to remove portions of semiconductor layers 10, 11, a barrier metal layer 12 and a low-resistance metal layer 13, which portions correspond to the resist-free area 8 of the resist pattern. As a result, the contact hole 59 is formed. Subsequently, the resist pattern is entirely subjected to an ashing operation, for example, to remove the positive resist portion 7 having the second thickness. Fig. 11B shows the active matrix substrate 9 after the etching and ashing operations.

[0015] Then, the substrate 9 is subjected to an etching operation, to remove portions of the semiconductor layers 10, 11, barrier metal layer 12 and low-resistance metal layer 13, which portions are not covered by the positive resist portion 6. As a result, the portions of the semiconductor layers 10, 11 which are left are formed into semiconductor elements. Fig. 11C shows the step in which the semiconductor layers 10, 11 on the active matrix substrate 9 are formed into the semiconductor elements.

[0016] Referring next to the flow chart of Fig. 3, there is illustrated a photomasking process performed in a process of manufacturing a liquid crystal display device of transverse electric-field type according to the first embodiment of the invention. In a first photomasking step 140, a positive resist is first formed on portions of the substrate 9 which correspond to the gate electrode 55 and a common electrode 20. In a second photomasking step 141, the positive resist portion 6 is formed on a portion of the substrate 9 corresponding to the thin-film transistor element 58, and the resist-free area 8 are formed on portions of the substrate 9 which correspond to the contact holes 18, 59, while the positive resist portion 7 is formed on the other portion of the substrate 9. The second photomasking step 141 is a halftone exposing step according to the present invention. In a third photomasking step 142, a positive resist is formed on portions of the substrate 9 which correspond to a source electrode 54, a drain electrode 56 and a picture-element electrode 22. In a fourth photomasking step 143, a positive resist is formed for forming a contact hole 24 at the scanning-line terminal portion 19, shown in Fig. 11F, and contact holes at image-signal-wire terminal portions 34 (Fig. 16).

[0017] Referring to the circuit diagrams of Figs. 5 and 6, there are shown circuits of the static-electricity protective transistor elements 42 used in the present invention. However, these circuits may be replaced by any other circuits, depending upon the desired function of the circuits. The plan views of Figs. 7-10 show the circuits of the static-electricity protective transistor elements 42 formed in the process of the invention.

[0018] In the conventional halftone exposing step disclosed in JP-A-2000-066240 uses the slit type photomask 70 as shown in Fig. 1. The slit type photomask 70 has a photomask metal 72, and a slit area having slits 73 which are formed so as to reduce the average amount of transmission of ultraviolet radiation through the slit area, so that a portion of the substrate 9 at which the channel portion of the thin-film transistor element is to be formed is provided with a positive resist portion having a smaller thickness than a positive resist portion formed at a portion of the substrate 9 which corresponds to the photomask metal 72. Thus, the use of the single photomask 70 permits formation of the semiconductor layers 10, 11 into semiconductor elements, and formation of the channel portion of the thin-film transistor element. In the prior art disclosed in JP-A-2000-066240, the active matrix substrate 9 is manufactured in a photomasking process illustrated in the flow chart of Fig: 22. However, the conventional photomasking process according to JP-A-2000-066240 suffers from a low degree of accuracy in the length of the channel portion, giving rise to a problem of a relatively large amount of variation in the characteristic of the thin-film transistor element.

[0019] Unlike the technique disclosed in JP-A-2000-066240, the process according to the present enibodiment is not formulated to form the channel portion of the thin-film transistor element in the halftone exposing step. In the present first embodiment, the channel portion 57 of the thin-film transistor element 58 is formed in the step of Fig. 11D, only after the semiconductor layers 10, 11 are formed into the semiconductor elements in the step of Fig. 11C. Therefore, the present process suffers from substantially no variation in the length of the channel portion 57 of the thin-film transistor element 58, and an extremely small amount of variation in the surface area at the portion of overlapping of the gate electrode 55, source electrode 54 and drain electrode 56. Accordingly, the present process makes it possible to minimize the amount of variation in the characteristic of the thin-film transistor element 58, assuring stable mass production of a product including the thin-film transistor element 58.

[0020] In the present first embodiment illustrated in Figs. 11A-11F, the active matrix substrate 9 can be manufactured by using metallic materials for forming two kinds of electrodes for the scanning lines and the image-signal wires, so that the cost of manufacture of the substrate 9 can be reduced. Although the substrate 9 subjected to the halftone exposing step may have a variation in its dimensional accuracy, this variation which may occur in the first embodiment does not have an adverse influence on the characteristic of the thin-film transistor element, making it possible to prevent reduction in the yield ratio of a liquid crystal display device manufactured in the present process, even if the display device has a large-sized screen. Further, the common electrode 20 and the picture-element electrode 22 are entirely covered by a passivation film 23, as shown in Fig. 11E, making it possible to minimize generation of an after-image phenomenon.

[0021] There will be described a second embodiment of this invention. Aspects of the second embodiment which are similar to those of the first embodiment will not be described. The plan views of Figs. 16 and 21 show active matrix substrates of transverse electric-field type manufactured by a process of manufacture according to the present second embodiment. The second embodiment does not use the slit type photomask 70 shown in Fig. 1, or the halftone photomask 6 used in the first embodiment.

[0022] A halftone exposing step in the second embodiment will be described. The cross sectional views of Figs. 12A, 12B and 12C show the active matrix substrate 9, for explaining the halftone exposing step. The active matrix substrate 9 is exposed to a ultraviolet radiation 25 through a photomask 80 shown in Fig. 12A. The photomask 80 includes a photomask metal 82 formed on the photomask substrate 1. The irradiation energy density of the ultraviolet radiation 25 is lowered than in an ordinary exposing step, so that only a portion of the thickness of a photoresist exposed to the ultraviolet radiation 25 is removed. The photomask metal 82 which functions as a fully light-shielding area contains Cr or Mo, and the photomask substrate 1 has a fully light-transmitting area 85. Fig. 12A shows a non-exposed portion 26 of the photoresist which corresponds to the photomask metal 82, and an exposed portion 27 of the photoresist which corresponds to the fully light-transmitting area 85.

[0023] In the next step shown in Fig. 12B, an area 29 of the exposed portion 27 in which contact grooves 91, 92, 93 (which will be described by reference to Figs. 13, 14 and 16) are to be formed is exposed to the ultraviolet radiation 25 which has been condensed by spot scan-exposing means in the form of a UV condenser lens 28. As a result, the area 29 of the exposed portion 27 of the positive resist is removed, and the substrate 9 is provided with a resist-free area 32 for the contact grooves 91-93, as shown in Fig. 12C and Fig. 15A.

[0024] Fig. 12C shows the positive resist 6 after the development following the exposure in the two steps shown in Figs. 12A and 12B. These two steps, namely, overall photomask scan exposure of the substrate 9 to the ultraviolet radiation whose irradiation energy density is lowered as described above, and spot scan exposure of the area 29 to spot lights of the condensed ultraviolet radiation 25 may be implemented by respective different devices. However, the halftone exposing process may be implemented by a single device such as scan-exposing devices 100, 110, 120, 130, which will be described.

[0025] In the second embodiment described above, the ultraviolet radiation 25 is condensed into a spot light for irradiating the area 29 of the positive resist to form the resist-free area 32 of the substrate 9. However, another photomask other than the photomask 80 may be used to expose the substrate 9, so as to form the resist-free area 32. In this case, the exposure must be conducted by using the two photomasks, so that the required exposure time is undesirably increased due to a change of the photomask. Nevertheless, this alternative exposure method is suitable where the substrate 9 is provided with a large number of contact holes.

[0026] Where an active matrix substrate having a considerable length larger than 40 inches is exposed, in particular, a single large one-piece photomask must be used to expose such a large substrate, since it is difficult to implement the halftone exposing step by using two or more photomasks which are joined together. Namely, it is difficult to suitable join the two or more photomasks into a mask assembly Where the photomask has a length of 40 inches or more, it takes a considerable time to change the photomask, resulting in a considerable reduction in the throughput. The throughput can be appreciably improved by implementing a combination exposure process in which the photomask exposure and the spot scan exposure may be effected independently of each other by a single device such as the scan-exposing devices 100, 110, 120, 130, which incorporates means for effecting photomask scan exposure using a photomask, and means for effecting spot scan exposure using condensed spot lights. It is also noted that the photomask scan exposure using the photomask as shown in Fig. 12A and the spot scan exposure shown in Fig. 12B may be effected concurrently, so as to maximize the efficiency of the halftone exposing process in the second embodiment.

[0027] The plan views of Figs. 13 and 14 show the static-electricity protective transistor elements 42 formed by the combination exposure process. The contact groove 91 serving as the first connecting portion, and the contact groove 92 serving as the second connecting portion are formed by spot scan-exposing means. The plan view of Figs. 16 and 21 show active matrix substrates of transverse electric-field type manufactured by the process of the second embodiment. These substrates have a static-electricity protective circuit 102 consisting of a single static-electricity protective transistor element 42 or a plurality of static-electricity protective transistor elements. The contact groove 93 serving as the third connecting portion has a width L_3 larger than widths L_1 and L_2 of the first and second connecting portions, that is, the contact grooves 91 and 92 of the terminal portions of the static-electricity protective transistor elements 42. Namely, the widths L1-L3 are determined so as to satisfy the following equation (1), which is formulated to minimize the contact resistance of the terminal portions of the scanning lines, for preventing a variation in the horizontal stripes on the screen of the display device.

$$L_1 = L_2 = (1 \cdot x) \times L_3 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

wherein the value "x" is equal to or larger than 1/100, and is equal to or smaller than 1/2.

[0028] The cross sectional views of Figs. 15A-15E show the active matrix substrate 9, for explaining three photomasking steps in the combination exposure according to the second embodiment. As in the first embodiment, the channel portion 57 of the thin-film transistor element 58 is not formed in the halftone exposing step, so that the length of the channel portion 57 has substantially no variation, making it possible to minimize a display variation due to a variation in the characteristic of the thin-film transistor element 58.

[0029] After the halftone exposing step, the source electrode 54 and the drain electrode 56 are formed, as shown in Fig. 15D, by removing by dry etching an n^+ layer which is formed by doping an ohmit contact layer in the form of the semiconductor layer 11 with phosphor.

[0030] Then, a passivation step in the second embodiment will be described. In the passivation step, the surface of the channel portion 57 is subjected to a plasma doping treatment in a hydrogen or nitrogen atmosphere containing a diborane (B_2H_6) gas, and the surface is then coated with a transparent flattening film 33 formed of BCB (benzocyclo butene) or polyphenyl silazane, as shown in Fig. 15E, by ink-jet printing, flexible printing, or any other suitable printing method. The transparent flattening film 33 has a thickness ranging from about 0.2μm (2000A) to about 0.6μm (6000A). This transparent flattening film 33 may be replaced by a polyimide film, which is usually used as an orientation film coated on an active matrix substrate. In this case, the polyimide film functions not only as a flattening film but also as an orientation film.

[0031] If the passivation step described above were not implemented, that is, if the substrate were not subjected to "back channel doping" wherein the surface of the channel portion 57 is subjected to the plasma doping treatment in the hydrogen or nitrogen gas containing the diborane (B_2H_6) gas, the thin-film transistor element 58 would not exhibit a high degree of reliability for a long period of time. If the back channel doping cannot be implemented for some reason or other, the contact groove may be formed by first forming a silicone nitriding film having a thickness from about 0.2μm (2000A) to about 0.4μm (4000A), by plasma CVD, then applying a positive resist to the thus formed film, subjecting only the terminal portions of the scanning-line terminal portion 19 and the static-electricity protective transistor elements 42 to a spot scan-exposing operation, and after the development, implementing a dry etching operation so as to form the contact groove.

[0032] Referring to the flow chart of Fig. 4, there is illustrated the photomasking steps in the process of manufacture of a liquid crystal display device of transverse electric-field type according to the second embodiment of the invention. In a first photomasking step 150, a positive resist is applied to portions of the substrate 9 which correspond to the gate electrode 55 and the common electrode 20. In a second photomasking step 151, the positive resist portion 6 is formed on a portion of the substrate 9 which corresponds to the thin-film transistor element 58, and the resist-free area 32 is formed on portions of the substrate 9 which correspond to the contact grooves 91, 92, 93, while a positive resist portion 30 is formed on the other portions of the substrate 9, as shown in Fig. 15A. The second photomasking step 151 is the halftone exposing step in the second embodiment. In a third photomasking step 152, a positive resist is applied to portions of the substrate 9 which correspond to the source electrode 54, drain electrode 56 and picture-element electrode 22. In a passivation step 153, the back channel portion of the thin-film transistor element 58 is subjected to the plasma doping treatment using a B_2H_6 gas, and is then coated with a layer of BCB, polyphenyl silazane or an organic material by ink-jet coating or flexo graphic printing method.

[0033] According to the second embodiment, the active matrix substrate 9 can be manufactured by only three photomasking steps, making it possible to considerably reduce the required number of process steps.

[0034] There will next be described a third embodiment of this invention. The plan view of Fig. 17 shows the scan-exposing device 100 used in the third embodiment. The scan-exposing device 100 is a multiple-lens type scan-exposing device including: an XY slide 37 which is arranged to hold a glass substrate and movable in the X-axis and Y-axis directions; a photomask substrate 36 which is movable in the Y-axis direction only; and a projection optical system 39. The scan-exposing device 100 includes a spot scan-exposing optical system in the form of stationary spot scan-exposing modules 40, so that the spot scan exposure by the spot scan-exposing means using the spot scan-exposing modules 40 can be implemented after the photomask scan exposure by the photomask scan-exposing means using the photomask substrate 36. The spot scan exposure is effected with a spot size ranging from about 0.1mm to about 0.5mm.

[0035] The scan-exposing device 110 shown in the plane view of Fig. 18 is used in a fourth embodiment of this invention. This scan-exposing device 110 includes a Y-axis slide 38 which is movable in the Y-axis direction only, a projection optical system 39, and a spot scan-exposing optical system in the form of a spot scan-exposing optical module 41 which is movable in the X-taxis only. In this scan-exposing device 110, the spot scan exposure using the spot scan-exposing optical module 41 is effected in the Y-axis direction with a spot size ranging from about 0.1mm to about 0.5mm, while the photomask scan exposure using the photomask substrate 36 is effected in the Y-axis direction. After the photomask scan exposure in the Y-axis direction by the photomask scan-exposing means using the photomask substrate 36 is effected over the entire surface of the substrate, the spot scan exposure by the spot scan-exposing means using the spot scan-exposing optical module 41 is effected in the X-axis direction.

[0036] Where a 60-inch active matrix liquid crystal display device is manufactured, there may arise an undesirable problem of deflection of a quartz photomask substrate due to its own weight. One considered solution to this problem of deflection of the photomask substrate is to dispose the quartz photomask substrate so as to extend in the longitudinal direction. Where the glass substrate is extremely large, the weight of the slide is accordingly large, and the slide cannot be smoothly moved.

