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(54) **Driving system for a display device**

Ansteuersystem für ein Anzeigegerät

Système de commande pour un dispositif d'affichage

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(56) References cited:
EP-A- 0 199 361
EP-A- 0 278 778
EP-A- 0 285 401

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Description

Background of the Invention

This invention relates to a driving method of a flat panel type display device with liquid crystal and the like. In particular, this invention is applied to the driving method of an active panel device having non-linear resistance elements therein.

Regarding an active panel device having 2-terminal active elements of non-linear resistance made of SiNx material and the like therein, it is not always true that the active elements themselves have symmetrical characteristics relative to the supplying voltage in the plus direction or in the minus direction. Namely, they have asymmetric characteristics in general. For example, when the voltage VS. current characteristics in case of applying the plus directional voltage is compared to said characteristics in case of applying the minus directional voltage, they are different from each other to be asymmetrical.

As shown in Fig. 3, voltage-averaging driving method is employed in the conventional matrix display device having liquid crystal. Referring to Fig. 3, dividing resistors 31, 32, 33, 34 and 35 are provided to divide an electric source voltage VDD and a liquid crystal driving voltage V_{LCD}. The divided voltages are amplified current by an operational amplifier circuit 40. The operational amplifier circuit 40 outputs voltages V1, V2, V3 and V4 via resistors 36, 37, 38 and 39. Furthermore, the electric source voltage V_{DD} becomes the highest positive driving voltage V_0. The liquid crystal driving voltage V_{LCD} becomes the lowest negative voltage V_5. The selected driving voltages V_0 and V_5 are inputted to a row electrode driving circuit and a column electrode driving circuit. And also, the bias voltages V_1 and V_4 are inputted to the row electrode driving circuit, and V_2 and V_3 are inputted to the column electrode driving circuit. Thus, as the selected driving voltage V_0, the same magnitude of voltage is inputted to the row electrode driving circuit and the column electrode driving circuit. And therefore, when the non-linearity of the active elements is asymmetrical, the amount of electric charge charged into the liquid crystal differs depending on the polarity voltage in the plus direction or in the minus direction, and the discharging time of said electric charge also differs.

As described above, when turning on and turning off, some display pattern is switched repeatedly, because of the asymmetry of the active elements, and because of different amount of charged electric charge and the discharging time depending on the voltage of positive polarity or of negative polarity, it occurrs the phenomenon of disappearing display together with instant stripe shaped display. And so-called charging-up phenomenon occurs as follows; when some display of a static pattern is switched to another display of pattern, the previous static pattern is overlapped to the new pattern to be displayed for a few seconds.

Fig. 4 is a matrix diagram illustrating the structure of a matrix-type display device having non-linear active elements therein. $X_1 \sim X_2$ are column electrododes, $Y_1 \sim Y_2$ are row electrododes, LA's are non-linear active elements, and LC's are liquid crystal display dots at the cross points. Fig. 5 shows the asymmetry of I-V characteristics of said non-linear active elements. As shown in the Fig. 5, when the case of supplying plus directional voltage to the non-linear active elements from the side of column electrodes is compared to the case of supplying minus directional voltage, it is necessary to make magnitude of the plus directional voltage larger in order to make flow same amount of current. Since the liquid crystal is displayed by means of holding the amount of electric charge charged by this current, it is important to make the plus directional voltage symmetrical with the minus directional voltage in case of driving the liquid crystal with non-linear active elements. When the plus directional voltage and the minus directional voltage the magnitude thereof being mutually equal are applied to the non-linear active elements, it will be understood by the fact that holding time of the electric charge amount differs depending on the plus directional voltage and the minus directional voltage, because impedance in the plus direction is different from that in the minus direction.

EP-A-278 778 discloses a liquid crystal display device as referred to in the preamble of claim 1. The driving signals applied to the row electrodes and the column electrodes are provided as puls signals having a peak value that lowers the resistance of the non-linear active elements and having the same phase and amplitude.

For a similar display device, as disclosed in EP-A-199 361, the column and row electrodes are connected to a field effect transistor one channel electrode ofwhich is connected through a liquid crystal cell to a common voltage. By varying at least one of the voltages in the DC level, the liquid crystal cells can be correctly AC-driven. The known arrangement cannot fully overcome the difference of the I-V characteristics of the non-linear active elements depending from the plus or minus directional voltages.

In order to solve the above noted problems of the conventional method, as object of the present invention is to provide a driving method for electrically compensating the asymmetry characteristics of the active elements.

Another object of the present invention is to provide a display device with high displaying quality.

According to the present invention there is provided a liquid crystal display device as claimed in claim 1.

In a preferred form, the voltage generating circuit comprises bias voltage generating circuit and selected voltage generating circuit, and the output voltage from the selected voltage generating circuit to the column electrode driver is not equal to the output voltage from the selected voltage generating circuit to the row electrode driver. In such case, the selected voltage generating circuit comprises an adjusting means such as volume resistor which is capable of adjusting voltage at either

one of the column electrodes and the row electrodes toward positive voltage or negative voltage.

Brief Description of the Drawings

Fig. 1 is a block diagram of the drive circuit of the matrix liquid crystal display device;

Fig. 2 is a circuit diagram illustrating one embodiment of this invention;

Fig. 3 is a diagram of a conventional drive voltage generator circuit;

Fig. 4 is a matrix diagram illustrating the structure of a matrix-type display device having non-linear active elements therein;

Fig. 5 is a diagram illustrating the asymmetry of I-V characteristics of the non-linear active elements;

Fig. 6 is a diagram illustrating conventional drive waves to drive the liquid crystal;

Fig. 7 is a diagram illustrating one embodiment of drive waves according to this invention;

Fig. 8 is a circuit diagram illustrating an alternate embodiment of this invention; and

Fig. 9 is a diagram illustrating an alternate embodiment of drive waves according to this invention.

