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(54) **ELECTROLUMINESCENT DISPLAY PANEL AND ELECTRONIC APPARATUS**

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H04N 5/335 (2006.01)

(52) **U.S. Cl.** **345/76**

(57) **ABSTRACT**

An electroluminescent display panel has pixel circuits for the active matrix driving system. Each pixel circuit has a thin-film transistor in which a portion of a pattern of a metal wiring material above the channel layer of the thin-film transistor is so laid out as to shield the channel region of the thin-film transistor.

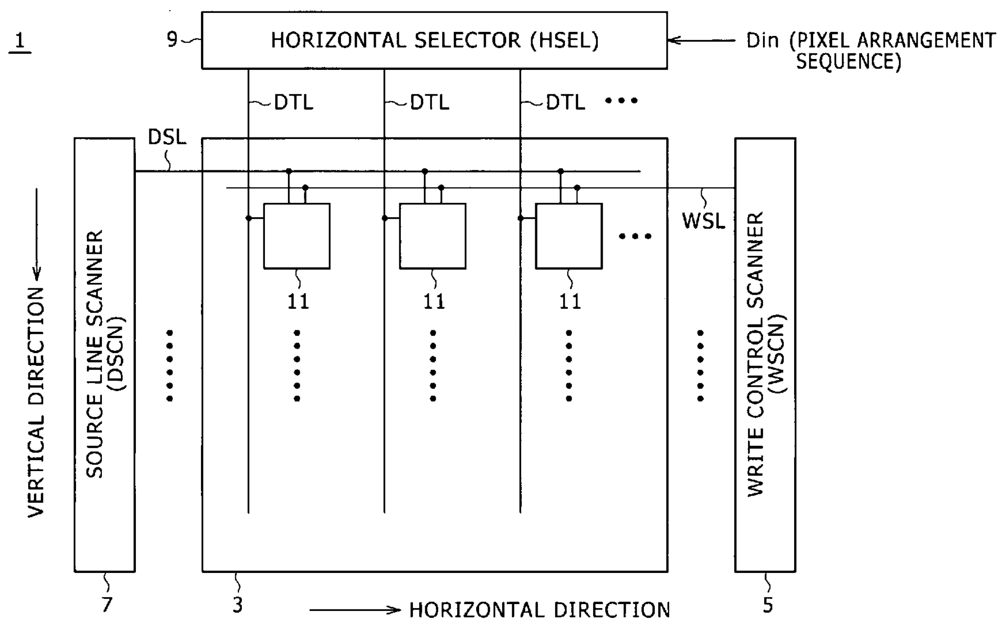


FIG. 1

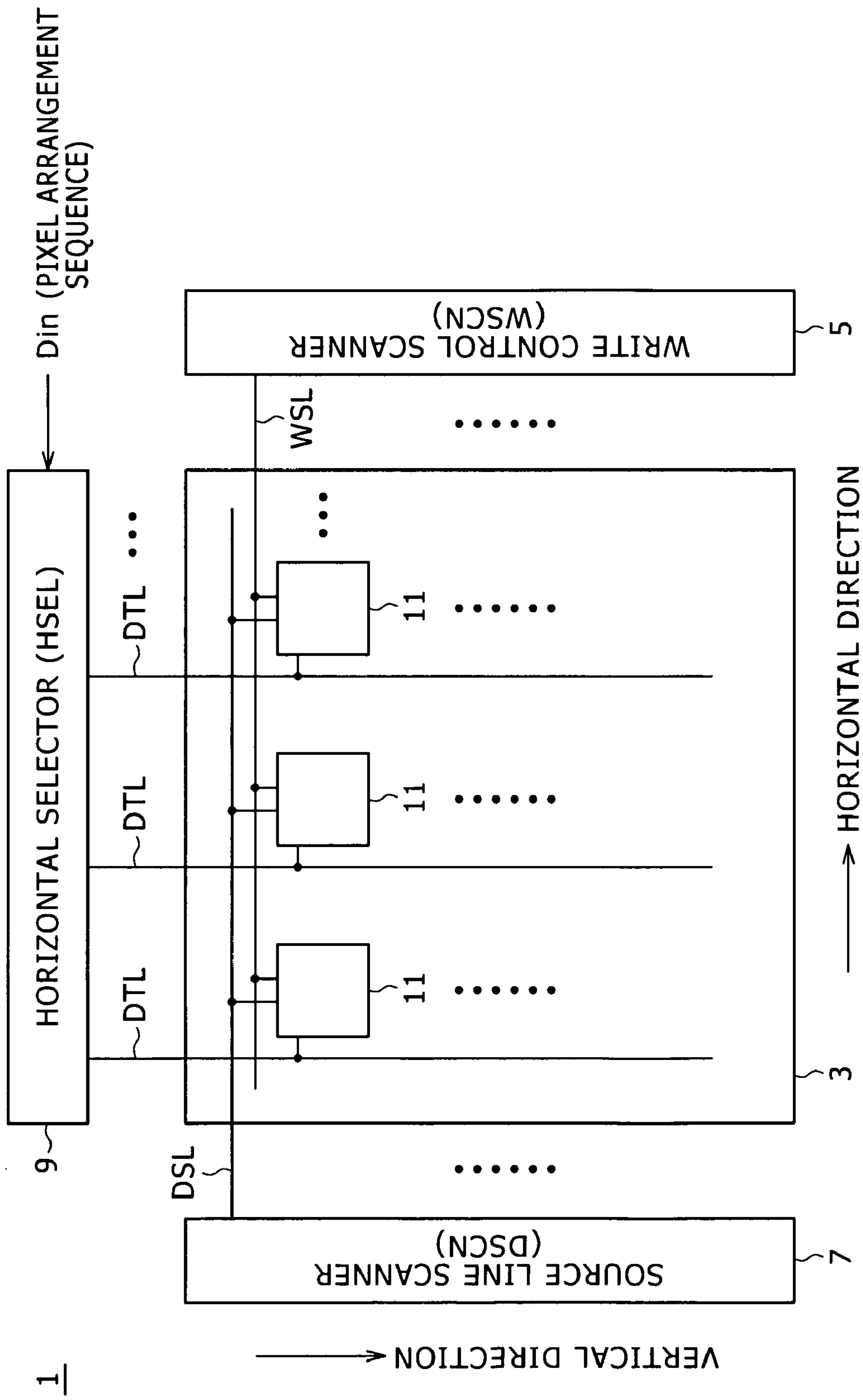
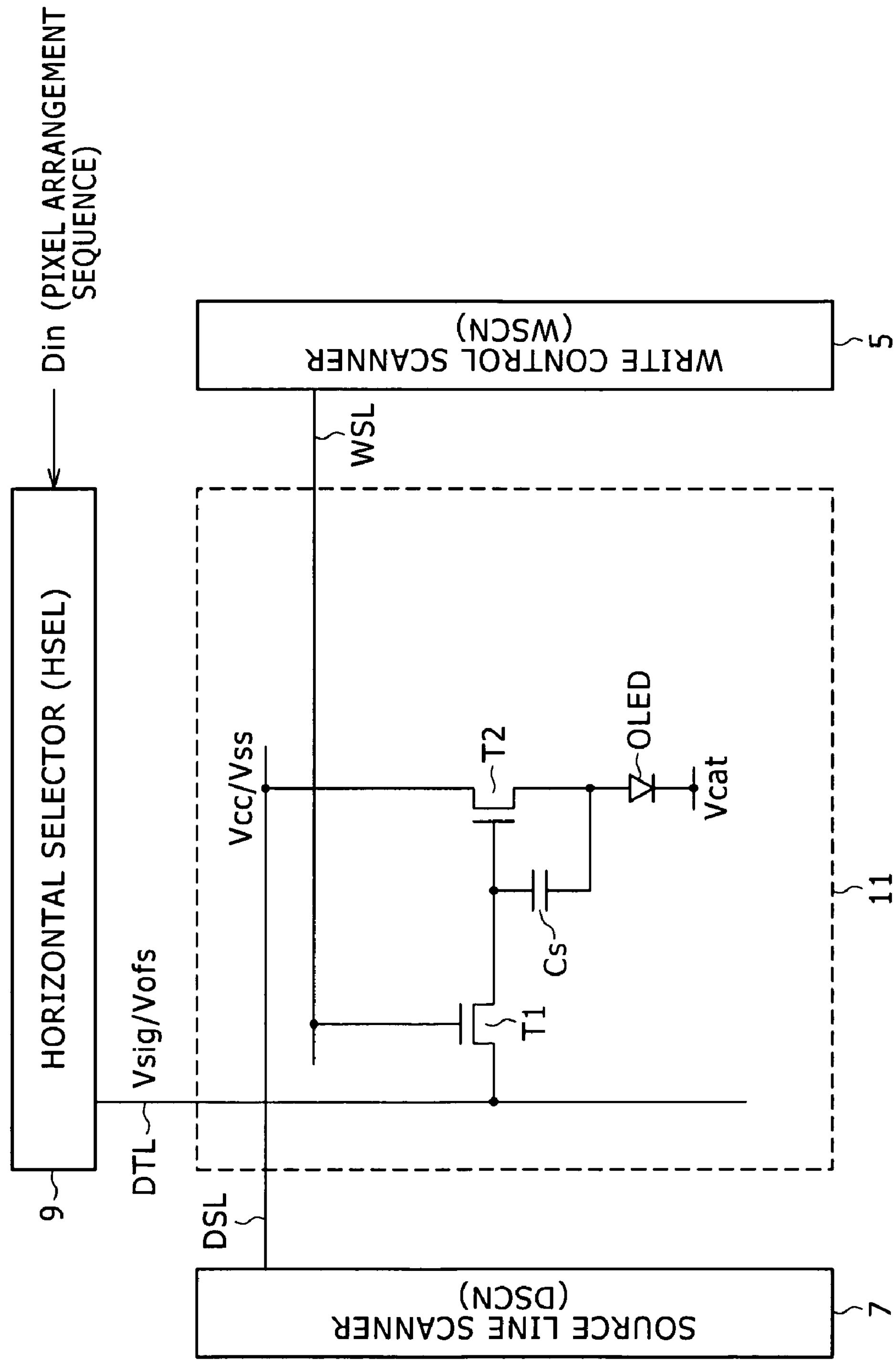