[0037] The scan-exposing device 120 used in a fifth embodiment of the invention is shown in the cross sectional view of Fig. 23. This scan-exposing device 120 includes a UV source 43 which is operable to generate the ultraviolet radiation and which is disposed on one of opposite sides of the quartz photomask substrate 36; non-contact type chucks in the form of Bernoulli chucks 45 which are disposed on the same side of the quartz photomask substrate 36 and which are operable to control local vertical positions of the photomask substrate 36, so as to reduce the amount of deflection of the substrate 36 due to its own weight; and red-laser displacement meters or gages 44 operable to measure a vertical displacement of the quartz photomask substrate 36, at its surface on the side of the Bernoulli chucks 45. The scan-exposing device 120 thus constructed is capable of exposing a glass substrate 49 (active matrix substrate), while compensating for the deflection of the quartz photomask substrate 36 due to its own weight, namely, while accurately controlling the position of the substrate 36 as held by the Bernoulli chucks 45, on the basis of the displacement measured by the red-laser displacement meters 44. To this end, a suitable substrate-position control device is provided to control the Bernoulli chucks 45 so as to reduce the amount of deflection of the quartz photomask substrate 36. Referring next to the cross sectional view of Fig. 24, there is shown the scan-exposing device 130 used in a sixth embodiment of this invention, wherein a quartz substrate 76 is disposed in opposition to the quartz photomask substrate 36 such that these substrates 76, 36 cooperate to define therebetween an air-tight space. The scan-exposing device 130 is capable of exposing the glass substrate 49, while compensating for the deflection of the quartz photomask substrate 36 due to its own weight, by controlling the pressure within the enclosed space, which is measured by a pressure sensor 51. To this end, a suitable pressure control device is provided to control the pressure within the air-tight space such that the pressure in the air-tight space is lower than the atmospheric pressure by a suitable difference, so as to reduce the deflection of the substrate 36. The scan-exposing devices 120, 130 eliminate a need of increasing the thickness of the quartz photomask substrate 36 to reduce its amount of deflection, even where the substrate 36 has a large size (e.g., 60 inches), making it possible to reduce the cost of the quartz photomask substrate 36. Further, the devices 120, 130 simplify the manufacture of the photomask substrate, resulting in a further reduction in the cost of manufacture of the quartz photomask substrate.

[0038] As shown in Figs. 23 and 24, the scan-exposing devices 120, 130 include a spot scan-exposing optical module 50 for implementing the spot scan exposure without using the quartz photomask substrate 36. The spot scan-exposing optical module 50 corresponds to the spot scan-exposing optical system, and is interposed between the photomask substrate 36 and the glass substrate 49, so that the glass substrate 49 is subjected to the spot scan exposure to a ultraviolet radiation transmitted through an optical fiber. The width of the spot scan exposure by the optical module 50 can be adjusted as needed. Reference sign 46 in Figs. 23 and 24 denotes a pellicle provided to prevent adhesion of foreign matters to the photomask substrate 36.

[0039] The yield ratio of the liquid crystal display can be improved by: first implementing the photomask scan exposure of the entire surface of the glass substrate 49 to the ultraviolet radiation by the photomask scan-exposing means through the quartz photomask substrate 36, with the density of the ultraviolet radiation being lowered so as to remove only a portion of the thickness of a photoresist 48; and then implementing the spot scan exposure of the glass substrate 49 by the spot scan-exposing means using the spot scan-exposing optical module 50. In the photomask scan exposure to the reduced density of the ultraviolet radiation, the required patterning resolution of the photoresist ranges from about 3μm to about 10μm. In the spot scan exposure, on the other hand, the required photoresist patterning resolution is as low as about 100μm. To improve the yield ratio, therefore, the photomask scan exposure of the glass substrate 49 which requires the higher resolving power must be implemented before dust is deposited on the glass substrate 49.

[0040] The compensation for the deflection of the photomask substrate 36 due to its own weight must be dynamically effected to hold the flatness of the substrate 36 within about $\pm$15μm from the horizontal plane, by using a laser displacement meter or gage or a digital differential pressure gage. The accuracy of the compensation must be changed as needed, depending upon the depth of focus of a projection lens 47 and the required resolving power. The red-laser displacement meters 44 shown in Fig. 23 or any other laser displacement meters may be used as the laser displacement meter.

[0041] In the third through sixth embodiments, the halftone exposure is feedback-controlled according to a feedback control routine illustrated in the flow chart of Fig. 19. This feedback control routine is initiated with step S1 to apply a positive resist coating of 1.5-2.0μm to the glass substrate 49. Step S1 is followed by step S2 to implement the halftone exposure of the glass substrate 49. After the halftone-exposed portion of the positive resist coating is developed in step S3, the control flow goes to step S4 to measure the actual thickness of the halftone-exposed and developed portion of the positive resist coating. Step S4 is followed by step S7 to feedback-control the amount of exposure of the positive resist coasting to the radiation, on the basis of the measured thickness of the halftone-exposed portion of the positive resist coating, so that the measured thickness is held within a predetermined range between about 0.4μm (4000A) and about 0.6μm (6000A). To this end, a suitable feedback control device is provided to feedback-control the amount of exposure of the resist coasting to the radiation. During repeated implementation of steps S2, S3, S4 and S4, step S5 is implemented to determine whether the measured thickness falls within the predetermined range. If an affirmative decision is obtained in step S5, the control flow goes to step S6 to perform a post-braking operation on the glass substrate 49. If the thickness measured a predetermined time after initiation of the feedback control in step S7 considerably deviates from the lower or upper limit of the predetermined range, the positive resist coating is removed from the glass substrate 49, and a positive resist coating is applied again to the glass substrate, and the halftone exposure must be effected again.

[0042] To assure a high degree of reproducibility of the halftone-exposed portion of the positive resist with high uniformity, it is desirable to inspect all of the workpieces of the glass substrate 49 in step S5. This inspection may be made by using film-thickness measuring means such as a laser thickness gage or a laser interferometer. In this specific example, a white light interferometer 68 is used to accurately measure a difference between the actual values of the thicknesses of the non-halftone-exposed portion and the halftone-exposed portion of the positive resist coating. The principle of operation of the white light interferometer 68 is illustrated in Fig. 20. This white light interferometer 68 permits simultaneous measurement of the difference between the first and second thickness values of the above-indicated two positive resist portions, and the second thickness value of the halftone-exposed portion of the positive resist as measured from the surface of the glass substrate 49 (from the resist-free area of the substrate). Accordingly, the required time for the measurement can be reduced.

[0043] The white light interferometer 68 shown in Fig. 20 is simple in operation principle and construction, and has measuring accuracy of about 1nm (10A), and is available at a considerably low cost even where the measuring system is arranged to measure a plurality of points at one time. Further the required measuring time of the white light interferometer 68 is relatively short, it may be used as an in-line inspection device. By feedback-controlling the condition of the photomask scan exposure of the glass substrate 49 on the basis of an output of the white light interferometer 68, the halftone exposure can be effected with a high degree of reproducibility, namely, without a variation in the thickness values of the positive resist pattern formed on the active matrix substrate.

[0044] While the scan-exposing devices 100 and 110 used in the third and fourth embodiments include the projection optical system 39 of multiple lens type, the scan-exposing devices may use a mirror-reflection type optical system.

[0045] The third through sixth embodiments using the scan-exposing devices 100, 110, 120, 130 and the white light interferometer 68 to feedback-control the halftone exposure on the basis of the output of the white light interferometer 68 assure a high degree of reproducibility of the halftone exposure, permitting a significant improvement of the yield ratio of the active matrix substrate. In these embodiments, the overall photomask scan exposure of the active matrix substrate to the reduced density of radiation through the photomask substrate 36 is suitably combined with the spot scan exposure of the active matrix substrate by the spot scan-exposing means, to implement the halftone exposing step which permits a considerable reduction in the variation of the characteristic of the thin-film transistor element, as compared with the conventional halftone exposing step. Thus, the present invention permits economical manufacture of an active matrix element with a high yield ratio, using an inexpensive photomask.

[0046] It is to be understood that the present invention may be embodied with various other changes, modifications and improvements, those skilled in the art, without departing from the scope of the invention defined in the following claims:

Claims

1. A process of manufacturing a liquid crystal display device including

(a) a pair of substrates (9, 49) at least one of which is transparent,
(b) a layer of a liquid crystal composition interposed between the pair of substrates,
(c) a plurality of scanning lines driven by an external scanning-line driver circuit through scanning-line terminal portions (19) and extending in a line direction,
(d) a plurality of image-signal wires extending in a column direction,
(e) picture-element electrodes (22) corresponding to respective picture elements,
(f) common electrodes (20) cooperating with said picture-element electrodes, and
(g) thin-film transistor elements (58) connected to said scanning lines and said mage-signal wires,

wherein said scanning lines, said image-signal wires, said picture-element electrodes, said common electrodes and said thin-film transistor elements are provided on a surface of one of said pair of substrates which faces said layer of said liquid crystal composition,
the process comprising:

a halftone exposing step of exposing a photoresist (26, 48) on said, one (9, 49) of said pair of substrates to a radiation, and thereby forming

(i) first positive resist portions (6) that cover portions of a semiconductor layer (10, 11) formed on said one substrate, which portions correspond to said thin-film transistor elements (58), each of said first positive resist portions having- a predetermined first thickness,
(ii) resist-free areas (8, 32) that cover portions of said semiconductor layer which correspond to a first connecting portion (18, 91), a second connecting portion (18, 92) and a third connecting portion (59, 93), said first connecting portion being provided to form first static-electricity protective transistor elements, (42, 102) connecting said common electrodes (20) and said scanning lines, said second connecting portion being provided to form second static-electricity protective transistor elements (42, 102) connecting said common electrodes and said image-signal wires, and said third connecting portion connecting said external scanning-line driver circuit and said scanning-line terminal portions (19), and
(iii) second positive resist portions (7, 30) having a second thickness smaller than said first thickness and covering the other portions of said semiconductor layer,

characterized in that
the liquid crystal display device to be manufactured is of transverse electric-field type and
said halftone exposing step is implemented by using a photomask (80) having a fully light-transmitting area (85) and a fully light-shielding area (82), while said photoresist (26) on said semiconductor layer (10, 11) is exposed

through said photomask to a ultraviolet radiation whose irradiation energy density is determined so as to remove only a portion of a thickness of said photoresist, said halftone exposing-step being implemented such that said first positive resist portions (6) having said first thickness are formed with said fully light-shielding area of said photomask preventing said ultraviolet radiation from exposing said portions of the semiconductor layer (10, 11) which correspond to said- thin-film transistor elements (58), while said second positive resist portions (30) having said second thickness are formed with said fully light-transmitting area of said photomask permitting said ultraviolet radiation to expose said other portions of the semiconductor layer, and wherein said halftone exposing step further includes an operation performed after said first and second positive resist portions are formed, to form said resist-free areas (32) by exposing portions (29) of said photoresist exposed to said ultraviolet radiation, which portions cover the portions of the semiconductor layer corresponding to said first, second and third connecting portions (91-93), such that said portions of the photoresist are exposed to a radiation through another photomask different from said photomask used to form said first and second positive resist portions, or to respective spot lights of a condensed ultraviolet radiation.

2. The process according to claim 1, **characterized in that** said halftone exposing step is implemented by using a halftone photomask (60) having a fully light-transmitting area (65), a semi-light-transmitting area (64) and a fully light-shielding area (62), such that said first positive resist portions (6) having said first thickness are formed with said fully light-shielding area of said halftone photomask preventing said radiation from exposing the portions of the semiconductor layer (10, 11) which correspond to said thin-film transistor elements (58), and said resist-free areas (8) are formed with said fully light-transmitting area of said halftone photomask permitting said radiation to expose the portions of the semiconductor layer which correspond to the first, second and third connecting portions (18, 59) of said semiconductor layer, while said second positive resist portions (7) having said second thickness are formed with said semi-light-transmitting area of said halftone photomask permitting partial exposure of said other portions of said semiconductor layer to said radiation.

3. A process according to claim 1 or 2, **characterized in that** said halftone exposing step is implemented by using a photomask (36) having a fully light-transmitting area (85) and a fully light-shielding area (82), while said photoresist (48) on said semiconductor layer (10, 11) is exposed through said photomask to a ultraviolet radiation whose irradiation energy density is determined so as to remove only a portion of a thickness of said photoresist, said halftone exposing step being implemented such that said first positive resist portions (6) having said first thickness are formed with said fully light-shielding area of said photomask preventing said ultraviolet radiation from exposing said portions of the semiconductor layer (10, 11) which correspond, to said thin-film transistor elements (58), and said second positive resist portions (30) having said second thickness are formed with said fully light-transmitting area of said photomask permitting said ultraviolet radiation to expose said other portions of the semiconductor layer, while at the same time said resist-free areas (32) are formed by exposing portions of said photoresist covering the portions of the semiconductor layer corresponding to said first, second and third connecting portions (91-93), to respective spot lights of a condensed ultraviolet radiation.

4. A liquid crystal display device of transverse electric-field type manufactured by a process as defined in one of claims 1 to 3.

5. A liquid crystal display device of transverse electric-field type according to claim 4, **characterized in that** said first and second connecting portions (18, 91, 92) have widths which are about 1/2 to about 1/100 of that of said third connecting portion (59, 93).

Patentansprüche

1. Verfahren zum Herstellen einer Flüssigkristallanzeigevorrichtung mit

(a) einem Paar Substrate (9, 49), von denen zumindest eines transparent ist,
(b) einer Schicht einer Flüssigkristallzusammensetzung, die zwischen dem Paar von Substraten liegt,
(c) einer Mehrzahl von Abtastleitungen, die über Abtastleitungsanschlussabschnitte (19) von einer externen Abtastleitungstreiberschaltung getrieben werden und sich in einer Zeilenrichtung erstrecken,
(d) einer Mehrzahl von Bildsignalverdrahtungen, die sich in einer Spaltenrichtung erstrecken,
(e) Bildelementelektroden (22), die jeweils Bildelementen entsprechen,
(f) gemeinsamen Elektroden (20), die mit den Bildelementelektroden zusammenwirken, und
(g) Dünnfilmtransistorelementen (58), die mit den Abtastleitungen und den Bildsignalverdrahtungen verbunden

sind,

wobei die Abtastleitungen, die Bildsignalverdrahtungen, die Bildelementelektroden, die gemeinsamen Elektroden und die Dünnfilmtransistorelemente an einer Oberfläche, die der Schicht der Flüssigkristallzusammensetzung zugewandt ist, eines Substrats aus dem Paar von Substraten angeordnet sind,
wobei das Verfahren enthält:

einen Halbtonbelichtungsschritt des Aussetzens eines Photoresists (26, 48) auf dem einen Substrat (9, 49) aus dem Paar von Substraten einer Strahlung und dadurch Bildens von

(i) ersten positiven Resistabschnitten (6), die Abschnitte einer Halbleiterschicht (10, 11) bedecken, die auf dem einen Substrat gebildet ist, welche Abschnitte den Dünnfilmtransistorelementen (58) entsprechen, wobei jeder der ersten positiven Resistabschnitte eine vorbestimmte erste Dicke hat,
(ii) resistfreien Flächen (8, 32), die Abschnitte einer Halbleiterschicht abdecken, die einem ersten Verbindungsabschnitt (18, 91), einem zweiten Verbindungsabschnitt (18, 92) und einem dritten Verbindungsabschnitt (59, 93) entsprechen, wobei der erste Verbindungsabschnitt bereitgestellt ist zum Bilden erster Transistorelemente (42, 102) zum Schutz gegen statische Elektrizität, die die gemeinsamen Elektroden (20) und die Abtastleitungen verbinden, der zweite Verbindungsabschnitt bereitgestellt ist zum Bilden zweiter Transistorelemente (42, 102) zum Schutz gegen statische Elektrizität, die die gemeinsamen Elektroden und die Bildsignalverdrahtungen verbinden, und der dritte Verbindungsabschnitt die externe Abtastleitungstreiberschaltung und die Abtastleitungsanschlussabschnitte (19) verbindet, und
(iii) zweiten positiven Resistabschnitten (7, 30), die eine zweite Dicke haben, die kleiner als die erste Dicke ist, und die die anderen Abschnitte der Halbleiterschicht bedecken, **dadurch gekennzeichnet, dass**

die herzustellende Flüssigkristallanzeigevorrichtung vom transversalelektrischen Feldtyp und
der Halbtonbelichtungsschritt durchgeführt wird unter Verwendung einer Photomaske (80) mit einem voll lichtdurchlässigen Bereich (85) und einem voll lichtabschirmenden Bereich (82), wobei der Photoresist (26) auf der Halbleiterschicht (10, 11) über diese Photomaske einer Ultraviolettstrahlung ausgesetzt wird, deren Bestrahlungsenergiedichte so festgelegt ist, dass nur ein Teil einer Dicke des Photoresists entfernt wird,
wobei der Halbtonbelichtungsschritt so durchgeführt wird, dass die ersten positiven Resistabschnitte (6), die die die erste Dicke haben, mittels des voll lichtabschirmenden Bereichs der Photomaske gebildet werden, der verhindert, dass die Ultraviolettstrahlung die Abschnitte der Halbleiterschicht (10, 11), die den Dünnfilmtransistorelementen (58) entsprechen, belichtet, während die zweiten positiven Resistabschnitte (30), die die zweite Dicke haben, mittels des voll lichtdurchlässigen Bereichs der Photomaske gebildet werden, der es ermöglicht, dass die Ultraviolettstrahlung die anderen Abschnitte der Halbleiterschicht belichtet, und
wobei der Halbtonbelichtungsschritt weiter einen Vorgang enthält, der durchgeführt wird, nachdem die ersten und zweiten Resistabschnitte gebildet wurden, zum Bilden der resistfreien Flächen (32) durch Belichten von Abschnitten (29) des Photoresists, die der Ultraviolettstrahlung ausgesetzt waren, welche Abschnitte die Abschnitte der Halbleiterschicht bedecken, die dem ersten, zweiten und dritten Verbindungsabschnitt (91-93) entsprechen, so dass diese Abschnitte des Photoresists einer Strahlung ausgesetzt werden durch eine weitere Photomaske, die von der Photomaske verschieden ist, die zum Bilden der ersten und zweiten positiven Resistabschnitte verwendet wurde, oder zu jeweiligen Spotbelichtungen einer kondensierten Ultraviolettstrahlung.

