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(54) **LIQUID CRYSTAL DISPLAY DEVICE**

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(57) **ABSTRACT**

The present invention provides a display device used in a miniaturized portable equipment which is capable of driving two display panels consisting of main and sub display panels. The display device includes a main display panel, a sub display panel and a drive circuit. The drive circuit can simultaneously drive the main display panel and the sub display panel. Output terminals are provided to the main display panel and signals are transmitted to the sub display panel from the output terminals. Further, the drive circuit includes a power source circuit which is capable of outputting proper common voltages to the main display panel and the sub display panel.

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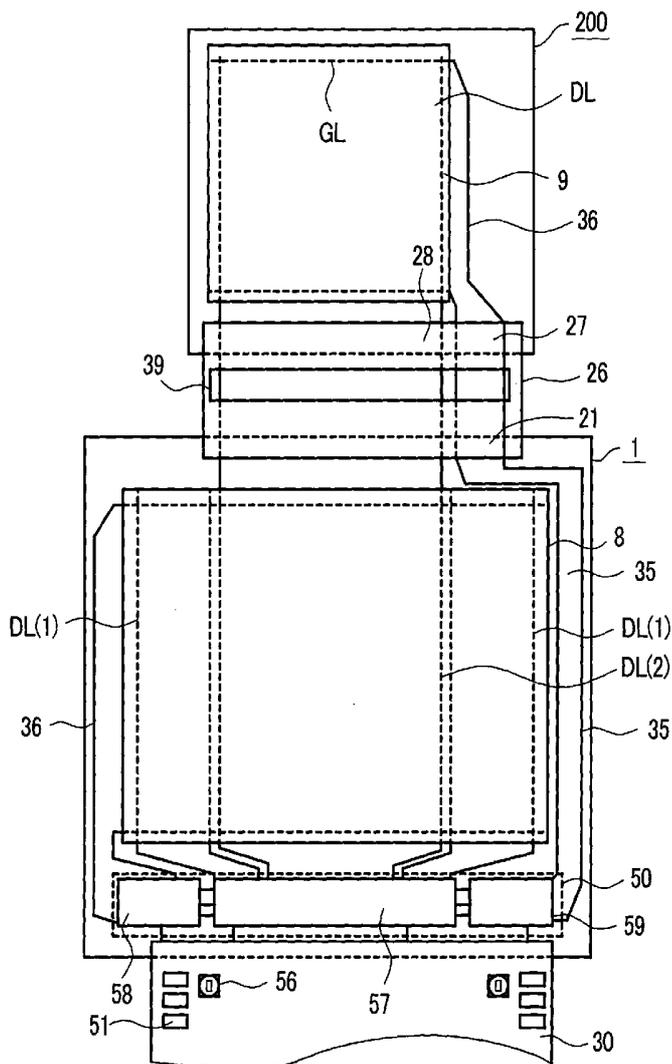
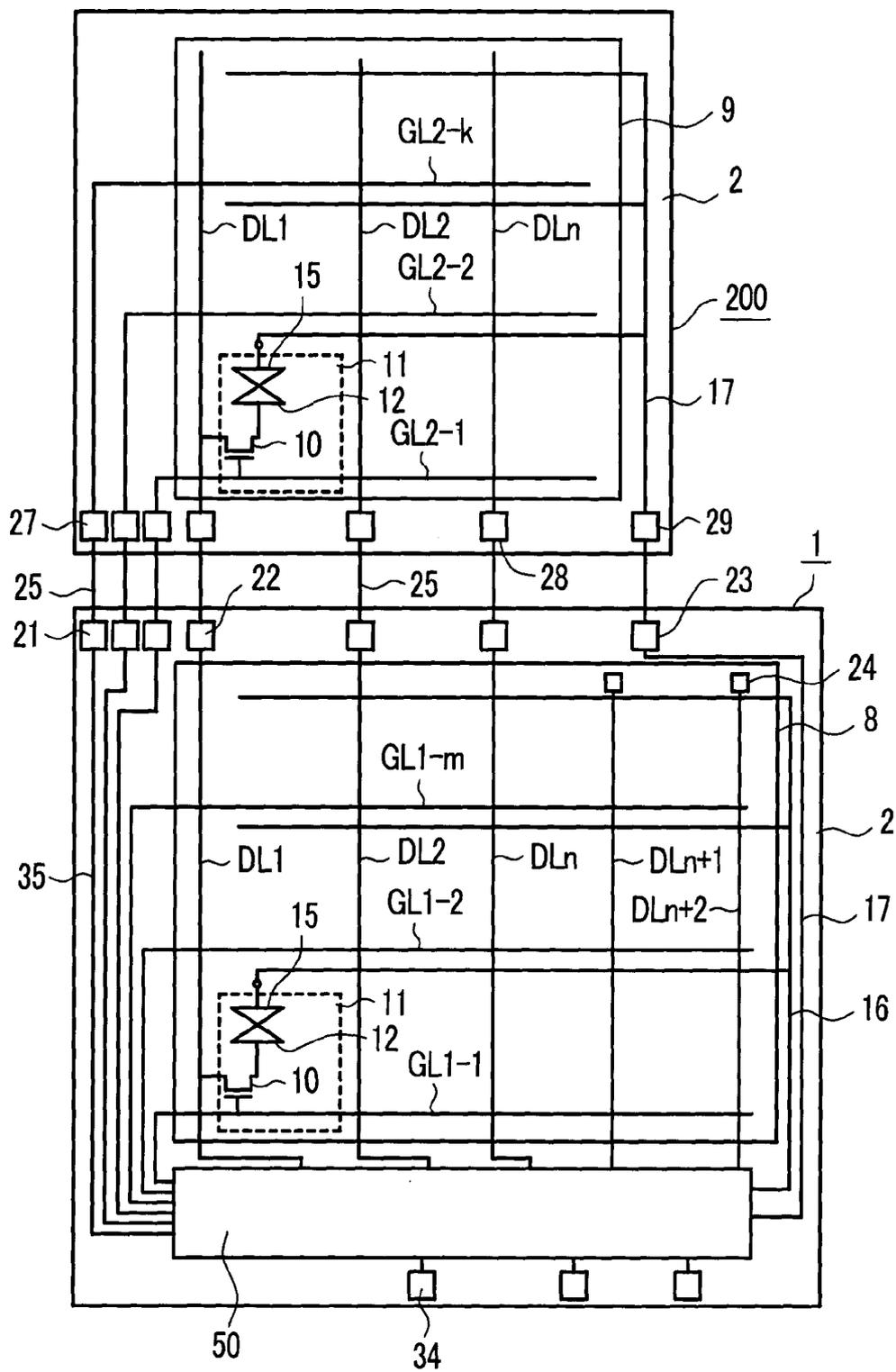


FIG. 1





*FIG. 3*

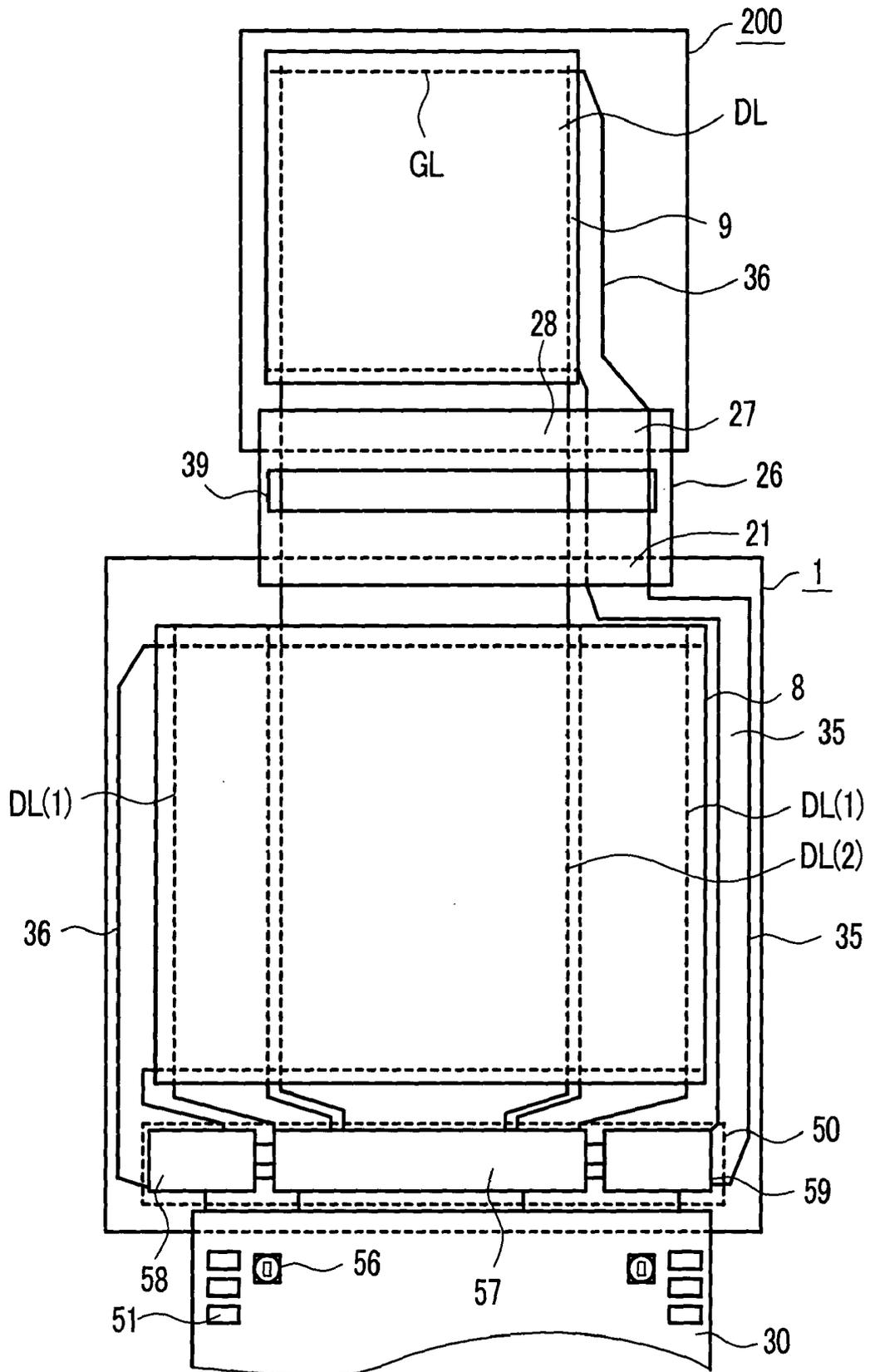
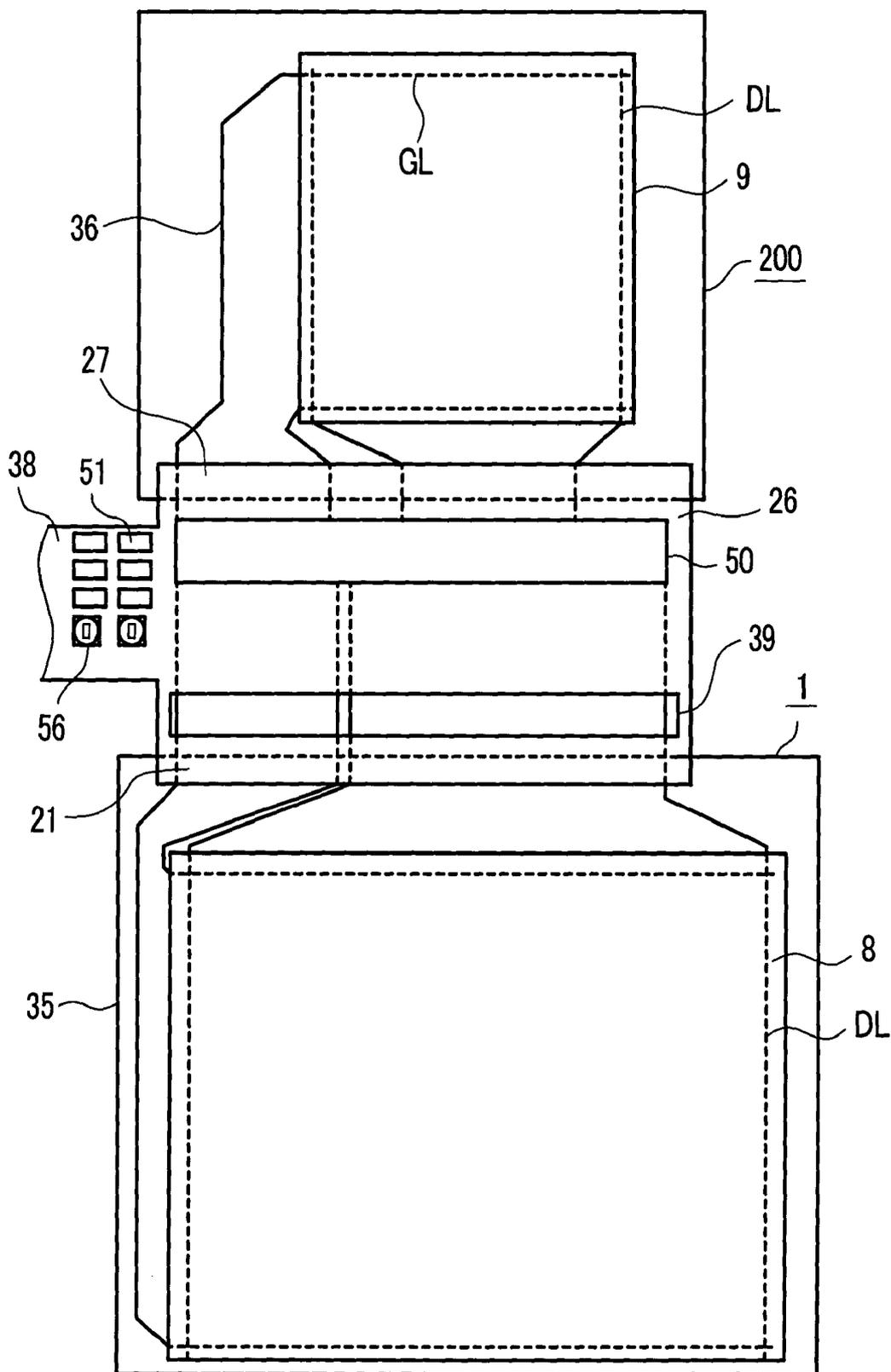
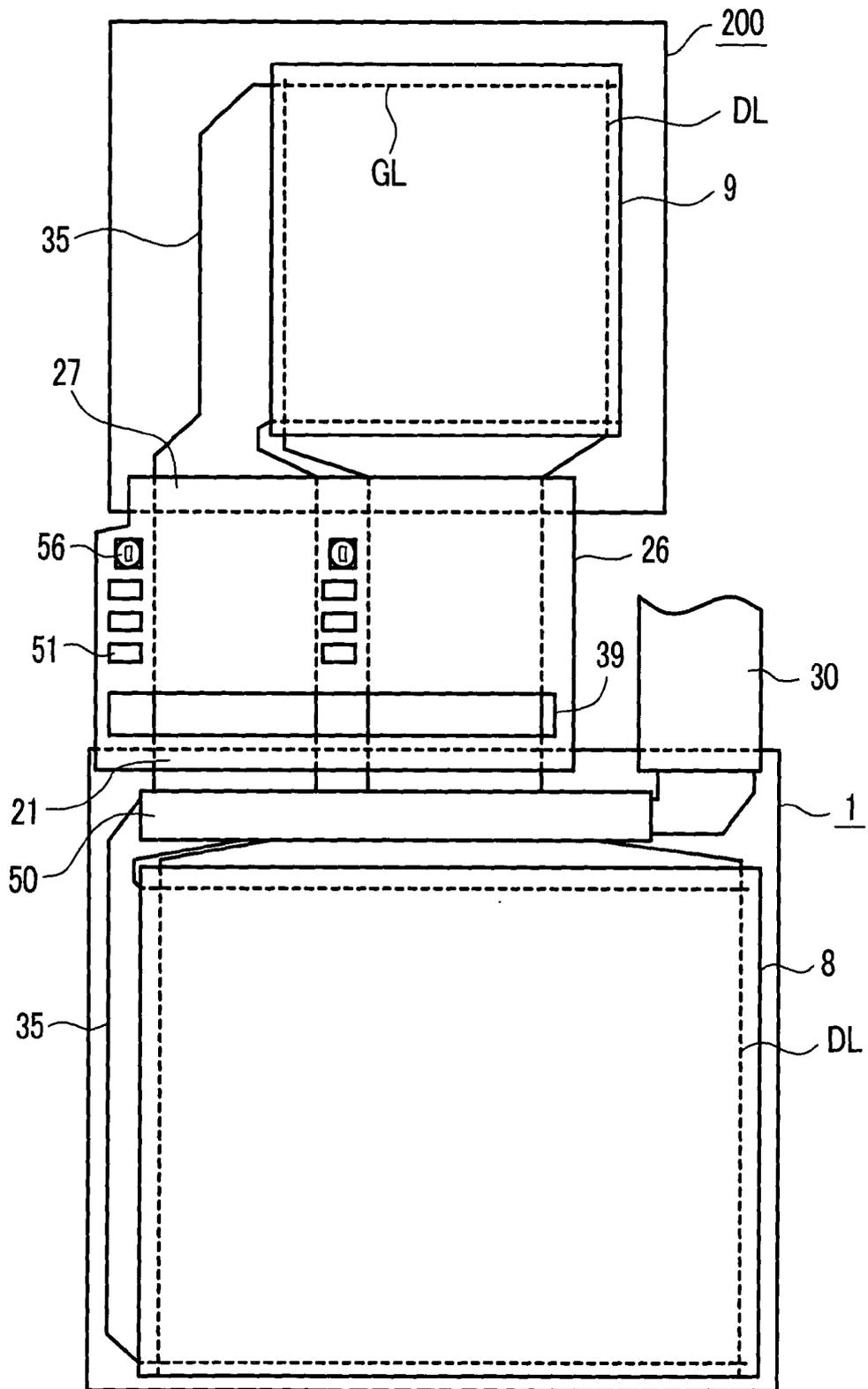