Detailed Description of the Embodiments

Next, preferred embodiments are described in conjunction with the drawings according to the present invention.

Fig. 1 is a block diagram of the drive circuit for use in explaining driving method according to the present invention. In Fig. 1, reference number 11 indicates the liquid crystal display panel. Reference number 12 indicates a row electrode driver which outputs scan pulses to each electrode. Reference number 13 indicates a column electrode driver which converts video signals that arrive at each column in series into parallel signals and simultaneously outputs these to each column electrode. Reference number 14 indicates a voltage generating circuit for providing driving voltage to the row electrode driver 12 and the column electrode driver 13. As shown in Fig. 1, the voltage generating circuit 14 comprises a bias voltage generating circuit 15 and a selected voltage generating circuit 16.

Fig. 2 is a circuit diagram illustrating one embodiment of a drive voltage generator circuit according to this invention. In Fig.2, 21, 22, 23, 24, and 25 are dividing resistors to divide voltage between electric source voltage V_{DD} and liquid crystal drive voltage V_{LCD}. An operational amplifier circuit 222 amplifies the divided voltage to provide bias drive voltages V1, V2, V3 and V4. Dividing resistors 210 and 211 divide voltage between electric source voltage V_{DD} and liquid crystal driving voltage V_{LCD}. And also, a variable resistor 212 divides voltage between V_{DD} and V_{SS} to output adjustable voltage. An operational amplifier circuit 221 amplifies said divided voltage and adjustable voltage to output selected drive voltages V_{01} and V_{02} of positive polarity.

Here, the selected drive voltage V_{01} of positive polarity is supplied to the column electrodes driving circuit, and the other selected drive voltage V_{02} is supplied to the row electrodes driving circuit, or vice versa. And also, the bias drive voltages V_1, V_4 and the selected drive voltage V_5 of negative polarity are supplied to the row electrodes driving circuit. The bias drive voltages V_2, V_3 and the selected drive voltage V_5 of negative polarity are supplied to the column electrodes driving circuit. According to the structure described above, when the selected drive voltage V_{01} of positive polarity is set between the electric source voltage V_{DD} and the grounded voltage V_{SS}, magnitude of the other selected drive voltage V_{02} of positive polarity may be made to be larger or smaller than that of said selected drive voltage V_{01} of positive polarity by means of adjusting the variable resistor 212.

Fig. 6 is a diagram illustrating a drive voltage wave applied to liquid crystal elements in case that a conventional drive voltage generator circuit is drived by means of a conventional driving method. Fig. 7 is a diagram illustrating a drive voltage wave with a drive voltage generator circuit according to this invention. As seen from Fig. 7, magnitude of the selected drive voltage of positive polarity is set to be larger than that of the selected drive voltage of negative polarity. On the other hand, it is also possible to set magnitude of the selected drive voltage of negative polarity larger than that of the selected drive voltage of positive polarity. As described above, magnitude of the drive voltage of one polarity is made to be larger than that of the drive voltage of the other polarity in order to compensate the asymmetry of the active elements.

According to the present embodiment asymmetry of the active elements is adjusted to be symmetrical depending on magnitude of the drive voltages, and therefore, the amount of electric charge charged into the liquid crystal display elements and the discharging time can be made to be equal irrespective of whether positive polarity or negative polarity.

Therefore, asymmetry of active elements is able to be compensated by means of making magnitude of one side of selected drive voltage larger or smaller than that of the other side, even if the asymmetry of active elements is in the plus direction or in its reverse direction. Accordingly, the problems of striping phenomenon, charging-up phenomenon and the like can be solved to provide a flat panel type display device with high displaying quality.

Fig. 8 illustrates a bias voltage generating circuit as modified embodiment of a drive system according to this invention. In Fig. 86~90 show resistors for dividing bias voltage. 81~85 show operational amplifier circuits. The value of V_{DD} is +5V, and V_{LC} is a negative voltage source for driving liquid crystals. V_{01}, V_{02} are respectively selected voltages in the plus direction for X electrode and for Y electrodode. In here, X electrode means column electrode and Y electrode means row electrode. V_5

shows a selected voltage in the minus direction. $V_1 \sim V_4$ show bias voltage in case of not selected state. When the resistance value of resistor 88 is 1.0R, then each resistance value of resistors 86, 87, 89, 90 is 1.5R, 0.5R, 1.5R and 0.5R. Also, 86 is composed of a variable resistor, and its central point voltage is amplified by the operational amplifier circuit 81. Accordingly, it is understood that magnitude of the selected voltage v_{02} is the plus direction applied to said Y electrode is made lower than that of the selected voltage V_{01} in the plus direction applied to said X electrode. And also, on one hand, difference of voltage between V_{01} and V_1 and that between V_3 and V_4 become larger depending on difference of voltage between V_2 and V_3, and on the other hand, difference of voltage between V_1 and V_2 and that between V_4 and V_5 become smaller than the difference between V_2 and V_3. Namely, the bias voltage is not equally divided, but it is featured by being unequally divided. Thus, said asymmetry of the non-linear active elements is compensated by this feature.

On the other hand, a conventional matrix-type display device with liquid crystal employs a drive bias circuit by means of voltage averaging method. That is, the portion between V_{DD} and V_{LC} is equally divided with resistors of mutually equal resistance so as to make the drive voltage applied in the plus direction of the liquid crystal to be equal to that applied in the minus direction thereof, whereby DC voltage is not applied to the liquid crystal.