2. Verfahren gemäß Anspruch 1, **dadurch gekennzeichnet, dass** der Halbtonbelichtungsschritt durchgeführt wird unter Verwendung einer Photomaske (60) mit einem voll lichtdurchlässigen Bereich (65), einem halb lichtdurchlässigen Bereich (64) und einem voll lichtabschirmenden Bereich (62), so dass die ersten positiven Resistabschnitte (6), die die die erste Dicke haben, mittels des voll lichtabschirmenden Bereichs der Photomaske gebildet werden, der verhindert, dass Strahlung die Abschnitte der Halbleiterschicht (10, 11), die den Dünnfilmtransistorelementen (58) entsprechen, belichtet, und die resistfreien Flächen (8) mittels des voll lichtdurchlässigen Bereichs der Photomaske gebildet werden, der es ermöglicht, dass die Strahlung die Abschnitte der Halbleiterschicht belichtet, die dem ersten, zweiten und dritten Verbindungsabschnitt (18, 59) entsprechen (18, 59), während die zweiten positiven Resistabschnitte (7) die die zweite Dicke haben, mittels des halb lichtdurchlässigen Bereichs der Photomaske gebildet werden, der ein partielles Belichten der anderen Abschnitte der Halbleiterschicht durch die Strahlung ermöglicht.

3. Verfahren gemäß Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** der Halbtonbelichtungsschritt durchgeführt wird unter Verwendung einer Photomaske (36) mit einem voll lichtdurchlässigen Bereich (85) und einem voll lichtabschirmenden Bereich (82), wobei der Photoresist (48) auf der Halbleiterschicht (10, 11) über diese Photomaske

einer Ultraviolettstrahlung ausgesetzt wird, deren Bestrahlungsenergiedichte so festgelegt ist, dass nur ein Teil einer Dicke des Photoresists entfernt wird,
wobei der Halbtonbelichtungsschritt so durchgeführt wird, dass die ersten positiven Resistabschnitte (6), die die die erste Dicke haben, mittels des voll lichtabschirmenden Bereichs der Photomaske gebildet werden, der verhindert, dass die Ultraviolettstrahlung die Abschnitte der Halbleiterschicht (10, 11), die den Dünnfilmtransistorelementen (58) entsprechen, belichtet, und die zweiten positiven Resistabschnitte (30), die die zweite Dicke haben, mittels des voll lichtdurchlässigen Bereichs der Photomaske gebildet werden, der es ermöglicht, dass die Ultraviolettstrahlung die anderen Abschnitte der Halbleiterschicht belichtet,
wobei gleichzeitig die resistfreien Flächen (32) gebildet werden durch Aussetzen von Abschnitten des Photoresists, die die Abschnitte der Halbleiterschicht bedecken, die dem ersten, zweiten und dritten Verbindungsabschnitt (91-93) entsprechen, zu jeweiligen Spotbelichtungen einer kondensierten Ultraviolettstrahlung.

4. Flüssigkristallanzeigevorrichtung vom transversalelektrischen Feldtyp, die durch ein Verfahren hergestellt wurde, wie es in einem der Ansprüche 1 bis 3 angegeben ist.

5. Flüssigkristallanzeigevorrichtung vom transversalelektrischen Feldtyp gemäß Anspruch 4, **dadurch gekennzeichnet, dass** der erste und zweite Verbindungsabschnitt (18, 91, 92) Breiten haben, die etwa 1/2 bis etwa 1/100 derjenigen des dritten Verbindungsabschnitts (59, 93) sind.

Revendications

1. Procédé pour fabriquer un dispositif d'affichage à cristaux liquides comprenant :

(a) une paire de substrats (9, 49) dont au moins l'un est transparent,
(b) une couche d'une composition de cristaux liquides intercalée entre la paire de substrats,
(c) une pluralité de lignes de balayage entraînées par un circuit d'entraînement de ligne de balayage externe par le biais de parties de borne de ligne de balayage (19) et s'étendant dans une direction de ligne,
(d) une pluralité de fils de signaux d'image s'étendant dans une direction de colonne,
(e) des électrodes d'élément d'image (22) correspondant aux éléments d'image respectifs,
(f) des électrodes communes (20) coopérant avec lesdites électrodes d'élément d'image, et
(g) des éléments de transistor à couche mince (58) raccordés auxdites lignes de balayage et auxdits fils de signaux d'image,

dans lequel lesdites lignes de balayage, lesdits fils de signaux d'image, lesdites électrodes d'élément d'image, lesdites électrodes communes et lesdits éléments de transistor à couche mince sont prévus sur une surface de l'un de ladite paire de substrats qui fait face à ladite couche de ladite composition de cristaux liquides,
le procédé comprenant :

une étape d'exposition de trame consistant à exposer un agent photorésistant (26, 48) sur ledit un substrat (9, 49) de ladite paire de substrats à un rayonnement, et former ainsi

(i) des premières parties de réserve positives (6) qui recouvrent des parties d'une couche de semi-conducteur (10, 11) formée sur ledit un substrat, lesquelles parties correspondent auxdits éléments de transistor à couche mince (58), chacune desdites premières parties de réserve positives ayant une première épaisseur prédéterminée,
(ii) des zones dépourvues de réserve (8, 32) qui recouvrent des parties de ladite couche de semi-conducteur qui correspondent à une première partie de raccordement (18, 91), une deuxième partie de raccordement (18, 92) et une troisième partie de raccordement (59, 93), ladite première partie de raccordement étant prévue pour former des premiers éléments de transistor de protection contre l'électricité statique (42, 102) raccordant lesdites électrodes communes (20) et lesdites lignes de balayage, ladite deuxième partie de raccordement étant prévue pour former des seconds éléments de transistor de protection contre l'électricité statique (42, 102) raccordant lesdites électrodes communes et lesdits fils de signaux d'image, et ladite troisième partie de raccordement raccordant ledit circuit d'entraînement de ligne de balayage externe et ladite partie de borne de ligne de balayage (19), et
(iii) des secondes parties de réserve positives (7, 30) ayant une seconde épaisseur inférieure à ladite première épaisseur et recouvrant les autres parties de ladite couche de semi-conducteur,

caractérisé en ce que :

le dispositif d'affichage à cristaux liquides à fabriquer est de type à champ électrique transversal, et
ladite étape d'exposition de trame est mise en oeuvre en utilisant un masque photographique (80) ayant une zone de transmission totale de la lumière (85) et une zone de protection totale de la lumière (82), alors que ledit agent photorésistant (26) sur ladite couche de semi-conducteur (10, 11) est exposé à travers ledit masque photographique à un rayonnement ultraviolet dont la densité d'énergie d'irradiation est déterminée afin de ne retirer qu'une partie d'une épaisseur dudit agent photorésistant, ladite étape d'exposition de trame étant mise en oeuvre de sorte que lesdites premières parties de réserve positives (6) ayant ladite première épaisseur sont formées avec ladite zone de protection totale de lumière dudit masque photographique qui empêche l'exposition desdites parties de la couche de semi-conducteur (10, 11) au rayonnement ultraviolet qui correspondent auxdits éléments de transistor à couche mince (58), alors que lesdites secondes parties de réserve positives (30) ayant ladite seconde épaisseur sont formées avec ladite zone de transmission totale de lumière dudit masque photographique permettant auxdites autres parties de la couche de semi-conducteur d'être exposées audit rayonnement ultraviolet, et dans lequel ladite étape d'exposition de trame comprend en outre une opération réalisée après que lesdites première et seconde parties de réserve positives ont été formées, consistant à former lesdites zones dépourvues de réserve (32) en exposant des parties (29) dudit agent photorésistant exposé audit rayonnement ultraviolet, lesquelles parties recouvrent les parties de la couche de semi-conducteur correspondant auxdites première, deuxième et troisième parties de raccordement (91-93), de sorte que lesdites parties de l'agent photorésistant sont exposées à un rayonnement à travers un autre masque photographique différent dudit masque photographique utilisé pour former lesdites première et seconde parties de réserve positives, ou à des éclairages directionnels respectifs d'un rayonnement ultraviolet condensé.

2. Procédé selon la revendication 1, **caractérisé en ce que** ladite étape d'exposition de trame est mise en oeuvre en utilisant un masque photographique de trame (60) ayant une zone de transmission totale de lumière (65), une zone de semi-transmission de lumière (64) et une zone de protection totale de lumière (62), de sorte que lesdites premières parties de réserve positives (6) ayant ladite première épaisseur sont formées avec ladite zone de protection totale de lumière dudit masque photographique de trame empêchant les parties de la couche de semi-conducteur (10, 11) d'être exposées audit rayonnement, qui correspondent auxdits éléments de transistor à couche mince (58), et lesdites zones dépourvues de réserve (8) sont formées avec ladite zone de transmission totale de lumière dudit masque photographique de trame permettant d'exposer les parties de la couche de semi-conducteur audit rayonnement, qui correspondent aux première, deuxième et troisième parties de raccordement (18, 59) de ladite couche de semi-conducteur, alors que lesdites secondes parties de réserve positives (7) ayant ladite seconde épaisseur sont formées avec ladite zone de semi-transmission de lumière dudit masque photographique de trame permettant l'exposition partielle desdites autres parties de ladite couche de semi-conducteur audit rayonnement.

3. Procédé selon la revendication 1 ou 2, **caractérisé en ce que** ladite étape d'exposition de trame est mise en oeuvre en utilisant un masque photographique (36) ayant une zone de transmission totale de lumière (85) et une zone de protection totale de lumière (82), alors que ledit agent photorésistant (48) sur ladite couche de semi-conducteur (10, 11) est exposé à travers ledit masque photographique à un rayonnement ultraviolet dont la densité d'énergie d'irradiation est déterminée afin de ne retirer qu'une partie d'une épaisseur dudit agent photorésistant, ladite étape d'exposition de trame étant mise en oeuvre de sorte que lesdites premières parties de réserve positives (6) ayant ladite première épaisseur sont formées avec ladite zone de protection totale de lumière dudit masque photographique empêchant ledit rayonnement ultraviolet d'exposer lesdites parties de la couche de semi-conducteur (10, 11) qui correspondent auxdits éléments de transistor à couche mince (58) et lesdites secondes parties de réserve positives (30) ayant ladite seconde épaisseur sont formées avec ladite zone de transmission totale de lumière dudit masque photographique permettant audit rayonnement ultraviolet d'exposer lesdites autres parties de la couche de semi-conducteur, alors qu'en même temps, lesdites zones dépourvues de réserve (32) sont formées en exposant des parties dudit agent photorésistant recouvrant les parties de la couche de semi-conducteur correspondant auxdites première, deuxième et troisième parties de raccordement (91-93), aux éclairages directionnels respectifs d'un rayonnement ultraviolet condensé.

4. Dispositif d'affichage à cristaux liquides du type à champ électrique transversal fabriqué par un procédé selon l'une des revendications 1 à 3.

5. Dispositif d'affichage à cristaux liquides du type à champ électrique transversal selon la revendication 4, **caractérisé en ce que** lesdites première et deuxième parties de raccordement (18, 91, 92) ont des largeurs qui représentent d'environ 1/2 à environ 1/100 de celle de ladite troisième partie de raccordement (59, 93).