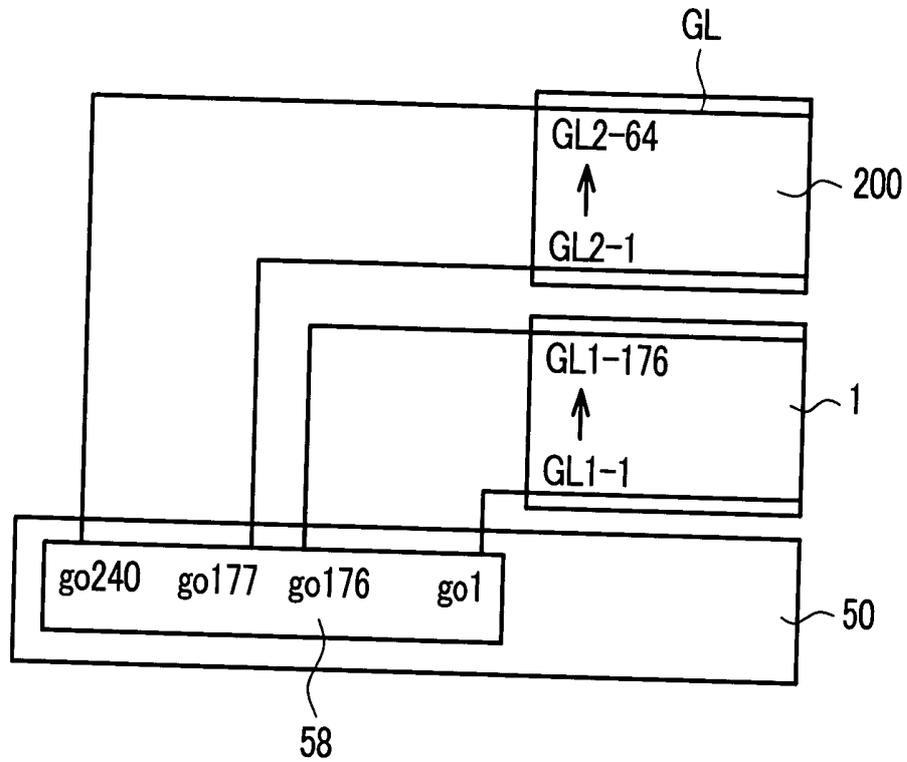
FIG. 4



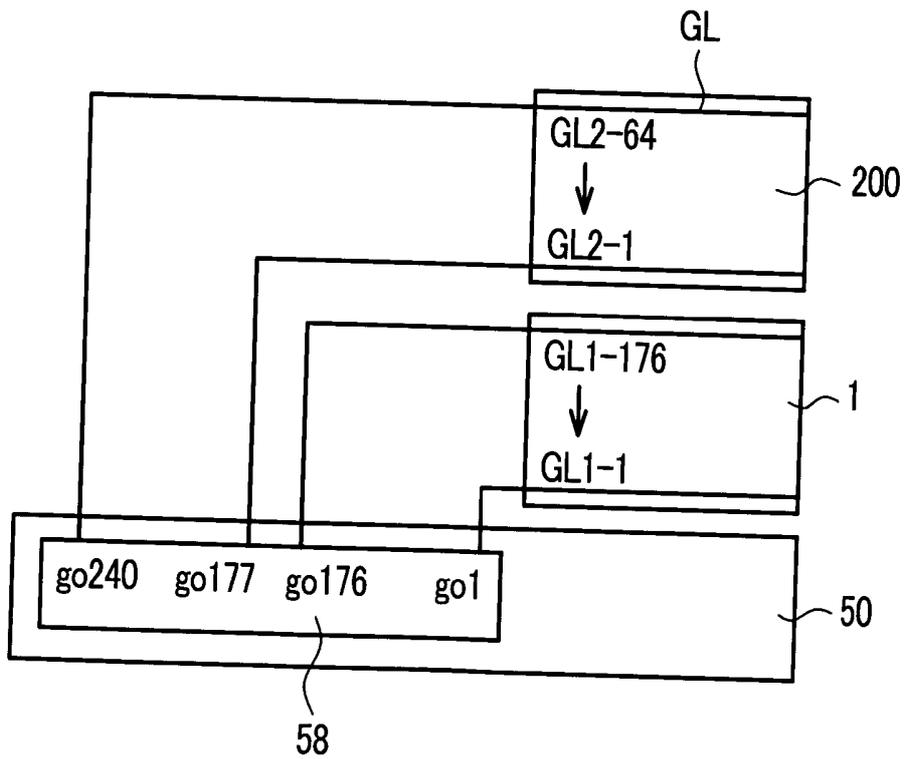
*FIG. 5*



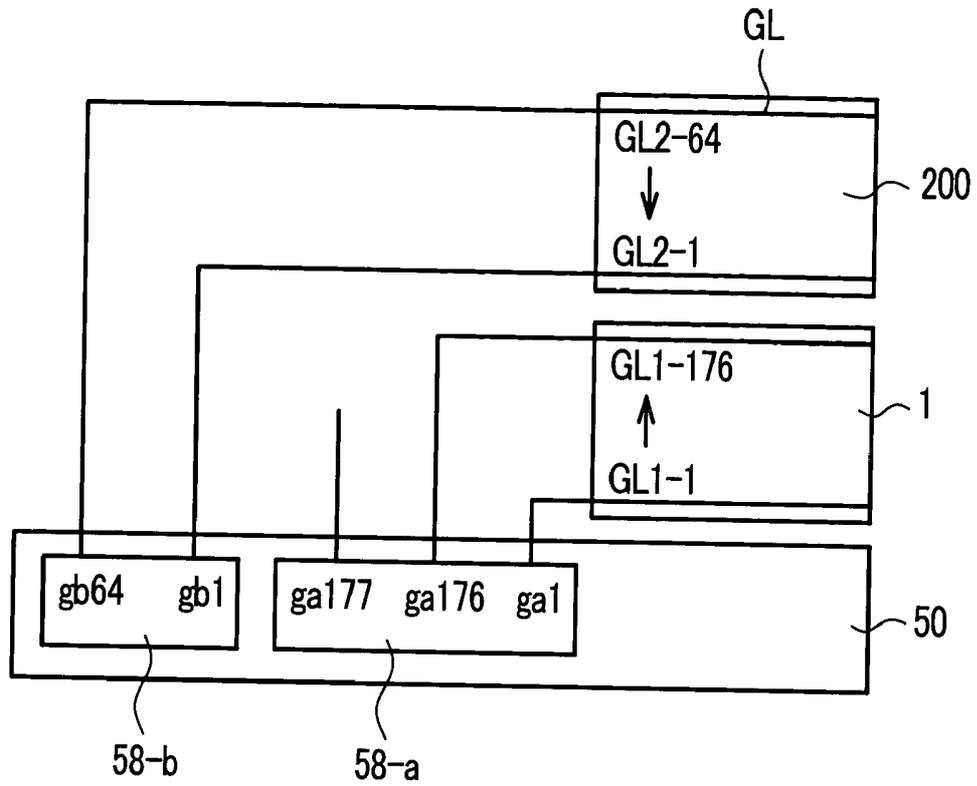
*FIG. 6A*



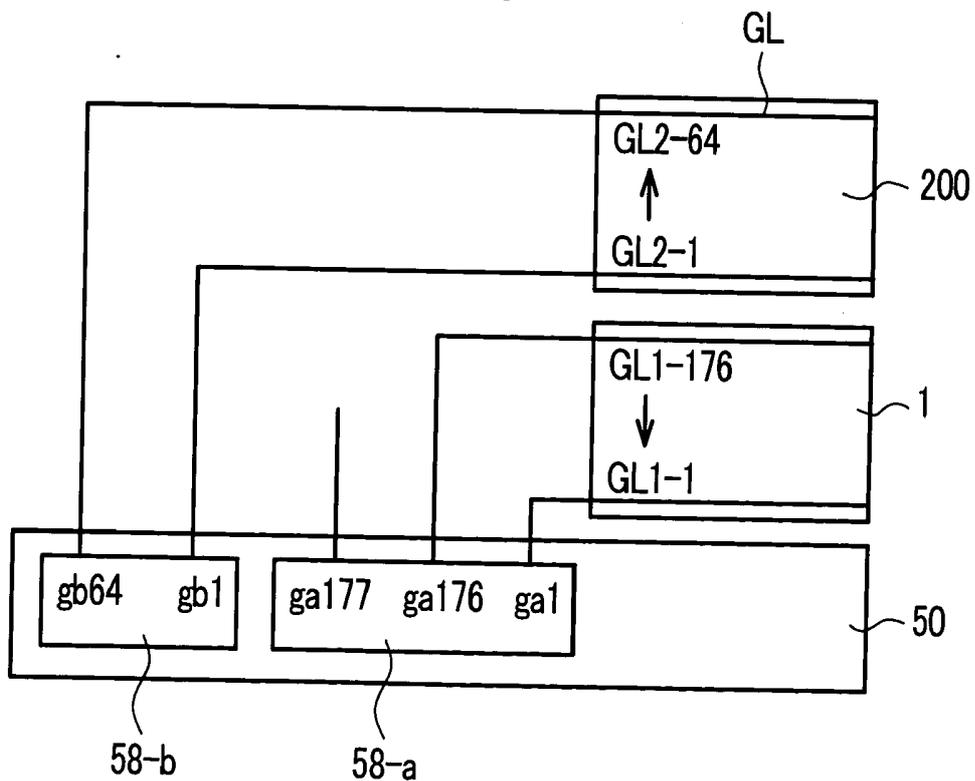
*FIG. 6B*



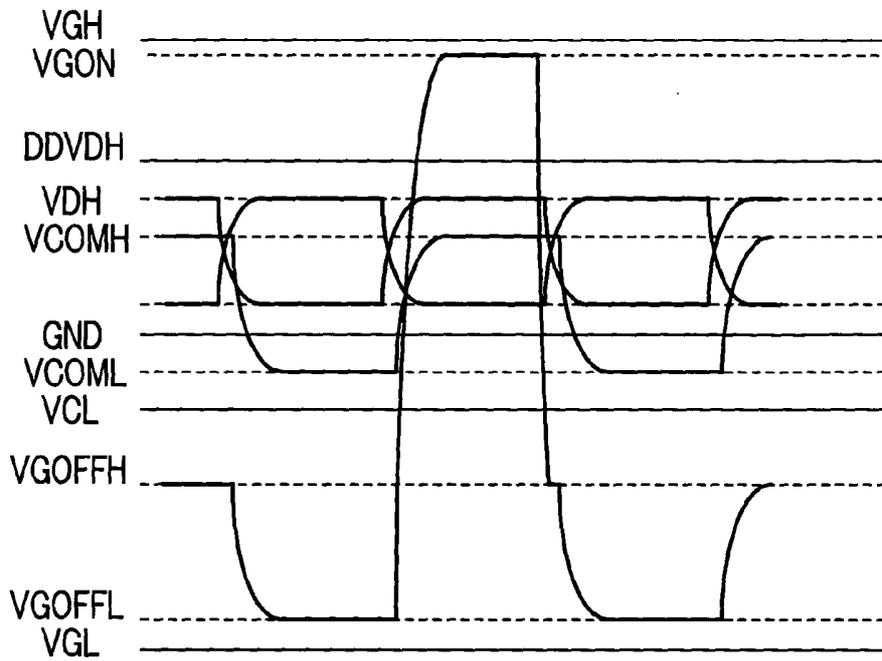
**FIG. 7A**



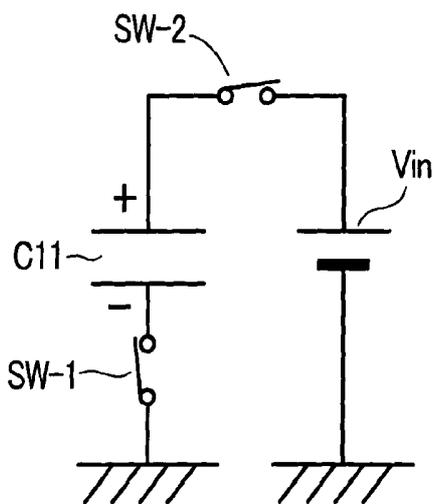
**FIG. 7B**



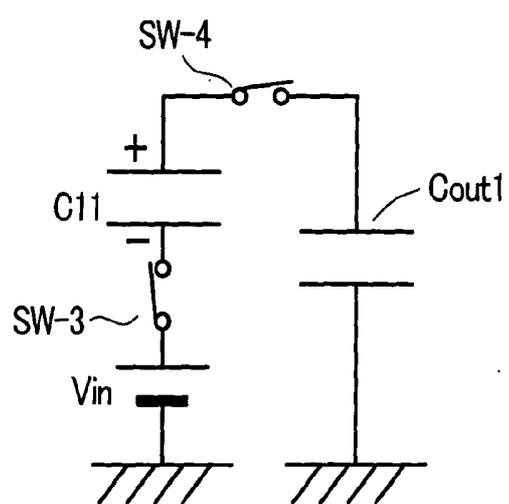
**FIG. 8**



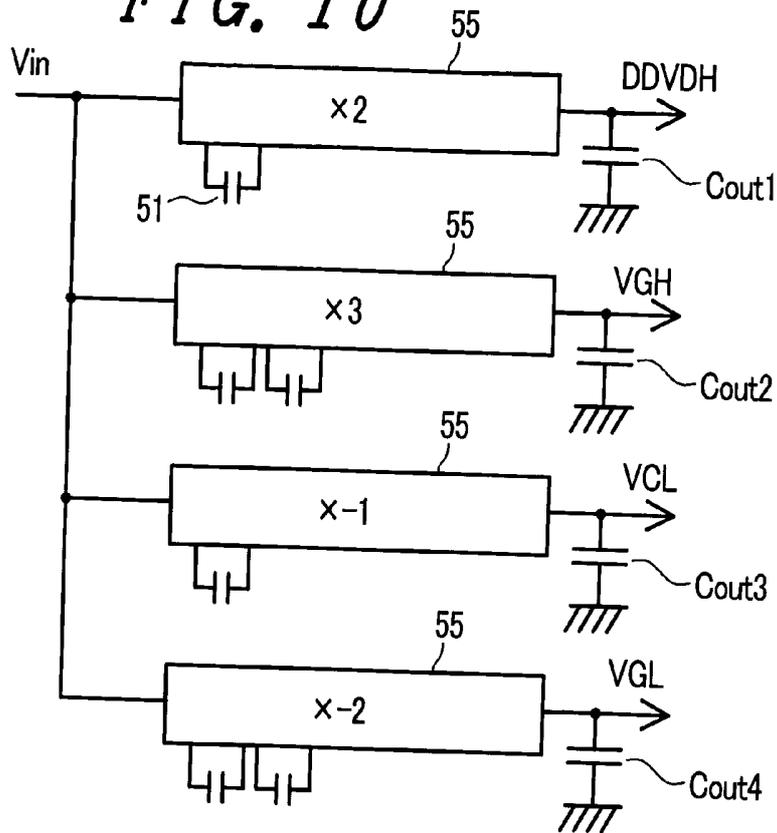
**FIG. 9A**



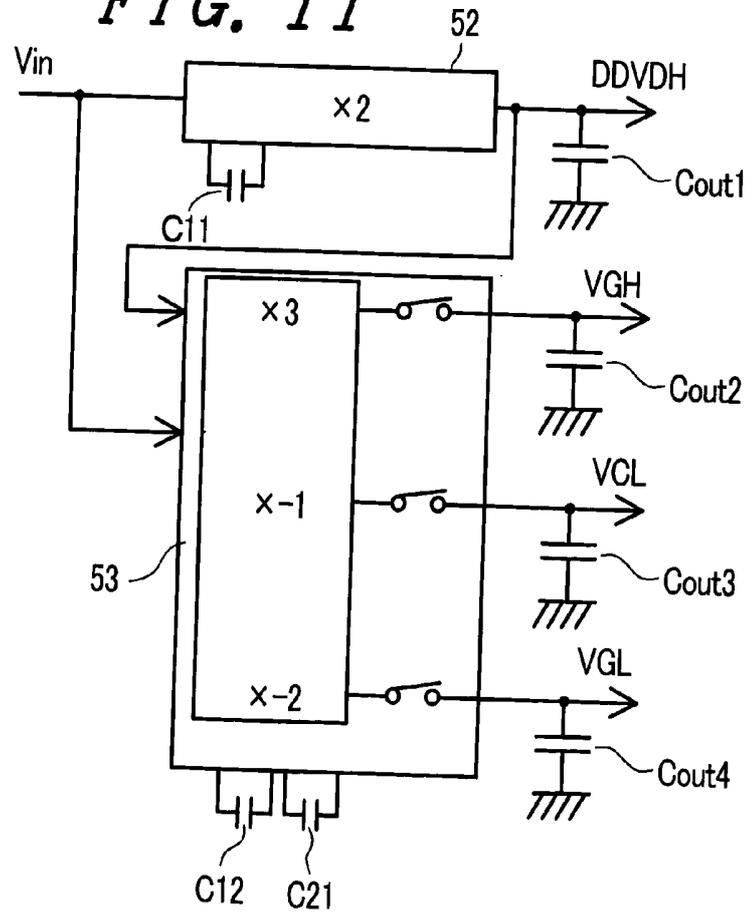
**FIG. 9B**



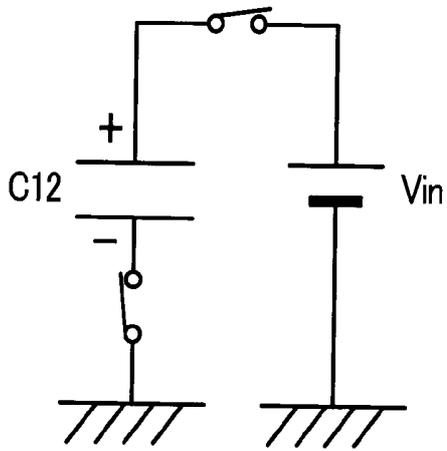
**FIG. 10**



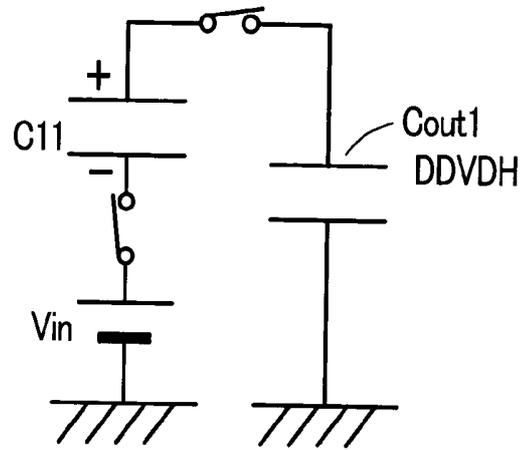
**FIG. 11**



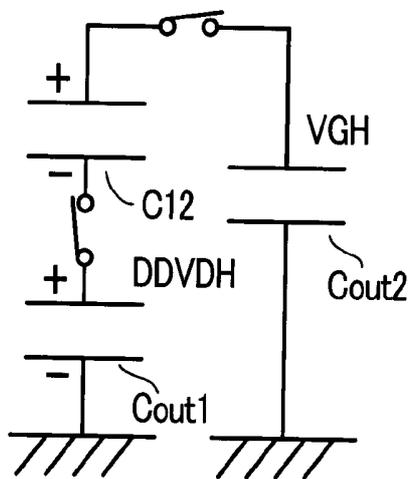
*FIG. 12A*



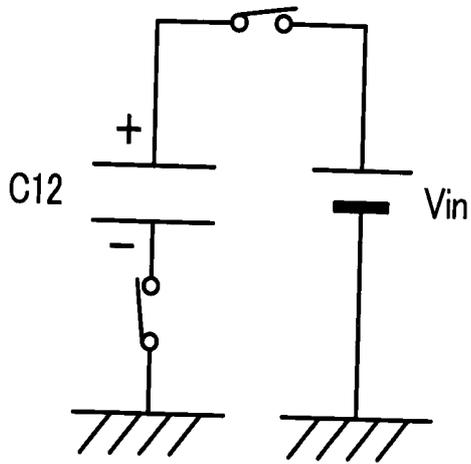
*FIG. 12B*



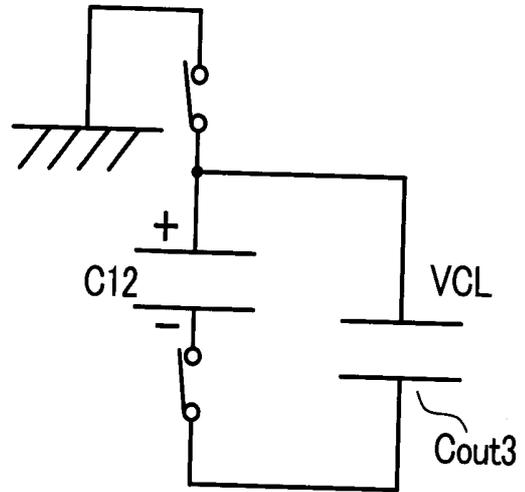
*FIG. 12C*



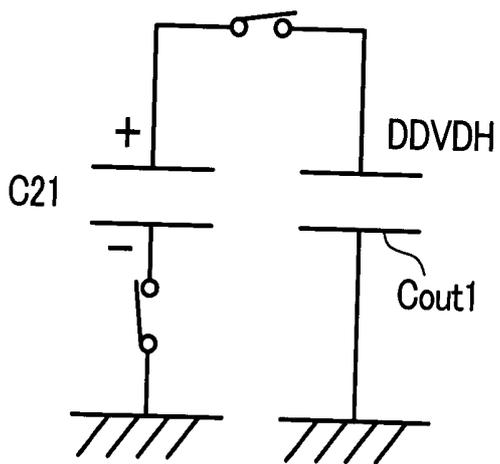
*FIG. 13A*



*FIG. 13B*



*FIG. 14A*



*FIG. 14B*

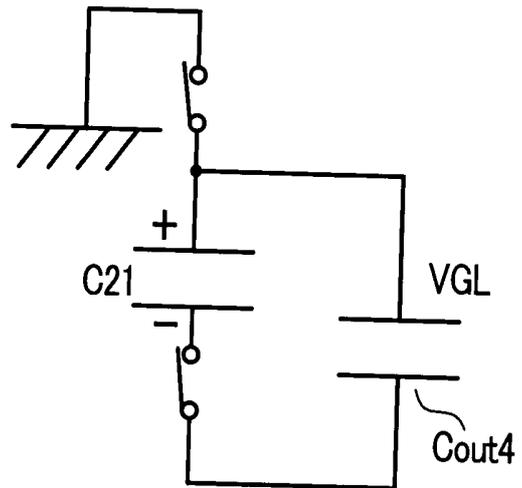
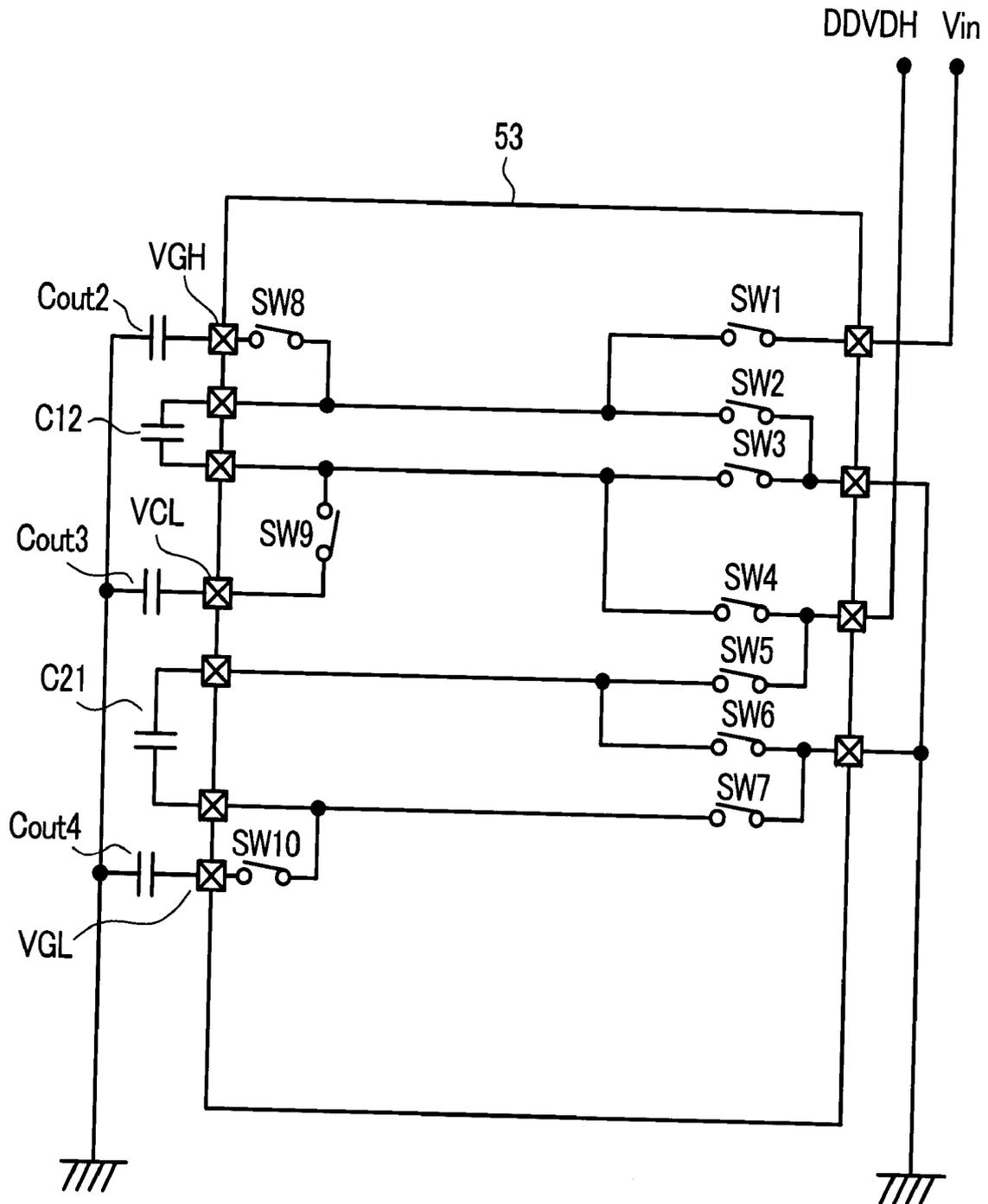