Din (PIXEL ARRANGEMENT SEQUENCE)
HORIZONTAL SELECTOR (HSEL)
WRITE CONTROL SCANNER (WSCN)
SOURCE LINE SCANNER (DSCN)
DTL
DTL
DTL
WSL
DSL
11
11
11
9
3
5
7
1
HORIZONTAL DIRECTION
VERTICAL DIRECTION

FIG. 2


Din (PIXEL ARRANGEMENT SEQUENCE)
HORIZONTAL SELECTOR (HSEL)
9
Vsig/Vofs
DTL
DSL
Vcc/Vss
WSL
WRITE CONTROL SCANNER (WSCN)
5
T1
T2
Cs
OLED
Vcat
11
SOURCE LINE SCANNER (DSCN)
7

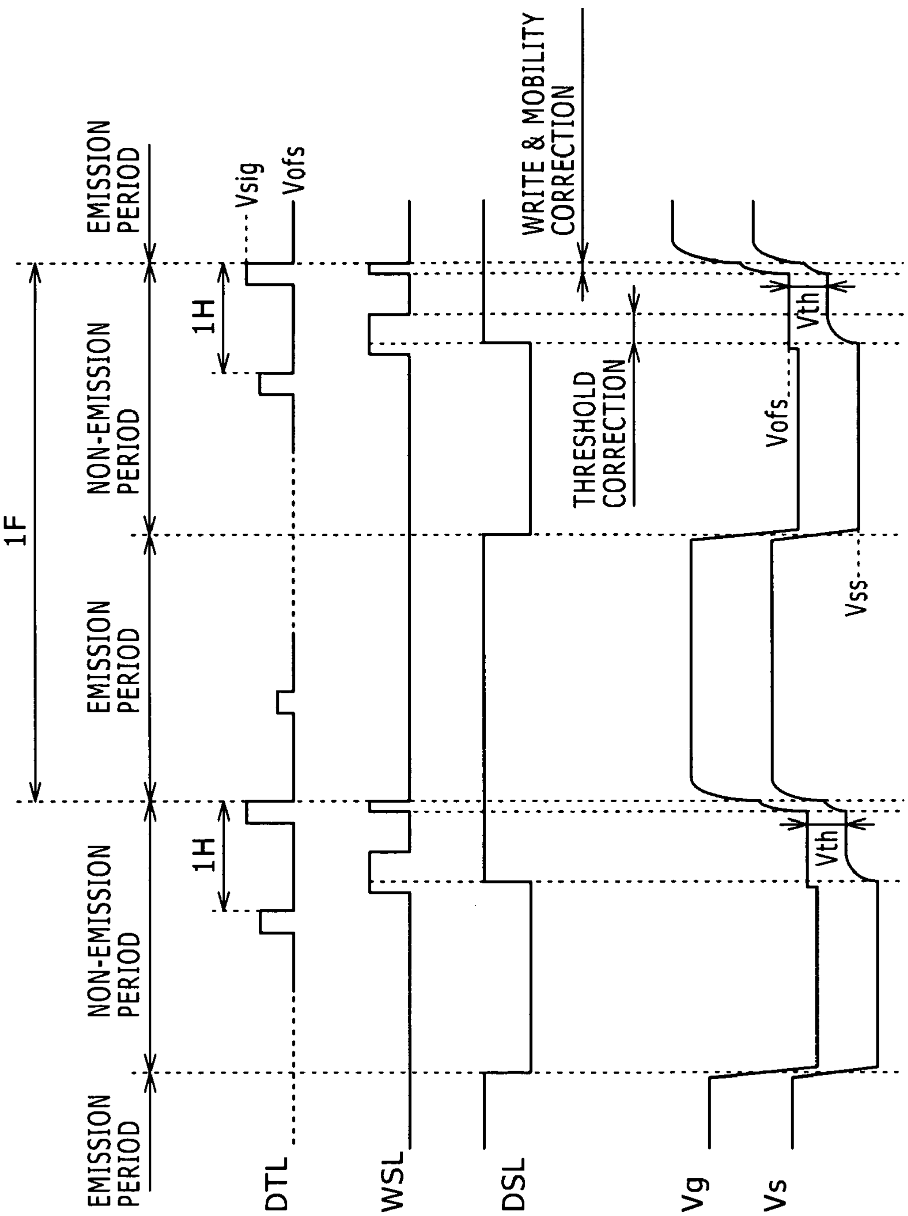


FIG.3A
FIG.3B
FIG.3C