Fig. 1

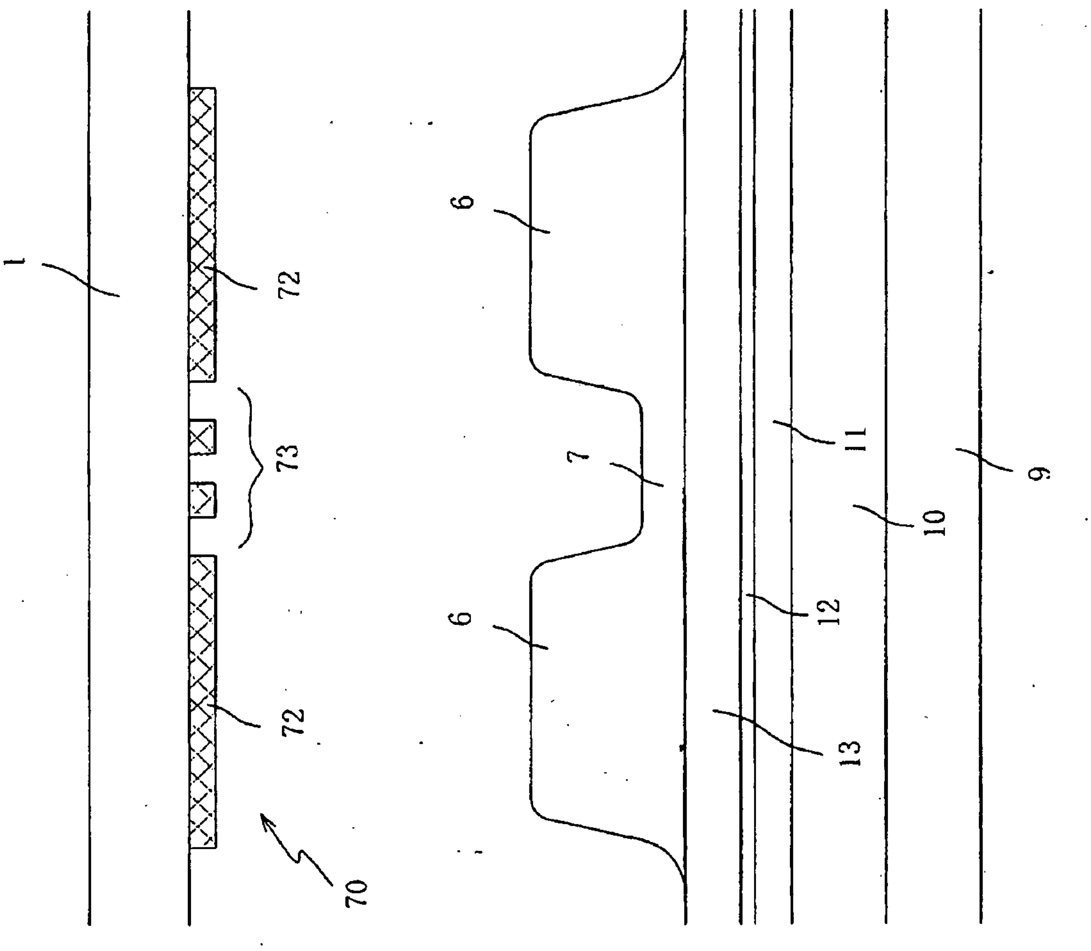


Fig. 2

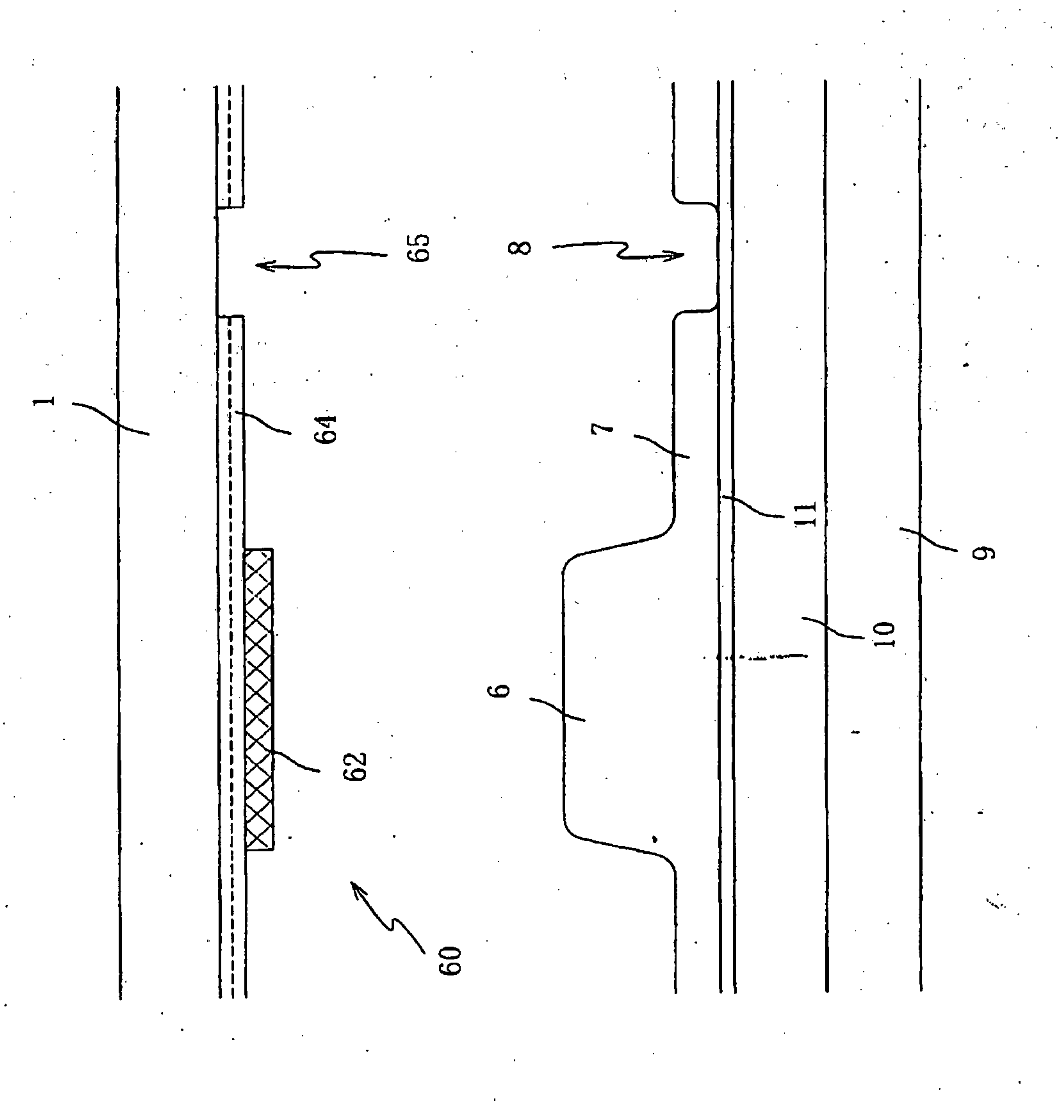


Fig. 3

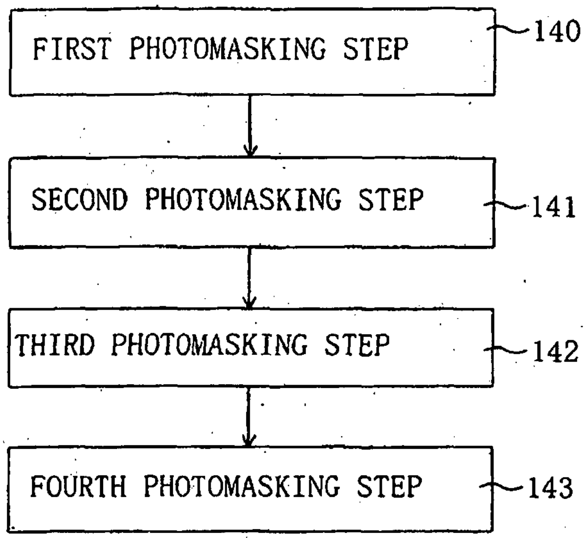

FIRST PHOTOMASKING STEP
140
SECOND PHOTOMASKING STEP
141
THIRD PHOTOMASKING STEP
142
FOURTH PHOTOMASKING STEP
143

Fig. 4

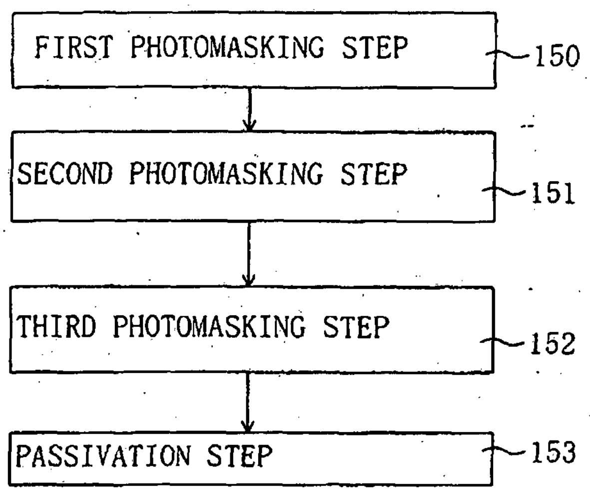
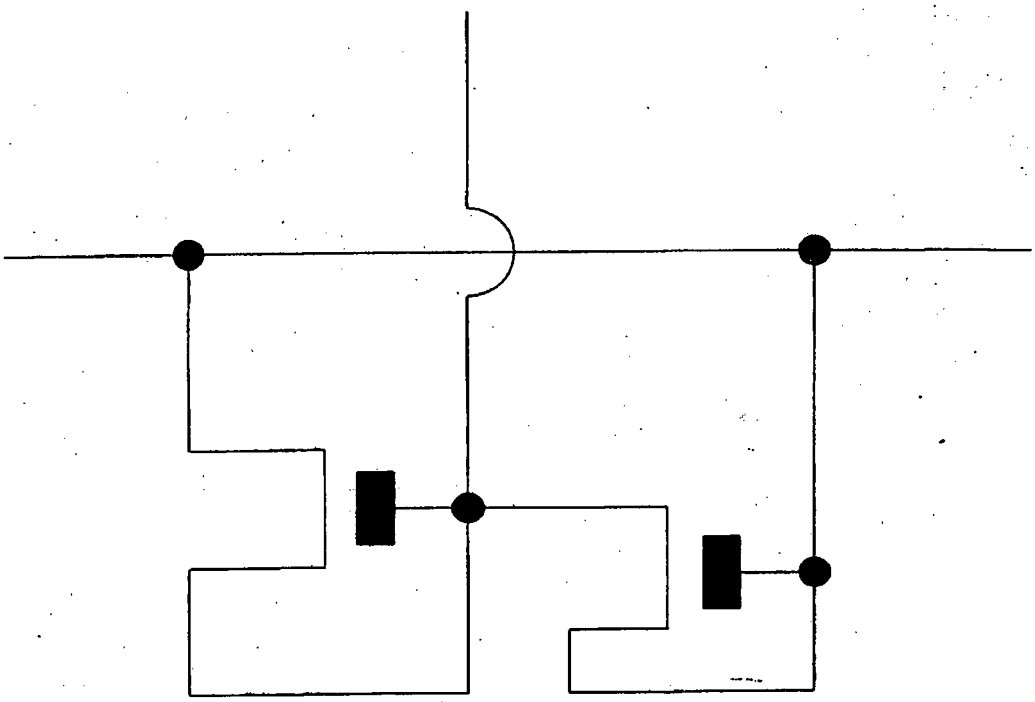