FIG. 15



*FIG. 16*

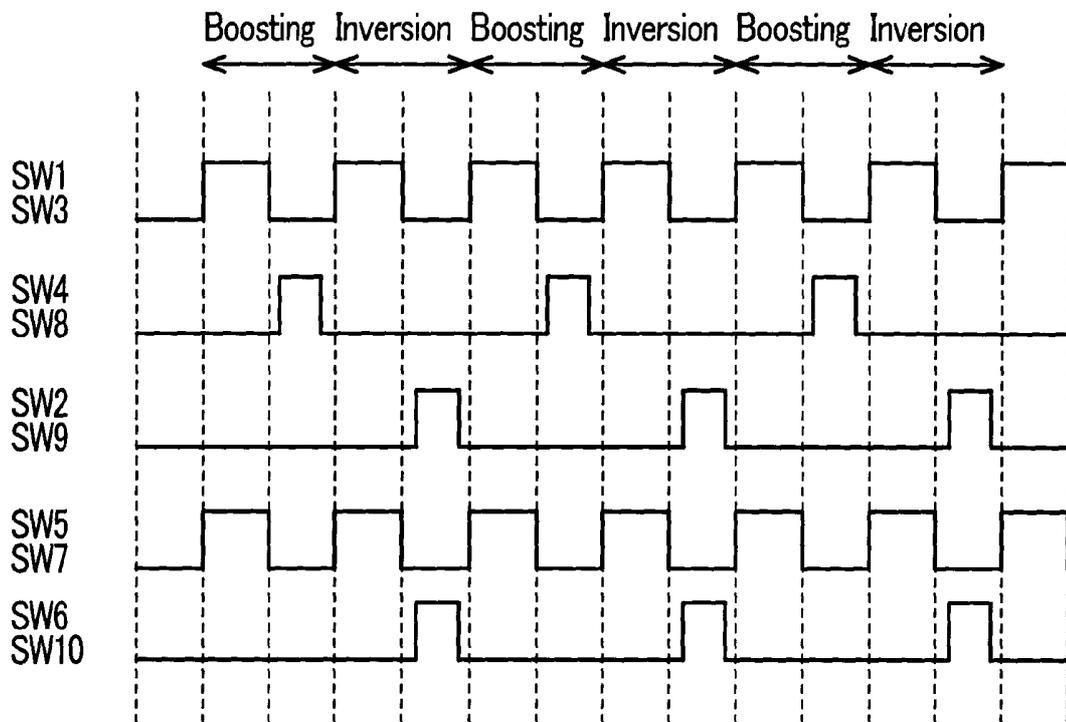
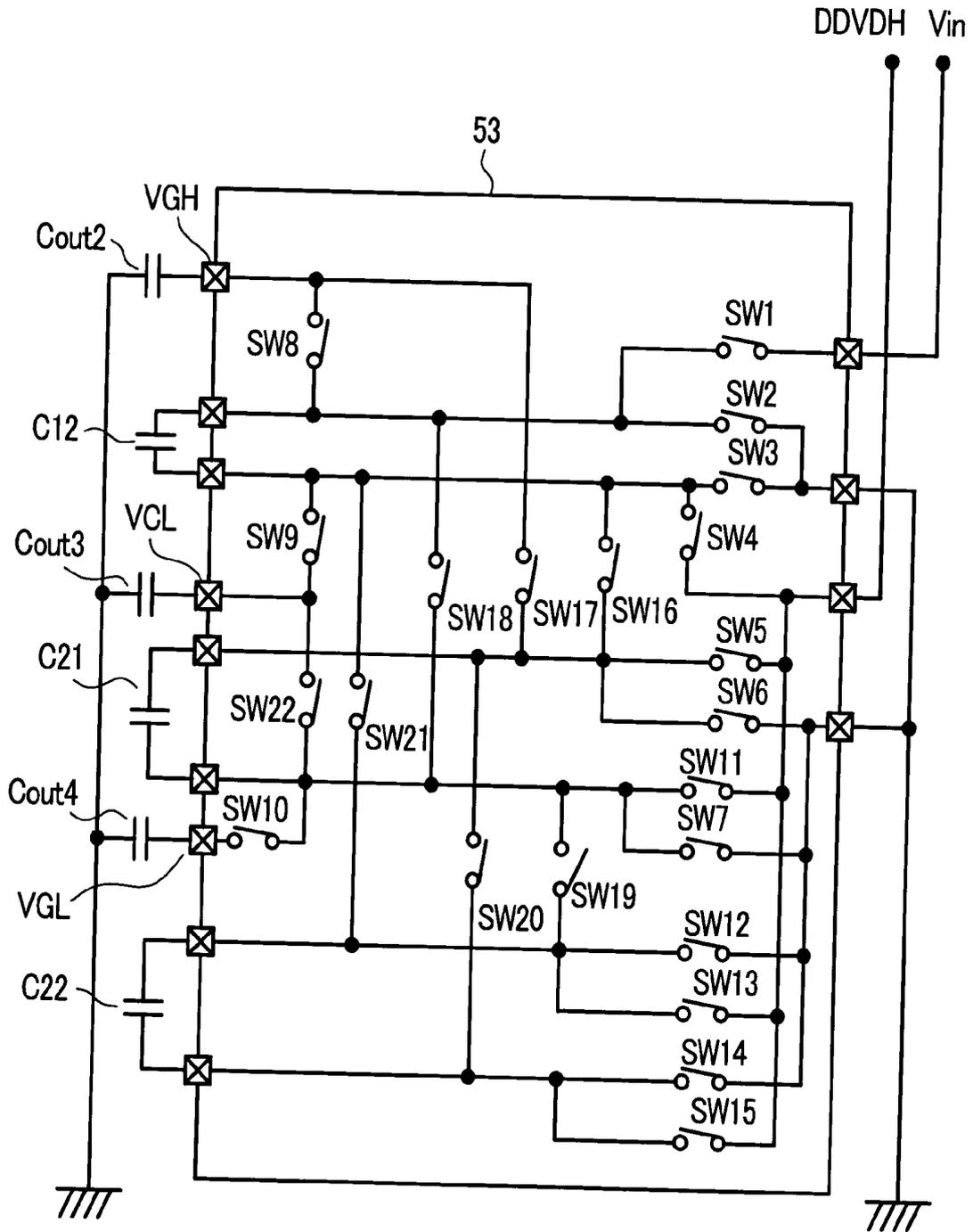
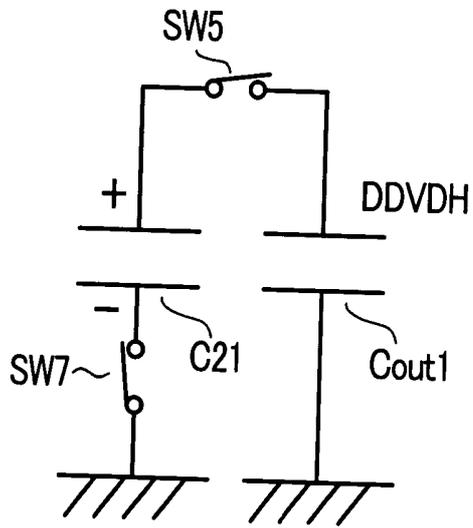


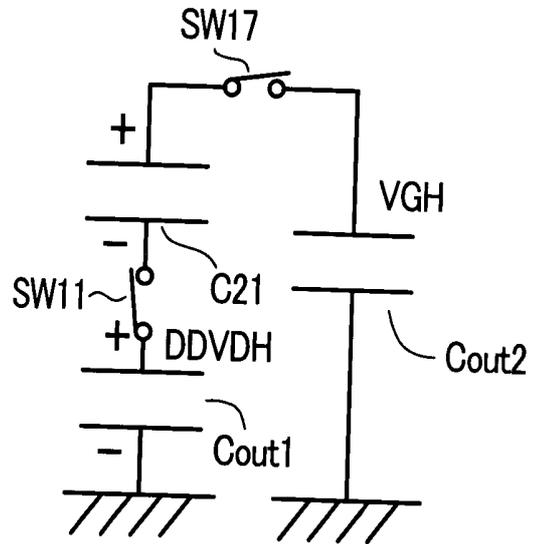
FIG. 17



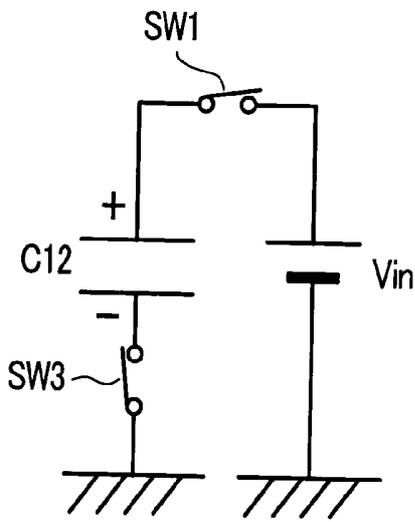
*FIG. 18A*



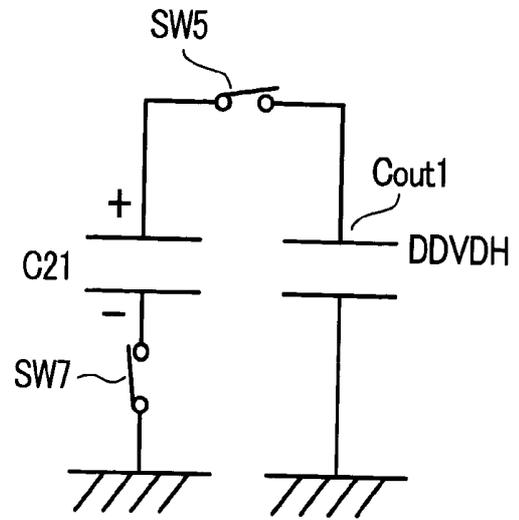
*FIG. 18B*



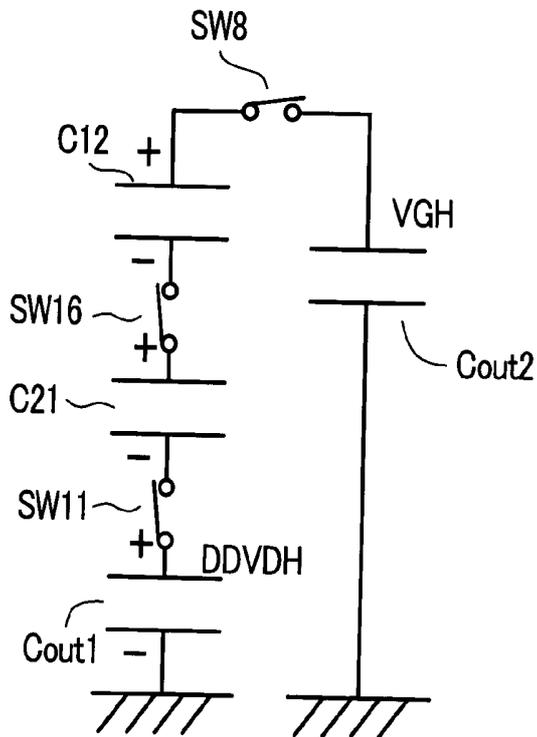
*FIG. 19A*



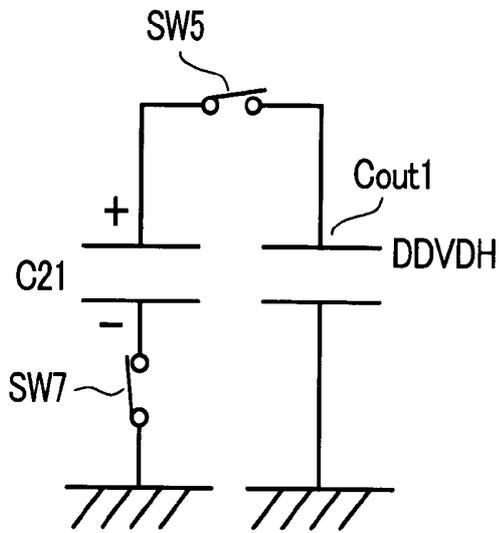
*FIG. 19B*



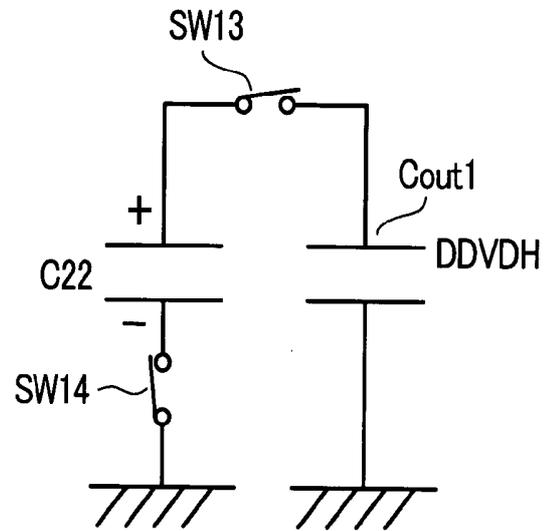
*FIG. 19C*



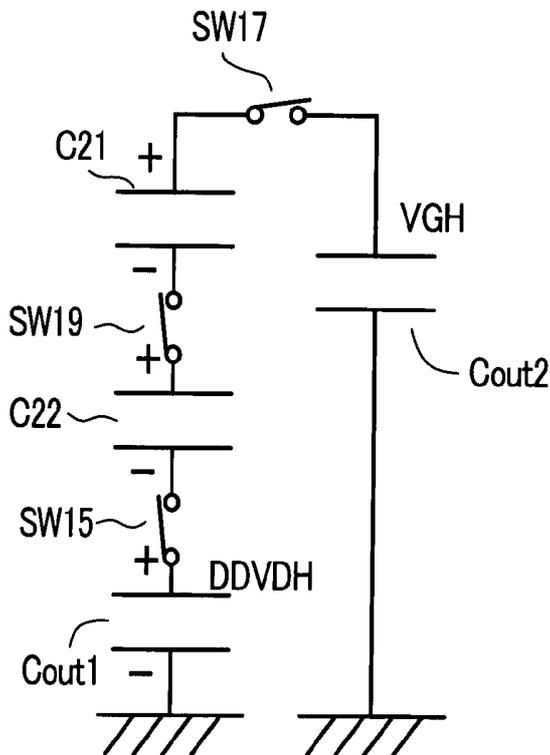
*FIG. 20A*



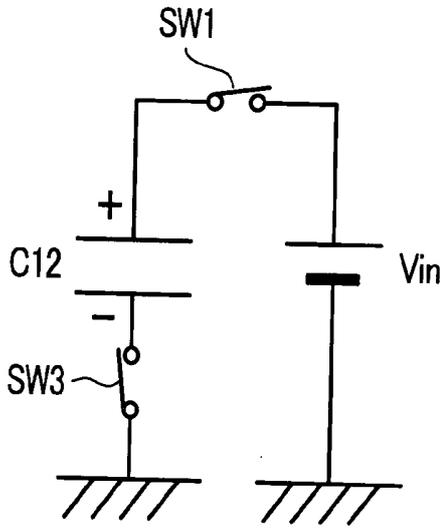
*FIG. 20B*



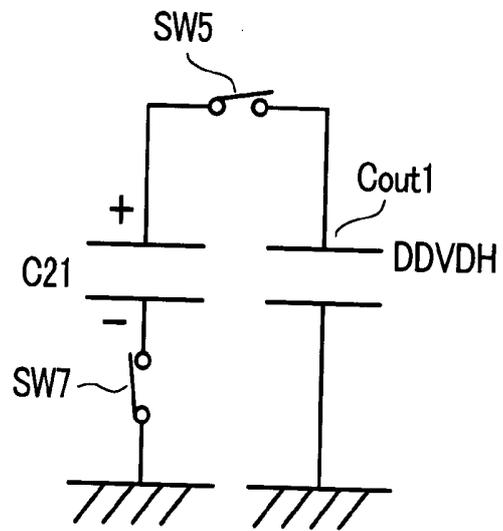
*FIG. 20C*



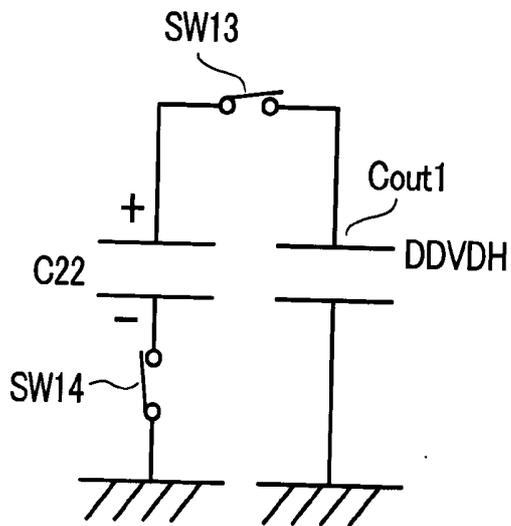
*FIG. 21A*



*FIG. 21B*



*FIG. 21C*



*FIG. 21D*

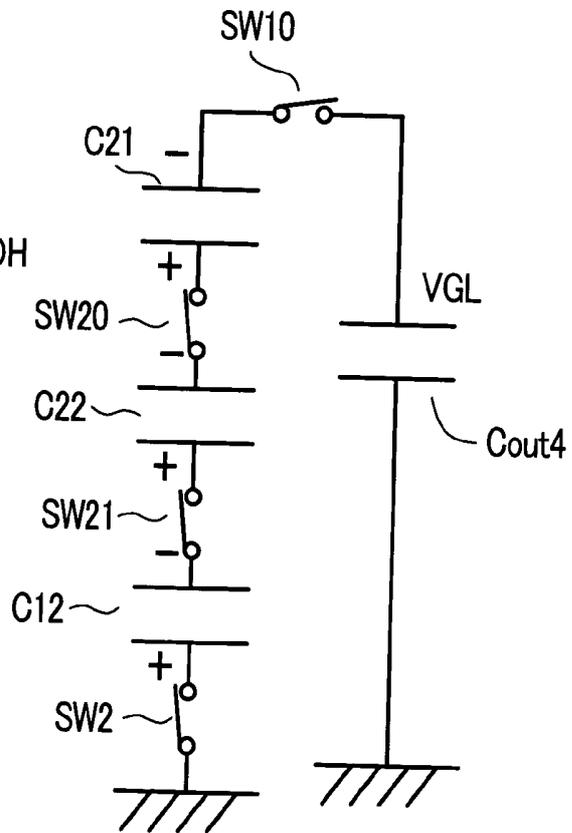


FIG. 22

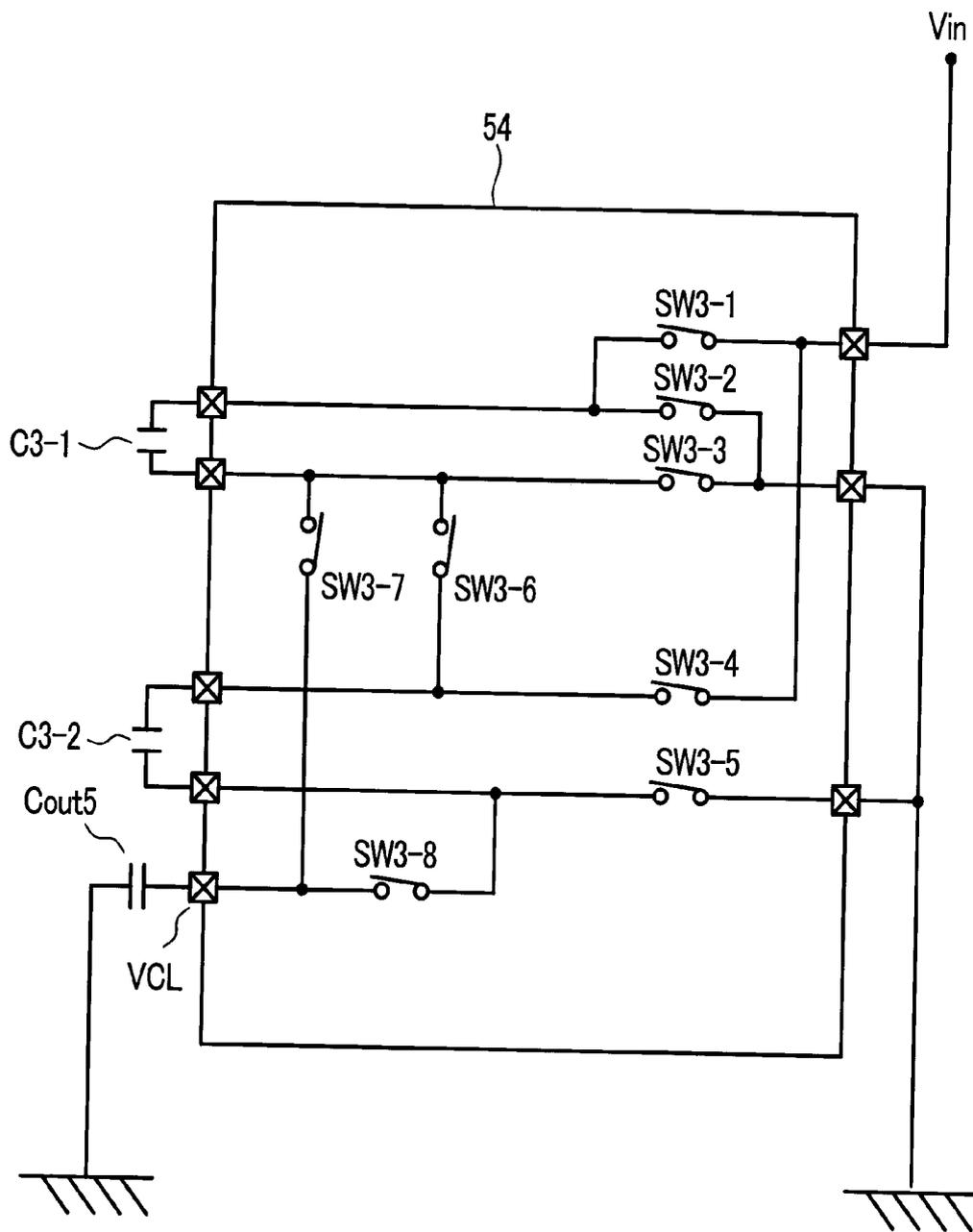
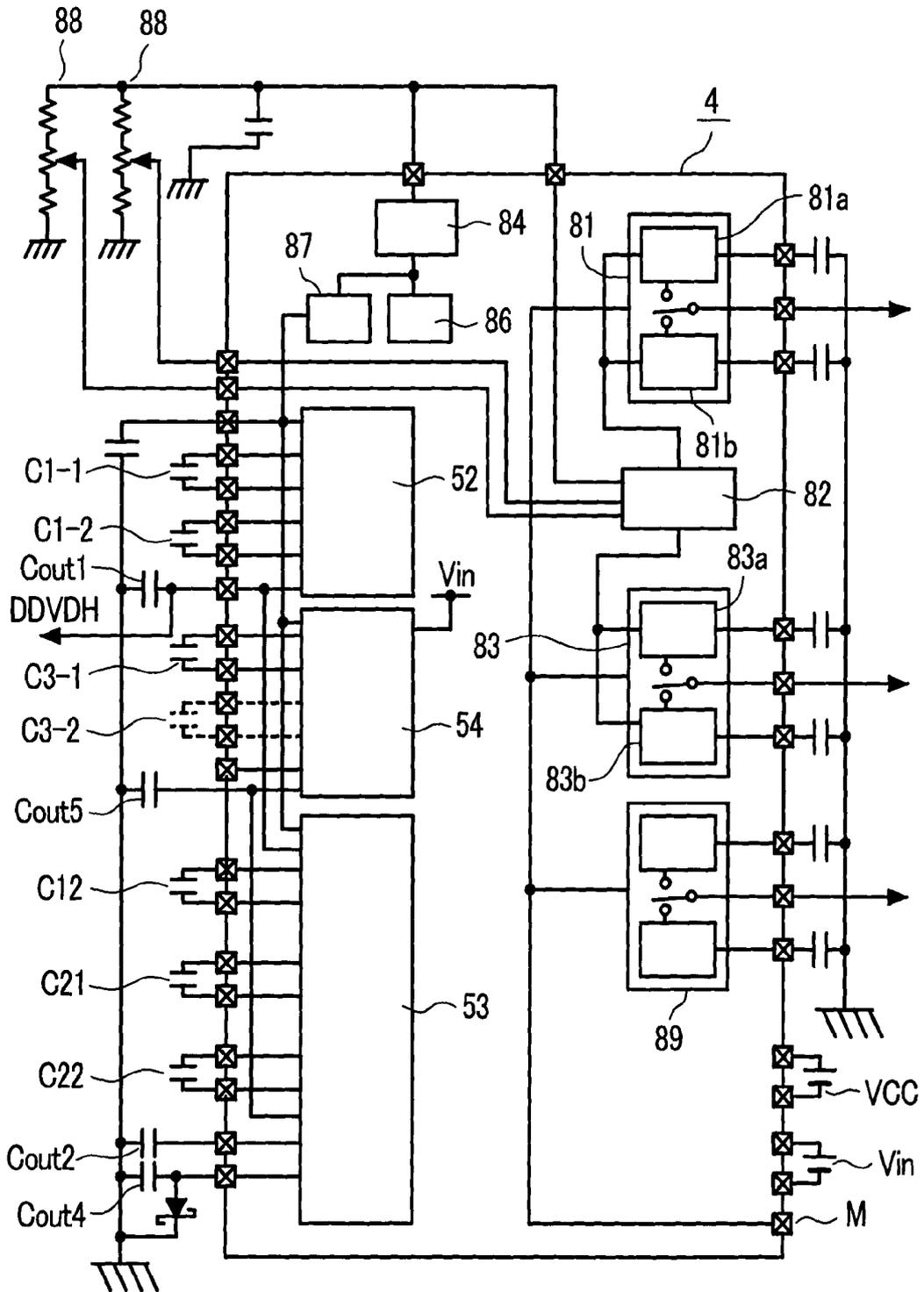
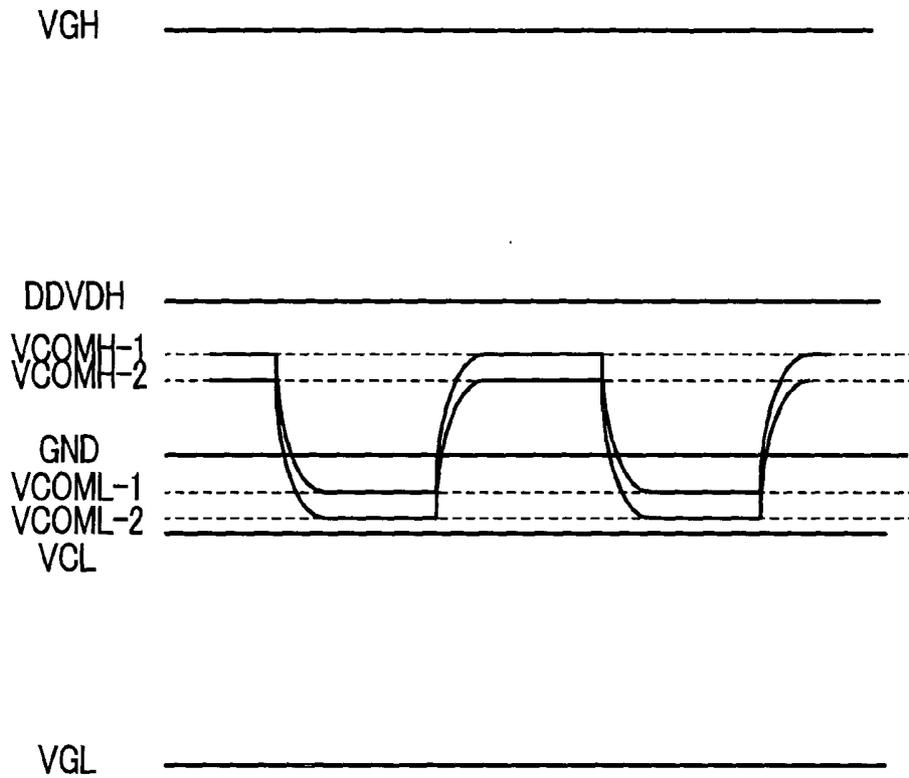