FIG.3D
FIG.3E

FIG.4

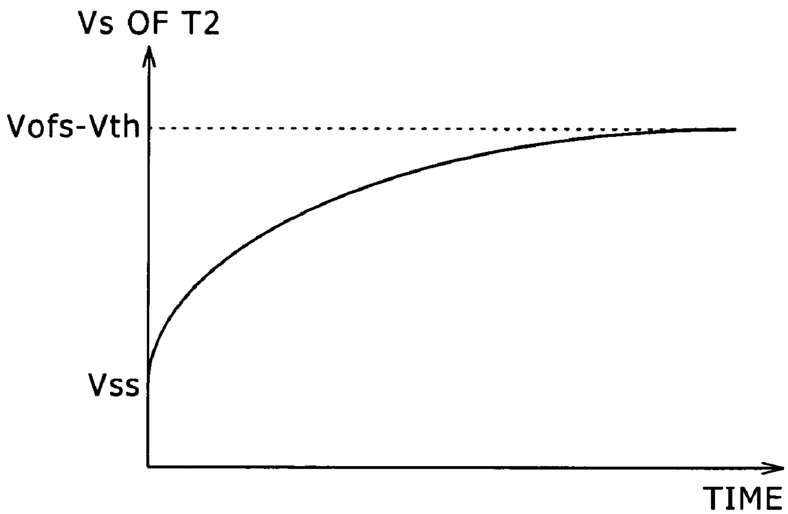

Vs OF T2
Vofs-Vth
Vss
TIME

FIG.5

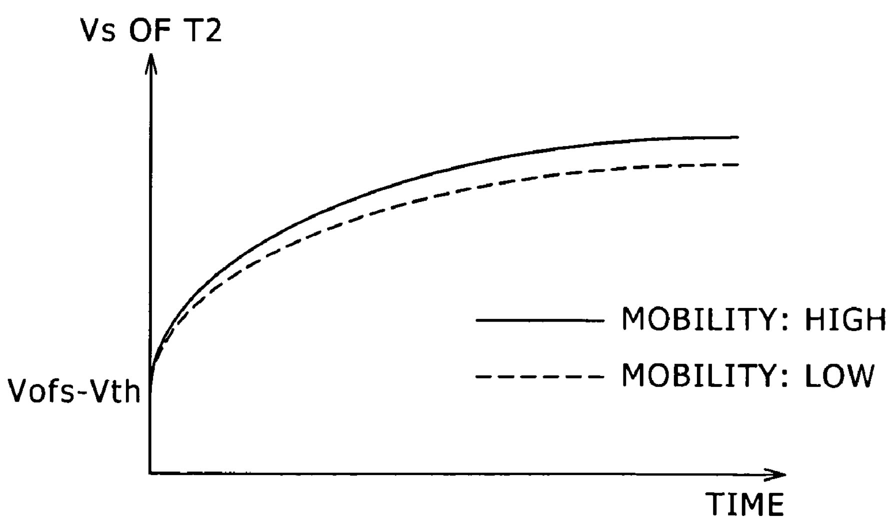

Vs OF T2
MOBILITY: HIGH
MOBILITY: LOW
Vofs-Vth
TIME

FIG. 6

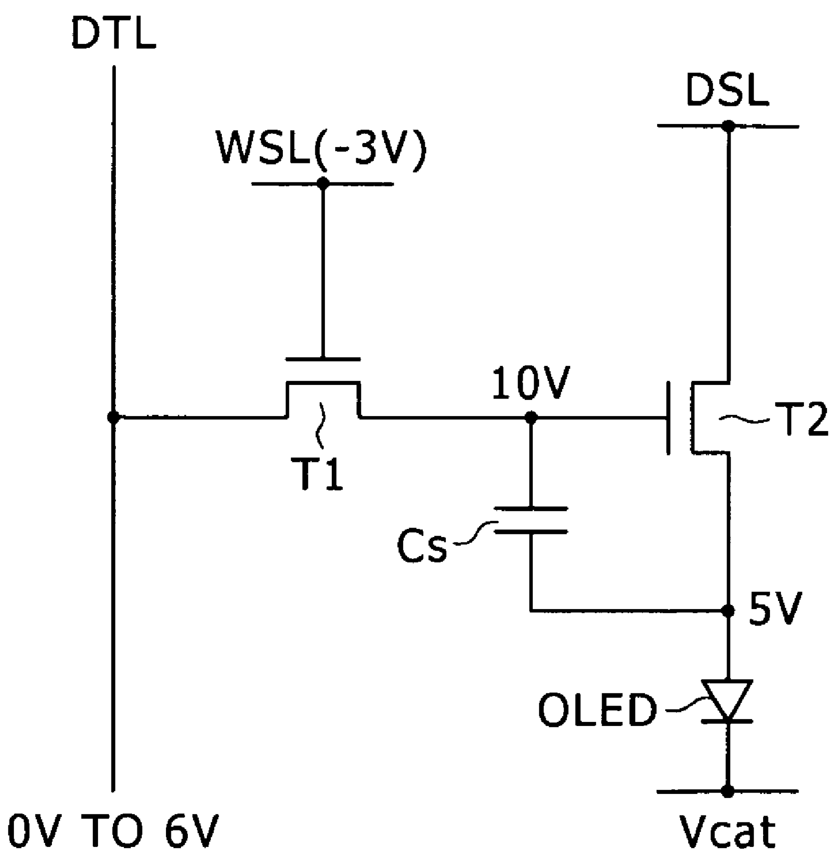


FIG. 7

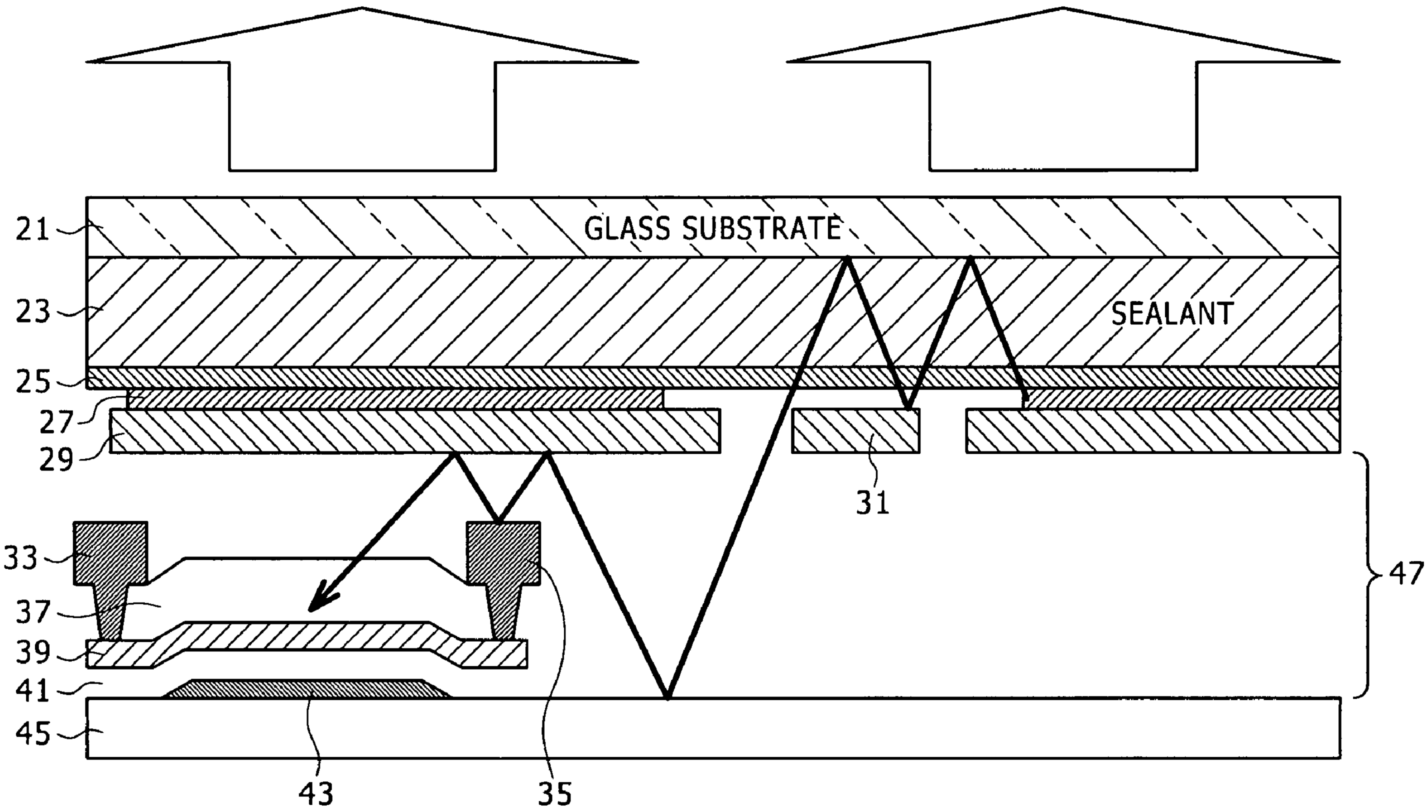


FIG. 8

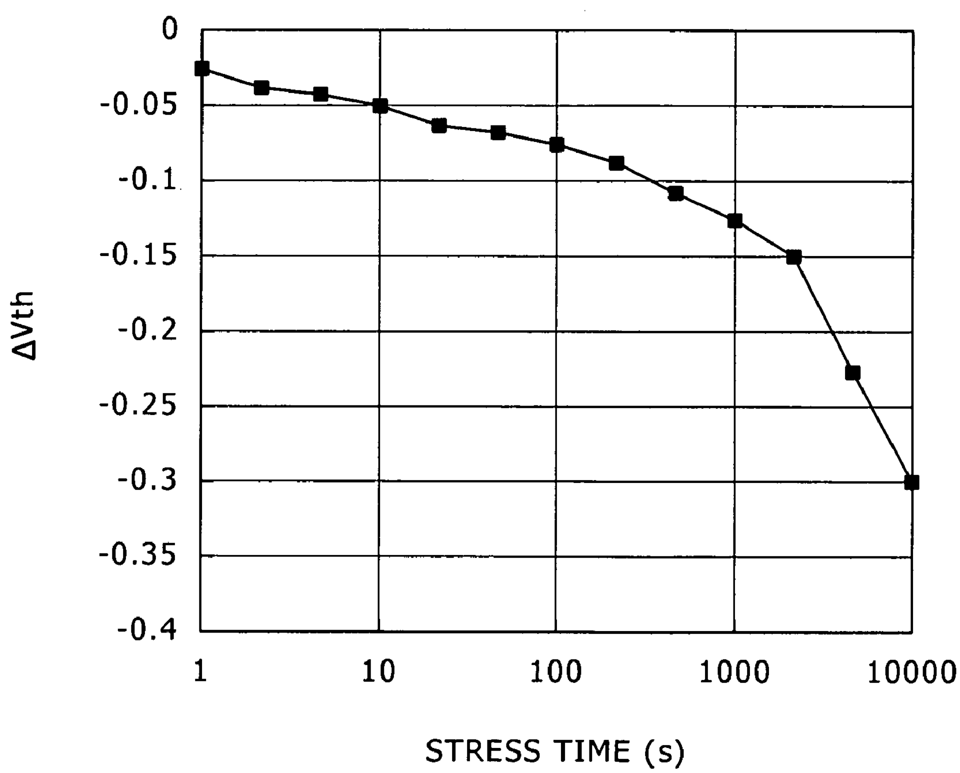

0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
ΔVth
1
10
100
1000
10000
STRESS TIME (s)