FIRST PHOTOMASKING STEP
150
SECOND PHOTOMASKING STEP
151
THIRD PHOTOMASKING STEP
152
PASSIVATION STEP
153

Fig. 5



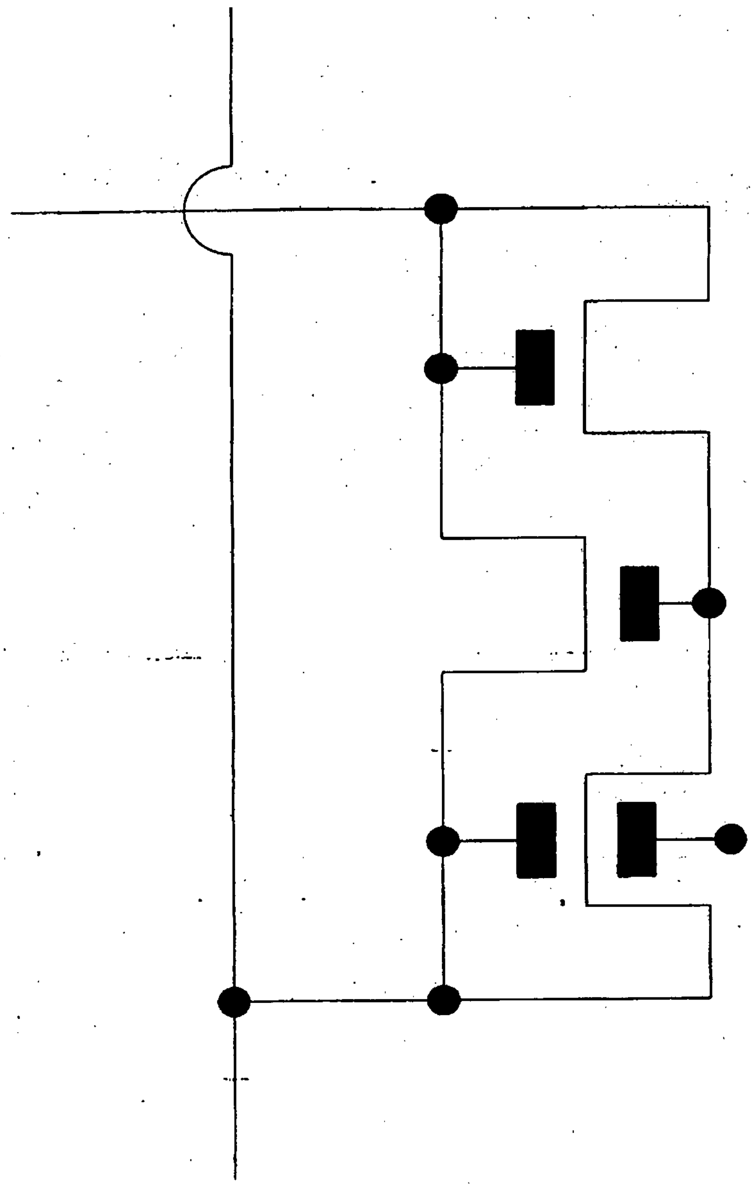


Fig. 6

Fig. 7

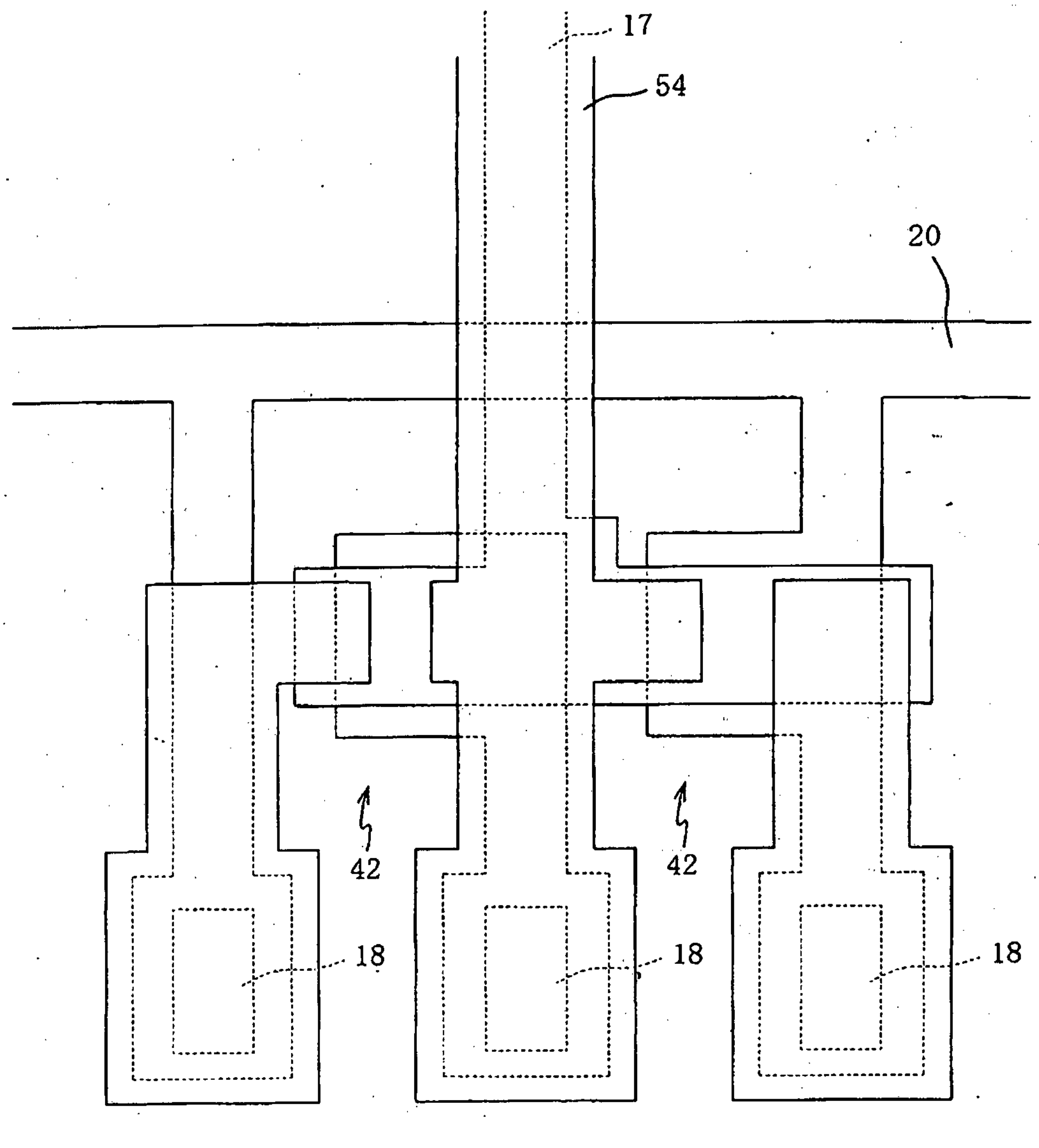


Fig. 8

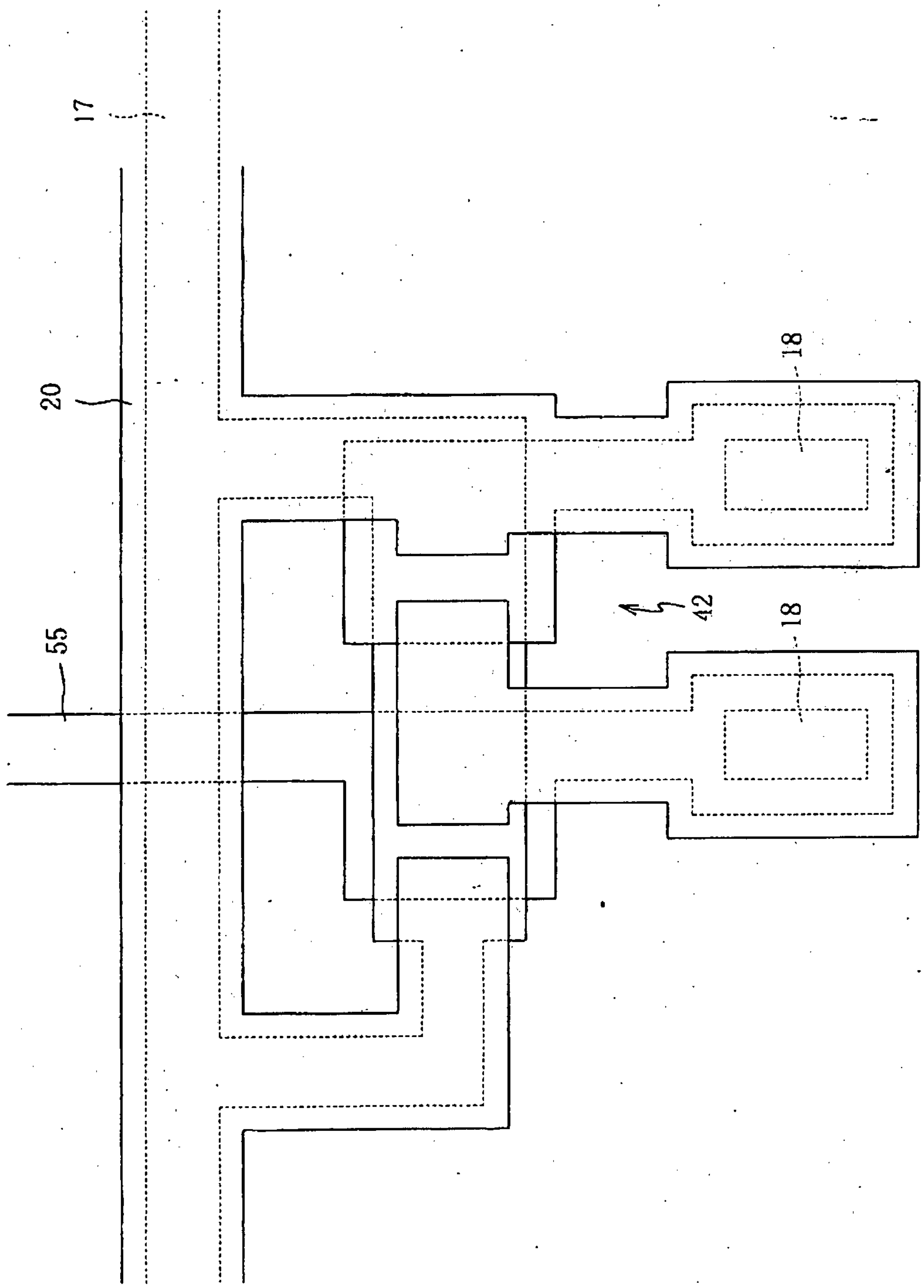


Fig. 9

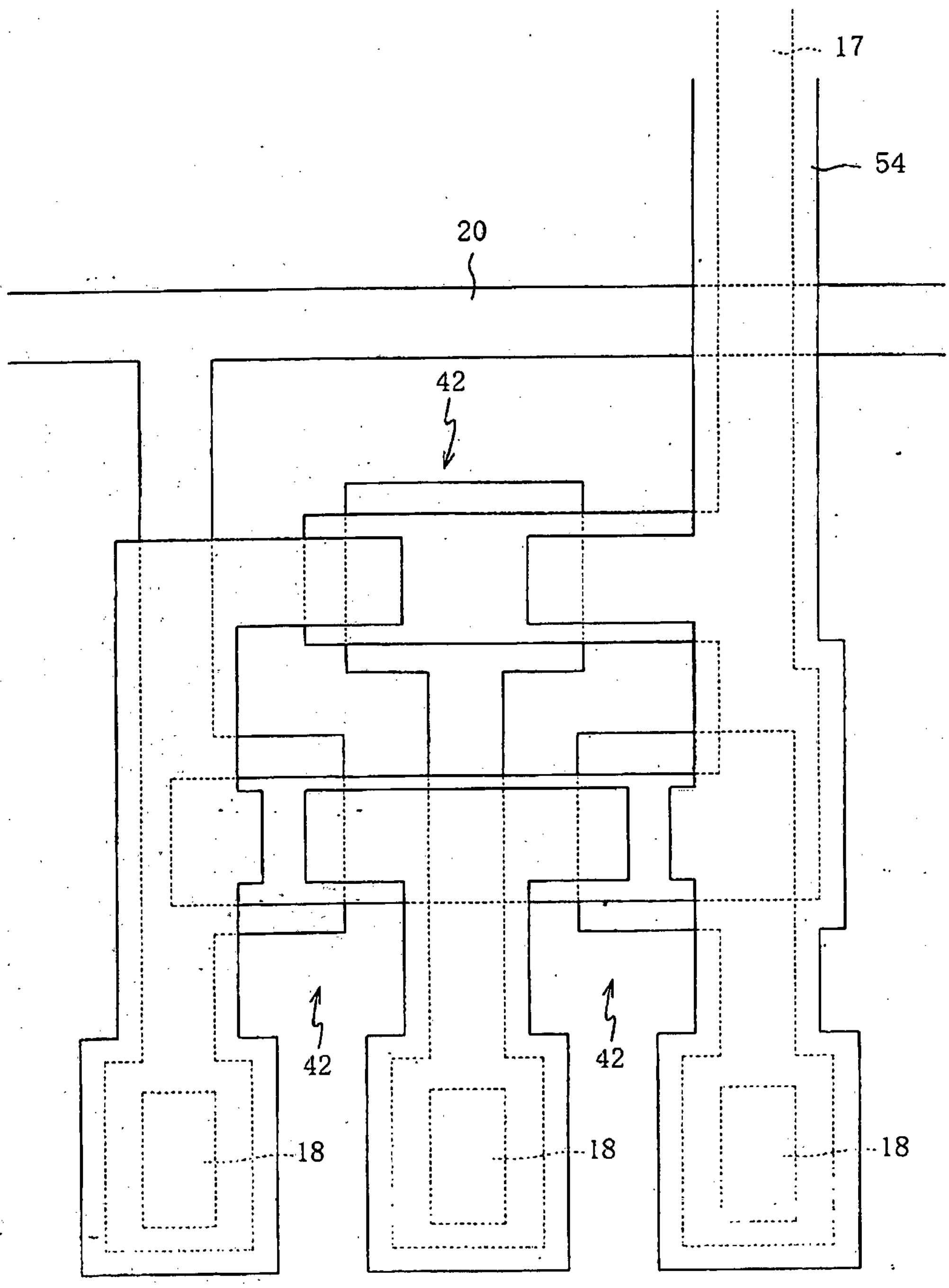


Fig. 10

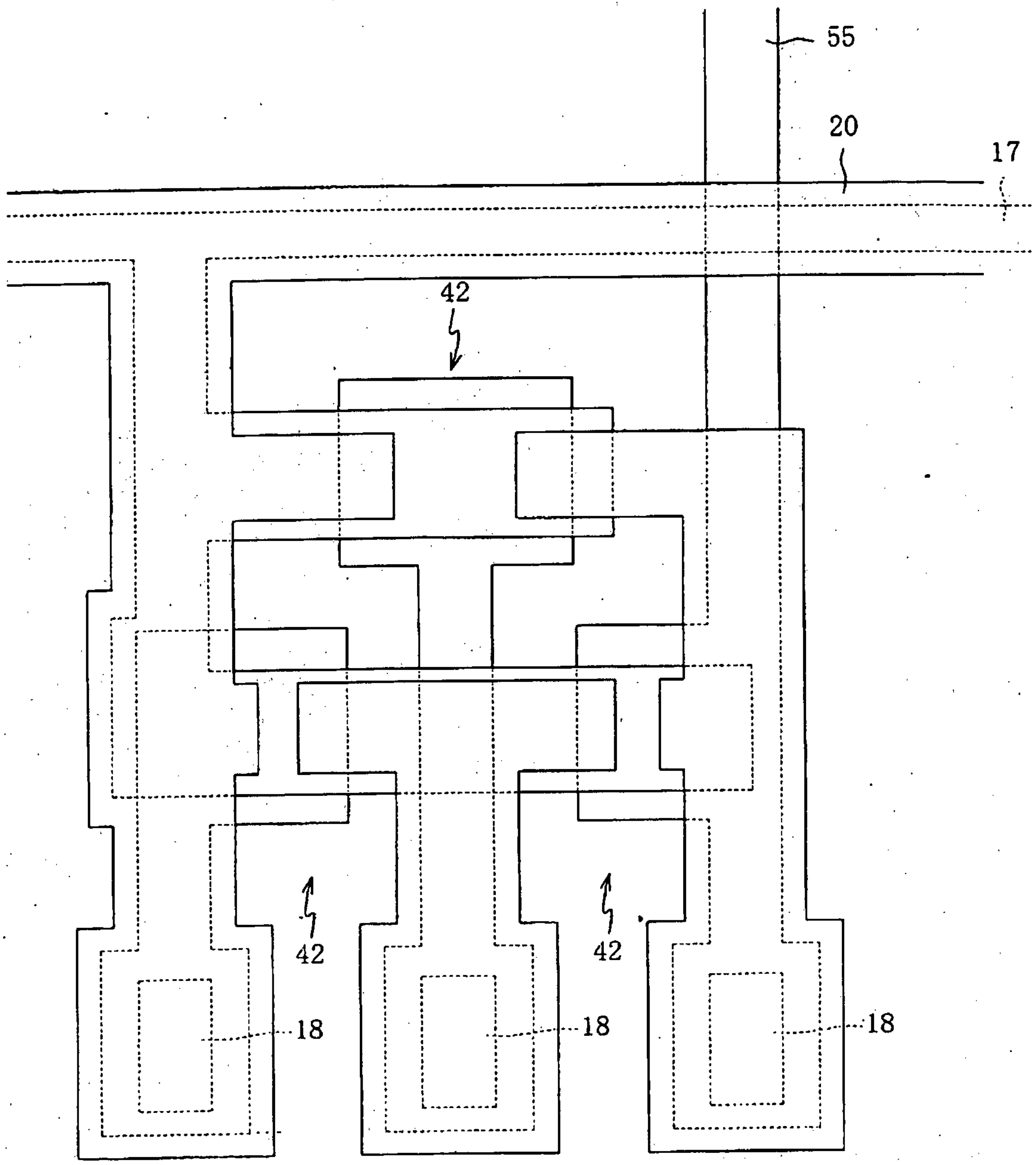


Fig. 11A

Fig. 11B

Fig. 11C

Fig. 11D

Fig. 11E

Fig. 11F

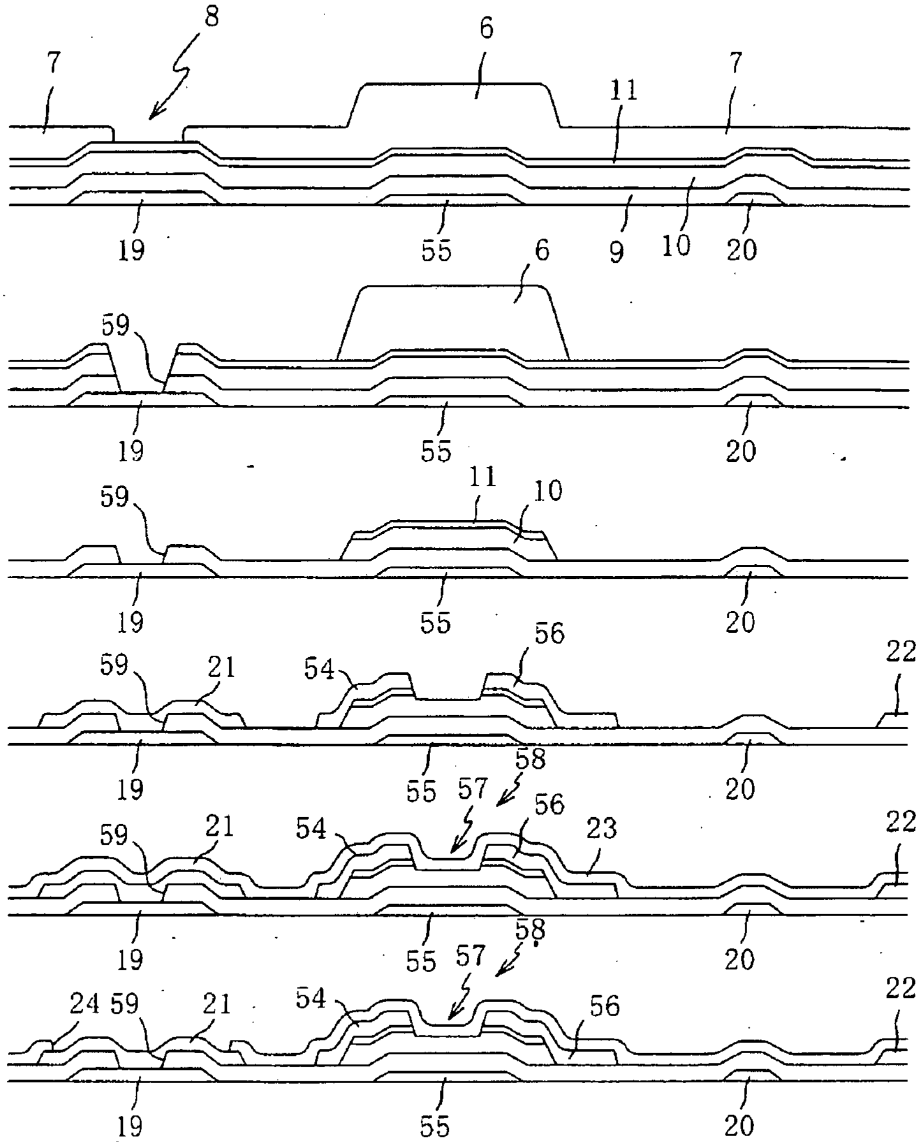


Fig. 12A