FIG. 23



*FIG. 24*



*FIG. 25*

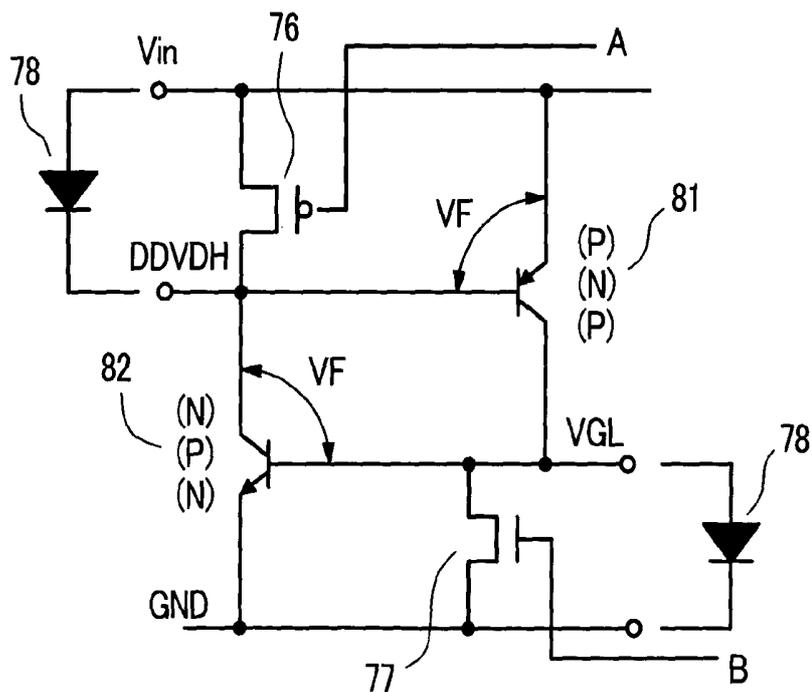


FIG 26A

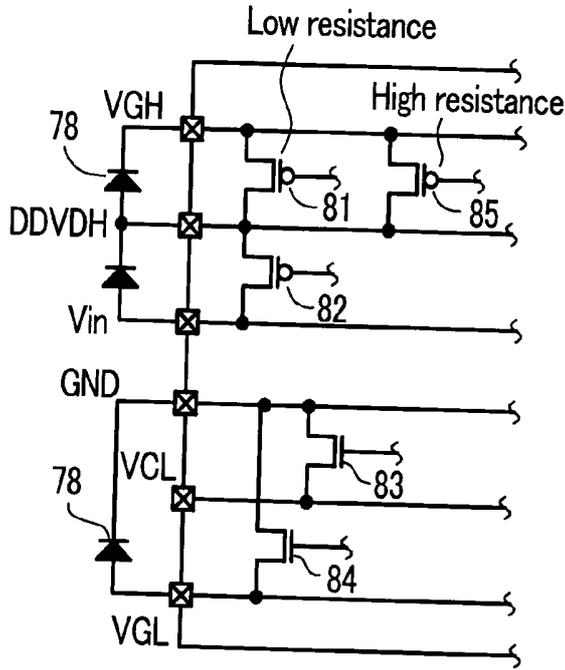
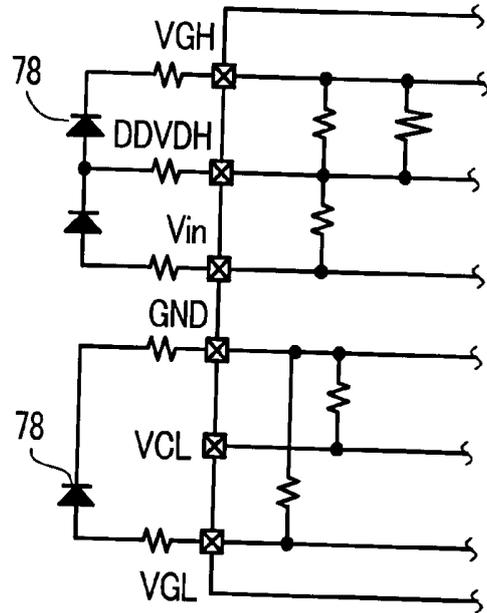
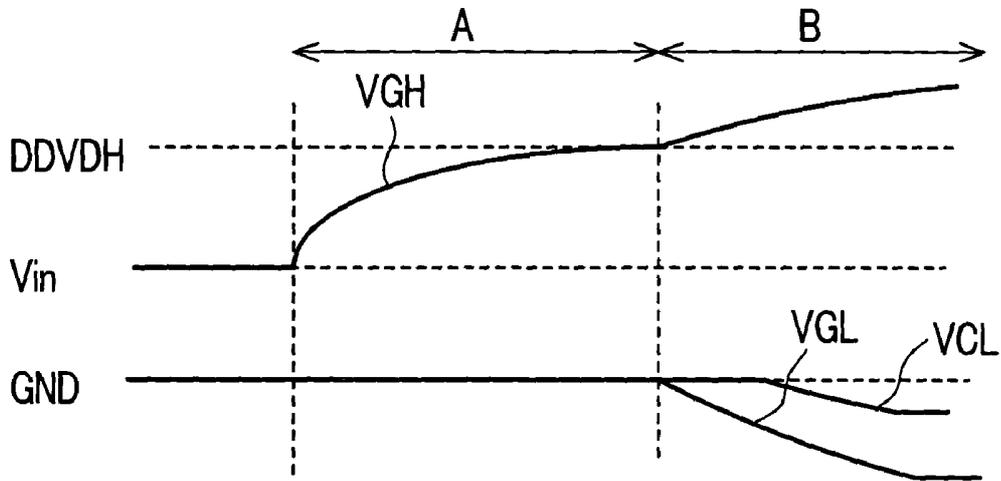


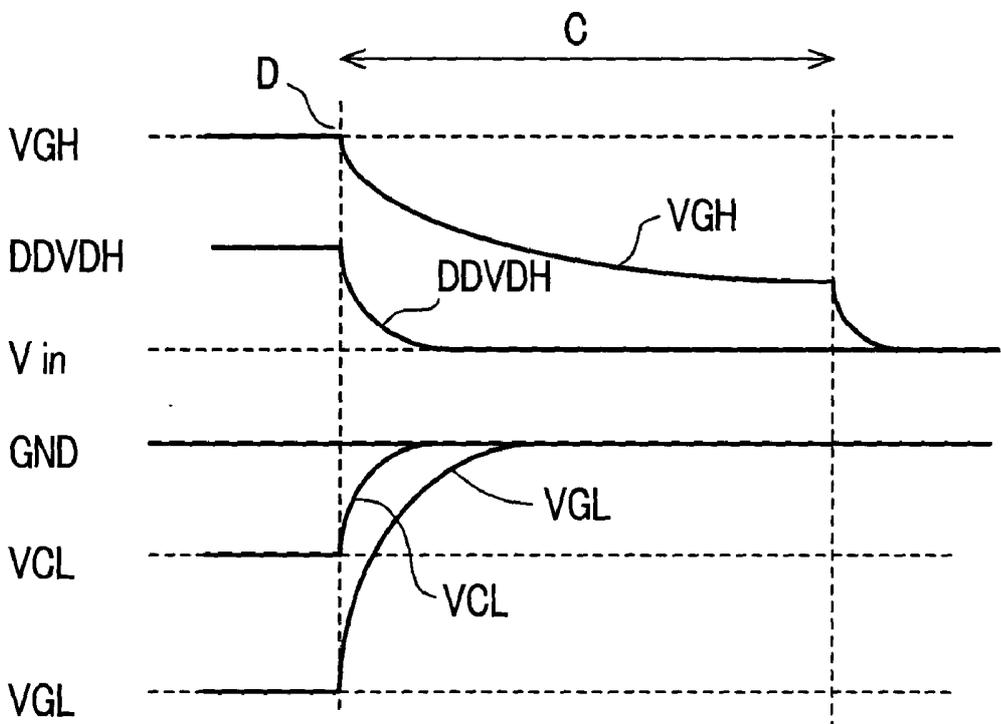
FIG. 26B



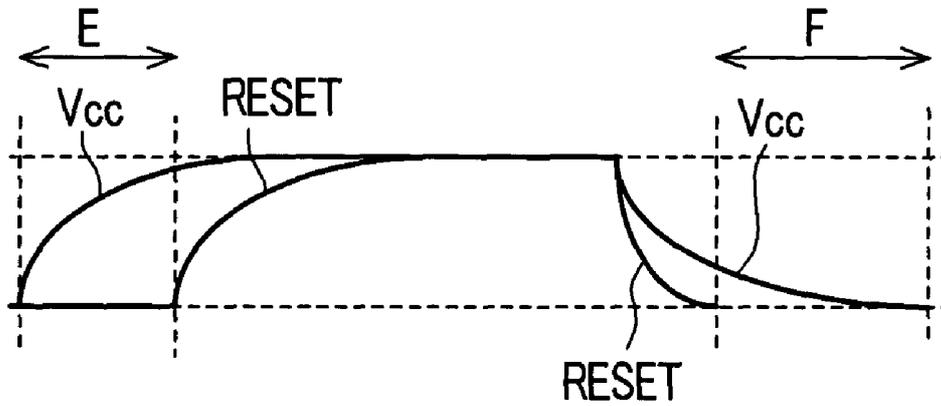
*FIG. 27A*



*FIG. 27B*



*FIG. 28A*



*FIG. 28B*

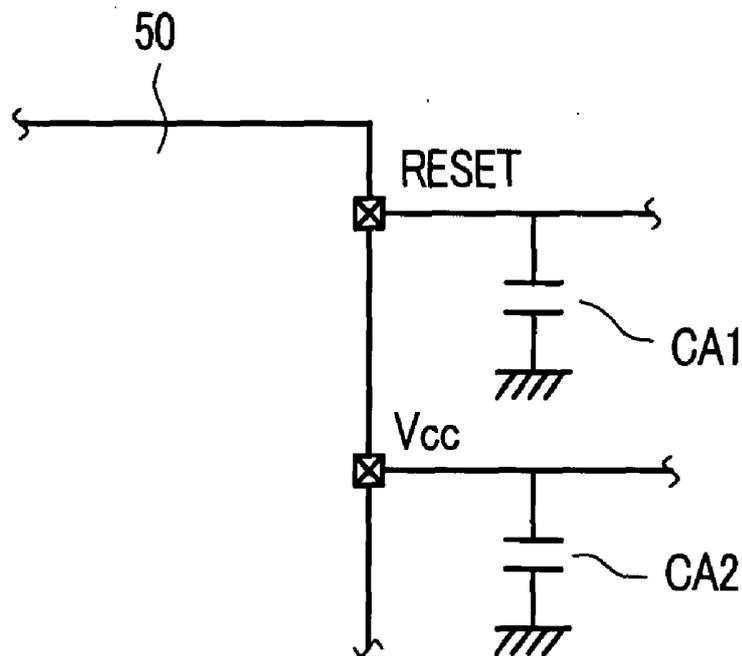
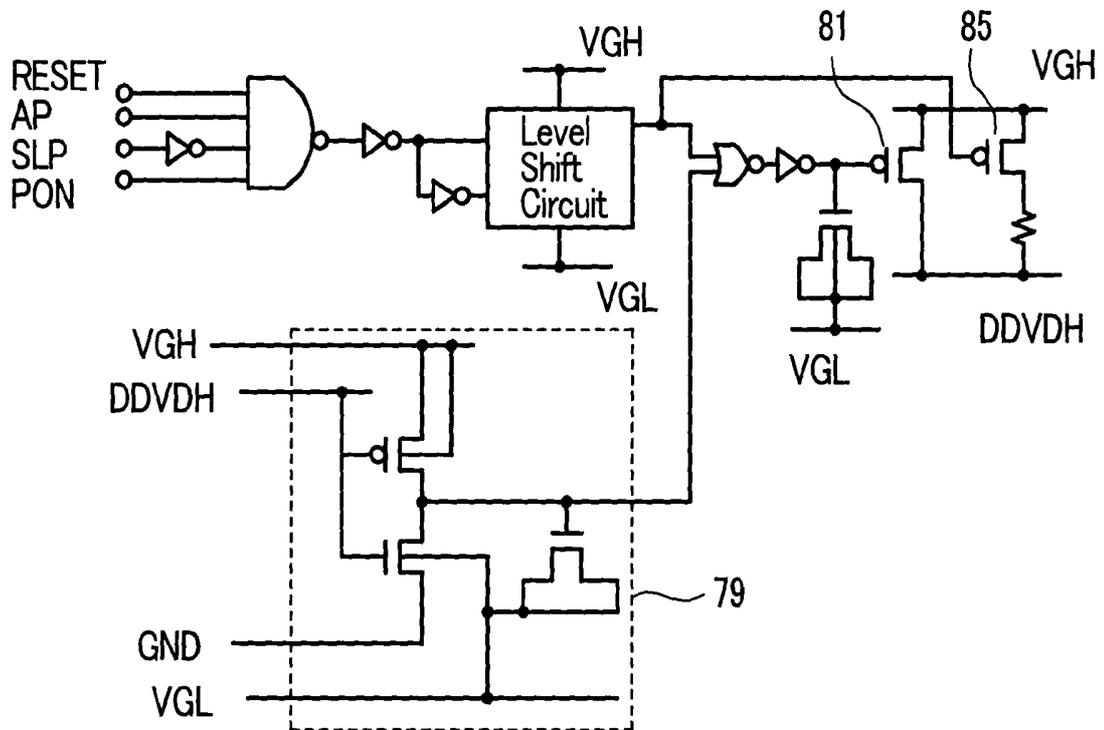
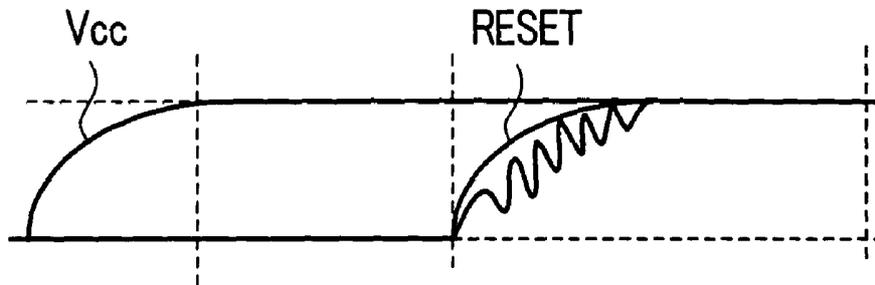