FIG. 9

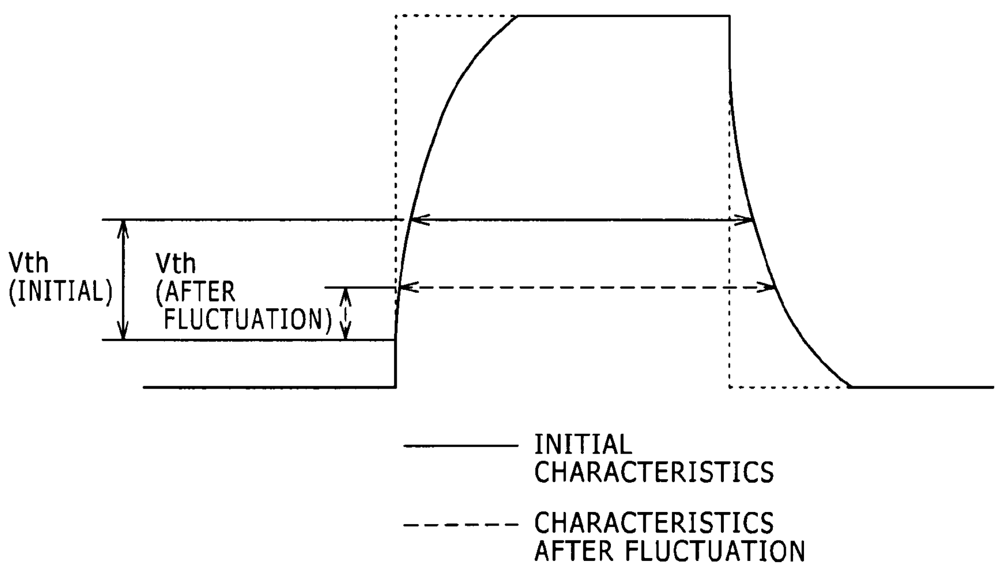
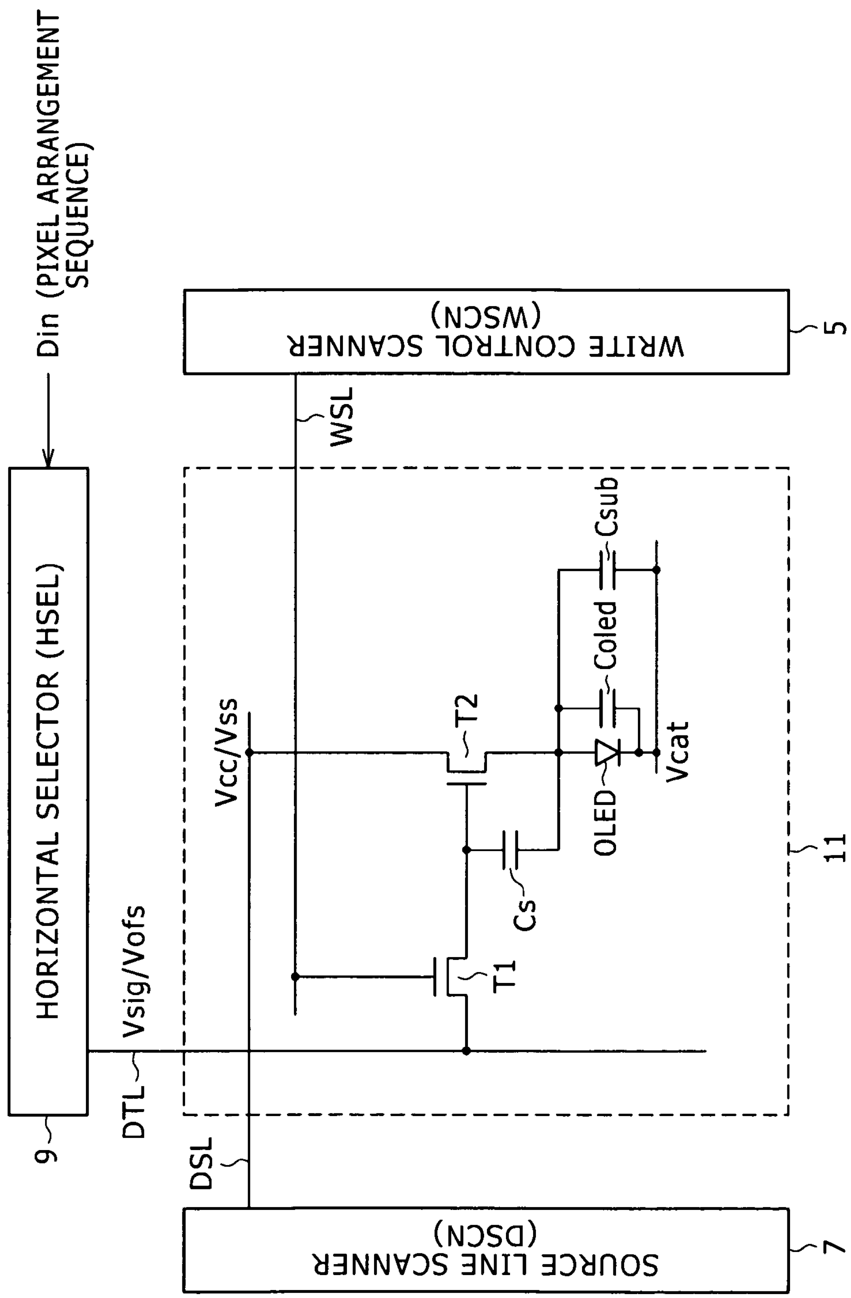
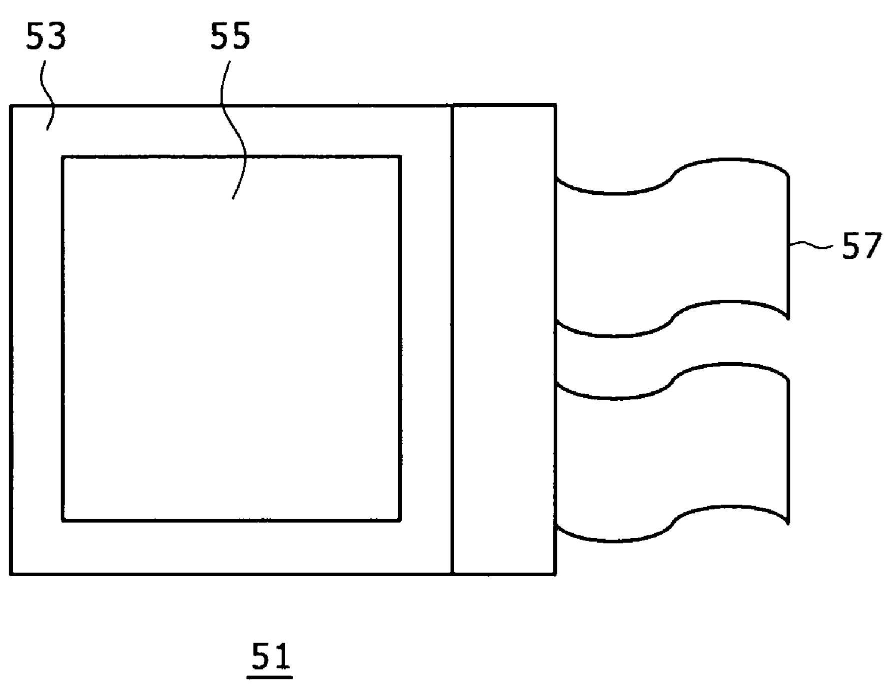

Vth
(INITIAL)
Vth
(AFTER
FLUCTUATION)
INITIAL
CHARACTERISTICS
CHARACTERISTICS
AFTER FLUCTUATION

FIG.10



Din (PIXEL ARRANGEMENT SEQUENCE)
HORIZONTAL SELECTOR (HSEL)
9
WRITE CONTROL SCANNER (WSCN)
5
SOURCE LINE SCANNER (DSCN)
7
WSL
DTL
DSL
Vsig/Vofs
Vcc/Vss
T1
T2
Cs
OLED
Coled
Csub
Vcat
11