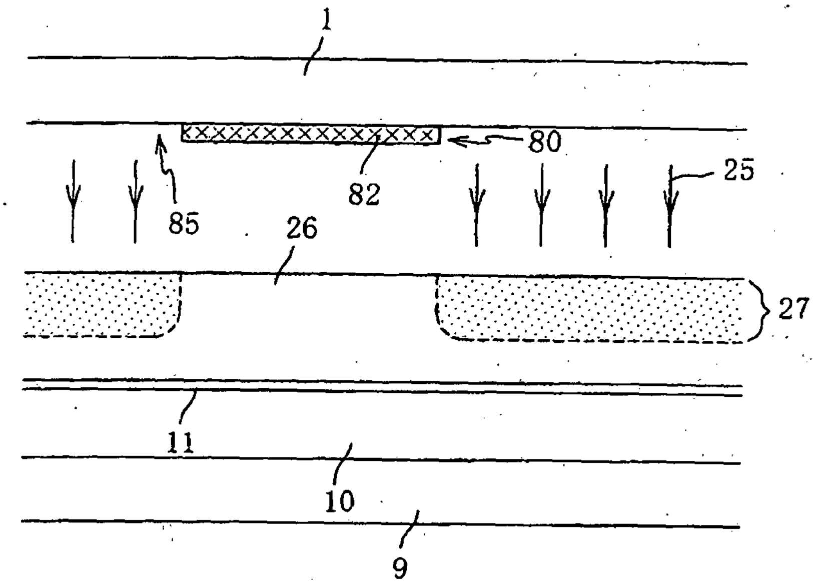


Fig. 12B

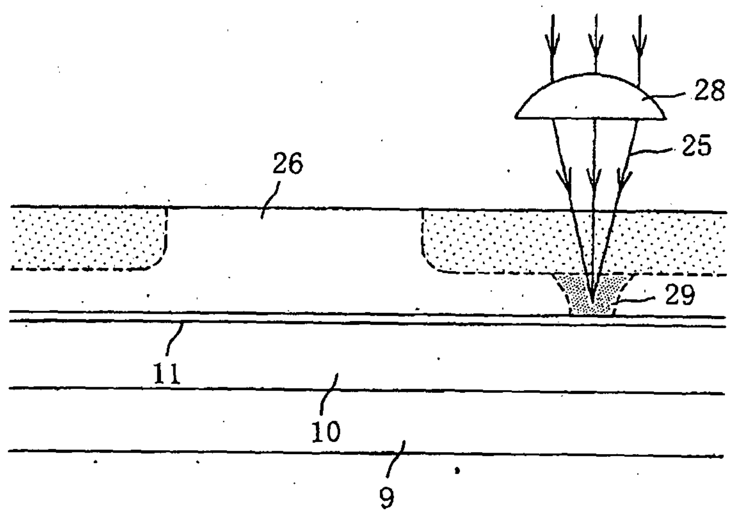


Fig. 12C

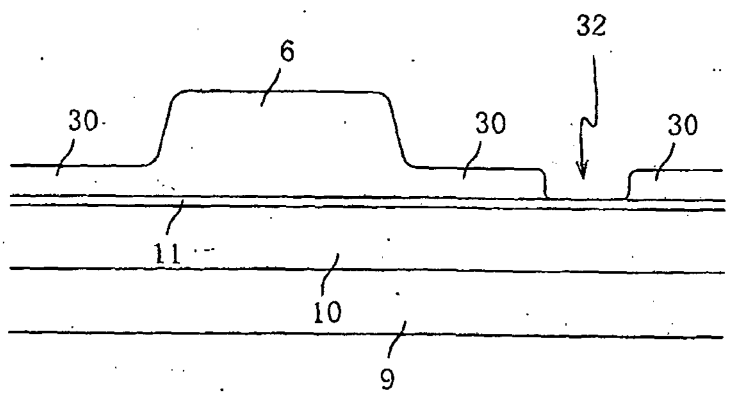


Fig. 13

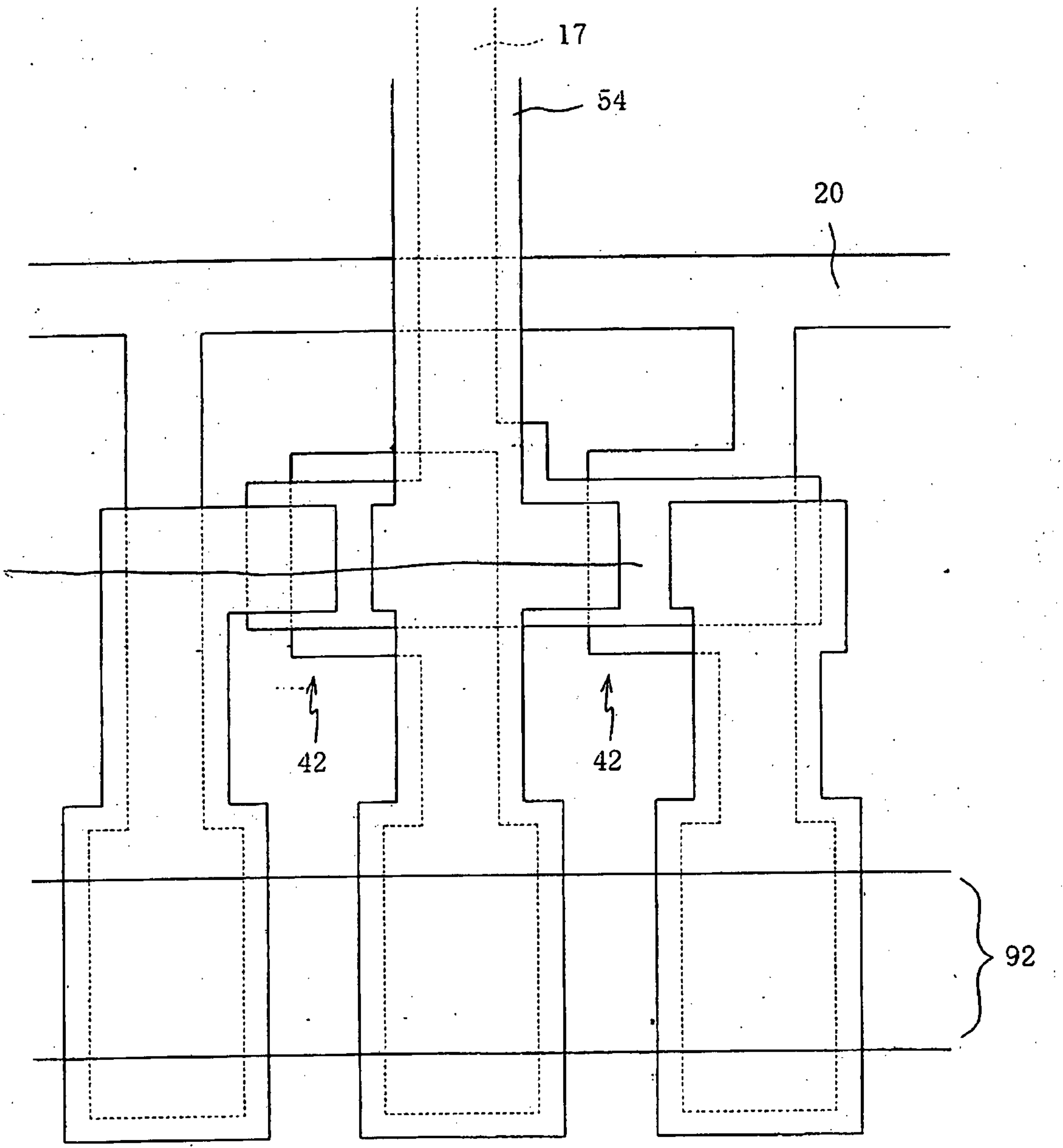


Fig. 14

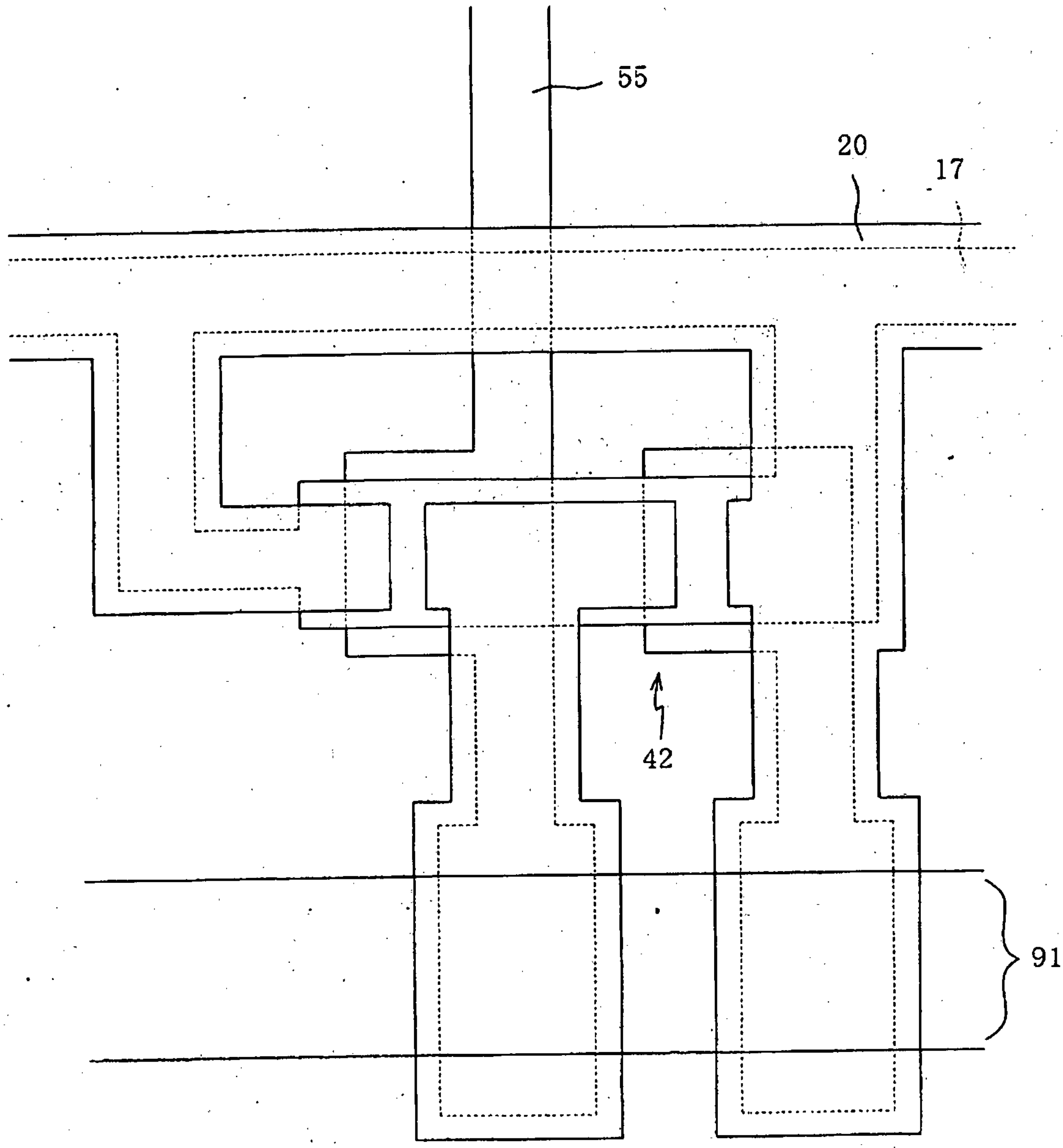


Fig. 15A

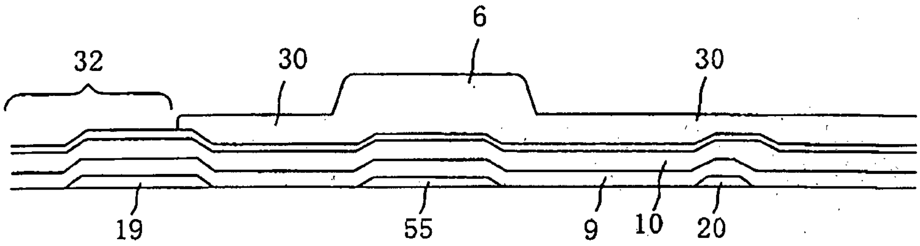


Fig. 15B

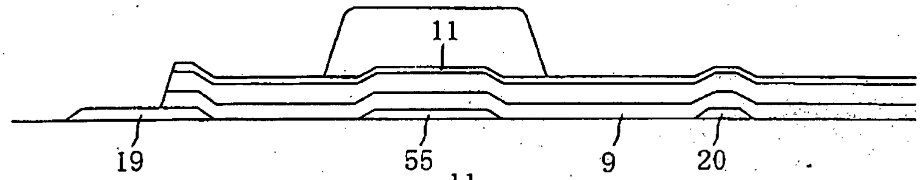


Fig. 15C

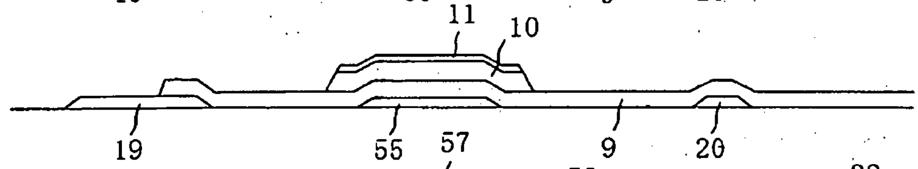


Fig. 15D

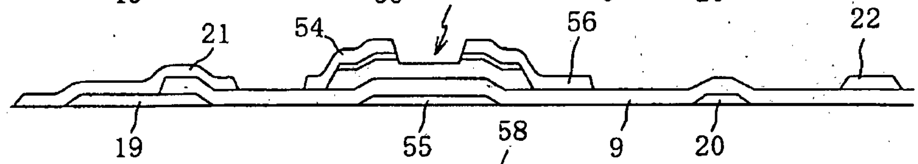
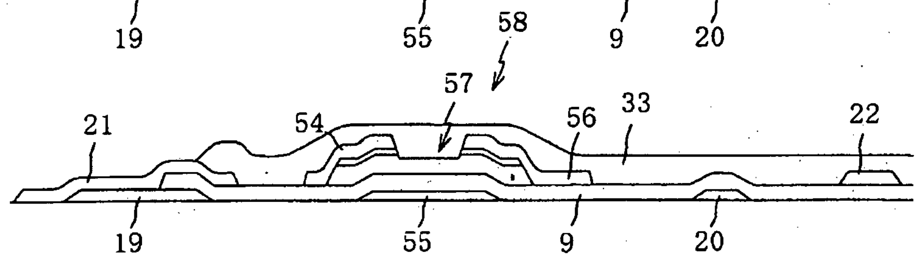