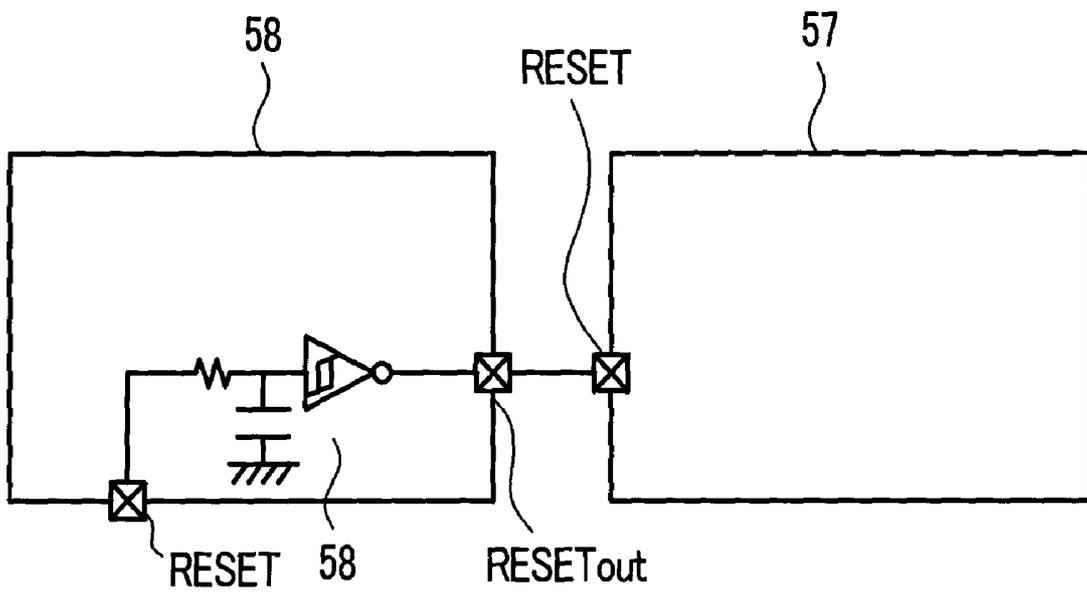
FIG. 29



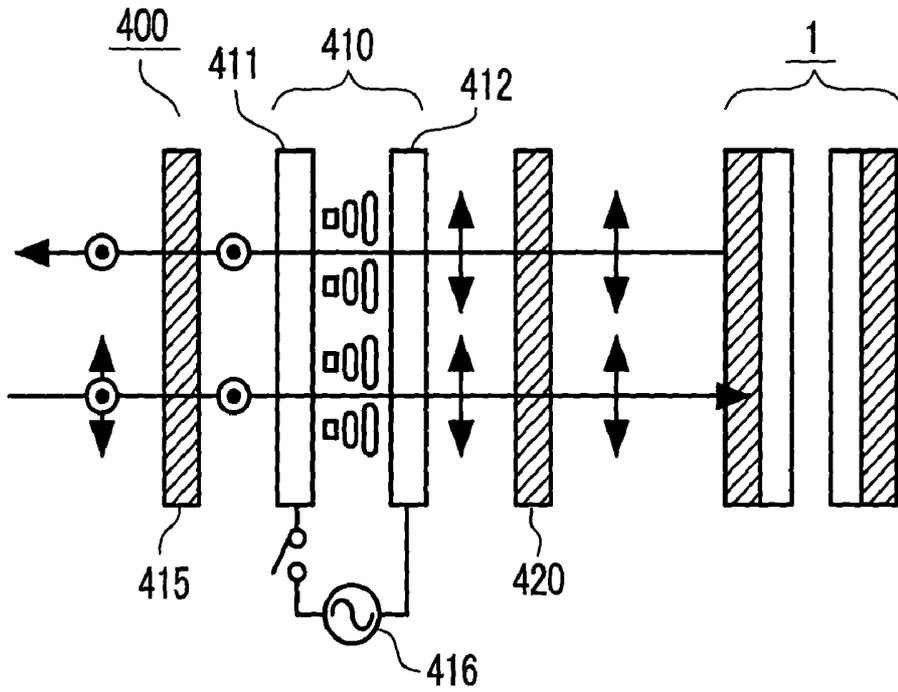
*FIG 30A*



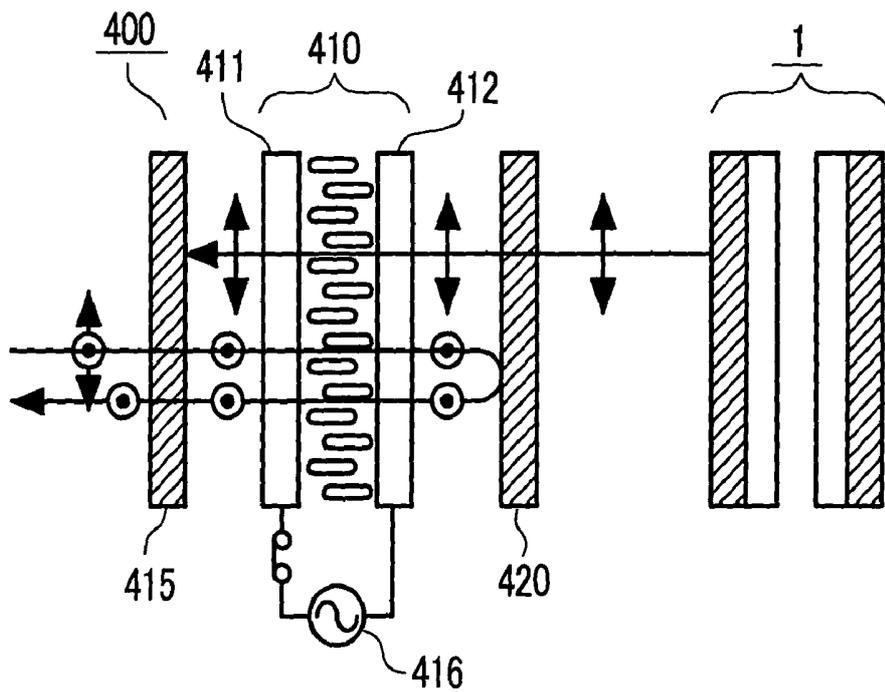
*FIG. 30B*



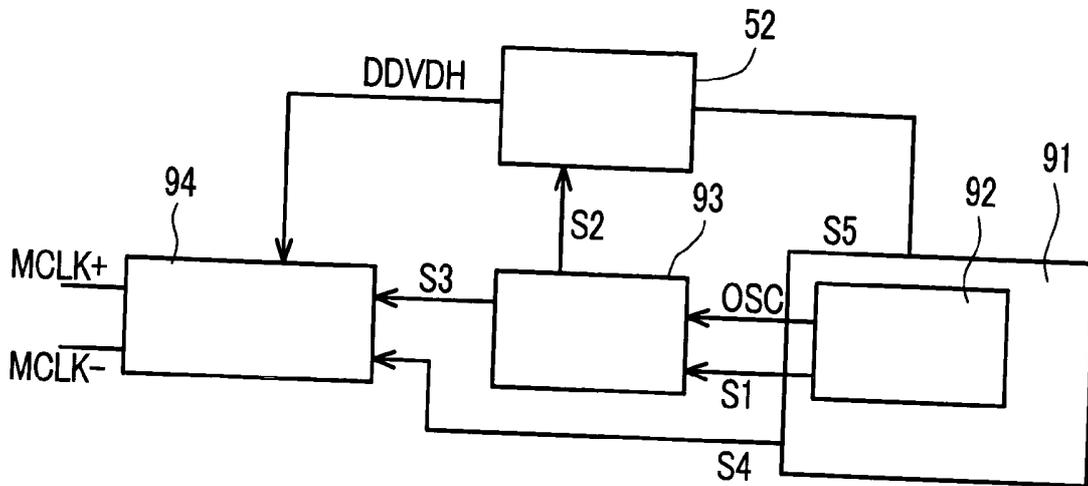
*FIG. 31A*



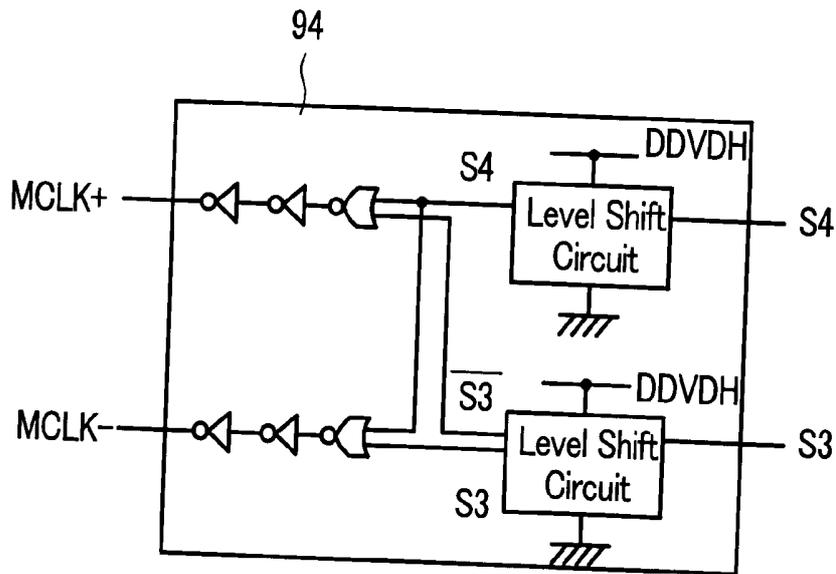
*FIG. 31B*



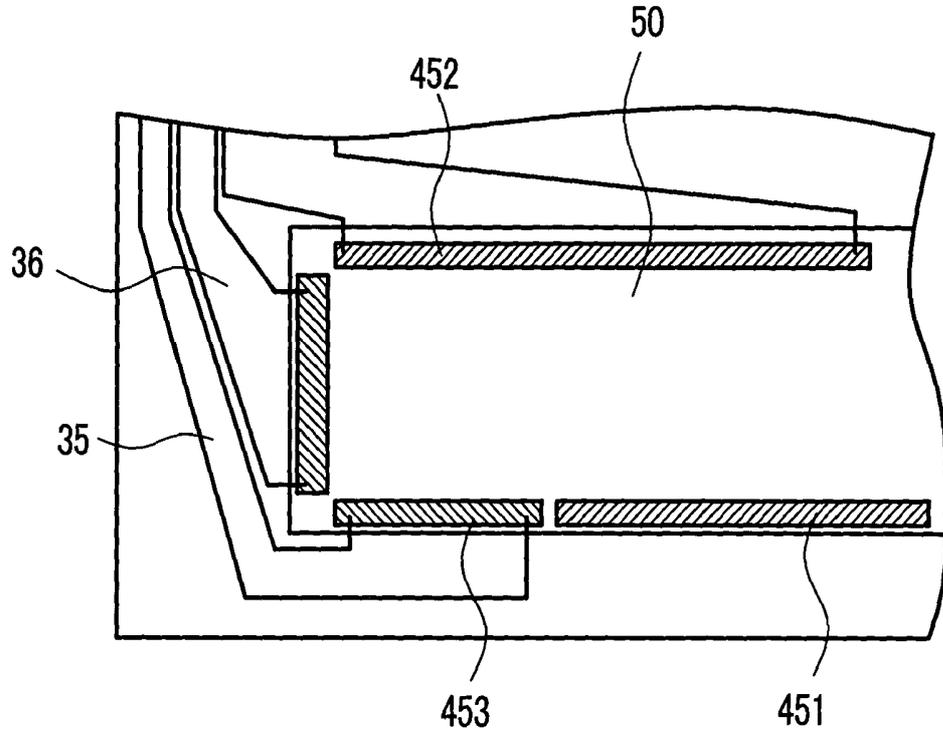
*FIG. 32A*



*FIG. 32B*



*FIG. 33*



*FIG. 34*

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	
0	0	0	*	GON	VCMG	BT2	BT1	BT0	DC2	DC1	DC0	AP2	AP1	AP0	SLP	
0	0	1	0	0	COM1	COM2	*	PON	*	*	*	*	*	*	*	
0	0	1	0	1	*	*	*	0	*	*	MI1	MI0	MFL2	MFL1	MFL0	
0	1	0	0	0	0	VDV4	VDV3	VDV2	VDV1	VDV0	VCM4	VCM3	VCM2	VCM1	VCM0	
1	1	0	0	0	GS	NL4	NL3	NL2	NL1	NL0	SC4	SC3	SC2	SC1	SC0	
1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	FL1	FL0

ID

## LIQUID CRYSTAL DISPLAY DEVICE

### BACKGROUND OF THE INVENTION

#### [0001] 1. Field of the Invention

[0002] The present invention relates to a liquid crystal display device, and more particularly to a technique which is effectively applicable to drive circuits of a liquid crystal display device used in a portable display device.

#### [0003] 2. Description of the Related Art

[0004] Liquid crystal display devices of STN (Super Twisted Nematic) type or liquid crystal display devices of TFT (Thin Film Transistor) type have been popularly used as display devices of notebook type personal computers or the like. The liquid crystal display device includes a liquid crystal display panel and drive circuits for driving the liquid crystal display panel.

[0005] Here, among these liquid crystal display devices, the use of liquid crystal display devices as display devices of portable terminal devices such as mobile telephones or the like is increasing in number. To use the liquid crystal display devices as the display devices of the portable terminal devices, further reduction of cost, miniaturization, enhancement of image quality, enhancement of reduction of power consumption are requested compared to conventional liquid crystal display devices. Further, when the liquid crystal display device is used as the display device of the mobile telephone or the like, a type of portable telephone set which mounts two liquid crystal display panels on one mobile telephone has been commercially available.

[0006] In the display devices of the portable terminal devices such as the mobile telephones, along with spreading of electronic mails attached with images, further enhancement of image display functions is demanded. Further, even when two liquid crystal display panels are mounted on one mobile telephone, both of these liquid crystal display panels are required to satisfy the high image display functions such as high display quality and high definition. Still further, in view of the nature of these display devices that they are used as the portable terminals, lower power consumption is also demanded. Still more, it is also a crucial task of the display devices which are used as the portable terminals to strengthen the competitiveness in cost.

[0007] As a problem which arises along with the miniaturization of the portable terminal device, the decrease of a space for mounting drive circuits of the liquid crystal display device is named. Further, with respect to a method for mounting the drive circuits, there has been a demand for so-called screen centering, that is, an arranging method in which a center line of the device and the center of a display screen are superposed to each other. This screen centering restricts positions where drive circuits are mounted and hence, it is necessary to pay sufficient consideration to the arrangement of the display devices. Further, in the conventional liquid crystal display device, although the drive circuits have been arranged at two neighboring sides of the display screen, there is a demand for mounting the drive circuits only at one side, that is, so-called three-side-free mounting. Further, it is also necessary to decrease the number of mounting parts for decreasing mounting areas as well as for lowering a manufacturing cost.

[0008] Particularly, when two liquid crystal display panels are mounted on one mobile telephone, it is necessary to mount the drive circuits and various parts to respective liquid crystal display panels and hence, there arises a drawback that the mounting area for these drive circuits and various parts is increased.

[0009] Still further, with respect to an equipment such as a mobile telephone which is intended for use by unspecified individuals, the stable operation is requested even when a manner of operation different from the usual manner of operation is performed. Accordingly, even in an unpredictable state such as a case that a battery which constitutes a power source of the mobile telephone slips off, an operation which is similar to the operation performed when the power source is normally turned off which does not display the image retention on a screen is requested.

[0010] The present invention has been made to overcome the above-mentioned drawbacks of the prior art and it is an object of the present invention to provide a technique which can realize an optimum drive circuit when two liquid crystal display panels are mounted in an equipment using small-sized liquid crystal display devices.

[0011] The above-mentioned and other objects and novel features of the present invention will become apparent from the description of this specification and attached drawings.

### SUMMARY OF THE INVENTION

[0012] To explain the summary of typical inventions among the present inventions disclosed in this specification, they are as follows.

[0013] In a liquid crystal display device including two liquid crystal display panels and a drive circuit, the drive circuit is mounted on one liquid crystal display panel, an output terminal is formed on one side of the liquid crystal display panel on which the drive circuit is mounted, the output terminal and another liquid crystal display panel are connected by wiring, wherein two liquid crystal display panels are driven by the drive circuit, common voltages which are suitable for two respective liquid crystal display panels are outputted from the drive circuit, and the common voltages are supplied to another liquid crystal display panel through the wiring.

[0014] Further, the drive circuit includes a power source circuit which is capable of outputting two common voltages for supplying the optimum common voltages for two liquid crystal display panels.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0015] **FIG. 1** is a schematic block diagram showing a liquid crystal display device of an embodiment of the present invention.

[0016] **FIG. 2** is a schematic plan view showing the liquid crystal display device of another embodiment of the present invention.

[0017] **FIG. 3** is a schematic plan view showing the liquid crystal display device of another embodiment of the present invention.

[0018] **FIG. 4** is a schematic plan view showing the liquid crystal display device of another embodiment of the present invention.

[0019] FIG. 5 is a schematic plan view showing the liquid crystal display device of another embodiment of the present invention.

[0020] FIG. 6A and FIG. 6B are schematic block diagrams showing the driving method of scanning signals used in the liquid crystal display device of the embodiment of the present invention.

[0021] FIG. 7A and FIG. 7B are schematic block diagrams showing the driving method of scanning signals used in the liquid crystal display device of the embodiment of the present invention.

[0022] FIG. 8 is a schematic timing chart showing voltage levels of signals used in a liquid crystal display device of the embodiment of the present invention.

[0023] FIG. 9A and FIG. 9B are schematic circuit diagrams for explaining booster circuits used in the liquid crystal display device of the embodiment of the present invention, wherein FIG. 9A is the circuit diagram in a charged state and FIG. 9B is the circuit diagram in a discharged state.

[0024] FIG. 10 is a schematic circuit diagram for explaining a booster circuit used in the liquid crystal display device of the embodiment of the present invention.

[0025] FIG. 11 is a schematic circuit diagram for explaining a booster circuit used in the liquid crystal display device of the embodiment of the present invention.

[0026] FIG. 12A, FIG. 12B and FIG. 12C are schematic circuit diagrams for explaining booster circuits used in the liquid crystal display device of the embodiment of the present invention.

[0027] FIG. 13A and FIG. 13B are schematic circuit diagrams for explaining booster circuits used in the liquid crystal display device of the embodiment of the present invention.

[0028] FIG. 14A and FIG. 14B are schematic circuit diagrams for explaining booster circuits used in the liquid crystal display device of the embodiment of the present invention.

[0029] FIG. 15 is a schematic circuit diagram for explaining a booster circuit used in the liquid crystal display device of the embodiment of the present invention.

[0030] FIG. 16 is a timing chart for explaining an operation of a booster circuit used in the liquid crystal display device of the embodiment of the present invention.

[0031] FIG. 17 is a schematic circuit diagram for explaining a booster circuit used in the liquid crystal display device of the embodiment of the present invention.

[0032] FIG. 18A and FIG. 18B are schematic circuit diagrams for explaining booster circuits used in the liquid crystal display device of the embodiment of the present invention.

[0033] FIG. 19A, FIG. 19B and FIG. 19C are schematic circuit diagrams for explaining booster circuits used in the liquid crystal display device of the embodiment of the present invention.

[0034] FIG. 20A, FIG. 20B and FIG. 20C are schematic circuit diagrams for explaining booster circuits used in the liquid crystal display device of the embodiment of the present invention.

[0035] FIG. 21A, FIG. 21B, FIG. 21C and FIG. 21D are schematic circuit diagrams for explaining booster circuits used in the liquid crystal display device of the embodiment of the present invention.

[0036] FIG. 22 is a schematic circuit diagram for explaining a booster circuit used in the liquid crystal display device of the embodiment of the present invention.

[0037] FIG. 23 is a schematic block diagram for explaining a power source circuit used in the liquid crystal display device of the embodiment of the present invention.

[0038] FIG. 24 is a schematic timing chart for showing voltage levels of common voltages used in the liquid crystal display device of the embodiment of the present invention.

[0039] FIG. 25 is a circuit diagram for explaining levels of power source voltages when the power source of the drive circuit used in the liquid crystal display device of the embodiment of the present invention is in the ON state.

[0040] FIG. 26A is a schematic circuit diagram for explaining a short-circuiting switch when the power source of the drive circuit used in the liquid crystal display device of the embodiment of the present invention is in the ON state, and FIG. 26B is an equivalent circuit diagram of FIG. 26A.

[0041] FIG. 27A is a circuit diagram for explaining levels of power source voltages when the power source of the drive circuit used in the liquid crystal display device of the embodiment of the present invention is in the ON state, and FIG. 27B is a circuit diagram for explaining levels of power source voltages when the power source of the drive circuit used in the liquid crystal display device of the embodiment of the present invention is in the OFF state.

[0042] FIG. 28A is an output waveform chart for explaining reset signals of the drive circuit used in the liquid crystal display device of the embodiment of the present invention, and FIG. 28B is a schematic circuit diagram of the drive circuit.

[0043] FIG. 29 is a schematic circuit diagram for explaining a level sensing circuit of the drive circuit used in the liquid crystal display device of the embodiment of the present invention.

[0044] FIG. 30A is an output waveform diagram for explaining reset signals of the drive circuit used in the liquid crystal display device of the embodiment of the present invention, and FIG. 30B is a schematic circuit diagram of a low-pass filter.

[0045] FIG. 31A and FIG. 31B are schematic block diagrams for explaining a mirror type liquid crystal display panel used in the liquid crystal display device of the embodiment of the present invention, wherein FIG. 31A is the schematic view showing an optical path in a state that a voltage is applied between electrodes and FIG. 31B is the schematic view showing an optical path in a state that a voltage is not applied between electrodes.

[0046] FIG. 32A is an overall block diagram for the mirror type liquid crystal display panel used in the liquid crystal display device of the embodiment of the present invention, and FIG. 32B is a schematic circuit diagram for explaining a mirror type liquid crystal display panel drive circuit.

[0047] FIG. 33 is a schematic block diagram for explaining the arrangement of terminals of a drive circuit used in the liquid crystal display device of the embodiment of the present invention.

[0048] FIG. 34 is a schematic view for explaining the function of the instruction signals and the arrangement of bits used in the liquid crystal display device of the embodiment of the present invention.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0049] Preferred embodiments of a display device according to the present invention are explained in detail hereinafter in conjunction with drawings. Here, in all drawings served for explaining the embodiments, parts having identical functions are given same symbols and their repeated explanation is omitted.

[0050] FIG. 1 is a block diagram showing the basic constitution of a display device using TFT (Thin Film Transistor) of the embodiment of the present invention. For example, organic electro luminescence display and liquid crystal display use TFT. As shown in the drawing, the display device of this embodiment includes a first display panel 1, a second display panel 200 and a drive circuit 50. When these display panels are used for a mobile telephone, the first display panel 1 is used as a main panel and the second display panel 200 is used as a sub panel which is mounted on a back surface of the equipment.

[0051] The following explanations are examples of the liquid crystal display device.

[0052] On the first liquid crystal display panel 1 and the second liquid crystal display panel 200, a plurality of scanning signal lines (or gate signal lines) GL and video signal lines (or drain signal lines) DL are respectively juxtaposed. Pixel portions 11 are formed corresponding to portions where the scanning signal lines GL and the video signal lines DL cross each other. A plurality of pixel portions 11 are arranged in a matrix array (not shown in the drawing) thus forming a display region 8 and a display region 9. Each pixel portion 11 includes a pixel electrode 12 and a thin film transistor 10. A TFT substrate 2 on which the pixel electrodes 12, the thin film transistors 10 and the like are formed and a filter substrate (not shown in the drawing) on which color filters and the like are formed are overlapped to each other with a given gap there between thus forming the liquid crystal display panel. A seal material is formed in a frame shape at a peripheral portion defined between both substrates, both substrates are laminated to each other, and liquid crystal is filled into and sealed in the inside of the seal material arranged between both substrates through a liquid crystal filling port formed in a portion of the seal material.

[0053] Conventionally, the main usage of the sub panel is to display letters or characters. Accordingly, a liquid crystal display panel having inferior image quality is used as the sub panel. However, the sub panel is now used as a finder in a

mobile telephone provided with a camera and hence, the sub panel is required to satisfy image qualities comparable to image qualities of the main panel. Accordingly, in the present invention, the second liquid crystal display panel 200 also uses a TFT type liquid crystal display panel.

[0054] Accordingly, in both of the first liquid crystal display panel 1 and the second liquid crystal display panel 200, the thin film transistor 10 is provided to each pixel portion. The thin film transistor 10 of each pixel has a source thereof connected to the pixel electrode 12, a drain thereof connected to the video signal line DL, and a gate thereof connected to the scanning signal line GL. The thin film transistor 10 functions as a switch for supplying display voltages (gray scale voltages) to the pixel electrode 12. By applying a voltage between the pixel electrodes 12 and the counter electrodes 15, the orientation direction of the liquid crystal molecules is changed and the display is performed by making use of a phenomenon that the property of a liquid crystal layer against light is changed corresponding to the change of the orientation direction of the liquid crystal molecules. The TFT type liquid crystal display panel is of a type in which the thin film transistors 10 function as switches and the voltage is held by the pixel electrodes 12 and hence, the liquid crystal display panel of high qualities with high contrast and the like can be realized.

[0055] Here, although naming of "source" and "drain" may be reversed depending on the bias relationship, the terminal which is connected to the video signal line DL is referred to as "drain". Further, this embodiment is also applicable in the same manner to a so-called lateral electric field type liquid crystal display panel in which counter electrodes 15 are formed on the TFT substrate 2 and also a so-called vertical electric field type liquid crystal display panel in which the counter electrodes 15 are formed on the filter substrates.

[0056] To drive the liquid crystal display panel 1 and the liquid crystal display panel 200 so as to make these panels perform display, the scanning signals and video signals are supplied to the scanning signal lines GL and the video signal lines DL, while signals are supplied to the counter electrodes 15 from the drive circuit 50. The drive circuit 50 is mounted (or formed) on a transparent insulating substrate (a glass substrate, a resin substrate or the like) which constitutes the TFT substrate 2 of the liquid crystal display panel 1. Further, the drive circuit 50 is electrically connected with the video signal lines DL, the scanning signal lines GL, a counter electrode line 16 for the first liquid crystal display panel and a counter electrode line 17 for the second liquid crystal display panel which are formed on the TFT substrate 2. Here, although the drive circuit 50 is constituted of a semiconductor integrated circuit (LSI), when the drive circuit 50 is formed on a substrate separate from the TFT substrate 2, the drive circuit 50 is directly mounted on the TFT substrate 2 or is mounted by means of a TCP (Tape Carrier Package). Further, it is also possible to constitute the drive circuit 50 using a semiconductor circuit which is directly formed on a substrate equal to the TFT substrate 2.

[0057] The drive circuit 50 functions such that the drive circuit 50 supplies the gray scale voltages to the video signal lines DL, controls ON/OFF of the thin film transistors 10 in response to the scanning signals and writes the gray scale voltages to the pixel electrodes 12. Further, the drive circuit

**50** supplies a common voltage to the counter electrodes **15**. Still further, the drive circuit **50** has a function of a controller and hence, signals are supplied to the drive circuit **50** from an external CPU or the like (not shown in the drawing). Accordingly, the drive circuit **50** is provided with input terminals **34** and signals from the outside are inputted into or supplied to the drive circuit **50** through the input terminals **34**. In response to respective display control signals inputted from the outside such as clock signals, display timing signals, horizontal synchronizing signals, vertical synchronizing signals and display data (R/G/B), the drive circuit **50** produces signals for controlling and driving the liquid crystal display panels.