FIG. 11



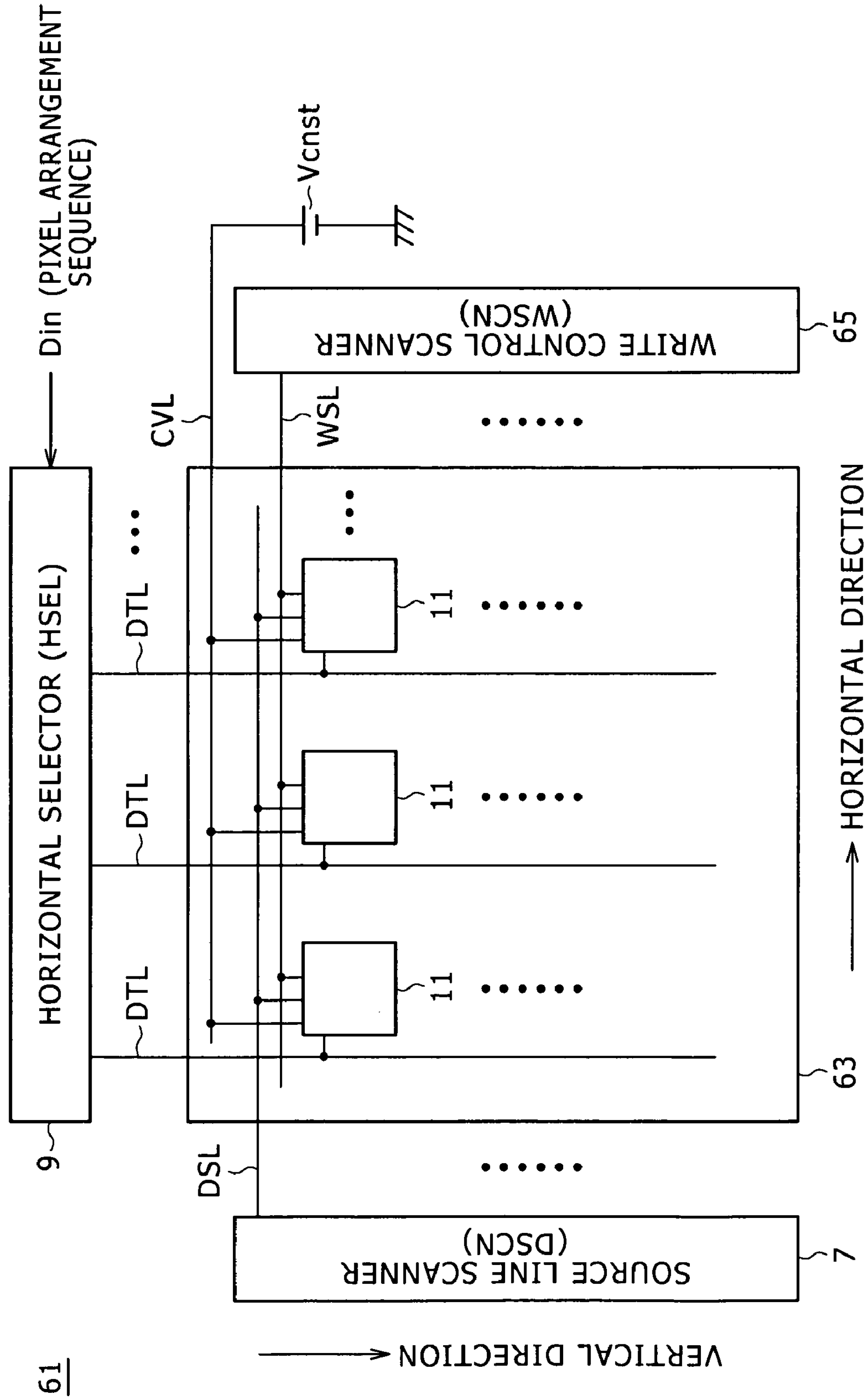

Din (PIXEL ARRANGEMENT SEQUENCE)
Vcnst
WRITE CONTROL SCANNER (WSCN)
65
CVL
WSL
HORIZONTAL SELECTOR (HSEL)
9
DTL
DTL
DTL
11
11
11
63
HORIZONTAL DIRECTION
DSL
SOURCE LINE SCANNER (DSCN)
7
VERTICAL DIRECTION
61

FIG. 12

FIG.13

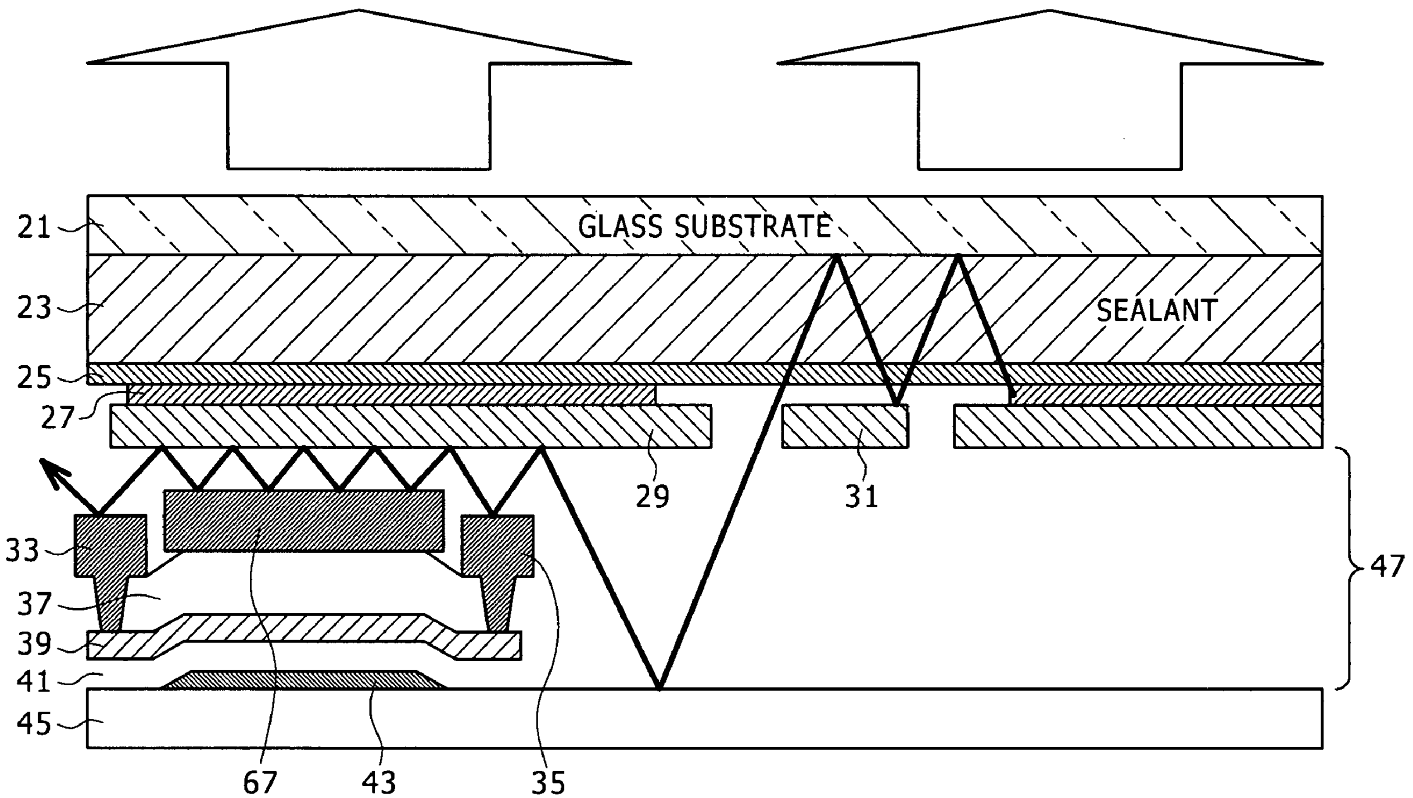

GLASS SUBSTRATE
SEALANT
21
23
25
27
29
31
33
37
39
41
45
47
67
43
35

FIG. 14

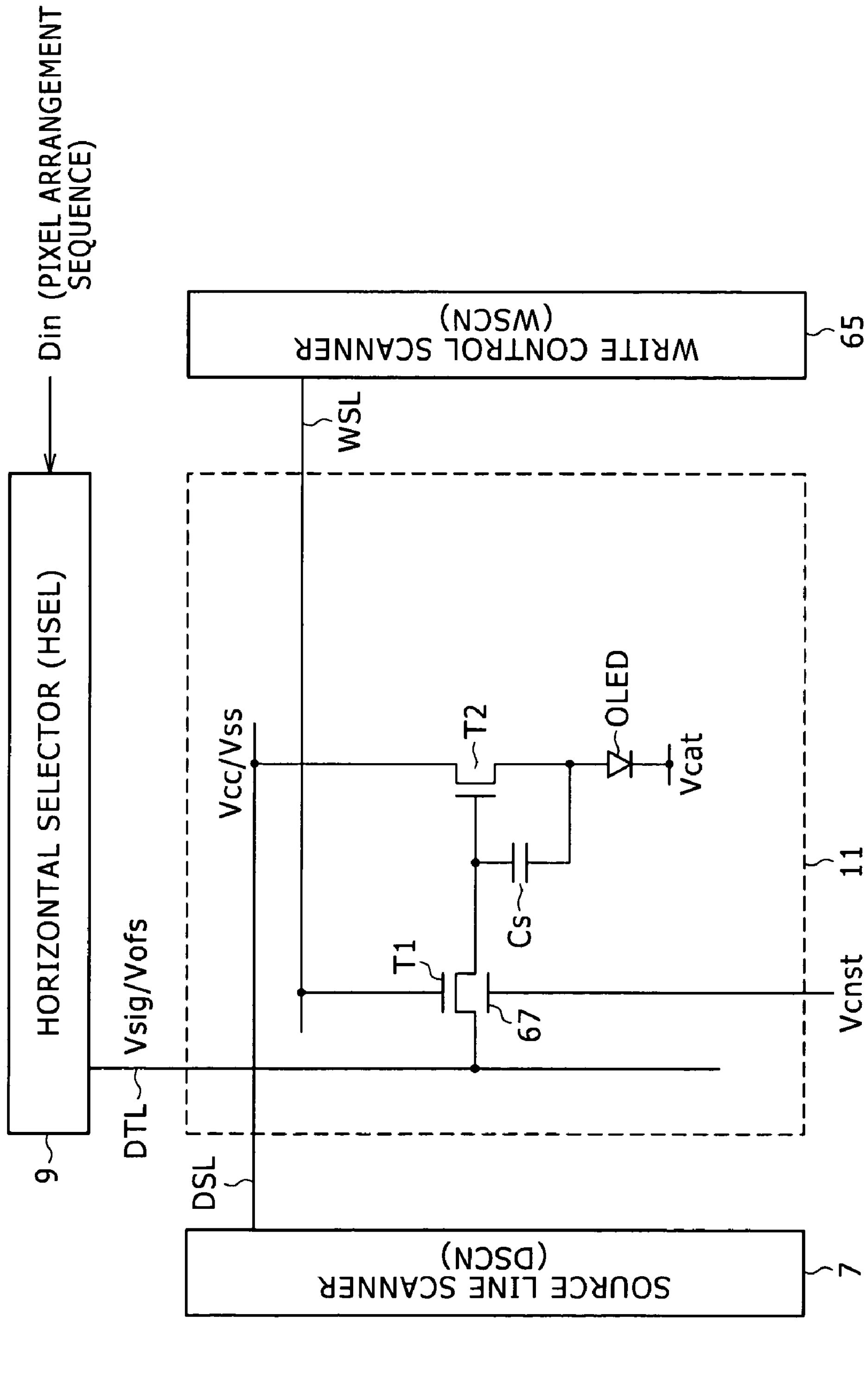

Din (PIXEL ARRANGEMENT SEQUENCE)
HORIZONTAL SELECTOR (HSEL)
9
WRITE CONTROL SCANNER (WSCN)
65
WSL
Vsig/Vofs
DTL
DSL
Vcc/Vss
T1
T2
Cs
67
OLED
Vcat
Vcnst
11
SOURCE LINE SCANNER (DSCN)
7