Fig. 15E



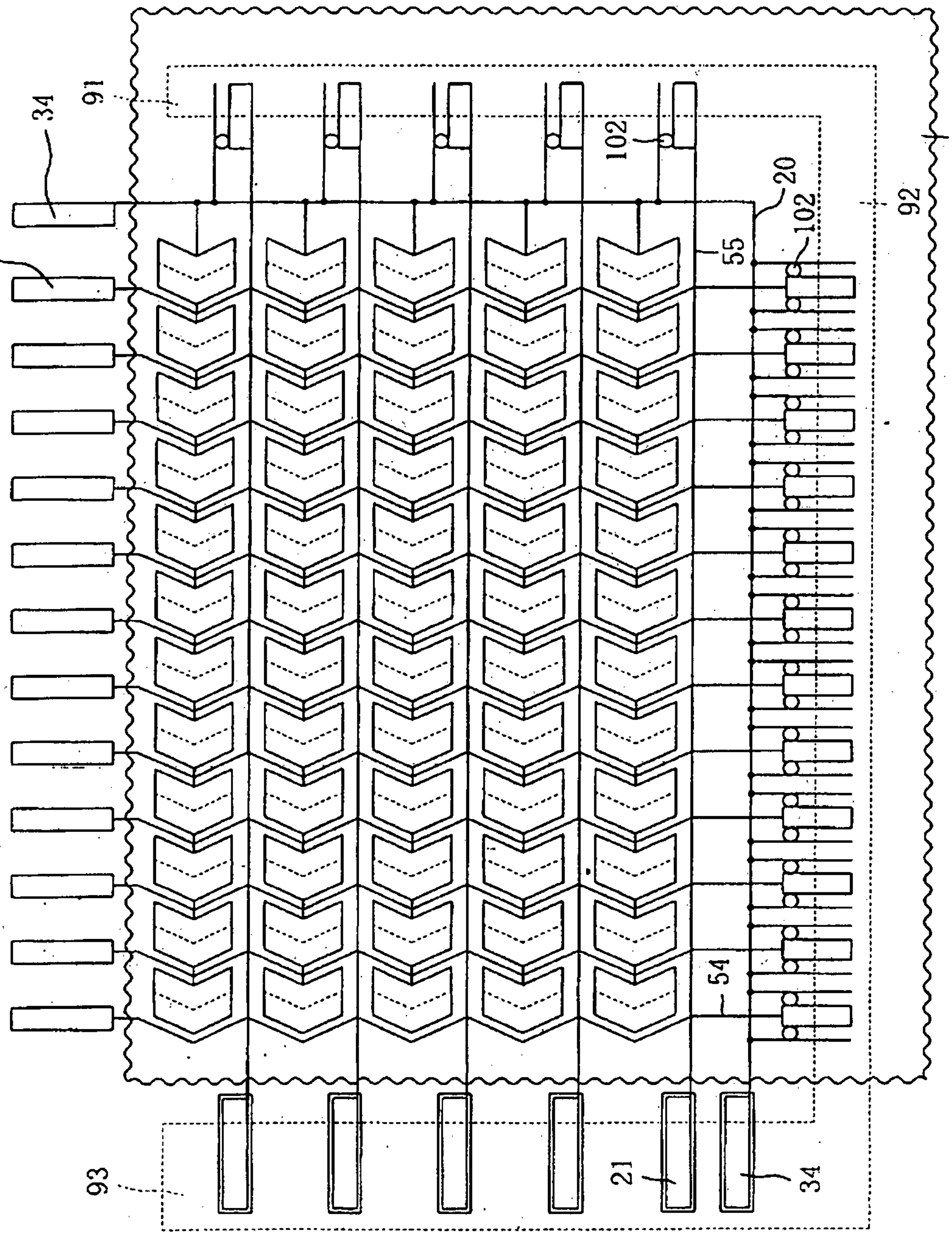


Fig. 16

Fig. 17

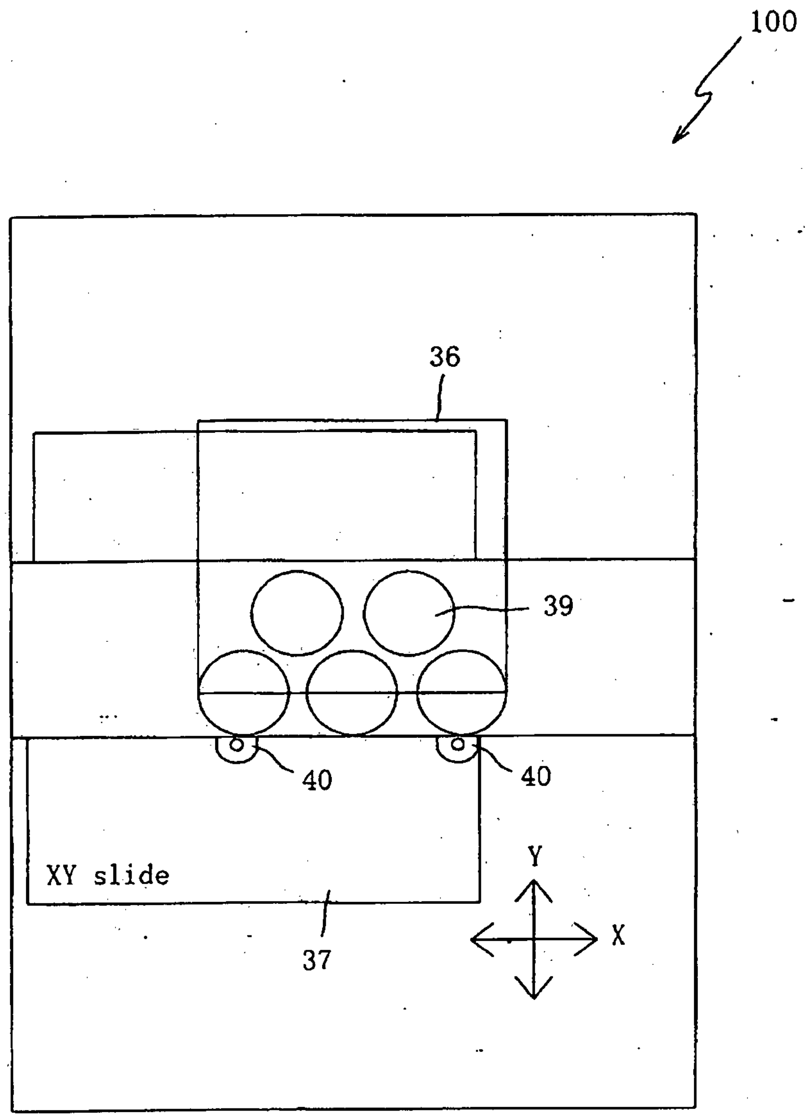


Fig. 18

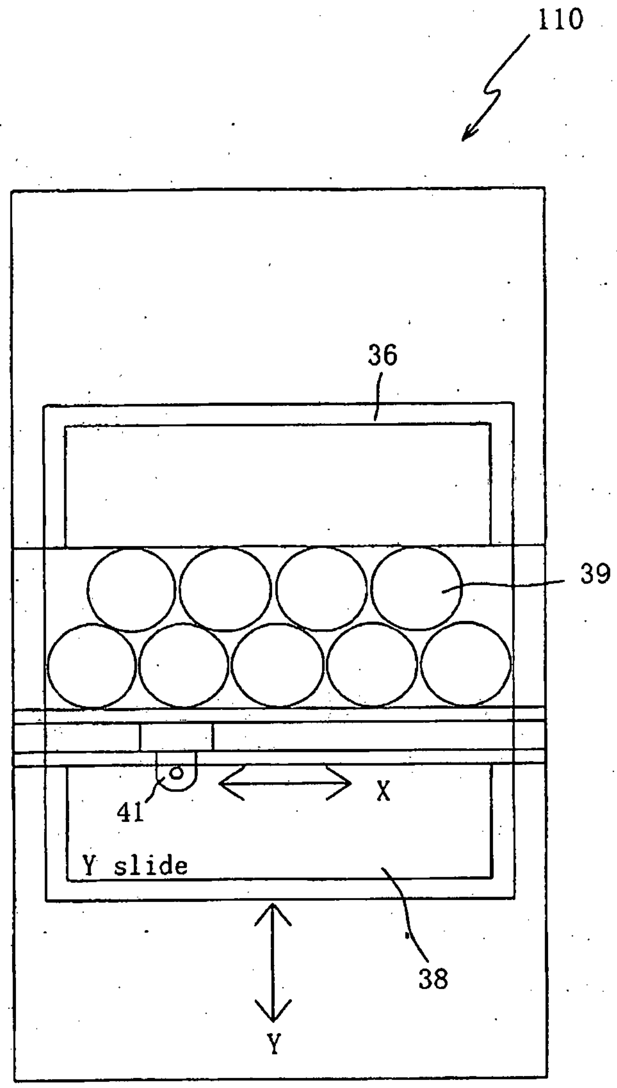


Fig. 19

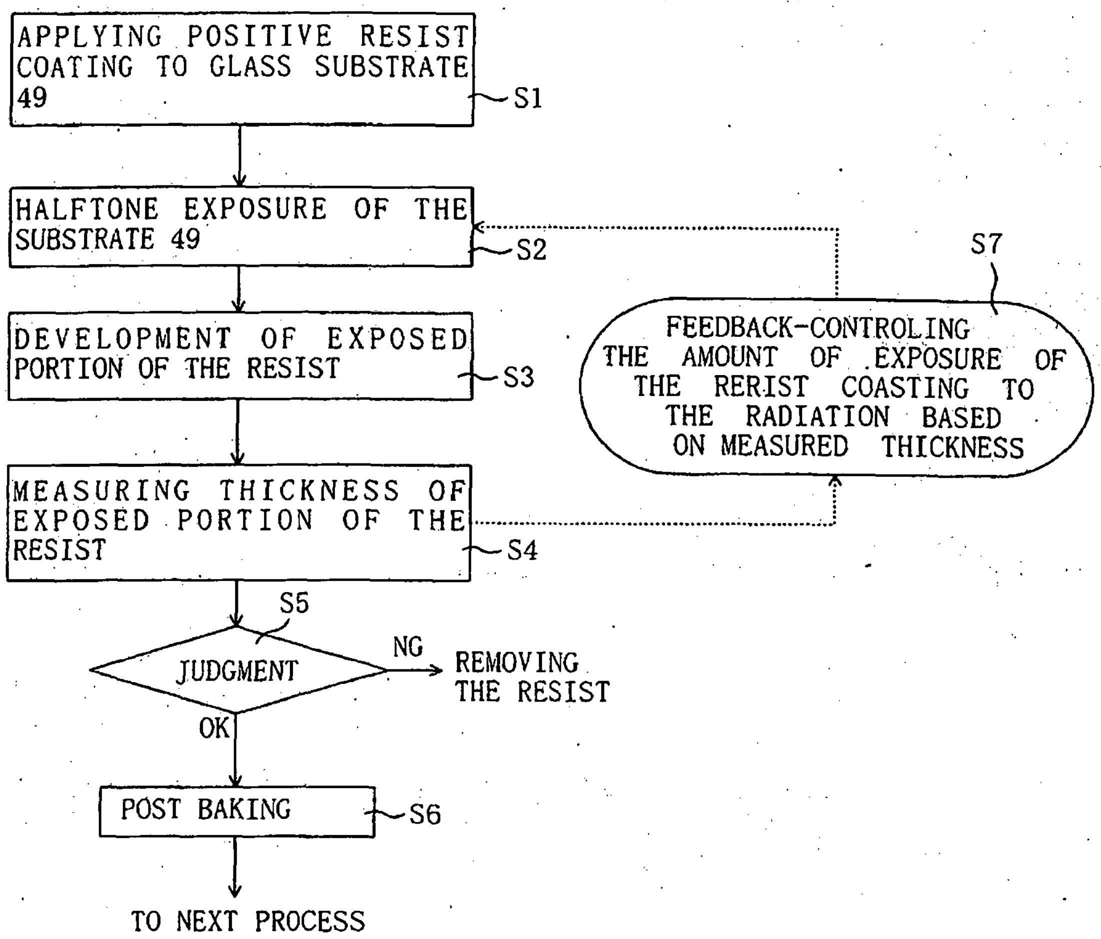

APPLYING POSITIVE RESIST COATING TO GLASS SUBSTRATE 49
S1
HALFTONE EXPOSURE OF THE SUBSTRATE 49
S2
DEVELOPMENT OF EXPOSED PORTION OF THE RESIST
S3
MEASURING THICKNESS OF EXPOSED PORTION OF THE RESIST
S4
S5
JUDGMENT
NG
REMOVING THE RESIST
OK
POST BAKING
S6
TO NEXT PROCESS
S7
FEEDBACK-CONTROLING THE AMOUNT OF EXPOSURE OF THE RERIST COASTING TO THE RADIATION BASED ON MEASURED THICKNESS