[0058] To briefly explain the manner of operation of the drive circuit **50**, the drive circuit **50** forms a frame start instruction signal (FLM, also referred to as start signal hereinafter) and a shift clock (CL1) in response to external signals and supplies selective scanning voltages (scanning signals) of High level to respective scanning signal lines GL of the liquid crystal display panel **1** and the liquid crystal display panel **200** for every 1 horizontal scanning time (hereinafter, also referred to as "1H"). Accordingly, a plurality of thin film transistors **10** which are connected to respective scanning signal lines GL of the liquid crystal display panel **1** and the liquid crystal display panel **200** become conductive for 1 horizontal scanning time 1H.

[0059] Further, the drive circuit **50** outputs a gray scale voltage corresponding to a gray scale to be displayed by the pixel to the video signal line DL. When the thin film transistor **10** assumes the ON state, the gray scale voltage (video signal) is supplied to the pixel electrode **12** from the video signal line DL. Thereafter, when the thin film transistor **10** assumes the OFF state, the gray scale voltage base on an image to be displayed by the pixel is held at the pixel electrode **12**.

[0060] The drive circuit **50** drives not only the liquid crystal display panel **1** but also the liquid crystal display panel **200**. Accordingly, the signals are also supplied to the liquid crystal display panel **200** from the liquid crystal display panel **1** on which the drive circuit **50** is mounted. Numeral **21** indicates output terminals of scanning signals which are connected to input terminals **27** of the liquid crystal display panel **200** side through lines **25**. Accordingly, on the liquid crystal display panel **1**, lines (wiring) **35** for supplying the scanning signals for the liquid crystal display panel **200** are formed. Further, numerals **22** indicate output terminals for video signals and gray scale voltages supplied to the liquid crystal display panel **200** are outputted from these output terminals **22**. Accordingly, the video signal lines DL connected to the drive circuit **50** are not only connected to the thin film transistors **10** within the display region **8** but also extend outside the display region **8** and are connected to output terminals **22**.

[0061] Here, when the number of video signal lines DL of the liquid crystal display panel **1** is large compared to the number of the video signal lines DL mounted on the liquid crystal display panel **200**, there exist the video signal lines DL which are not connected to the liquid crystal display panel **200**. In FIG. 1, although the video signal line DL<sub>n+1</sub> and ensuing video signal lines are not connected to the liquid crystal display panel **200**, these video signal lines are different from the video signal lines DL<sub>n</sub> and the like which

have line capacitances thereof connected to the liquid crystal display panel **200**. Accordingly, line capacitance adjusting elements **24** are provided to the video signal lines which are not connected to the liquid crystal display panel **200**.

[0062] As a method for driving the liquid crystal display panel **1** and the liquid crystal display panel **200**, it is possible to adopt a method in which two liquid crystal display panels **1**, **200** are driven as if one liquid crystal display panel is driven. That is, for example, the scanning of the signal lines starts from the scanning signal line GL1-1 of the liquid crystal display panel **1** and scanning signal lines are scanned in order until the scanning signal line GL1-m. Subsequently, the scanning signal lines are scanned from the scanning signal line GL2-1 to the scanning signal line GL2-k of the liquid crystal display panel **200**. Here, although the gray scale voltage is outputted to the video signal line DL in the above operation, during a period in which the scanning signal lines are scanned from the scanning signal lines GL2-1 to GL2-k, the gray scale voltage to be supplied to the liquid crystal display panel **200** is outputted also to the video signal lines DL mounted on the liquid crystal display panel **1**.

[0063] Further, in the drive circuit **50**, the counter electrode line **16** for the first liquid crystal display panel and the counter electrode line **17** for the second liquid crystal display panel are electrically connected to the counter electrodes **15**. The liquid crystal display panel **1** is provided with an output terminal **23** which is connected to the counter electrode line **16**, while the output terminal **23** and an input terminal **29** formed on the liquid crystal display panel **200** are connected to each other using lines **25**.

[0064] In the liquid crystal display device to which the present invention is applicable, AC driving which periodically inverts the polarity of voltage applied to the liquid crystal layer is performed. This AC driving is performed for the purpose of preventing degradation generated by applying a DC voltage to the liquid crystal. However, even when the AC driving is performed, there may be a case that a minute DC component is applied to the liquid crystal layer. In such a case, the DC component can be eliminated by adjusting the common voltage applied to the counter electrodes. Accordingly, an optimum common voltage value is set for each liquid crystal display panel.

[0065] As mentioned previously, the liquid crystal display panel **1** and the liquid crystal display panel **200** are driven using the same drive circuit **50**. However, a cause which generates the DC component is not attributed only to the difference between voltages applied to the pixel electrode **12** and the counter electrode **15** and hence, even when these display panels are driven by the same drive circuit **50**, the DC components which are generated in the liquid crystal display panel **1** and the liquid crystal display panel **200** differ delicately. Accordingly, the individually optimum common voltages are supplied between the liquid crystal display panel **1** and the liquid crystal display panel **200**.

[0066] When the optimum common voltage is not set, a phenomenon referred to as flicker is generated on the display so that display quality is remarkably degraded. It is possible to output two common voltages for liquid crystal display panel **1** and liquid crystal display panel **200** from the drive circuit **50** and two common voltages can be finely adjusted. Accordingly, by individually finely adjusting respective

common voltages such that flickers on respective liquid crystal display panels can be reduced, it is possible to supply two optimum common voltages for the liquid crystal display panel 1 and the liquid crystal display panel 200 whereby the degradation of display quality due to flicker or the like can be prevented.

[0067] In the liquid crystal display device shown in FIG. 1, the liquid crystal display panel 1 and the liquid crystal display panel 200 can be driven by the common drive circuit 50 and hence, it is possible to miniaturize the liquid crystal display device by reducing an area for mounting the drive circuit and to reduce cost by using parts in common. Further, not only by outputting common signals to the liquid crystal display panel 1 and the liquid crystal display panel 200, but also by outputting common voltages peculiar to two liquid crystal display panels, it is possible to perform favorable displays even when two liquid crystal display panels are driven using the same drive circuit.

[0068] Next, FIG. 2 is a plan view which schematically shows the connection between the liquid crystal display panel 1 and the liquid crystal display panel 200 using a flexible board 26. Connection terminals are provided to the flexible board 26 and these connection terminals are electrically connected to the output terminals 21, 22, 23 provided to the liquid crystal display panel 1 and input terminals 27, 28, 29 provided to the liquid crystal display panel 200 using an anisotropic conductive film or the like. Respective output terminals and input terminals are electrically connected using this flexible board 26 and signals can be transmitted between the liquid crystal display panel 1 and the liquid crystal display panel 200.

[0069] Here, respective terminals are juxtaposed in large number at a narrow pitch so that it is difficult to describe the terminals in the drawing. Accordingly, only terminals at both ends are indicated with respect to respective terminals and the description of each terminal is omitted in the drawing. Further, in the mobile telephone, a use mode in which the flexible board is bent so as to mount the liquid crystal display panel 1 and the liquid crystal display panel 200 on a front surface and a back surface of a light guide plate is adopted. To facilitate understanding of the drawing, the liquid crystal display panel 1 and the liquid crystal display panel 200 are described on the same plane.

[0070] FIG. 2 shows a case in which the drive circuit 50 mounted on the liquid crystal display panel 1 is divided into a scanning signal line drive circuit 58 and a video signal line drive circuit 57. A sub panel scanning signal line 35 is formed on the liquid crystal display panel 1. A line 35 for sub panel scanning signal 35 which is outputted from the scanning signal line drive circuit 58 is connected to a scanning signal output terminal 21. Further, scanning signals which are supplied to the liquid crystal display panel 200 are outputted from the scanning signal output terminal 21 and are transmitted to an input terminal 27 of the liquid crystal display panel 200 through the flexible board 26. A line 36 for scanning signal lines is formed on the liquid crystal display panel 200 and is connected to respective scanning signal lines GL through the input terminal 27. Here, the line 36 for scanning signals is formed on the liquid crystal display panel 1 in the same manner and connects between the scanning signal line drive circuit 58 provided on a lower side of the liquid crystal display panel 1 and respective scanning signal lines GL.

[0071] Further, a counter electrode line 16 for liquid crystal display panel 1 and a counter electrode line 17 for liquid crystal display panel 200 are outputted from the scanning signal line drive circuit 58. They are arranged to pass between the video signal line drive circuit 57 and the TFT substrate 2. The counter electrode line 16 is connected to the counter electrodes of the liquid crystal display panel 1, while the counter electrode line 17 is arranged along a side (a right side in the drawing) which opposes a side on which the line 36 for scanning signal for the TFT substrate 2 is formed and is connected to the output terminal 23. Further, the counter electrode line 17 for liquid crystal display panel 200 is connected to the counter electrode of the liquid crystal display panel 200 through the flexible board 26.

[0072] In FIG. 2, since the display region 8 of the liquid crystal display panel 1 is present between the display region 9 of the liquid crystal display panel 200 and the drive circuit 50, the lines for driving the liquid crystal display panel 200 are formed around the display region 8 as in the case of the line 35 for sub panel scanning signals. However, since the video signal lines DL can be used in common by the liquid crystal display panel 1 and the liquid crystal display panel 200, the video signal lines DL can be arranged inside the display region 8 and can extend to the outside of the display region 8 and can be arranged in the liquid crystal display panel 200. Here, in the display device, it is preferable that an area of portions other than the display region is as small as possible and hence, it is taken into consideration in this embodiment that a region in which the sub panel scanning signal line 35 around the display region is made as small as possible.

[0073] Numeral 30 indicates a flexible board to which signals and the power source voltages and the like to be inputted to the drive circuit 50 are supplied. Further, numeral 51 indicates a capacitor which is used in a booster circuit or the like of the drive circuit 50. Further, numeral 56 indicates a variable resistor which is used for finely adjusting the common voltage.

[0074] Here, the gray scale voltages are outputted to the liquid crystal display panel 200 from the video signal line drive circuit 57, wherein the gray scale voltages are supplied to the liquid crystal display panel 1 by the video signal lines DL(2) and, at the same time, the gray scale voltages are supplied also to the liquid crystal display panel 200. To make the center line 43 of the liquid crystal display panel 200 and the center line 44 of the liquid crystal display panel 1 superposed to each other as much as possible, as the video signal lines DL(2) which supply the gray scale voltages also to the liquid crystal display panel 200, the video signal lines at the center portion of the liquid crystal display panel 1 are used. Accordingly, at both ends of the region where the video signal lines DL(2) are formed, the video signal lines DL(1) which are not connected to the liquid crystal display panel 200 are provided.

[0075] The flexible substrate 25 is formed of a flexible material and hence can be folded. Accordingly, by folding the flexible board 25, it is possible to form the liquid crystal display panel 1 and the liquid crystal display panel 200 on two respective surfaces of the light guide plate while sandwiching one light guide plate there between. Further, a slit 39 is formed in the flexible board 25 to facilitate folding of the flexible board 25.

[0076] FIG. 3 shows an embodiment in which the scanning signal line drive circuit 58 for liquid crystal display panel 1 and the scanning signal line drive circuit 59 for liquid crystal display panel 200 are formed while sandwiching a video signal line drive circuit 57 there between. On a side of the liquid crystal display panel 1 disposed at the left side of the drawing, a line 36 for scanning signals is formed and this line 36 connects the scanning signal line drive circuit 58 and the respective scanning signal lines GL. Further, a line 35 for sub panel scanning signals is formed on the right side of the liquid crystal display panel 1. The line 35 for sub panel scanning signals which is outputted from the scanning signal line drive circuit 59 is connected to a scanning signal output terminal 21. Further, scanning signals which are supplied to the liquid crystal display panel 200 are outputted from the scanning signal output terminals 21 and are transmitted to input terminals 27 of the liquid crystal display panel 200 through the flexible board 26.

[0077] As shown in FIG. 3, by providing the scanning signal line drive circuit 58 and the scanning signal line drive circuit 59 in a state that the video signal line drive circuit 57 is sandwiched, it is possible to separately arrange the line 36 for scanning signals and the line 35 for sub-panel scanning signals at both left and right end portions of the display region 8. Further, the scanning signal line drive circuit 58, the scanning signal line drive circuit 59 and the video signal line drive circuit 57 can be integrally formed as one driver circuit 50.

[0078] Here, although not shown in the drawing, the common voltage for the liquid crystal display panel 1 is outputted from the scanning signal line drive circuit 58 and the common voltage for the liquid crystal display panel 200 is outputted from the scanning signal line drive circuit 59 and hence, the optimum common voltages for respective liquid crystal display panels are supplied.

[0079] FIG. 4 shows an embodiment in which the drive circuit 50 is mounted on the flexible board 26 and the flexible board 26 is provided between the liquid crystal display panel 1 and the liquid crystal display panel 200. From the drive circuit 50, signals for the liquid crystal display panel 1 are outputted to the lower side in the drawing and signals for the liquid crystal display panel 200 are outputted to the upper side in the drawing.

[0080] Since the drive circuit 50 is provided between the display region 8 of the liquid crystal display panel 1 and the display region 9 of the liquid crystal display panel 200, signal lines for the liquid crystal display panel 200 formed on the liquid crystal display panel 1 can be omitted, whereby the line 35 for sub panel scanning signal is not provided to the liquid crystal display panel 1. Accordingly, the line (wiring) region can be reduced so that the liquid crystal display device can be miniaturized. Further, a capacitor 51, a variable resistor 56 and the like are also mounted on the flexible board 26. Numeral 38 indicates a wiring portion for external connection which extends outward so as to be connected to external equipments. Accordingly, the flexible board for inputting can be used in common and hence, the number of parts can be reduced.

[0081] In the drive circuit 50 shown in FIG. 4, the lines (wiring) are extended to the lower side in the drawing from one output and is connected to the liquid crystal display panel 1 and, at the same time, the lines (wiring) are extended

to the upper side in the drawing from the same output and is connected to the liquid crystal display panel 200 whereby it is possible to use one output in common. However, separate outputs may be provided for the liquid crystal display panel 1 and the liquid crystal display panel 200 respectively. Further, it is also possible to mount a plurality of drive circuits as the drive circuit for the liquid crystal display panel 1 and as the drive circuit for the liquid crystal display panel 200 on the flexible board 26.

[0082] Here, although not shown in the drawing, the common voltage for the liquid crystal display panel 1 and the common voltage for the liquid crystal display panel 200 are outputted from the drive circuit 50 and hence, the optimum common voltages for respective liquid crystal display panels are supplied.

[0083] FIG. 5 shows another embodiment in which the drive circuit 50 is mounted on a side of the liquid crystal display panel 1 which is disposed close to the liquid crystal display panel 200 side. In the same manner as the embodiment shown in FIG. 4, the drive circuit 50 is provided between the display region, 8 of the liquid crystal display panel 1 and the liquid crystal display panel 200. From the drive circuit 50, signals for the liquid crystal display panel 1 are outputted to the lower side in the drawing and signals for the liquid crystal display panel 200 are supplied to the upper side in the drawing. Further, in the same manner as the embodiment shown in FIG. 4, the signal line for the liquid crystal display panel 200 which is mounted on the liquid crystal display panel 1 can be omitted and the line 35 for sub panel scanning signals is not mounted on the liquid crystal display panel 1.

[0084] Also with respect to the drive circuit 50 shown in FIG. 5, the lines (wiring) are extended to the lower side in the drawing from one output and is connected to the liquid crystal display panel 1 and, at the same time, the lines (wiring) are extended to the upper side in the drawing from the same output and is connected to the liquid crystal display panel 200 whereby it is possible to use one output in common. Further, it is possible to form separate outputs for the liquid crystal display panel 1 and the liquid crystal display panel 200 respectively.

[0085] Here, although not shown in the drawing, the common voltage for the liquid crystal display panel 1 and the common voltage for the liquid crystal display panel 200 are outputted from the drive circuit 50 and hence, the optimum common voltages for respective liquid crystal display panels are supplied.

[0086] Next, the relationship between the order of outputting from the scanning signal line drive circuit 58 and the scanning signal lines GL is described in conjunction with FIG. 6 and FIG. 7. First of all, as shown in FIG. 6A, when the number of scanning signal lines in the liquid crystal display panel 1 is 176 and the number of scanning signal lines in the liquid crystal display panel 200 is 64, a following driving method can be used. That is, the scanning signal line drive circuit 58 has the outputting number of 240 and starts outputting in response to an output go1, and sequentially scans the scanning signal lines GL1-1 to GL1-176. Further, the scanning signal line drive circuit 58 scans GL2-1 next to GL1-176 and finally scans the scanning signal line GL2-64 in response to an output go240.

[0087] Here, when only either one of the liquid crystal display panel 1 and the liquid crystal display panel 200 is

display ed or when a portion of both panels is display ed or the like, since the scanning signal line drive circuit **58** and the video signal line drive circuit **57** are in common, a voltage is applied also to a non-display part. Accordingly, it is necessary to perform the AC driving of the non-display part and hence, signals having different polarities are supplied in the same manner as the display part.

[0088] For example, in case that the liquid crystal display panel **1** is in a non-display state, since the number of scanning signal lines GL is 240, when 1 screen (1 frame) is display ed with 50 Hz, the line frequency becomes  $50 \times 240 = 12$  kHz per 1 scanning signal line (1 line). However, the number of scanning signal lines which are actually served for display is only 64 lines and hence, the line frequency of  $50 \times 64 = 3.2$  kHz is sufficient. Rewriting of data with high driving frequency in spite of the non-display state of the liquid crystal display panel **1** impedes the reduction of power consumption.

[0089] Accordingly, in this embodiment, the scanning of the scanning signal lines at the non-display part is collectively performed. For example, when the liquid crystal display panel **1** is in a non-display state, the scanning signal lines GL1-1 to GL1-176 are simultaneously scanned during 1 horizontal scanning period 1H (or several H) and, thereafter, the scanning signal lines GL2-1 to GL2-64 are scanned in a usual manner. In the same manner, by performing the collective scanning even when the liquid crystal display panel **200** is in a non-display state or when only portions of both panels are displayed, it is possible to reduce the power consumption.

[0090] Next, as shown in FIG. 6B, depending on the arrangement of the liquid crystal display panel, it is necessary to scan the liquid crystal display panel **200** first. In such a case, outputting is started in response to the output go240 so as to scan the scanning signal line GL2-64 first and to scan the scanning signal line GL1-1 in response to the output go1 finally.

[0091] To distinguish the order of scanning shown in FIG. 6A and the order of scanning shown in FIG. 6B, the scanning signal line drive circuit **58** provides an instruction signal or the like and sets the scanning direction to the normal direction and the reverse direction. Here, when the number of outputting is **240** or more, setting of starting position of outputting and the effective number of outputting are set in response to the instruction signal or the like.

[0092] Next, FIG. 7 shows a case in which the scanning direction of the liquid crystal display panel **1** and the scanning direction of the liquid crystal display panel **200** are different from each other. In this case, the scanning signal line drive circuit **58** is divided into scanning signal drive parts **58-a**, **58-b** and the scanning directions are set to the normal direction and the reverse direction. Further, one side at which scanning is started first is set and, after confirming the completion of scanning at one side, scanning at another side is started.

[0093] Further, as indicated by symbol ga177, when there exist excessive outputs which are not connected to the scanning signal lines, the effective number of scanning of the scanning signal line drive part **58-a** is set to **176** and the scanning signal line drive part **58-b** is informed of the completion of scanning by the scanning signal line drive part

**58-a** by counting the scanning **176** times using a counter or the like. Here, the reason that the number of scanning signal lines is set to disagree with the number of outputting is to enable the drive circuit **50** to cope with plural types of liquid crystal display panels. That is, this provision is made to allow the drive circuit **50** to universally cope with a plurality of liquid crystal display panels which differ in the number of scanning signal lines.

[0094] In FIG. 7B, in the scanning signal line drive part **58-a**, outputting starts at 2, the effective number of scanning is **176** and the scanning direction is set to the reverse direction. The scanning signal line drive part **58-a** counts the number of scanning by the scanning signal line drive part **58-b** and starts outputting in response to output ga176 (second outputting in the reverse direction) after confirming counting of the effective number of scanning of 64 by the scanning signal line drive part **58-b**.

[0095] In this manner, when two liquid crystal display panels are driven, the scanning direction and the scanning order can be selected in a plural number depending on the arrangement, wherein the scanning direction, the scanning order and the like can be set in response to the instruction signal or the like to cope with respective cases.

[0096] Subsequently, a booster circuit is explained. In the miniaturized portable equipment such as the mobile telephone or the like, a battery is generally used as a power source. Further, in view of respective amounts of various batteries which are available on a market, the batteries having an output voltage of about 1.5V to 4V are used.

[0097] Accordingly, the power source voltage for liquid crystal display device is generated using the booster circuit. FIG. 8 shows the power source voltage necessary for the thin film transistor type liquid crystal display device. FIG. 8 shows respective driving voltages when a so-called common voltage inversion driving method in which common voltages VCOM which are supplied to the counter electrodes **15** of the liquid crystal display panels **1** and **200** are inverted at a fixed period.

[0098] In FIG. 8, VGON indicates a High voltage of the scanning signal VG for turning on the thin film transistor **10** (TFT) of the pixel portion and about 7.5V is necessary as the High voltage VGON. Further, VGOFF is a voltage for turning off the thin film transistor and a Low voltage of the scanning signal VG. About -5.5V is necessary as the low voltage VGOFF. VGH is a High power source for the scanning signal line drive circuit **58** (gate driver) which outputs the scanning signal VG and VGL is a Low power source for the scanning signal line drive circuit **58**. Since the High voltage VGON of the scanning signal is about 7.5V, the High power source VGH for the scanning signal line drive circuit **58** assumes 8V, while since the Low voltage VGOFF of the scanning signal is about -5.5V, the Low power source VGL for the scanning signal line drive circuit **58** is required to assume -6V.

[0099] Subsequently, VDH is a gray scale reference voltage. The video signal line drive circuit (source driver) **57** generates the gray scale voltage using the gray scale reference voltage VDH as the reference. It is necessary to set the gray scale reference voltage VDH to about 5.0V in view of the characteristics of the liquid crystal material. DDVDH is the power source voltage for the drive circuit **50**. Since the

gray scale reference voltage VDH which the video signal line drive circuit 57 generates is 5.0V and the maximum rated voltage of the video signal line drive circuit 57 is 6V, it is necessary to set the power source voltage DDVDH for the drive circuit 50 to about 5.5V.

[0100] VCOMH is a High voltage for counter electrode and VCOML is a Low voltage for counter electrode. It is necessary to set the High voltage VCOMH for counter electrode to 5V or less, while it is necessary to set the Low voltage VCOML for counter electrode to  $-2.5V$ . VCL is a voltage generating power source for counter electrode and constitutes a power source voltage for generating the Low voltage VCOML for counter electrode. It is necessary to set the voltage generating power source VCL for counter electrode to about  $-3V$  in view of an operational margin of a VCOML generating circuit.