FIG. 15

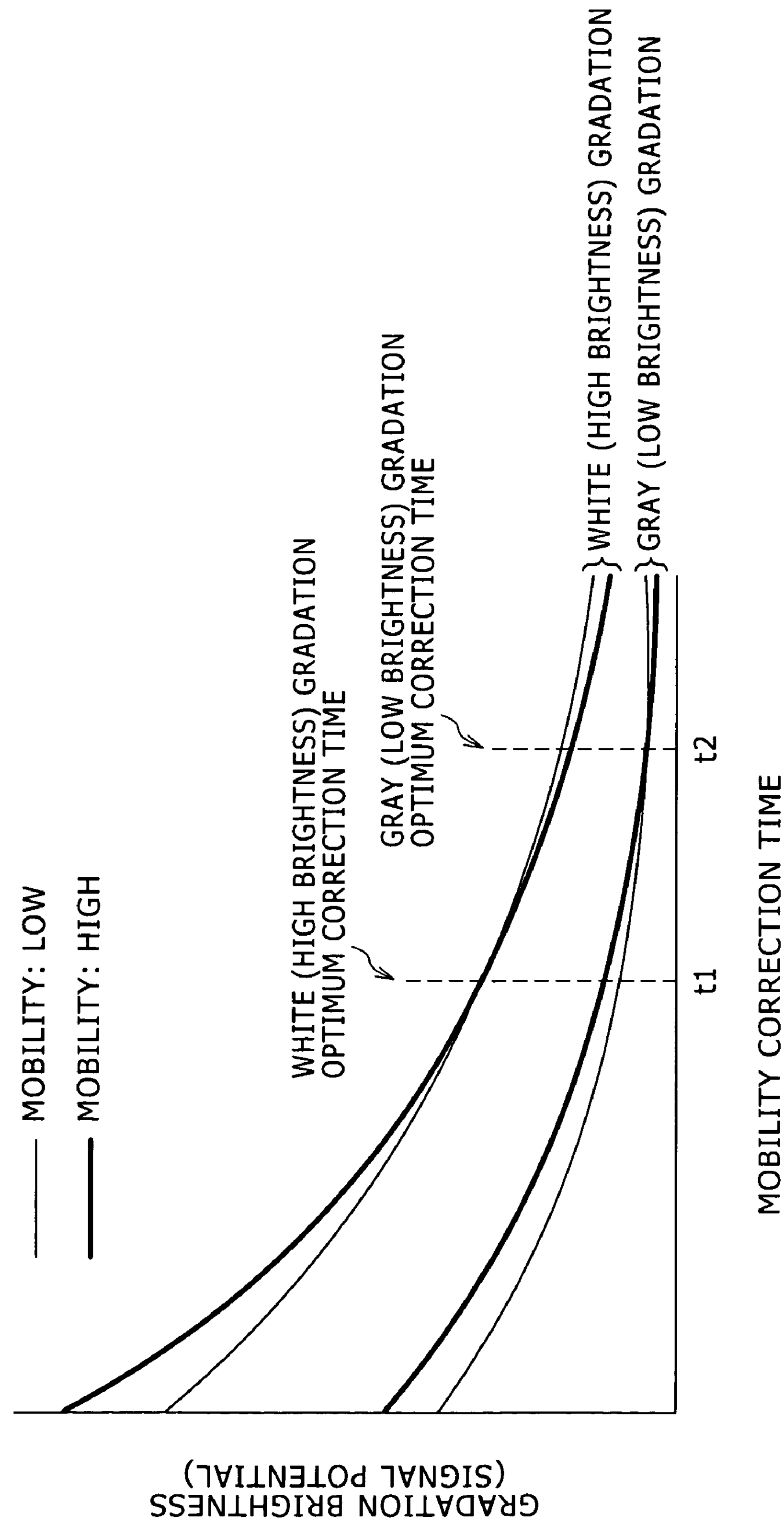

MOBILITY: LOW
MOBILITY: HIGH
WHITE (HIGH BRIGHTNESS) GRADATION OPTIMUM CORRECTION TIME
GRAY (LOW BRIGHTNESS) GRADATION OPTIMUM CORRECTION TIME
WHITE (HIGH BRIGHTNESS) GRADATION
GRAY (LOW BRIGHTNESS) GRADATION
t1
t2
MOBILITY CORRECTION TIME
GRADATION BRIGHTNESS (SIGNAL POTENTIAL)

FIG. 16

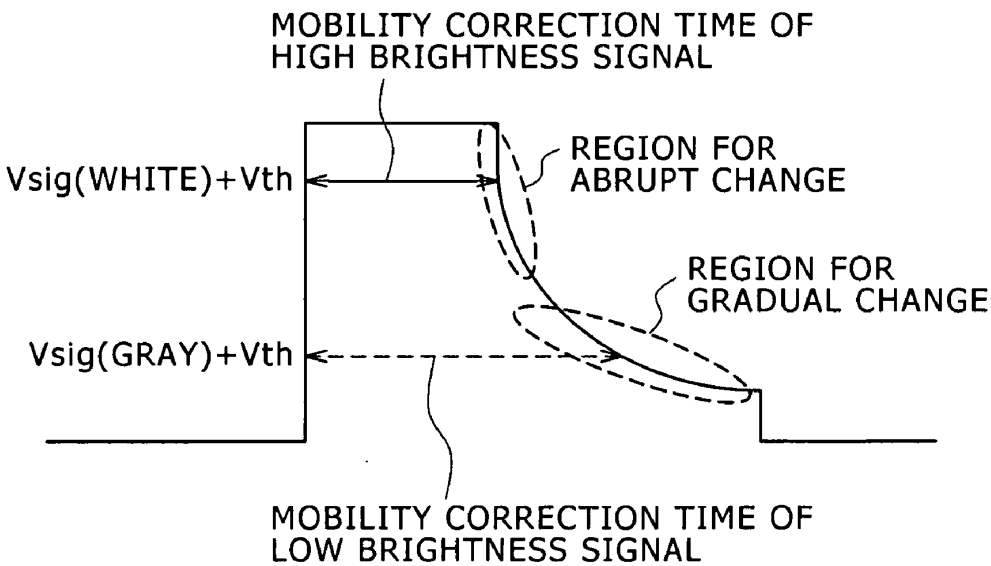

MOBILITY CORRECTION TIME OF HIGH BRIGHTNESS SIGNAL
REGION FOR ABRUPT CHANGE
Vsig(WHITE)+Vth
REGION FOR GRADUAL CHANGE
Vsig(GRAY)+Vth
MOBILITY CORRECTION TIME OF LOW BRIGHTNESS SIGNAL