Fig. 9 illustrates various driving waves for the embodiment of this invention. In Fig. 9, the driving waves are illustrated the case of 1 dot-display and non-display being repeated at every line. M is a polarity inverted signal at every frame, and DFM shows a polarity inverted signal at every 2 lines. Y_1, X_1 are respectively driving waves applied to row electrode and column electrode. And also, Y_1-X_1 is a driving voltage wave to be applied to the liquid crystal at the cross point of Y_1-X_1. As shown in Fig. 9, it is understood that the driving wave between Y_1 -X_1 is wholly shifted to the side of column electrode, and the minus directional voltage is applied to the plus directional voltage at the side of column electrode so that larger voltage can be applied to the side of column electrode. Accordingly, larger voltage is applied to the side of column electrode in order to compensate the asymmetry of said non-linear active elements, and thus same amount of charging current can be supplied for the voltage driving operation both in the plus direction and in the minus direction, thereby the compensating operation becomes capable to hole the same charged electric charge.

As described above, according to this embodiment, the asymmetry of non-linear active elements is compensated by the drive voltage. Accordingly, the problem of striping phenomenon as the conventional problem could be solved by means of obtaining uniform going down time by changing said resistance values and by adjusting the variable resistance value. Said problem was presented as follows: while the display operation is performed by the drive voltage in the plus direction or in the minus direction, the time difference (about 2 - 10 ms) of going down response in case of the non-display phenomenon being occurred is the cause of said problem of striping phenomenon. And also, the problem of charging-up could be solved. Said problem was presented as follows: because of over stored electric charge, the off-time is lengthened and the display state is continued for a relatively long time. Furthermore, since the liquid crystal at the cross points of X abscissa and Y ordinate is substantially AC driven without having DC component, life of the liquid crystal may be lengthened compared to the conventional art.

Claims

1. A liquid crystal display device including a plurality of column electrodes (X1, X2), a plurality of row electrodes (Y1, Y2) which intersects with the plurality of column electrodes (X1, X2) to define a matrix picture element at each intersection between the column electrodes and the row electrodes, a column drive means (13) for applying column driving signals to the plurality of column electrodes, a row drive means (12) for applying row driving signals to the plurality of row electrodes and a voltage generating means (14) including a bias voltage generating circuit (15) for providing voltages to both the column drive means (13) and the row drive means (12), wherein the bias voltage generating circuit (15) includes dividing resistors (86, 87, 88, 89, 90) to control voltage levels of both the column driving signals and the row driving signals in a first period and a second period, the matrix picture element has both a non-linear active element (LA) having an asymmetry of I-V characteristics and a liquid crystal display dot (LC) being electrically connected in series between the column electrode (X) and the row electrode (Y), combined voltages defined by the voltage difference between the column driving voltages and the row driving voltages are applied to the matrix picture element, and the combined voltages include a selected voltage and a nonselected voltage in both the first period and the second period,
   characterized in
   that a magnitude of the combined voltages of the plus direction is different from a magnitude of the combined voltages of the minus direction so as to compensate asymmetry characteristics between the plus direction and the minus direction of the non-linear active element (LA).

2. A liquid crystal display device as claimed in claim 1; wherein the combined voltages in the first period have an opposite polarity to the combined voltages in the second period, and a magnitude of the selected voltage in the first period is different from a

magnitude of the selected voltage in the second period.

3. A liquid crystal display device as claimed in claim 1; wherein a mean voltage value of the non-selected voltages is shifted from 0 voltage level in both the first period and the second period.

4. A liquid crystal display device as claimed in any of claims 1, 2, and 3; wherein the dividing resistors include resistors of R1, R2, R3, R4 and R5 which are connected in series, the resistor R1 is a variable resistor, voltages of V01 and V5 are applied to end terminals of the resistors R1 and R5 respectively, voltages between the voltage V01 and the voltage V5 are divided into voltages of V1, V2, V3, and V4 from terminals between the resistors of R1 (86) and R2 (87), R2 (87) and R3 (88), R3 (88) and R4 (89), and R4 (89) and R5 (90) respectively, the voltages V02 and V4 are supplied to the row drive means to form the selected voltage and the non-selected voltage respectively in the first period, the voltages V5 and V3 are supplied to the column drive means to form the selected voltage and the non-selected voltage respectively in the first period, voltages V5 and V1 are supplied to the row drive means to form the selected voltage and the non-selected voltage respectively in the second period, voltages V01 and V2 are supplied to the column drive means to form the selected voltage and the non-selected voltage respectively in the second period, so that a magnitude of voltage difference between the non-selected voltages of the plus direction and the minus direction is controlled by setting a rate of resistance value between the resistors R2 and R4, and a magnitude of voltage difference between the selected voltages of the first period and the second period by setting a resistance value of the variable resistor R1.