[0101] In the above-mentioned power sources necessary for the liquid crystal display device, the power source voltage DDVDH for the drive circuit 50, the High power source VGH for the scanning signal line drive circuit 58, the low power source VGL for the scanning signal line drive circuit 58, and the voltage generating power source VCL for counter electrodes are generated using a charge pump type booster circuit, while other voltages are generated by dividing the voltages generated by the booster circuit or the like.

[0102] The operational principle of the charge pump type booster circuit is briefly explained in conjunction with FIG. 9 by taking two fold or double boosting as example. A booster circuit is comprised of an input power source  $V_{in}$ , a booster capacitance C11, a holding capacitance Cout1 and changeover switches SW-1, SW-2 and realizes the charge state shown in FIG. 9A and the discharge state shown in FIG. 9B by a changeover switch.

[0103] First of all, in the charge state shown in FIG. 9A, one electrode of the booster capacitance C11 is connected to the GND potential by the changeover switch SW-1 and other electrode of the booster capacitance C11 is connected to the input power source  $V_{in}$  by the changeover switch SW-2, and the booster capacitance C11 is connected to the input power source  $V_{in}$  in parallel. Due to such a constitution, the charge corresponding to the input power source  $V_{in}$  is charged into the booster capacitance C11.

[0104] Subsequently, in FIG. 9B, to the electrode which is connected to the GND potential of the booster capacitance C11 in FIG. 9A, the input power source  $V_{in}$  is connected in series to apply the input power source  $V_{in}$  by operating the changeover switch SW-3. Here, other electrode of the booster capacitance C11 assumes a voltage of  $233 V_{in}$  which is twice as large as the input power source  $V_{in}$ . The holding capacitance Cout1 is connected to the booster capacitance C11 and the input power source  $V_{in}$  in parallel by operating the changeover switch SW-4. Due to such a constitution, the voltage of  $2 \times V_{in}$  is held in the holding capacitance Cout1.

[0105] Then, here studied is a case in which, in the booster circuit shown in FIG. 9, the power source voltage DDVDH (about 5.5V) for the video signal line drive circuit 57, the High power source VGH (about 7.5V) for the scanning signal line drive circuit 58, the Low power source VGL (about  $-6.0V$ ) for the scanning signal line drive circuit 58, and the voltage generating power source VCL for the counter electrode (about  $-3V$ ) are generated. Here, with

respect to the mobile telephone, although the input power source  $V_{in}$  is often an output voltage of the power source battery, the input power source  $V_{in}$  implies a voltage supplied to the booster circuit including the output voltage of the power source battery in this specification.

[0106] Assume the input power source  $V_{in}$  as 3V, since the power source voltage DDVDH (about 5.5V) for the video signal line drive circuit 57 is about twice as high as the input power source  $V_{in}$ , the booster circuit which doubles the input power source  $V_{in}$  is necessary. Since such double boosting is not sufficient for the High power source VGH (about 7.5V) for the scanning signal line drive circuit 58, the booster circuit which can triple the input power source  $V_{in}$  is necessary. Since the Low power source VGL for the scanning signal line drive circuit 58 is about  $-6V$ , the booster circuit which magnifies the input power source  $V_{in}$  by  $-2$  times becomes necessary, while since the voltage generating power source VCL for the counter electrode voltage is about  $-3V$ , the booster circuit which magnifies the input power source  $V_{in}$  by  $-1$  time becomes necessary.

[0107] FIG. 10 shows the constitution of the booster circuit 55 which magnifies the input power source  $V_{in}$  by 2 times, 3 times,  $-2$  times and  $-1$  time. When the input power source  $V_{in}$  is magnified by  $-2$  times or  $-1$  time, these are not boosting in a strict sense. Here, however, the booster circuit means a circuit which generates a voltage different from an input voltage. With respect to the number of capacitors 51, six capacitors in total are necessary. That is, one capacitor is necessary in the circuit which doubles the input power source  $V_{in}$ , two capacitors are necessary in the circuit which triples the input power source  $V_{in}$ , two capacitors are necessary in the circuit which magnifies the input power source  $V_{in}$  by  $-2$  times, and one capacitor is necessary in the circuit which magnifies the input power source  $V_{in}$  by  $-1$  time. In this manner, in the circuit shown in FIG. 10, as externally mounted parts of the circuit, a large number of capacitors 51 are used. When the number of mounting parts is increased, there arises a problem that the part mounting area is increased. Here, symbols Cout1 to Cout4 in the drawing indicate holding capacitances for holding output voltages.

[0108] Subsequently, FIG. 11 is a conceptual block diagram of a circuit which can decrease the number of externally mounted capacitors 51 by making use of the output of the booster circuit 55 as the input power source and by using some of the externally mounted capacitors 51 in common. In the circuit shown in FIG. 11, as the externally mounted capacitors, three capacitors consisting of an externally mounted capacitor C11 connected to the booster circuit 52 and two externally mounted capacitors C12, C21 connected to the booster circuit 53 are necessary. With respect to the circuit shown in FIG. 10, the number of externally mounted capacitors can be reduced from 6 pieces to 3 pieces. Here, the externally mounted capacitor C11 is provided for boosting by 2 times, the externally mounted capacitor C12 is provided in common for boosting by 3 times and  $-1$  times, and the externally mounted capacitors C21 is provided for boosting by  $-2$  times.

[0109] An operation to triple the input power source  $V_{in}$  of the booster circuit 53 shown in FIG. 11 is explained in conjunction with FIG. 12. In FIG. 12A, the booster capacitance (externally mounted capacitor) C12 is charged using

the input power source voltage  $V_{in}$ . Further, FIG. 12B shows a booster circuit 52 in which the voltage DDVDH which is twice as high as the input power source voltage  $V_{in}$  is produced as explained in conjunction with FIG. 9. In the circuit shown in FIG. 12, by making use of the voltage DDVDH which is obtained by doubling the input power source voltage  $V_{in}$ , the number of externally mounted capacitors is omitted. As shown in FIG. 12C, using the voltage DDVDH which constitutes the output of the holding capacitance Cout1, the holding capacitance Cout1 and the booster capacitance C12 are connected in series thus generating a voltage which is three times as high as the input power source  $V_{in}$ .

[0110] Then, an operation to booster the input power source  $V_{in}$  by  $-1$  time is explained in conjunction with FIG. 13. In FIG. 13A, the booster capacitance C12 is charged to the voltage  $V_{in}$  using the input power source  $V_{in}$ . Thereafter, in FIG. 13B, by connecting the positive-polarity-side electrode of the booster capacitance 12 to the GND potential, the voltage VCL having the polarity thereof inverted from that of the input power source  $V_{in}$  is generated. Then, by connecting the booster capacitance C12 and the holding capacitance Cout4 in parallel, the voltage VCL which is obtained by magnifying the input power source  $V_{in}$  by  $-1$  time is held in the holding capacitance Cout3. In the circuit shown in FIG. 13, by using the externally mounted capacitors C12 used in the circuit for boosting the voltage by three times in FIG. 12 in common, the number of capacitors C12 is reduced.

[0111] Then, an operation for magnifying the input power source  $V_{in}$  by  $-2$  times is explained in conjunction with FIG. 14. In FIG. 14A, the booster capacitance C21 is charged to the voltage DDVDH using the voltage DDVDH which constitutes the output of the holding capacitance Cout1 of the booster circuit 52. Thereafter, in FIG. 14B, by connecting the positive-polarity-side electrode of the booster capacitance 21 to the GND potential, the voltage VGL having the polarity thereof inverted from that of the voltage DDVDH is generated. Then, by connecting the booster capacitance C21 and the holding capacitance Cout4 in parallel, the voltage VGL which is obtained by magnifying the input power source  $V_{in}$  by  $-2$  times is held in the holding capacitance Cout4.

[0112] In this manner, in the booster circuit shown in FIG. 11, by making use of the boosted voltage which is held by the holding capacitance Cout1, the capacitors can be omitted and hence, the number of parts can be reduced. Further, in the circuits shown in FIG. 13 and FIG. 14, by inverting the connection between the negative-polarity-side voltage and the capacitor and by making use of the input power source  $V_{in}$  in addition to the boosted voltage of the holding capacitance, the capacitors can be used in common and hence, the number of parts is reduced. To explain the constitution which enables the omission of the number of capacitors and the common use of the capacitors, the liquid crystal display device has a plurality of power sources peculiar to the liquid crystal display device, that is, the power source voltage DDVDH for the video signal line drive circuit 57, the High power source VGH for the scanning signal line drive circuit 58, the Low power source VGL for the scanning signal line drive circuit 58, and the voltage generating power source VCL for the counter electrode, and also the liquid crystal display device has the

negative-polarity side voltages. Accordingly, by making use of the time-division of the booster capacitances C12, C21, C22, it is possible to use them in common among a plurality of booster circuits or to make use of the boosted voltage.

[0113] FIG. 15 shows the more specific constitution of the booster circuit 53 shown in FIG. 11. An operation of the booster circuit 53 is explained hereinafter in conjunction with a timing chart shown in FIG. 16. First of all, a method for realizing the operation shown in FIG. 12 for generating the voltage VGH is explained. To obtain the circuit shown FIG. 12A, a switch SW1 and a switch SW3 shown in FIG. 15 are turned on. When the switch SW1 and the switch SW3 are turned on, the voltage of the input power source  $V_{in}$  is charged to the booster capacitance C12. At this point of time, as in the case of the circuit shown in FIG. 12B, the voltage DDVDH is outputted from the booster circuit 52. Subsequently, to obtain the circuit shown in FIG. 12C, the switches SW1 and the switch SW3 shown in FIG. 15 are turned off, while the switch SW4 shown in FIG. 15 is turned on so as to apply the voltage DDVDH to the booster capacitance C12. At the same time, the switch SW8 is turned on to charge the holding capacitance Cout2. In this manner, the voltage which is three times as high as the input power source  $V_{in}$  is held in the holding capacitance Cout2.

[0114] Then, an operation of the circuit shown in FIG. 13 is explained. To obtain the circuit shown in FIG. 13A, a switch SW1 and a switch SW3 in FIG. 15 are turned on so as to charge the booster capacitance C12 with the input power source  $V_{in}$ . Subsequently, the switch SW1 and the switch SW3 are turned off and the switch SW2 is turned on thus inverting the polarities of the voltages and, further, the switch SW9 is turned on to charge the holding capacitance Cout3. In this manner, the voltage obtained by magnifying the input power source  $V_{in}$  by  $-1$  time is held in the holding capacitance Cout3.

[0115] Then, an operation of the circuit shown in FIG. 14 is explained. To obtain the circuit shown in FIG. 14A, a switch SW5 and a switch SW7 in FIG. 15 are turned on so as to charge the booster capacitance C21 with the voltage DDVDH. Subsequently, the switch SW5 and the switch SW7 are turned off and the switch SW6 is turned on thus inverting the polarities of the voltages and, further, the switch SW10 is turned on to charge the holding capacitance Cout4.

[0116] As described above, in the circuit shown in FIG. 15, the booster capacitances C12, C21 are used in common by time division. Further, as shown in FIG. 16, the booster capacitances C12, C21 are repeatedly charged in response to the operation of the switches SW1, SW3, SW5 and SW7, are used for the boosting operation in response to the operation of the switches SW4 and SW8, and are further used for inversion (boosting) operation in response to the operation of the switches SW2, SW9, SW6 and SW10. In this manner, by enabling the common use of the booster capacitances C12 and C21 in the time-division manner, the number of externally mounted capacitors can be reduced and hence, the number of parts of a liquid crystal display device can be reduced.

[0117] Although the booster circuit shown in FIG. 15 is sufficient for outputting the set voltage, it is difficult for the booster circuit to change the outputting voltage. Along with wide spreading of mobile telephones, the liquid crystal

display panels which are available become diverse and hence, requested voltages also take diverse values. Further, a demand for reduction of manufacturing cost is strong and hence, it is desirable that the booster circuits are also formed of products for general use.

[0118] Accordingly, there is provided a circuit shown in FIG. 17 which can change the magnification of the booster circuit by changeover of switches. The change of magnification can be set in response to instruction signals or the like.

[0119] The manner of operation of the circuit shown in FIG. 17 is explained hereinafter in conjunction with FIG. 18 to FIG. 21. FIG. 18 is a schematic circuit diagram for explaining the manner of operation when the High power source VGH for the scanning signal line drive circuit 58 is obtained by magnifying the input power source  $V_{in}$  by 4 times. Here, it is assumed that as the voltage DDVDH, the voltage which is twice as high as the input power source  $V_{in}$  is prepared by the booster circuit 52.

[0120] When a switch SW5 in the circuit shown in FIG. 17 is turned on so as to apply the voltage DDVDH to one electrode of a capacitor C21 and a switch SW7 is turned on so as to connect another electrode of the capacitor C21 to a ground, a circuit shown in FIG. 18A is obtained. There after, when the switches SW5 and SW7 are turned off and switches SW11 to SW17 are turned on, a circuit shown in FIG. 18B is obtained and hence, the voltage which is 4 times as high as the input power source  $V_{in}$  is held in the capacitor Cout12.

[0121] Next, FIG. 19 is a schematic circuit diagram for explaining the manner of operation when the High power source VGH for the scanning signal line drive circuit 58 is obtained by magnifying the input power source  $V_{in}$  by 5 times. The voltage of the input power source  $V_{in}$  is held by the capacitor C12 in FIG. 19A, the voltage DDVDH is held in the capacitor C21 in FIG. 19B, and the capacitor C12, the capacitor C21 and the voltage DDVDH are connected in series in FIG. 19C so as to obtain a voltage which is 5 times as high as the input power source  $V_{in}$ . Here, the capacitor C12 and the capacitor C21 are connected in series by the switch SW16.

[0122] Next, FIG. 20 is a schematic circuit diagram for explaining the manner of operation when the High power source VGH for the scanning signal line drive circuit 58 is obtained by magnifying the input power source  $V_{in}$  by 6 times. However, with respect to the circuit shown in FIG. 20, as shown in FIG. 20B, by adding the capacitor C22, a voltage value which can be boosted is increased. In FIG. 20C, the capacitor C21 and the capacitor C22 are connected in series by a switch SW19 and, further, the capacitor C22 and the voltage DDVDH are connected in series by a switch SW15 thus obtaining the voltage which is 6 times as high as the input power source  $V_{in}$ .

[0123] Next, FIG. 21 is a schematic circuit diagram for explaining the manner of operation when the Low power source VGL for the scanning signal line drive circuit 58 is obtained by magnifying the input power source  $V_{in}$  by  $-5$  times. However, FIG. 21A shows a mode in which the voltage of the power source  $V_{in}$  is held by the capacitor C12, FIG. 21B shows a mode in which the voltage DDVDH is held by the capacitor C21, and FIG. 21C shows a mode in which the voltage DDVDH is held by the capacitor C22. In

FIG. 21D, the capacitors which hold respective voltages are connected in series with reverse polarities so as to obtain a voltage which is  $-5$  times as high as the input power source  $V_{in}$ . In this manner, by connecting the externally mounted capacitors in series, it is possible to obtain the voltage which is desired times as high as the input power source  $V_{in}$ .

[0124] However, in the circuit shown in FIG. 21, all externally mounted capacitors are connected in series simultaneously and hence, there arises a problem that only one voltage can be obtained at a time. Accordingly, although the use of the circuit in time-division can be considered to obtain a plurality of voltages, this also gives rise to a problem that a current value which can be supplied is decreased when the circuit is used in time division.

[0125] Further, inventors of the present invention have found out a drawback that the circuit is short of driving ability of the voltage generating power source VCL for counter electrodes. Accordingly, while ensuring outputting of the voltage generating power source VCL for counter electrodes from the booster circuit shown in FIG. 17, a booster circuit dedicated to the voltage generating power source VCL for counter electrodes is added. That is, the circuit is configured such that when the voltage generating power source VCL for counter electrodes requires a large driving ability, the dedicated booster circuit is used, while when the voltage generating power source VCL for counter electrodes does not require a large driving ability, the booster circuit with small number of externally mounted capacitors can be selected.

[0126] FIG. 22 shows a booster circuit dedicated for the voltage generating power source VCL for counter electrodes. In the circuit shown in FIG. 22, as externally mounted capacitors, two capacitors consisting of a capacitor C3-1 and a capacitor C3-2 can be connected. By turning on the switches SW3-1 and SW3-3, the voltage of the input power source  $V_{in}$  is held in the capacitor C3-1 and, thereafter, the switch SW3-2 is turned on to reverse the polarity and, further, the input power source  $V_{in}$  is connected to a capacitor Cout5 through a switch SW3-7, whereby voltage is obtained by magnifying the input power source  $V_{in}$  by  $-1$  time.

[0127] Further, with the provision of the externally mounted capacitor C3-2, the voltage of the input power source  $V_{in}$  is also held in the capacitor C3-2 due to switches C3-4 and C3-5 and, thereafter, the capacitors C3-1 and C3-2 are connected in series through a switch SW3-6, and the input power source  $V_{in}$  is connected to the capacitor Cout5 by a switch SW3-8, whereby a voltage can be obtained by magnifying the input power source  $V_{in}$  by  $-2$  times. As described above according to the circuits explained in conjunction with FIG. 15, FIG. 17 and FIG. 22, the magnification of the booster circuit can be selected in response to the voltage necessary for liquid crystal display panel and hence, it is possible to obtain the necessary voltage by suitably providing necessary capacitors and switches.

[0128] Then, a power source circuit part 4 of the drive circuit 50 is explained in conjunction with FIG. 23. FIG. 23 is a schematic block diagram of the power source circuit part 4. In the drawing, numeral 81 indicates a counter electrode voltage outputting circuit for main panel, numeral 82 indicates a level adjusting circuit, numeral 83 indicates a counter electrode voltage outputting circuit for sub panel, numeral

**84** indicates a regulator, numeral **86** indicates an inner reference voltage generating circuit, numeral **87** indicates a reference voltage outputting circuit, and symbol **M** indicates an AC signal inputting terminal. A power source **VCC** is a power source voltage of the drive circuit **50** and an output voltage from a battery is inputted in the same manner as the input power source  $V_{in}$ .

[0129] The AC driving is performed in the above-mentioned manner. As one method for performing the AC driving, a so-called common inversion driving method is performed. In the circuit shown in **FIG. 23**, to enable the common inversion driving, the counter electrode voltage outputting circuit **81** for main panel and the counter electrode voltage outputting circuit **83** for sub panel are configured such that a voltage which is inverted at a fixed interval can be outputted. An AC signal is transmitted to the counter electrode voltage outputting circuit **81** for main panel and the counter electrode voltage outputting circuit **83** for sub panel through an AC signal line **42** and the circuits **81** and **83** output a counter electrode High level voltage **VCOMH** and a counter electrode Low level voltage **VCOML** in response to the AC signal. **FIG. 24** shows output waveforms of the counter electrode voltage having the counter electrode High level voltage **VCOMH-1** for main panel, the counter electrode Low level voltage **VCOML-1** for main panel, the counter electrode High level voltage **VCOMH-2** for sub panel, and the counter electrode Low level voltage **VCOML-2** for sub panel.

[0130] Here, the amplitude adjusting circuit **82** determines the reference voltage amplitude and respective voltages of the counter electrode voltage outputting circuit **81** for main panel and the counter electrode voltage outputting circuit **83** for sub panel can be finely adjusted by semifixed resistances **88**.

[0131] In the circuit shown in **FIG. 23**, from the regulator **84**, as the counter electrode High level voltage **VCOMH**, the reference voltage is supplied to the level adjusting circuit **82**. The level adjusting circuit **82** outputs the reference voltages which are finely adjusted by the semifixed resistances **88** to a high level outputting part **81a** of the counter electrode voltage outputting circuit **81** for main panel and a high level outputting part **83a** of the counter electrode voltage outputting circuit **83** for sub panel as the counter electrode voltages. Further, in the level adjusting circuit **82**, the amplitude reference voltage is generated such that the amplitude reference voltage assumes the optimum amplitude and, then, the amplitude reference voltage is deducted from the counter electrode High level voltage **VCOMH** so as to generate the counter electrode Low level voltage **VCOML** and this voltage **VCOML** is outputted to a Low level outputting part **81b** of the counter electrode voltage outputting circuit **81** for main panel and a Low level outputting part **83b** of the counter electrode voltage outputting circuit **83** for sub panel. The counter electrode voltage outputting circuit **81** for main panel changes over the connection between the High level outputting part **81a** and the Low level outputting part **81b** in accordance with the AC signal and outputs the counter electrode High level voltage **VCOMH-1** and the counter electrode Low level voltage **VCOML-1**. On the other hand, the counter electrode voltage outputting circuit **83** for sub panel changes over the connection between the High level outputting part **83a** and the Low level outputting part **83b** in accordance with the AC signal and outputs the counter

electrode High level voltage **VCOMH-2** and the counter electrode Low level voltage **VCOML-2**.

[0132] Here, the counter electrode voltage outputting circuit **81** for main panel, the counter electrode voltage outputting circuit **83** for sub panel and the level adjusting circuit **82** are capable of changing the voltage values of the reference voltage and the amplitude reference voltage of the counter electrode based on the control from the controller. In the circuit shown in **FIG. 23**, the booster circuit **54** is a booster circuit dedicated to the voltage generating power source **VCL** for counter electrode. Further, the booster circuit **52** includes two externally mounted capacitors **C1-1** and **C1-2** and can output voltages which are respectively twice and three times as high as the input power source  $V_{in}$  as the voltage **DDVDH**. Further, when the scanning signal line **GL** is used as one electrode of the holding capacitance, a scanning signal OFF circuit **89** is provided in the same manner as the counter electrode voltage outputting circuits **81**, **82** whereby the high-level side voltage **VGOFFH** and the low-level side voltage **VGOFFL** can be outputted also with respect to the voltage **VGOFF** at the low side of the scanning signal.

[0133] In a circuit shown in **FIG. 23**, a booster circuit **54** dedicated to the voltage generating power source **VCL** for counter electrodes is provided, wherein the booster circuit **53** can stop outputting of the voltage generating power source **VCL** for counter electrodes. When the driving ability of the power source **VCL** due to the booster circuit **53** becomes short, it is possible to operate the booster circuit **54** dedicated to the voltage generating power source **VCL** for counter electrodes. Further, provided that there is no problem even when the image quality is low, outputting of the power source **VCL** from the booster circuits **53** and **54** is stopped, the counter electrode high-level voltage **VCOMH** is outputted from the counter electrode voltage outputting circuits **81**, **82**, and the counter electrode low-level voltage **VCOML** is not outputted, whereby the reduction of a power consumption can be realized.

[0134] Here, in the booster circuit **54** shown in **FIG. 23**, an externally mounted capacitor **C3-2** (indicated by a dotted line in the drawing) is not provided and outputting is performed only by boosting the input power source  $V_{in}$  by  $-1$  time using the externally mounted capacitor **C3-1**. In this manner, since an undesired booster voltage is present depending on the liquid crystal display panel, capacitors which are not necessary to be mounted are omitted for reducing the number of parts.