FIG.17

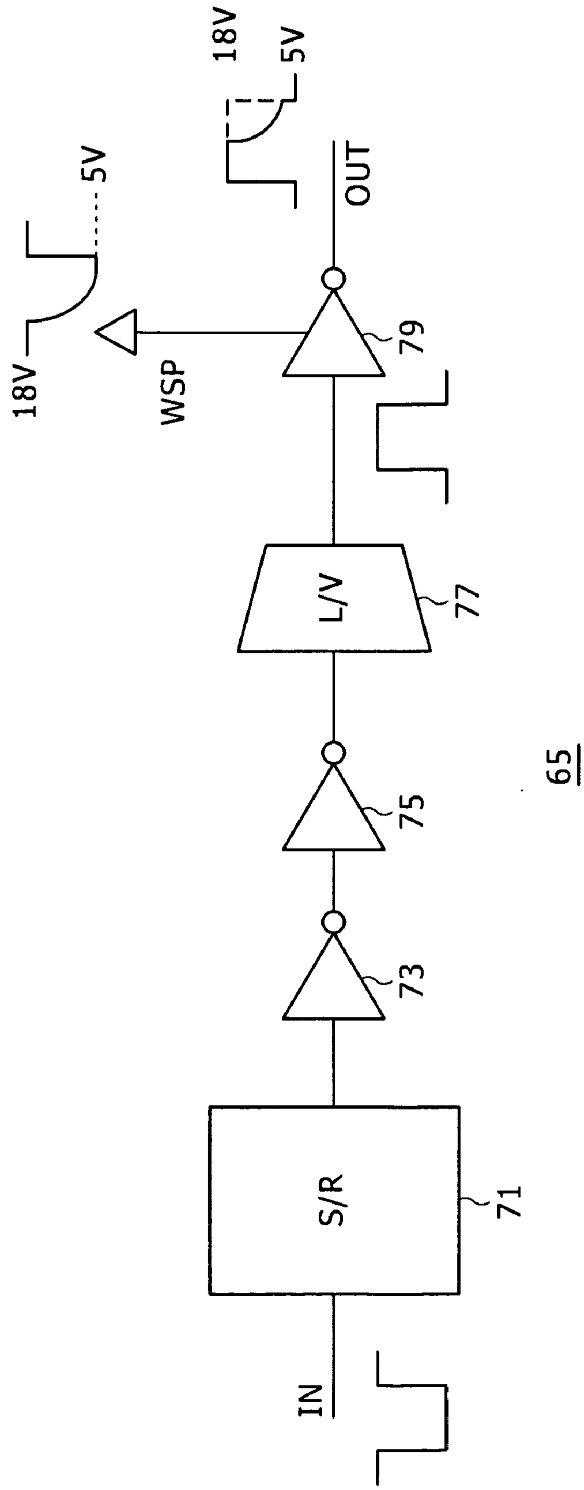


FIG. 18

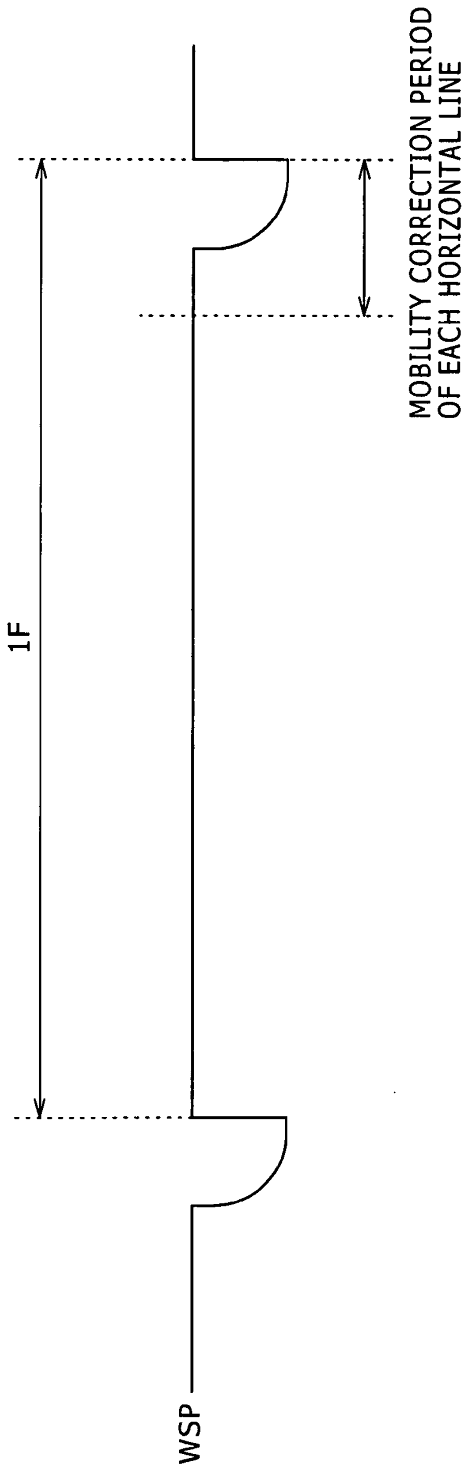


FIG. 19

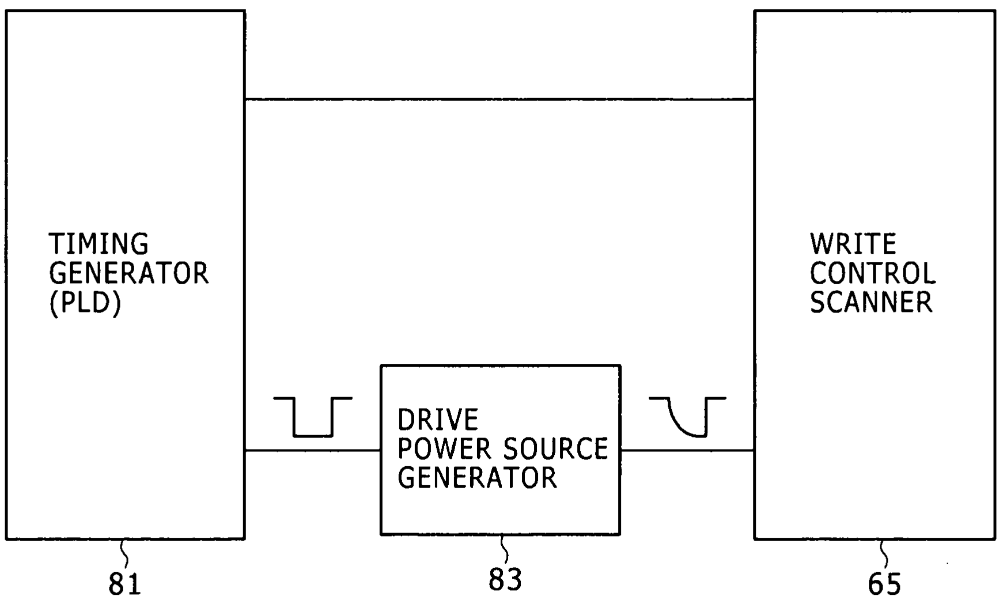

TIMING
GENERATOR
(PLD)
WRITE
CONTROL
SCANNER
DRIVE
POWER SOURCE
GENERATOR
81
83
65

FIG.20

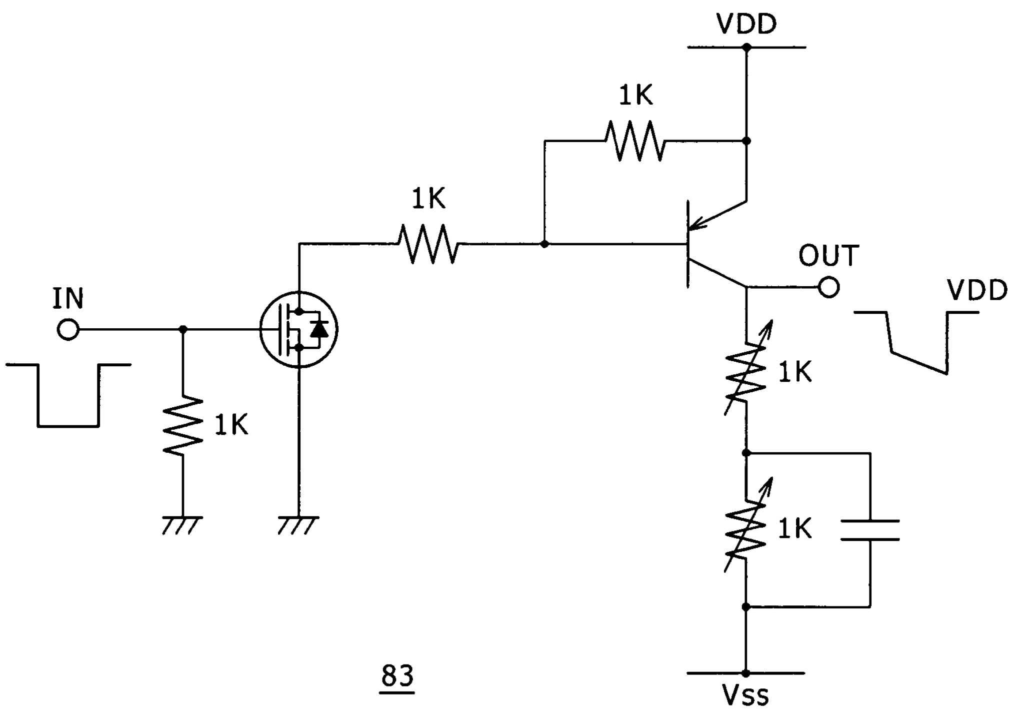


FIG.21A

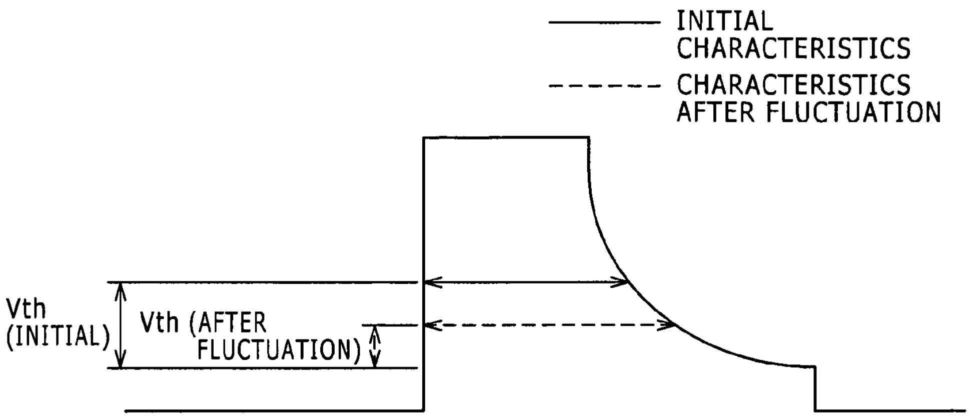


FIG.21B

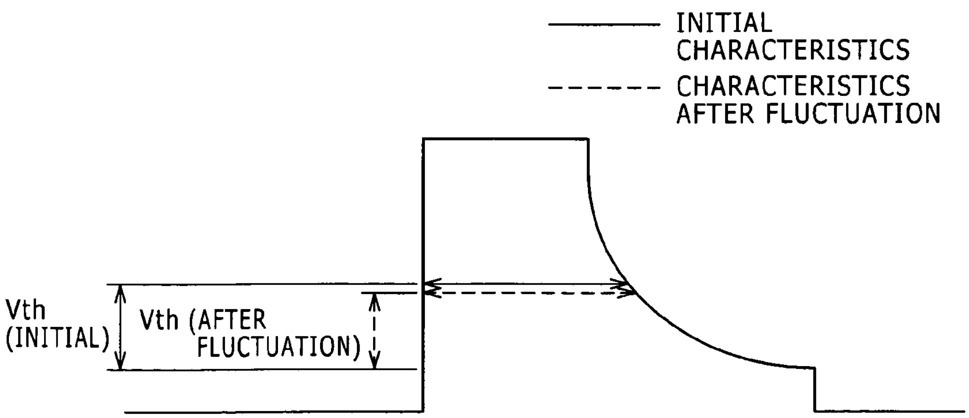
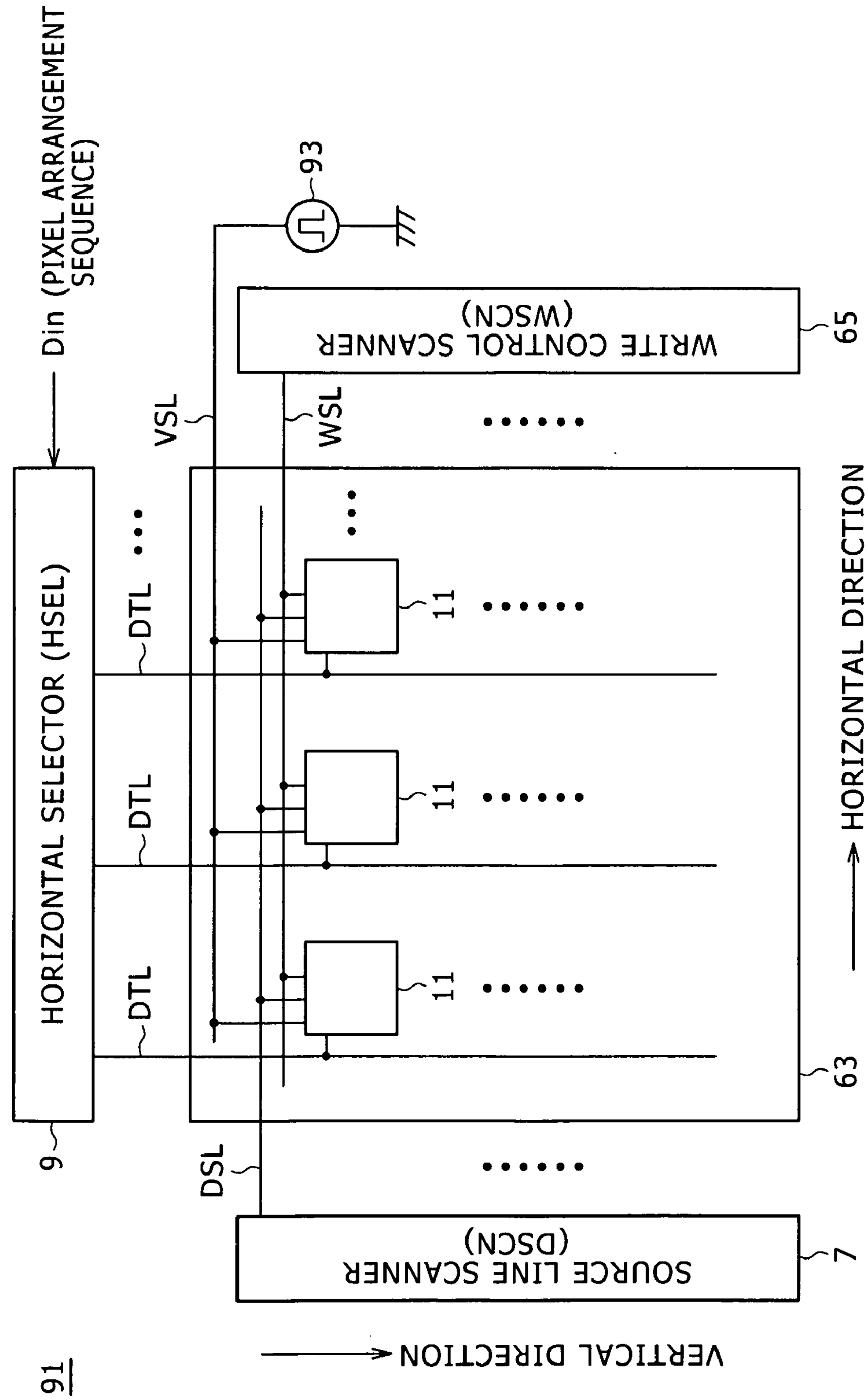


FIG.22