Patentansprüche

1. Eine Flüssigkristall-Anzeigevorrichtung mit einer Vielzahl von Spaltenelektroden (X1,X2), einer Vielzahl von Zeilenelektroden (Y1, Y2), die sich mit der Vielzahl der Spaltenelektroden (X1, X2) überkreuzen, um an jedem Kreuzungspunkt zwischen den Spaltenelektroden und den Zeilenelektroden ein Matrixbildelement zu definieren, einem Spaltentreibermittel (13), um Spaltentreibersignale an die Vielzahl von Spaltenelektroden zu legen, einem Zeilentreibermittel (12) um Zeilentreibersignale an die Vielzahl von Zeilenelektroden zu legen, und mit einem Spannungsgenerierungsmittel (14), einschließlich eines Vorspannungsgenerierungsschaltkreises (15), um Spannungen sowohl an die Spaltentreibermittel (13) als auch an die Zeilentreibermittel (12) zu legen, wobei der Vorspannungsgenerierungsschaltkreis (15) Teilerwiderstände (86, 87, 88, 89, 90) zum Steuern der Spannungshöhen sowohl der Spaltentreibersignale als auch der Zeilentreibersignale in einem ersten Zeitraum und in einem zweiten Zeitraum aufweist, das Matrixbildelement sowohl ein nichtlineares aktives Element (LA) mit einer Asymmetrie von I-V- Charakteristik, als auch einen Flüssigkristallanzeigepunkt (LC), der zwischen der Spaltenelektrode (X) und der Zeilenelektrode (Y) elektrisch in Reihe geschaltet ist, aufweist, kombinierte Spannungen von der Spannungsdifferenz zwischen der Spaltentreiberspannung und der Zeilentreiberspannung definiert werden und an das Matrixbildelement angelegt werden, und die kombinierten Spannungen eine ausgewählte Spannung und eine nichtausgewählte Spannung sowohl in der ersten als auch in der zweiten Periode beinhalten,
dadurch gekennzeichnet, daß
eine Größe der kombinierten Spannungen der Plusrichtung sich von der Größe der kombinierten Spannungen in Minusrichtung unterscheidet, um die Asymmetrie-Charakteristiken zwischen der Plusrichtung und der Minusrichtung des nichtlinearen aktiven Elements (LA) zu kompensieren.

2. Eine Flüssigkristall-Anzeigevorrichtung gemäß Anspruch 1, in der die kombinierten Spannungen in der ersten Periode die entgegengesetzte Polarität zu den kombinierten Spannungen in der zweiten Periode aufweisen, und eine Größe der ausgewählten Spannung in der ersten Periode sich von der Größe der ausgewählten Spannung in der zweiten Periode unterscheidet.

3. Eine Flüssigkristall-Anzeigevorrichtung gemäß Anspruch 1, in der ein Spannungsmittelwert der nichtausgewählten Spannungen sowohl in der ersten als auch in der zweiten Periode vom 0-Spannungs-Pegel wegbewegt wird.

4. Eine Flüssigkristall-Anzeigevorrichtung gemäß einem der Ansprüche 1, 2 oder 3, in der die Teilerwiderstände die in Reihe geschalteten Widerstände R1, R2, R3, R4 und R5 beinhalten, der Widerstand R1 ein Stellwiderstand ist, Spannungen von V01 bis V5 an die Klemmen der Widerstände R1 bzw. R5 gelegt werden, Spannungen zwischen der Spannung V01 und der Spannung V5 geteilt werden in die Spannungen V1, V2, V3 und V4 von den Klemmen zwischen den Widerständen R1 (86) und R2 (87), R2 (87) und R3 (88), R3 (88) und R4 (89), und R4 (89) und R5 (90), die Spannungen V02 und V4 an die Zeilentreibermittel angelegt werden, um die gewählte bzw. nichtgewählte Spannung in der ersten Periode zu bilden, die Spannungen V5 und V3 an die Spaltentreibermittel gelegt werden, um die gewählte bzw. nichtgewählte Spannung in der

ersten Periode zu bilden, die Spannungen V5 und V1 an die Zeilentreibermittel angelegt werden, um die gewählte bzw. nichtgewählte Spannung in der zweiten Periode zu bilden, die Spannungen V01 und V2 an die Spaltentreibermittel gelegt werden, um die gewählte bzw. nichtgewählte Spannung in der zweiten Periode zu bilden, so daß eine Größe der Spannungsdifferenz zwischen der nichtgewählten Spannung in Plusrichtung und in Minusrichtung durch Einstellen des Verhältnisses der Widerstandswerte zwischen den Widerständen R2 und R4, und eine Größe der Spannungsdifferenz zwischen den gewählten Spannungen der ersten Periode und der zweiten Periode durch Einstellen eines Widerstandswerts des Stellwiderstands R1 gesteuert wird.

Revendications

1. Dispositif d'affichage à cristaux liquides comportant une pluralité d'électrodes de colonnes (X1, X2), une pluralité d'électrodes de lignes (Y1, Y2) qui intersectent la pluralité d'électrodes de colonnes (X1, X2) pour définir un élément d'image matricielle ou par points à chaque intersection entre une électrode de colonne et une électrode de ligne, un moyen de commande de colonnes (13) pour appliquer des signaux de commande de colonnes à la pluralité d'électrodes de colonnes, un moyen de commande de lignes (12) pour appliquer des signaux de commande de lignes à la pluralité d'électrodes de lignes, ainsi qu'un moyen générateur de tensions (14) comportant un circuit générateur de tensions de polarisation (15) pour fournir des tensions à la fois au moyen de commande de colonnes (13) et au moyen de commande de lignes (12), dispositif dans lequel le circuit générateur de tensions de polarisation (15) comporte des résistances diviseuses (86, 87, 88, 89, 90) pour contrôler des niveaux de tension à la fois des signaux de commande de colonnes et des signaux de commande de lignes dans une première et une seconde période, l'élément d'image matricielle possède à la fois un élément actif non-linéaire (LA) dont les caractéristiques I-V sont asymétriques et un point d'affichage par cristal liquide (LC) connecté électriquement en série entre une électrode de colonne (X) et une électrode de ligne (Y), et des tensions combinées, définies par la différence de tension entre les tensions de commande de colonnes et les tensions de commande de lignes, sont appliquées à l'élément d'image matricielle, les tensions combinées comportant une tension sélectionnée et une tension non- sélectionnée à la fois dans la première période et dans la seconde période,
caractérisé en ce que
l'amplitude des tensions combinées appliquées dans le sens positif diffère de l'amplitude des tensions combinées appliquées dans le sens négatif, de manière à compenser les caractéristiques d'asymétrie entre le sens positif et le sens négatif de l'élément actif non-linéaire (LA).