Fig. 20

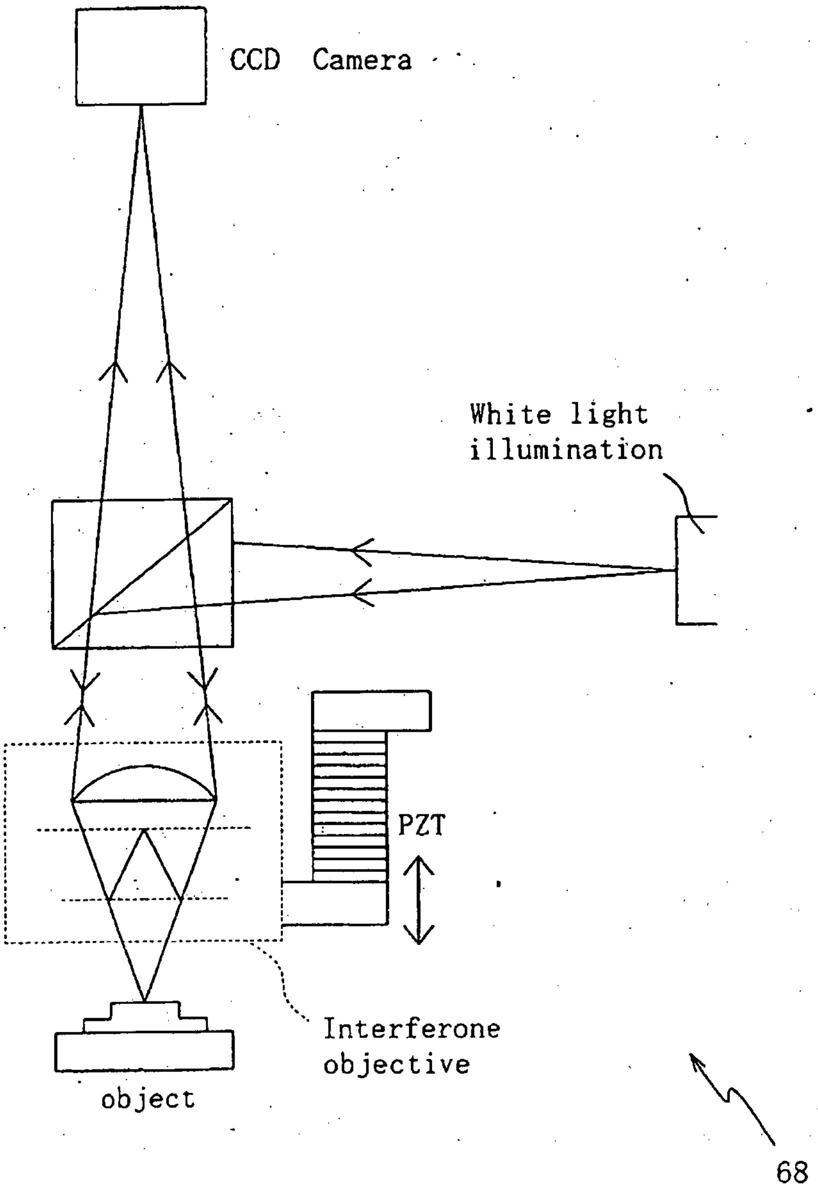

CCD Camera
White light
illumination
PZT
Interferone
objective
object
68

Fig. 21

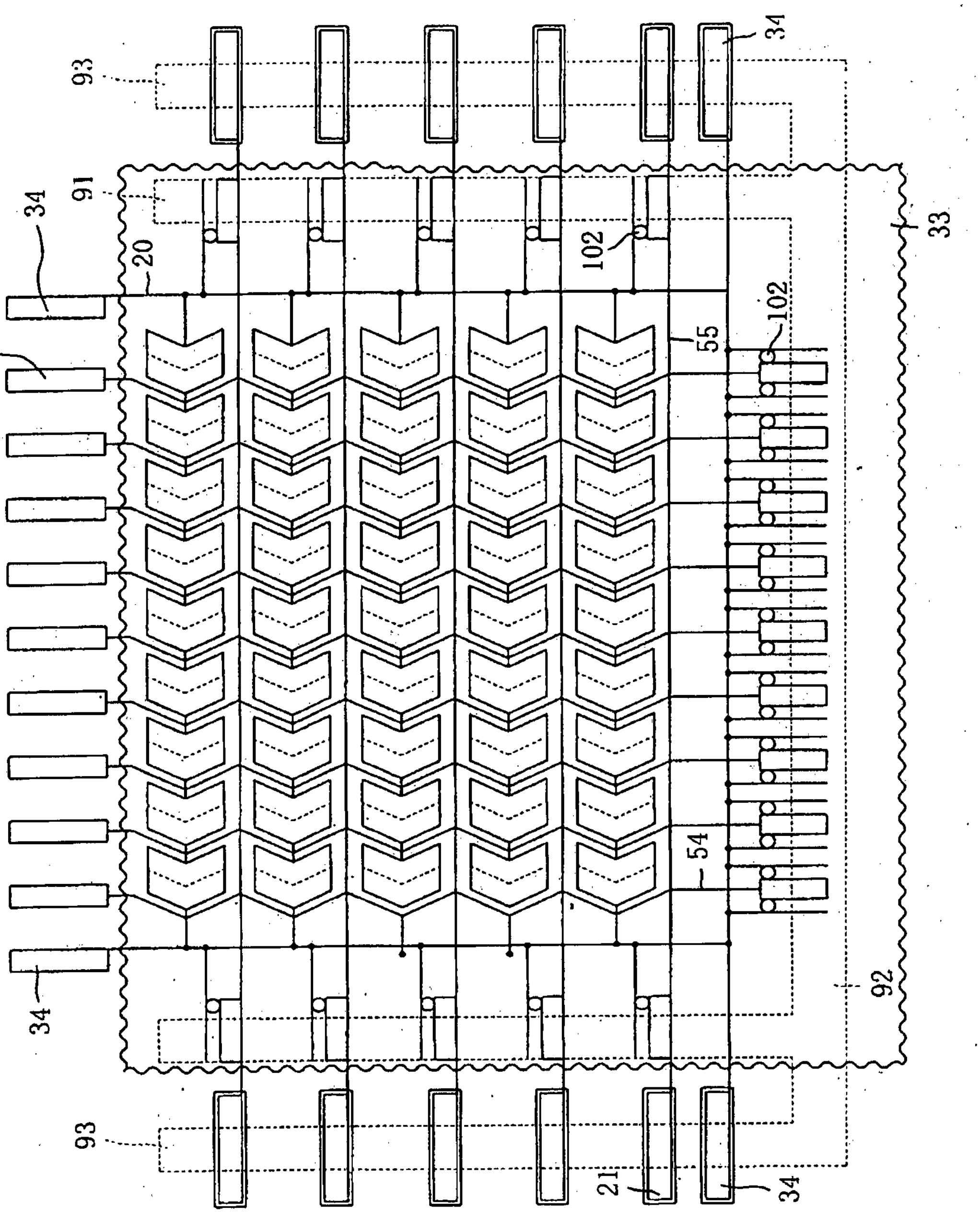


Fig. 22

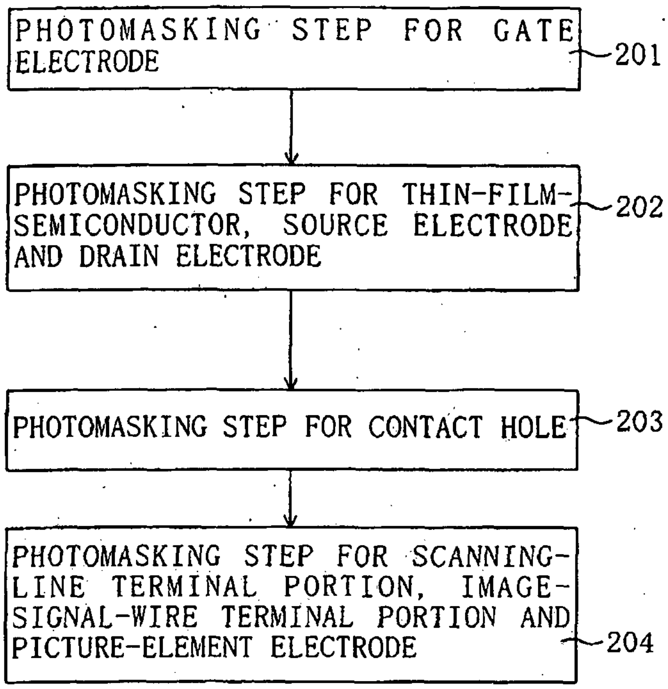

PHOTOMASKING STEP FOR GATE ELECTRODE
201
PHOTOMASKING STEP FOR THIN-FILM-SEMICONDUCTOR, SOURCE ELECTRODE AND DRAIN ELECTRODE
202
PHOTOMASKING STEP FOR CONTACT HOLE
203
PHOTOMASKING STEP FOR SCANNING-LINE TERMINAL PORTION, IMAGE-SIGNAL-WIRE TERMINAL PORTION AND PICTURE-ELEMENT ELECTRODE
204

Fig. 23

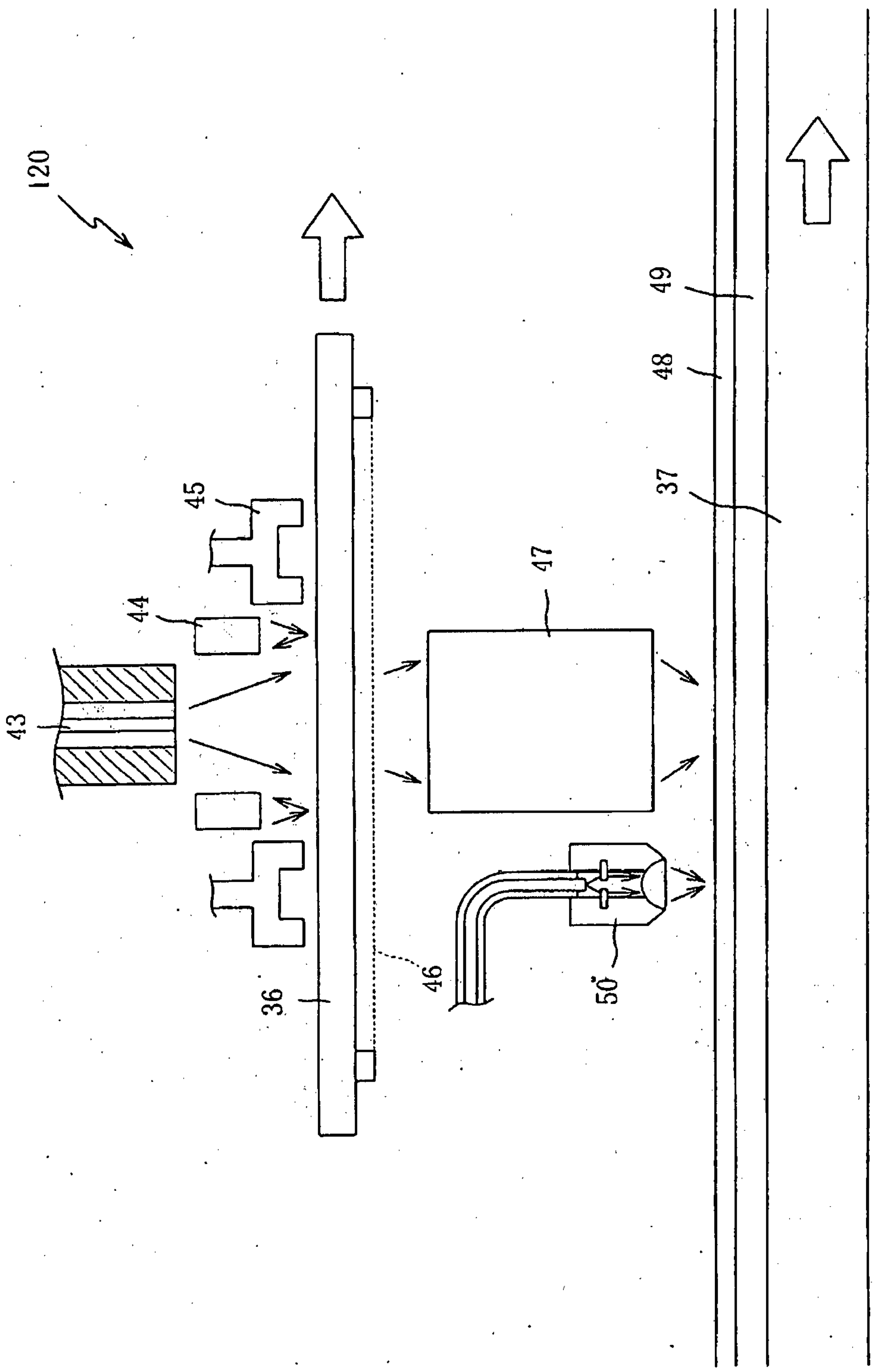
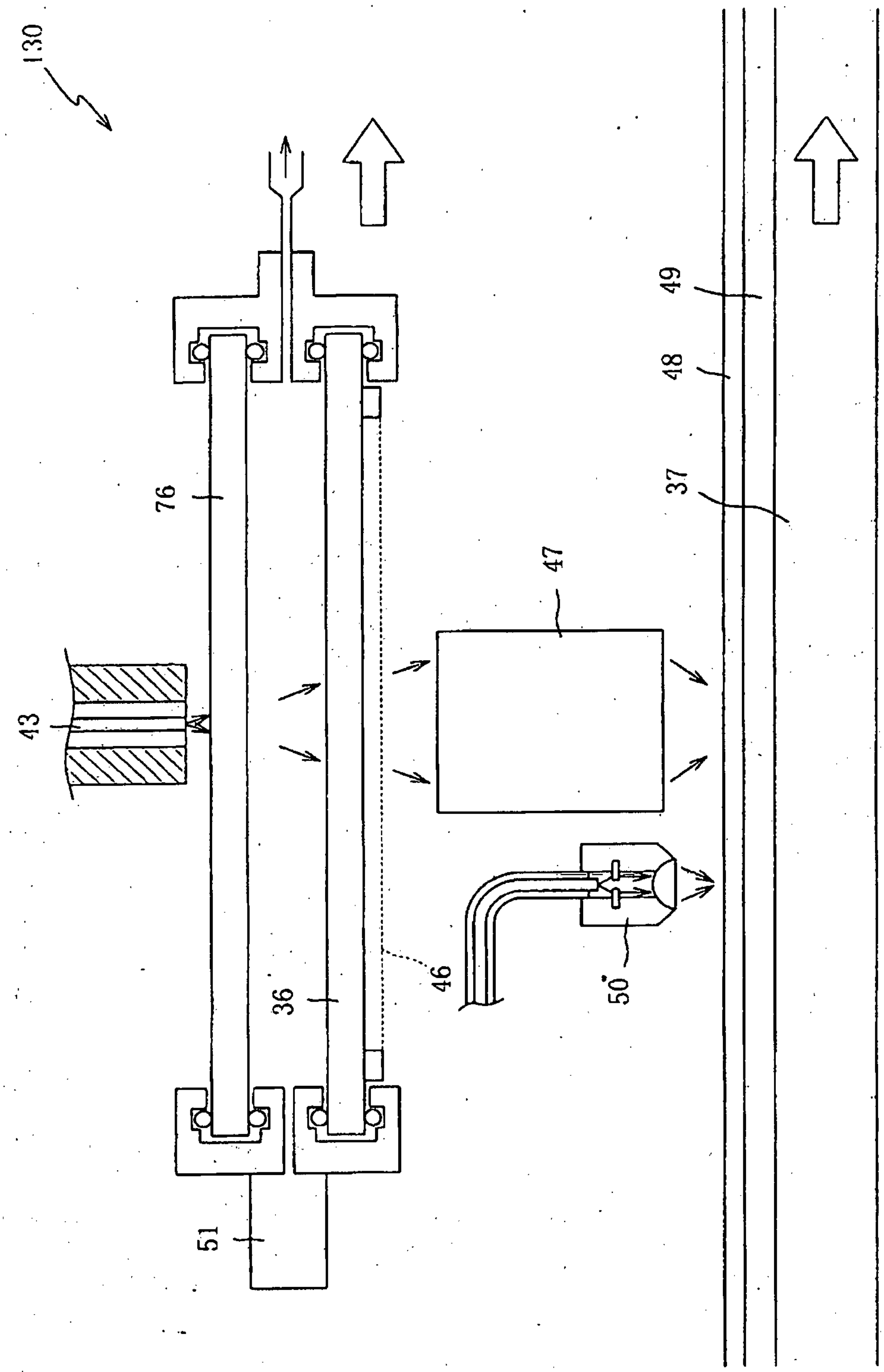


Fig. 24



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2000066240 A **[0002] [0003] [0007] [0008] [0018] [0019]**
- JP 200066240 A **[0002]**

专利名称(译)	横向电场型液晶显示装置，其制造方法以及扫描曝光装置

公开(公告)号	EP1378788B1	公开(公告)日	2015-06-17
申请号	EP2003014265	申请日	2003-06-25

[标]申请(专利权)人(译)	大林精工株式会社
申请(专利权)人(译)	OBAYASHISEIKOU CO.，LTD.
当前申请(专利权)人(译)	OBAYASHISEIKOU CO.，LTD.
[标]发明人	HIROTA NAOTO
发明人	HIROTA, NAOTO
IPC分类号	G02F1/1362 G02F1/1368 G02F1/1343 G03F1/00 G02F1/13 G02F1/136 G03F1/14 G03F1/50 G09F9/30 G09F9/35 H01L21/336 H01L29/786
CPC分类号	G03F7/7045 G02F1/134363 G02F1/136204 G02F1/136286 G02F1/1368 G02F2001/136236 G03B27/10 G03F1/144 G03F1/50 G03F7/70358 G03F7/70458
优先权	2002237219 2002-07-01 JP
其他公开文献	EP1378788A2 EP1378788A3
外部链接	Espacenet

摘要(译)

一种制造横向电场型液晶显示装置的方法，其中用于形成光刻胶图案的半色调光掩模（60）具有完全遮光区域（62），防止一部分活性物质的紫外线照射其中要形成薄膜晶体管元件（58）的矩阵衬底，使得光刻胶图案包括具有第一厚度并覆盖衬底的上述部分的正抗蚀剂部分（6）。半色调掩模（60）还具有完全透光区域（65），其允许通过其完全UV透射，以为光致抗蚀剂图案提供无抗蚀剂区域（8），该区域覆盖到其中具有接触孔的基板的一部分。（59）用作连接外部扫描线驱动电路和扫描线端子部分（19）通过连接电极（21）的第三连接部分。光致抗蚀剂图案还具有正抗蚀剂部分（7），其覆盖基板的另一部分并且具有小于第一厚度的第二厚度。还在该过程中使用的扫描曝光装置（100,110,120,130）中公开。