[0135] Further, with respect to switches **SW3-4**, **SW3-5** and the like shown in **FIG. 22**, when these switches are not necessary as the drive circuit **50**, there may be a case that these switches are not provided. That is, for realizing the miniaturization and the reduction of power consumption, with respect to the number of mounting parts and the scale of the circuit, optimum values are selected corresponding to driven liquid crystal display panels. The drive circuit **50** is set corresponding to respective liquid crystal display panels in response to the instruction signals and the like whereby optimum driving of the respective liquid crystal display panels can be realized.

[0136] Next, problems which may arise at the time of producing the power source voltage using the booster circuit are explained. In producing the power source voltage using

the booster circuit, the power source voltage does not assume a given voltage at the time of supplying the power source to the mobile telephone. Accordingly, the inside of the driving circuit **50** assumes the power source voltage state shown in **FIG. 25**. In the drawing, numeral **81** indicates a parasitic PNP bipolar and numeral **82** indicates a NPN bipolar. An NPN thyristor and a PNP thyristor are constituted of these parasitic bipolars. When a  $V_{in} > DDVDH$  voltage and a  $GND > VGL$  voltage exceed threshold values  $V_F$  of the thyristors and a potential inversion phenomenon such as  $V_{in} < DDVDH$ ,  $VGL > GND$  is generated, the thyristors cannot be turned off. However, at the time of supplying the power source, the power source  $VGL$  assumes a potential equal to or more than the  $GND$  potential and the power source voltage  $VDH$  of the drive circuit **5** also assumes the potential equal to or less than the input power source  $V_{in}$ . Accordingly, there arises a latch-up phenomenon in which a large current flows between  $V_{in} > GND$  and hence, the thyristors cannot be turned off.

[0137] Accordingly, to prevent the generation of such a latch-up phenomenon, as shown in **FIG. 25**, short-circuiting switches **76** and **77** are provided. **FIG. 26A** shows the constitution which provides a short-circuiting switch between respective power sources and **FIG. 26B** shows an equivalent circuit when the short-circuiting switch is turned on. As shown in **FIG. 26B**, the short-circuiting switch has a resistance component and hence, the short-circuiting switch has possibility of inducing the potential inversion phenomenon. Accordingly, the  $GND > VGL$  voltage is fixed using an externally mounted diode **78** such that the  $GND > VGL$  voltage does not exceed the threshold value  $V_F$  of the thyristor. However, with respect to the wiring formed on the liquid crystal display panel, the wiring resistance value is large and hence, there may arise a drawback that the current which flows in the parasitic bipolar cannot be absorbed by the externally mounted diode. Accordingly, to prevent the occurrence of further potential inversion phenomenon, the power source ON sequence is taken into consideration.

[0138] **FIG. 27A** shows the power source ON sequence. Here, as shown in **FIG. 26B**, between the power source  $DDVDH$  and the power source  $VGH$ , two switches consisting of a low resistance switch **81** and a high resistance switch **85** are provided. First of all, during a period A, the short-circuiting switch **82** between the power source  $DDVDH$  and the power source  $V_{in}$  is turned off and the short-circuiting switch **81** between the power source  $DDVDH$  and the power source  $VGH$  is turned on so that the booster circuit **52** shown in **FIG. 23** is operated and the power source  $DDVDH$  is started. At this point of time, the short-circuiting switch **81** between the power source  $DDVDH$  and the power source  $VGH$  is turned on, the level of the power source  $VGH$  assumes the level of the power source  $DDVDH$ . Here, the operation during the above-mentioned period A is determined based on AP bits of instruction signals described later.

[0139] Next, during a period B, the booster circuit **53** is operated so as to start the power source  $VGH$  and the power source  $VGL$ . Here, the power source  $VCL$  is delayed to prevent the potential inversion with the power source  $VGL$ . Alternatively, since the relationship  $VGH > DDVDH$  is established at this point of time, it is possible to operate the power sources  $VGL$  and  $VCL$  simultaneously. Due to the above-mentioned power source ON sequence, the power

sources can be started without inverting respective potentials so that it is possible to increase a margin of starting the power source circuit. The operation during the period B is determined based on PON bits of instruction signals.

[0140] Then, the power source OFF sequence is explained. With respect to the mobile telephone or the like, due to a sudden interruption of the original power source caused by slipping off of a battery or the like, there has been a drawback that an image retention occurs on a screen. Accordingly, to obviate such an image retention, the power source OFF sequence becomes necessary. **FIG. 27B** shows the power source OFF sequence. First of all, assume that the supply of a voltage from the input power source  $V_{in}$  is stopped due to some reason at a point of time D. During a period C, the power sources  $DDVDH$ ,  $VCL$  and  $VGL$  are discharged to assume a state before starting the power source. Further, the counter electrode voltage  $VCOM$  output and the video signal line output also assume the  $GND$  level during the period C. Here, to discharge the charge charged in the pixel, it is necessary to make the thin film transistor **10** assume the ON state. Accordingly, to make the thin film transistor **10** assume the ON state, it is necessary to delay the discharge of the power source  $VGH$  compared to other power sources. Here, when the drive circuit **50** is reset in response to the reset signal explained in conjunction with **FIG. 28**, the drive circuit **50** sets the value of GON bits of instruction signals explained later and sets all outputs to the scanning signal lines at a high level.

[0141] In the power source ON sequence, it is desirable that the low resistance is provided between the power source  $DDVDH$  and the power source  $VGH$ . To the contrary, in the power source OFF sequence, it is desirable that the power source  $VGH$  assumes the high resistance to delay discharging. Accordingly, to enable the drive circuit **50** to recognize the power source ON time and the power source OFF time, a POWER ON RESET signal is used. Waveforms of the POWER ON RESET signal are shown in **FIG. 28A**. The POWER ON RESET signal has the specification that the signal rises in several ms after supplying the power source when the liquid crystal display panel is turned on, wherein the POWER ON RESET signal resets the drive circuit **50** within the low period of several ms and, thereafter, the signal rises and releases resetting of the drive circuit **50**. Here, although resetting is released with respect to the drive circuit **50**, the inner state of the drive circuit is fixed and the state thereof is univocally determined.

[0142] To the contrary, at the time of turning off the power source, resetting is performed by making the state of discharge of respective power sources different from each other based on capacitances connected to respective power source terminals. The liquid crystal display panel adopts the specification in which the capacitance of the capacitor  $CA1$  of the circuit shown in **FIG. 28B** is set smaller than the capacitance of the capacitor  $CA2$  so that a RESET signal rises before the power source voltage  $VCC$ . Due to such a constitution, in a state that the charge remains in the power source  $VCC$  at the time of interruption of power source, due to the falling of the RESET signal, it is possible to reset the drive circuit **50**. Here, the power source voltage  $VCC$  is a power source voltage supplied to the drive circuit **50** from the outside.

[0143] In this manner, although it is possible to recognize ON and OFF of the power source by making use of the

RESET signal, the drive circuit 50 enters the resetting operation in the RESET state and hence, the state of the inside of the drive circuit 50 is fixed univocally. Accordingly, to recognize ON and OFF by making use of the RESET signal, a level sensing circuit is provided between the power source voltages DDVDH and VGH.

[0144] FIG. 29 shows a circuit which includes the level sensing circuit 79 and controls ON/OFF of the low resistance switch 81 and the high resistance switch 85. Here, the low resistance switch 81 and the high resistance switch 85 are switches which make the power source voltages DDVDH and VGH shown in FIG. 26 short-circuited. Further, symbol RESET is a RESET signal, symbol AP is a signal which indicates that a period is the period A in FIG. 27A, symbol SLP is a sleep mode signal which is served for stopping the operation of the power source circuit and converts the display to the non-display, and symbol PON is a signal which indicates outputting/stopping of the power sources VGH, VGL and VCL and is a signal which indicates that a period is the period B in FIG. 27A.

[0145] The level sensing circuit 79 shown in FIG. 29 outputs the voltage VGH when the relationship  $VGH > DDVDH$  is established and outputs the voltage VGL when the relationship  $VGH < DDVDH$  is established. As shown in FIG. 27, since the relationship  $VGH < DDVDH$  is established during the power source ON state and the relationship  $VGH > DDVDH$  is established during the power source OFF state, the low resistance switch 81 assumes the ON state during the power source ON period and the OFF state during the power source OFF period, while the high resistance switch 85 assumes the ON state when the power source OFF period. Here, in the circuit shown in FIG. 29, although the high resistance switch 85 assumes the ON state even during the power source ON period, since the low resistance switch 81 assumes the ON state during the power source ON period, with respect to the resistance between the power source VGH and the power source DDVDH, the low resistance switch 81 is dominant. Accordingly, it is not always necessary for the high resistance switch 85 to assume the OFF state and hence, it is possible to use the level sensing circuit 79 shown in FIG. 29.

[0146] FIG. 30 shows rising waveforms of the POWER ON RESET signal. When the POWER ON RESET signal rises during the starting period of an oscillator, the waveform becomes unstable as shown in FIG. 30A. Accordingly, the drive circuit 50 suffers from erroneous operations. Accordingly, to prevent an erroneous operation, a low pass filter is provided inside the driving circuit. As shown in FIG. 30B, the low pass filter is provided inside the drive circuit 50 so as to reduce noises carried by the RESET signal. In FIG. 30, the low pass filter is provided to the scanning signal line drive circuit 58 and the reset signals are transmitted to the video signal line drive circuit 57 through output terminals RESETout.

[0147] The mirror-type liquid crystal is explained in conjunction with FIG. 31. In FIG. 31, numeral 1 indicates the liquid crystal display panel and is served for display. At the side for observing the liquid crystal display panel 1, a mirror liquid crystal display panel 400 is provided. The mirror liquid crystal display panel 400 includes a transmission polarization axis variable portion 410, a reflection-type polarization portion 420 and an absorption-type polarization portion 415.

[0148] The transmission polarization axis variable portion 410 is capable of controlling the polarization axis of light of the incident rectilinear polarization to a state in which the polarization axis is changed and a state in which the polarization axis is not changed when the light passes through the transmission polarization axis variable portion 410. As shown in FIG. 31A, between the electrodes formed on a pair of substrate 411 and substrate 412, when the voltage from the power source 416 is not applied, the polarization axis of the light of the incident rectilinear light is changed and the light passes through the reflection-type polarization portion 420 and reaches the liquid crystal display panel 1. To the contrary, when the light irradiated from the liquid crystal display panel 1 is rectilinear polarized light which passes through the reflection-type polarization portion 420, the light irradiated from the liquid crystal display panel 1 passes through the mirror liquid crystal display panel 400 and reaches an observer.

[0149] To the contrary, when the voltage is applied between the electrodes formed on the substrate 411 and the substrate 412 shown in FIG. 31B, the polarization axis of the light of rectilinear polarized light incident on the transmission polarization axis variable portion 410 is not changed and hence, the light is reflected on the reflection-type polarization portion 420. On the other hand, when the light irradiated from the liquid crystal display panel 1 is the rectilinear polarized light which passes through the reflection-type polarization portion 420, the light is absorbed by an absorption-type polarization portion 415 and does not reach the observer.

[0150] Here, the voltage applied to the mirror liquid crystal display panel 400 is subjected to AC driving in the same manner as the liquid crystal display panel 1. Accordingly, the mirror liquid crystal display panel drive circuit 94 is provided to the drive circuit 50. FIG. 32A shows the overall constitution of the mirror liquid crystal circuit. A mirror liquid crystal display panel driving signal MCLK is outputted from the mirror liquid crystal circuit. It is possible to drive the mirror liquid crystal display panel using frequency which is sufficiently late not to cause a problem on the liquid crystal so that the mirror liquid crystal display panel drive circuit 94 is driven with low frequency for power saving of the mirror liquid crystal display panel drive circuit 94. However, since the signal OSC transmitted from the controller or the like is a high frequency signal, the mirror liquid crystal display panel drive circuit 94 is provided with a frequency dividing circuit 93.

[0151] In FIG. 32A, the mirror liquid crystal circuit includes an oscillator 92, the frequency dividing circuit 93 which divides the frequency of the clock, a booster circuit 52 and the mirror liquid crystal display panel drive circuit 94. The frequency dividing circuit 93 produces a clock S2 for operating the booster circuit 52 and a clock S3 for operating the mirror liquid crystal display panel drive circuit 94 in response to a signal S1 from the controller 91. The booster circuit 52 supplies the power source DDVDH to the mirror liquid crystal display drive circuit 94. Further, in response to the signal S4 from the controller, the mirror liquid crystal display panel drive circuit 94 controls outputting of a clock MCLK+ and a clock MCLK- for mirror liquid crystal driving.

[0152] Next, FIG. 32B shows the mirror liquid crystal display drive circuit 94. The clock MCLK+ and the clock

MCLK- are outputted at a cycle of the clock S3 and the clock MCLK- has an output level thereof inverted with respect to the clock MCLK+.

[0153] The mirror liquid crystal display panel assumes a state in which the mirror liquid crystal display panel reflects light when a certain voltage is applied between the counter electrodes. The clock MCLK+ is applied to one electrode of the mirror liquid crystal display panel and the clock MCLK- is applied to another electrode of the mirror liquid crystal display panel. A seizure phenomenon occurs in the liquid crystal when a DC voltage is applied thereto and hence, AC driving is necessary. An amplitude is set to the power source DDVDH at the High side and GND at the low side. This is because that it has been found out as a result of study that such constitution can minimize the use of the booster circuit and hence, the power consumption can be minimized. Here, since the level of the voltage which drives the mirror liquid crystal display panel differs depending on the threshold value of the liquid crystal to be used, to cope with the liquid crystal having the low threshold value, the mirror liquid crystal display panel is configured such that the level (approximately 3V) of the input power source voltage  $V_{in}$  can be also used in addition to the level (5V) of the power source DDVDH as the level of voltage for driving.

[0154] Next, the display state of the mirror liquid crystal and the outputting levels of the clock MCLK+ and the clock MCLK- and the levels of respective power sources are explained. First of all, when the mirror liquid crystal is not used (when the transmission of light is allowed), both of the clock MCLK+ and the clock MCLK- assume the GND level. This control is performed to prevent the application of the DC voltage to the liquid crystal. The control is performed in response to the signal S4 in FIG. 32A, wherein when the signal S4 is at the High level, outputting of the clock MCLK+ and the clock MCLK- assumes GND. This can be realized by the circuit shown in FIG. 32B. When the mirror liquid crystal is used (when the light is reflected), the clock MCLK+ and the clock MCLK- at the High-side level can output both of the voltage at the DDVDH level and the voltage at the  $V_{in}$  level.

[0155] The High-side level is equal to the level of the power source voltage of the circuit shown in FIG. 32B and hence, the booster circuit 52 is controlled in response to the signal S5 from the controller 91 so as to control the voltage value of the power source DDVDH inputted to the circuit shown in FIG. 32B. When the voltage value is at the  $V_{in}$  level, the short-circuiting switches 81, 82, 83 and 84 shown in FIG. 26A are short-circuited and all booster circuits stop the boosting operations. Accordingly, in the circuit shown in FIG. 26A, since the short-circuiting switch 82 is turned on the voltage of the power source DDVDH of the circuit shown assumes the same voltage value as that of the power source  $V_{in}$  and the voltage of the power source DDVDH of the circuit shown in FIG. 32 assumes the same voltage value as that of the power source  $V_{in}$ . Eventually, with respect to the power source voltage, only the power source voltage having the  $V_{in}$  level necessary for the mirror liquid crystal driving is present and hence, the reduction of power consumption can be achieved and there is no inversion of the respective levels due to the short-circuiting switches whereby the stable operation is ensured.

[0156] Next, when the voltage value is at the DDVDH level, the short-circuiting switches 81, 83 and 84 shown in

FIG. 26A are short-circuited so as to operate the booster circuit 52. Due to this control, the DDVDH level which is necessary for the mirror liquid crystal driving is produced and other booster circuits are stopped and hence, the reduction of power consumption can be achieved and there is no inversion of the respective power source levels due to the short-circuiting switches whereby the stable operation is ensured.

[0157] Then, the arrangement of terminals of the drive circuit 50 is shown in FIG. 33. Numeral 451 indicates an input terminal region, numeral 452 indicates a scanning signal line terminal region for the liquid crystal display panel (main panel) 1, and numeral 453 indicates a scanning signal line terminal region for the liquid crystal display panel (sub panel) 200. The scanning signal line terminal regions 452, 453 are formed in a concentrated manner on two sides where the line 35 for sub panel scanning signals and the line 36 for scanning signal of the drive circuit 50 are formed. On the other hand, the input terminal region 451 is formed in a concentrated manner on the side to which the flexible board 30 is connected. Further, since the externally mounted capacitors are mounted on the flexible substrate 30, terminals which are connected to these externally mounted capacitors are also formed on the same input terminal region 451.

[0158] The liquid crystal display device of the present invention uses instruction signals for changing the scanning method or the magnification of booster circuits depending on the arrangement of two liquid crystal display panels. FIG. 34 shows an example of instruction signals. The instruction signals shown in FIG. 34 show serial data constituted of 16 bits. Signals of 16 bits arranged in the lateral direction in the drawing are transmitted to the drive circuit 50 from the outside as instruction signals. Although 6 instruction signals are arranged in parallel in the longitudinal direction in the drawing, with respect to the instruction signals shown in FIG. 34, 3 bits ranging from D15 to D13 form index codes and discriminate contents of the instruction signals.

[0159] With respect to the instruction signals in the index code (000), DO constitutes a SLP bit for setting a sleep mode, D11 constitutes a GON bit for setting display ON/OFF. In a range from D1 to D3, a fixed current quantity of fixed current sources in a built-in operational amplifier is adjusted with the AP bits. When all of AP0 to AP2 are 0, the period A shown in FIG. 27A is set. During this period A, the booster circuit output DDVDH is operated in a state that the operation of the operational amplifier is stopped. In a range from D4 to D6, the boosting cycle of the booster circuit is set with the DC bits. Although the driving ability of the booster circuit is enhanced by accelerating the boosting cycle, the consumption of current is increased. In a range from D7 to D9, the boosting magnification of the booster circuit 53 with respect to the power source circuit 4 shown in FIG. 23 can be changed in response to the BT bit.

[0160] With respect to the instruction signals of the index code (001), the D11 constitutes the function allocation bits and functions of respective bits differ depending on whether D11 is 1 and 0. First of all, a case in which D11 is 0 is explained. D7 assumes the PON bit and the operation and the stop of the power sources VGH, VGL and VCL are set. When PON bit=1, the operation of the power sources VGH,

VGL and VCL is started to set the operation during the period B shown in FIG. 27A. D9 and D10 set the outputting and the stop of the common voltage VCOM1 for main liquid crystal display panel and the common voltage VCOM2 for sub liquid crystal display panel. When D11 bit is 1, D3 and D4 assume the MI bits and set the outputting and the stop of the clock MCLK+ and the clock MCLK- for mirror liquid crystal driving. D1 to D3 assume the MFL bits, wherein the frequency of the input clock is divided so as to adjust the alternating cycle of the clock MCLK+ and the clock MCLK- for mirror liquid crystal driving.

[0161] With the instruction signal having the index code (010), D0 to D4 assume the VCM bit and set the common voltage VCOM2 for sub liquid crystal display panel. Here, when (1111) is set to D0 to D4, the adjustment based on a built-in volume is stopped so as to enable the adjustment using the externally mounted resistances. D5 to D9 constitute VDV bits and set AC amplitudes of the common voltage VCOM1 for main liquid crystal display panel and the common voltage VCOM2 for sub liquid crystal display panel.

[0162] With the instruction signal having the index code (110), 5 bits from D0 to D4 constitute SC0 to SC4 bits for setting the output start position of the scanning signal lines, while 5 bits from D5 to D9 constitute NL0 bit to NL4 bit for setting the effective number of lines of the scanning signal lines. D10 constitutes the GS bit which sets whether the outputting direction is the normal direction or the reverse direction. With the instruction signals of the index code (111), 2 bits consisting of D0 and D1 constitute FL bits which set the field number of the interlace mode.

[0163] Here, with respect to the output start position and the effective line number designated by the instruction signals, it is possible to designate the number of scanning signal lines or designate the output line numbers in response to a mode such as the 110 line outputting mode, the 100 line outputting mode or the like.

[0164] To briefly recapitulate the advantageous effects obtained by typical inventions out of inventions disclosed in the present application, they are as follows.

[0165] (1) According to the liquid crystal display device of the present invention, in the portable equipment on which the main panel and the sub panel are mounted, it is possible to reduce the mounting area of the drive circuits and hence, it is possible to freely choose the arrangements of the drive circuits.

[0166] (2) According to the liquid crystal display device of the present invention, the number of the externally mounted parts can be reduced and hence, it is possible to realize the liquid crystal display device driven by a battery which can be conveniently carried.

What is claimed is:

1. A display device comprising:

a first display panel;

a second display panel;

wiring which connects between the first display panel and the second display panel;

a drive circuit which is connected to the first display panel;

output terminals which are mounted on the first display panel and to which signals are supplied from the drive circuit; and

signal wiring which is outputted from the drive circuit, the signal wiring being electrically connected to pixels mounted on the first display panel and being connected to output terminals; wherein

the drive circuit outputs a first common voltage for the first display panel and a second common voltage for the second display panel.

2. A display device according to claim 1, wherein counter electrode lines for the first display panel and counter electrode lines for the second display panel are individually connected to the drive circuit.

3. A display device according to claim 1, wherein the drive circuit is mounted on an insulating substrate which constitutes the first display panel.

4. A display device according to claim 1, wherein the signal wiring includes first signal wiring which has one end thereof connected to the drive circuit and another end connected to an output wiring and second signal wiring which has one end thereof connected to the drive circuit and another end connected to a wiring capacitance adjusting element.

5. A display device comprising:

a first display panel;

a second display panel;

wiring which connects between the first display panel and the second display panel;

drive circuit which is connected to the first display panel;

output terminals which are mounted on the first display panel and to which signals are supplied from the drive circuit; and

signal wiring which is outputted from the drive circuit, the signal wiring being electrically connected to pixels mounted on the first display panel and being connected to output terminals; wherein

the drive circuit includes a booster circuit,

the booster circuit outputs a first common voltage for the first display panel and a second common voltage for the second display panel, and the booster circuit is capable of changing magnification for boosting in response to an external signal.

6. A display device according to claim 5, wherein the drive circuit is mounted on an insulating substrate which constitutes the first display panel.

7. A display device according to claim 5, wherein the signal wiring includes first signal wiring which has one end thereof connected to the drive circuit and another end connected to an output wiring and second signal wiring which has one end thereof connected to the drive circuit and another end connected to a wiring capacitance adjusting element.

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#### 摘要(译)

本发明提供一种用于小型化便携式设备的显示装置，该显示装置能够驱动由主显示面板和子显示面板组成的两个显示面板。显示装置包括主显示面板，子显示面板和驱动电路。驱动电路可以同时驱动主显示面板和子显示面板。输出端子被提供给主显示板，并且信号从输出端子传输到子显示板。此外，驱动电路包括电源电路，该电源电路能够向主显示板和子显示板输出适当的公共电压。