2. Dispositif d'affichage à cristaux liquides selon la revendication 1, dans lequel les tensions combinées dans la première période ont une polarité opposée à celle des tensions combinées dans la seconde période, et l'amplitude de la tension sélectionnée dans la première période diffère de l'amplitude de la tension sélectionnée dans la seconde période.

3. Dispositif d'affichage à cristaux liquides selon la revendication 1, dans lequel la valeur moyenne des tensions non-sélectionnées est décalée du niveau de tension nulle à la fois dans la première et dans la seconde période.

4. Dispositif d'affichage à cristaux liquides selon l'une quelconque des revendications 1, 2 et 3, dans lequel les résistances diviseuses comprennent des résistances R1, R2, R3, R4 et R5 qui sont connectées en série, la résistance R1 étant une résistance variable, des tensions V01 et V5 sont appliquées aux bornes des résistances R1 et R5 respectivement, les tensions comprises entre la tension V01 et la tension V5 sont divisées en tensions V1, V2, V3 et V4 transmises à partir de bornes situées entre les résistances R1 (86) et R2 (87), R2 (87) et R3 (88), R3 (88) et R4 (89), et R4 (89) et R5 (90) respectivement, les tensions V02 et V4 sont fournies au moyen de commande de lignes en vue de la formation de la tension sélectionnée et de la tension non-sélectionnée respectivement dans la première période, les tensions V5 et V3 sont fournies au moyen de commande de colonnes en vue de la formation de la tension sélectionnée et de la tension non-sélectionnées respectivement dans la première période, les tensions V5 et V1 sont fournies au moyen de commande de lignes en vue de la formation de la tension sélectionnée et de la tension non-sélectionnée respectivement dans la seconde période, les tensions V01 et V2 sont fournies au moyen de commande de colonnes en vue de la formation de la tension sélectionnée et de la tension non-sélectionnée respectivement dans la seconde période, de manière que la grandeur de la différence de tension entre les tensions non-sélectionnées dans le sens positif et les tensions non-sélectionnées dans le sens négatif soient contrôlées par le réglage d'une valeur de résistance entre les résistances R2 et R4, et que la grandeur de la différence de tension entre les tensions sélectionnées de la première et celles de la seconde période soit contrôlée par le réglage d'une valeur de résistance de la résistance variable R1.

FIG. 1

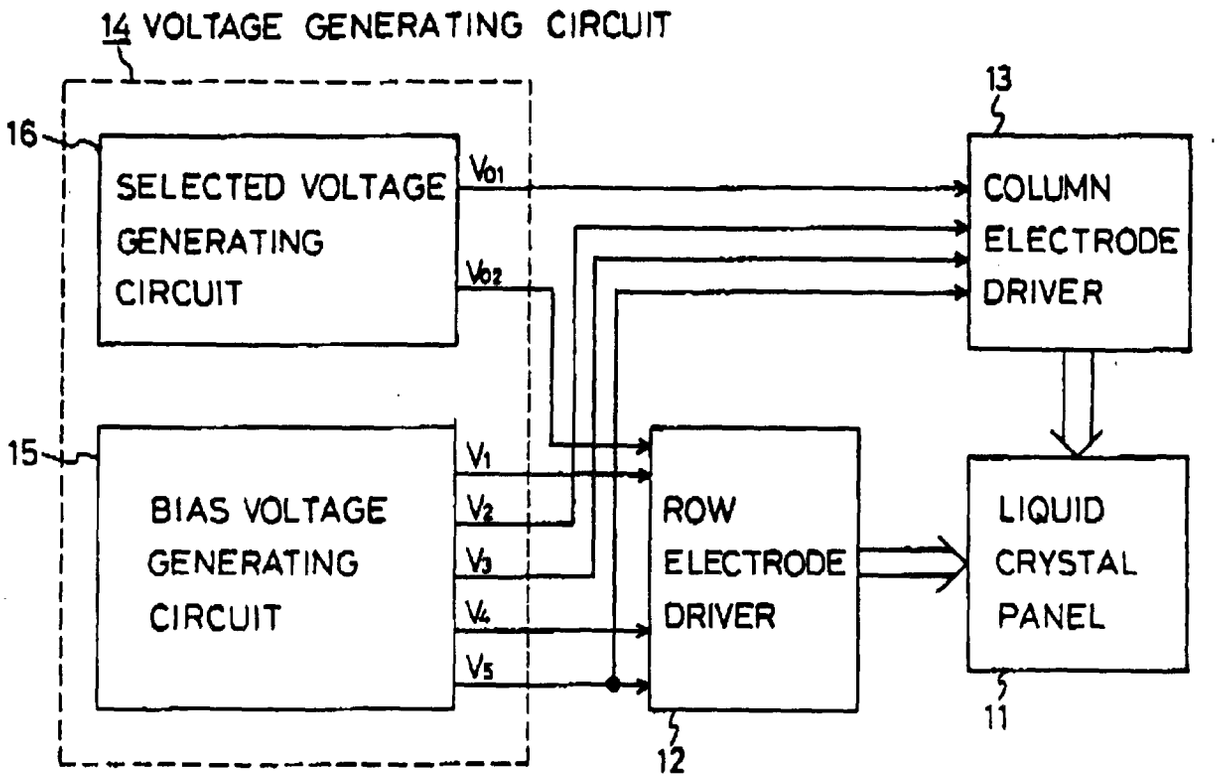

14 VOLTAGE GENERATING CIRCUIT
16
SELECTED VOLTAGE GENERATING CIRCUIT
V_{01}
V_{02}
15
BIAS VOLTAGE GENERATING CIRCUIT
V_1
V_2
V_3
V_4
V_5
ROW ELECTRODE DRIVER
12
13
COLUMN ELECTRODE DRIVER
LIQUID CRYSTAL PANEL
11

FIG. 2

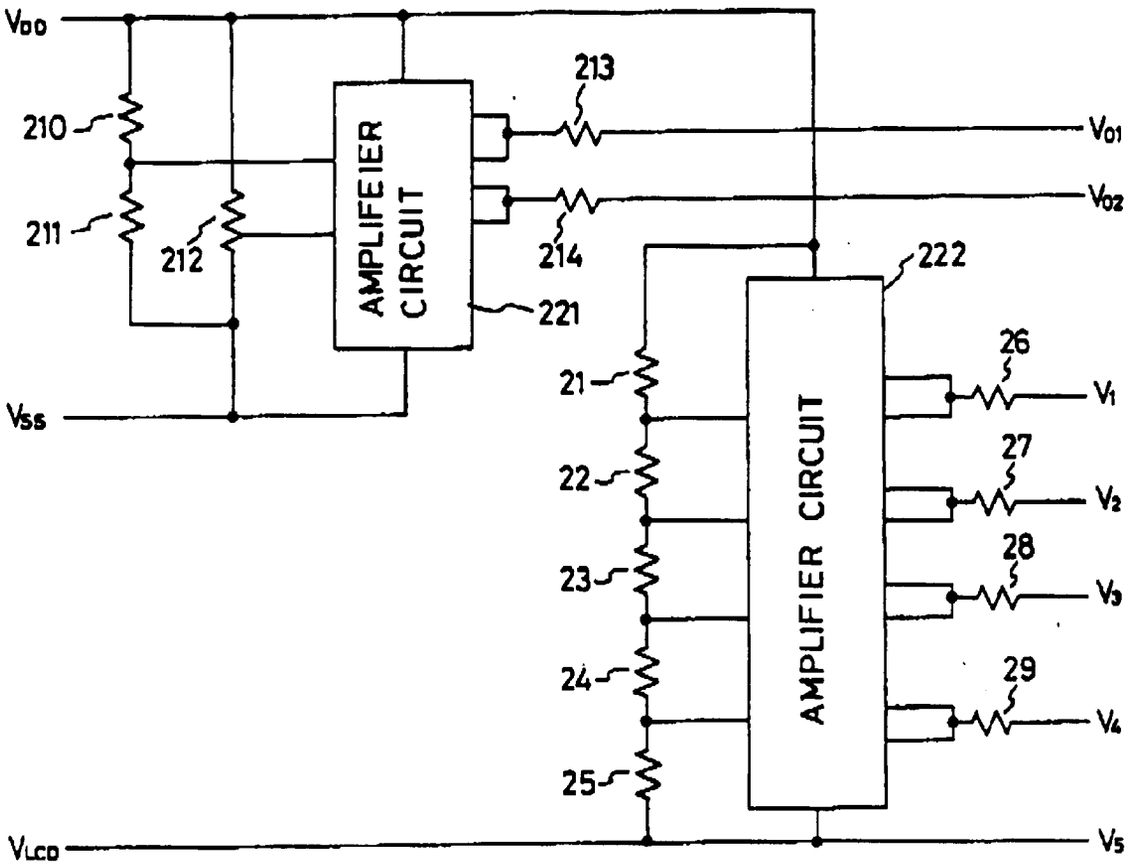


FIG. 3 PRIOR ART

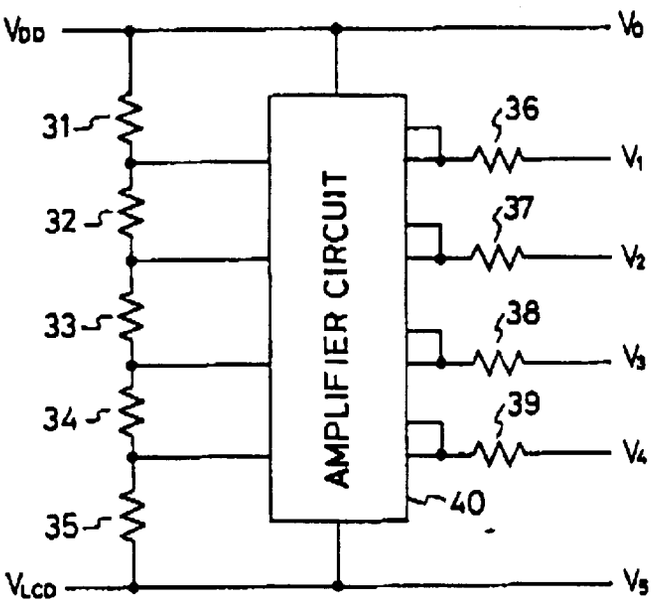


FIG. 4

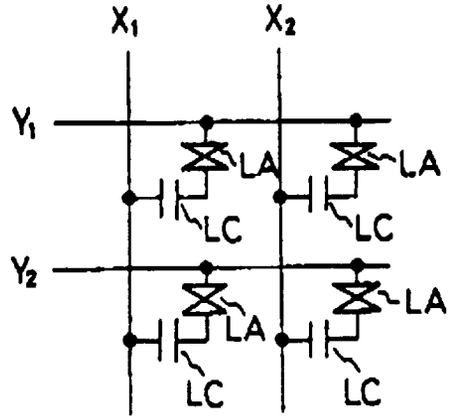


FIG. 5

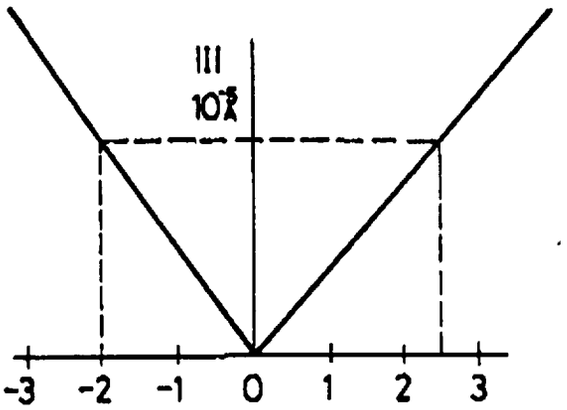


FIG. 6 PRIOR ART

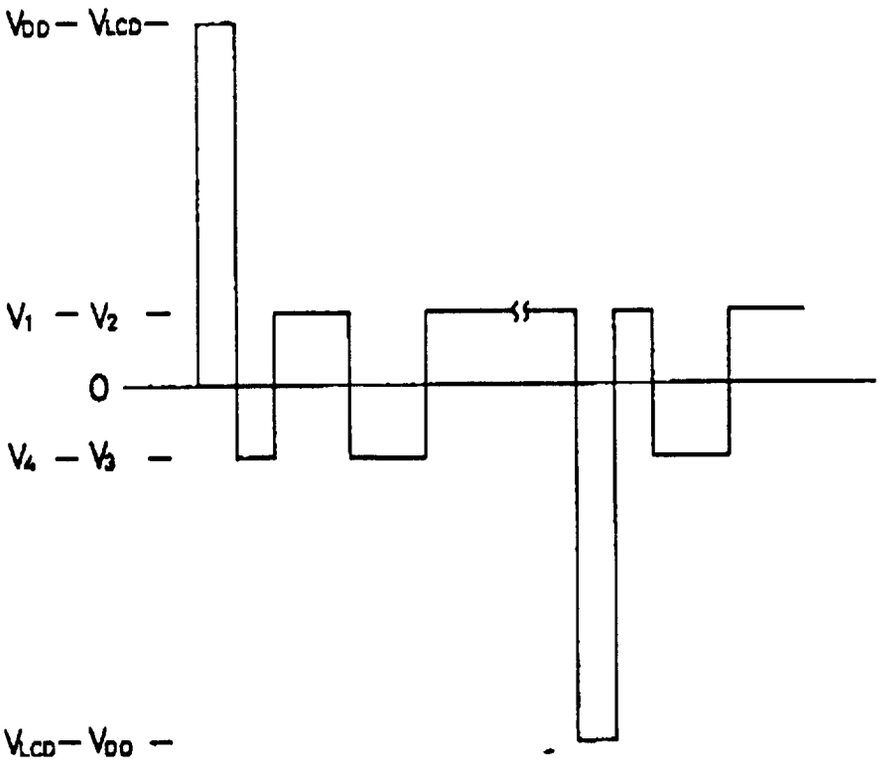


FIG. 7

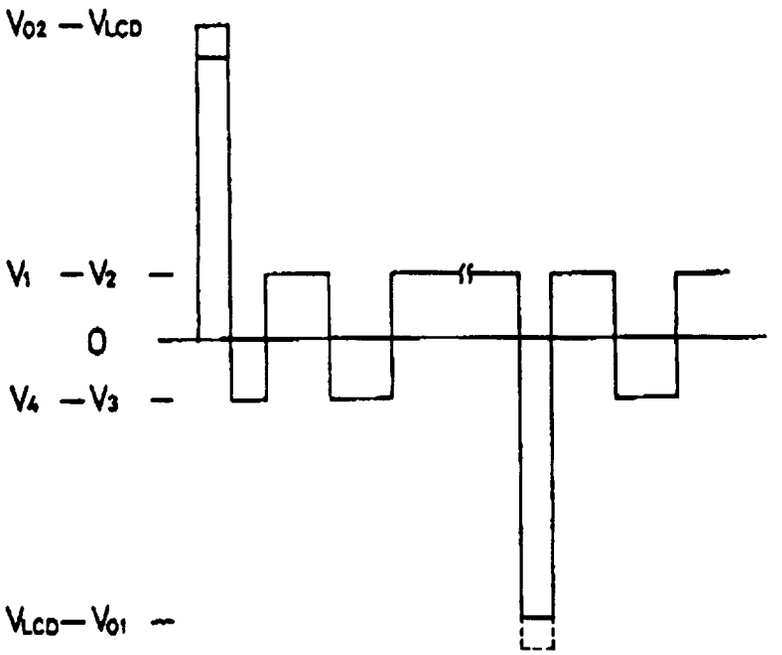

$V_{02} - V_{LCD}$
$V_1 - V_2$
0
$V_4 - V_3$
$V_{LCD} - V_{01}$

FIG. 8

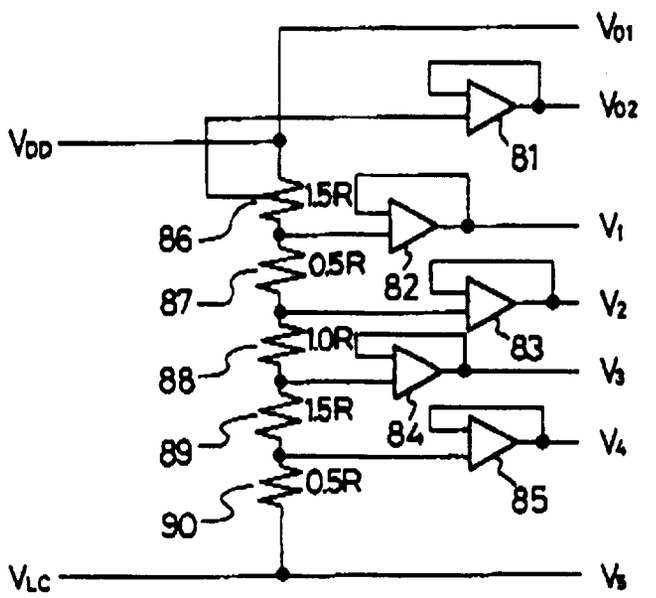
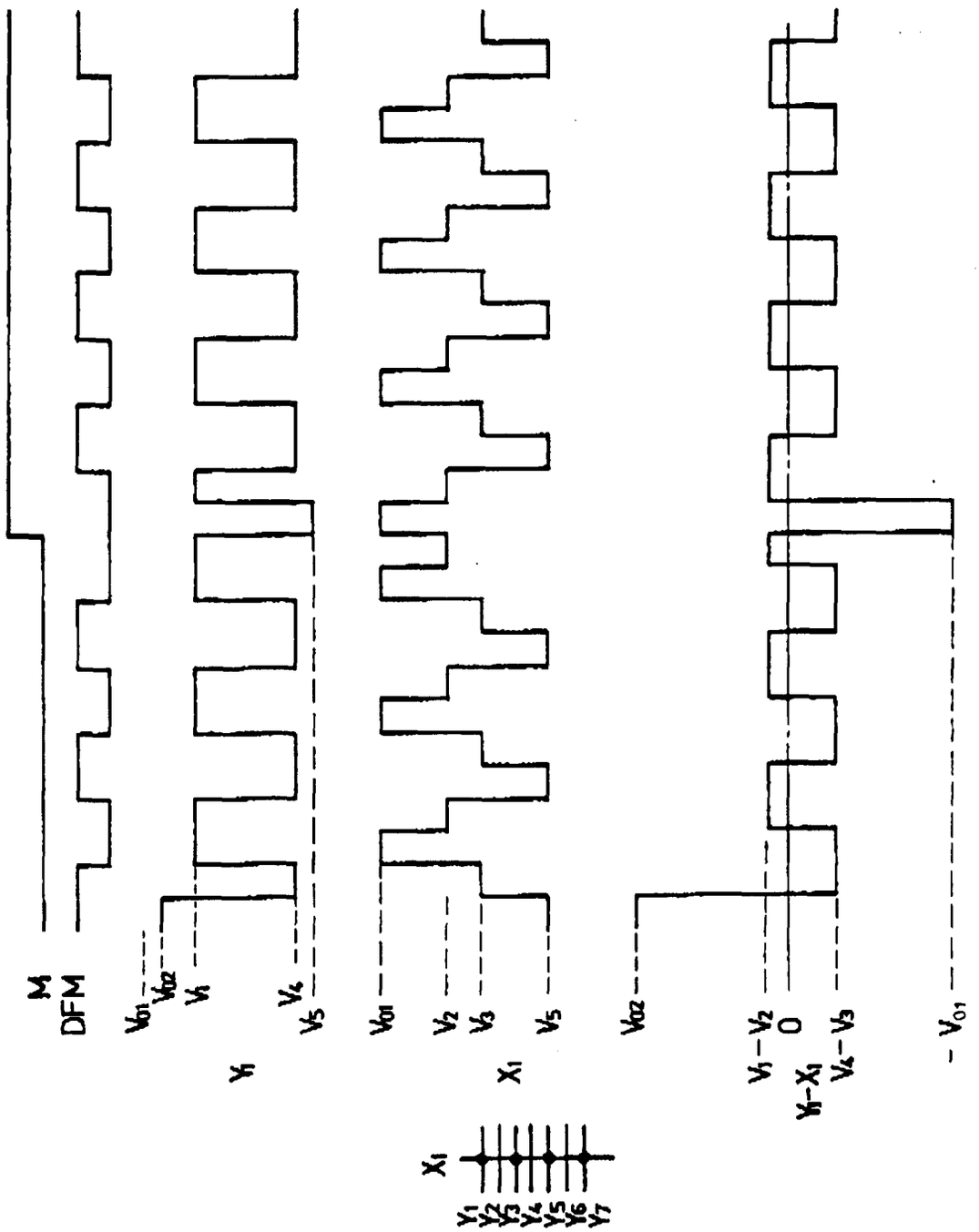

V_{01}
V_{02}
V_{DD}
81
1.5R
V_1
86
0.5R
82
V_2
87
1.0R
83
V_3
88
1.5R
84
V_4
89
0.5R
85
90
V_{LC}
V_5

FIG. 9


M
DFM
V_{01}
V_{02}
V_1
V_4
V_5
Y_1
V_{01}
V_2
V_3
V_5
X_1
V_{02}
$V_1 - V_2$
0
$V_4 - V_3$
$-V_{01}$
$V_1 - X_1$
X_1
Y_1
Y_2
Y_3
Y_4
Y_5
Y_6
Y_7