Din (PIXEL ARRANGEMENT SEQUENCE)
HORIZONTAL SELECTOR (HSEL)
9
DTL
DTL
DTL
VSL
WSL
DSL
93
WRITE CONTROL SCANNER (WSCN)
65
11
11
11
63
SOURCE LINE SCANNER (DSCN)
7
HORIZONTAL DIRECTION
VERTICAL DIRECTION
91

FIG.23

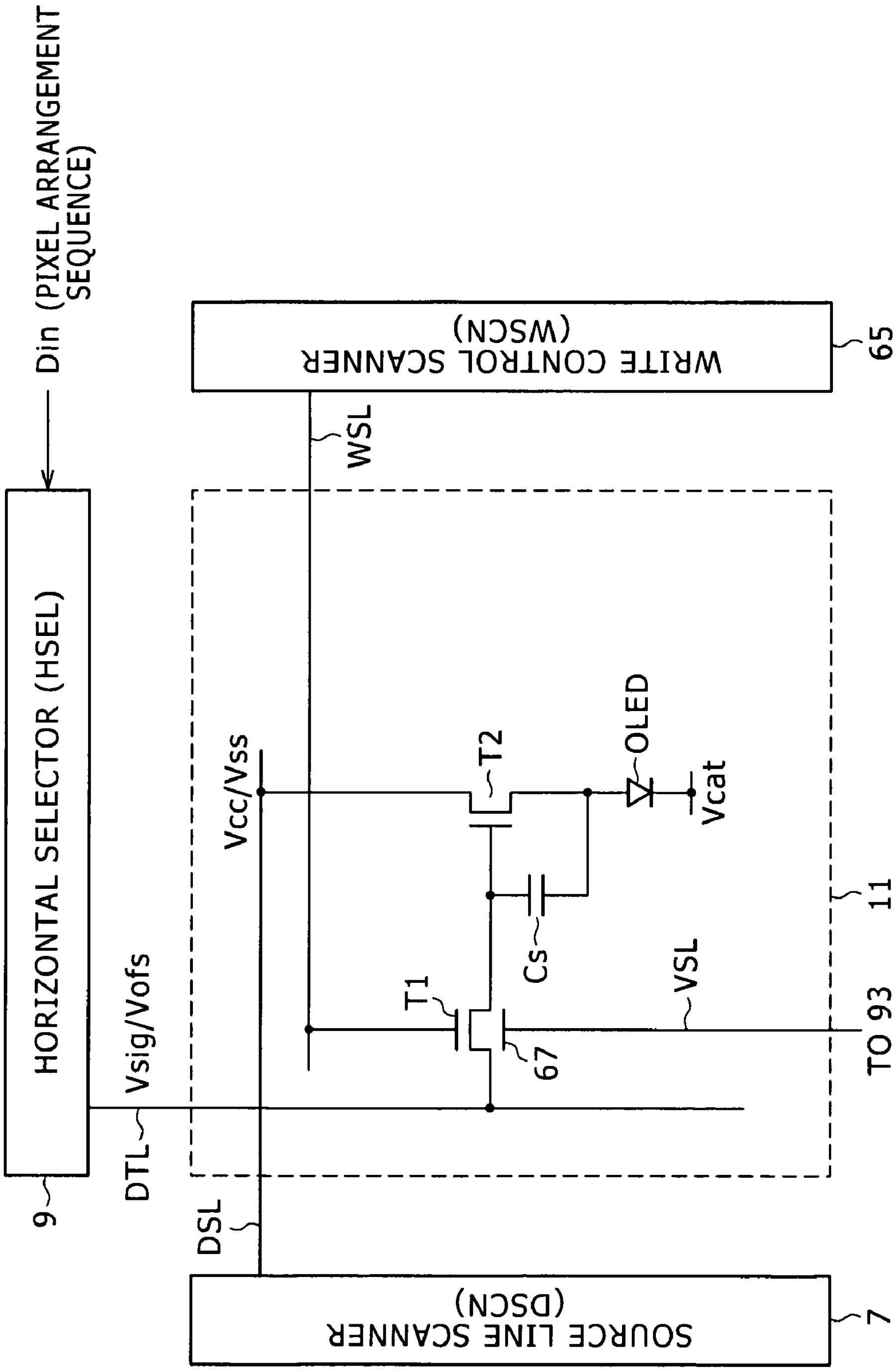

Din (PIXEL ARRANGEMENT SEQUENCE)
HORIZONTAL SELECTOR (HSEL)
9
Vsig/Vofs
DTL
WRITE CONTROL SCANNER (WSCN)
65
WSL
Vcc/Vss
T2
OLED
Vcat
Cs
T1
67
VSL
TO 93
11
DSL
SOURCE LINE SCANNER (DSCN)
7

FIG.24

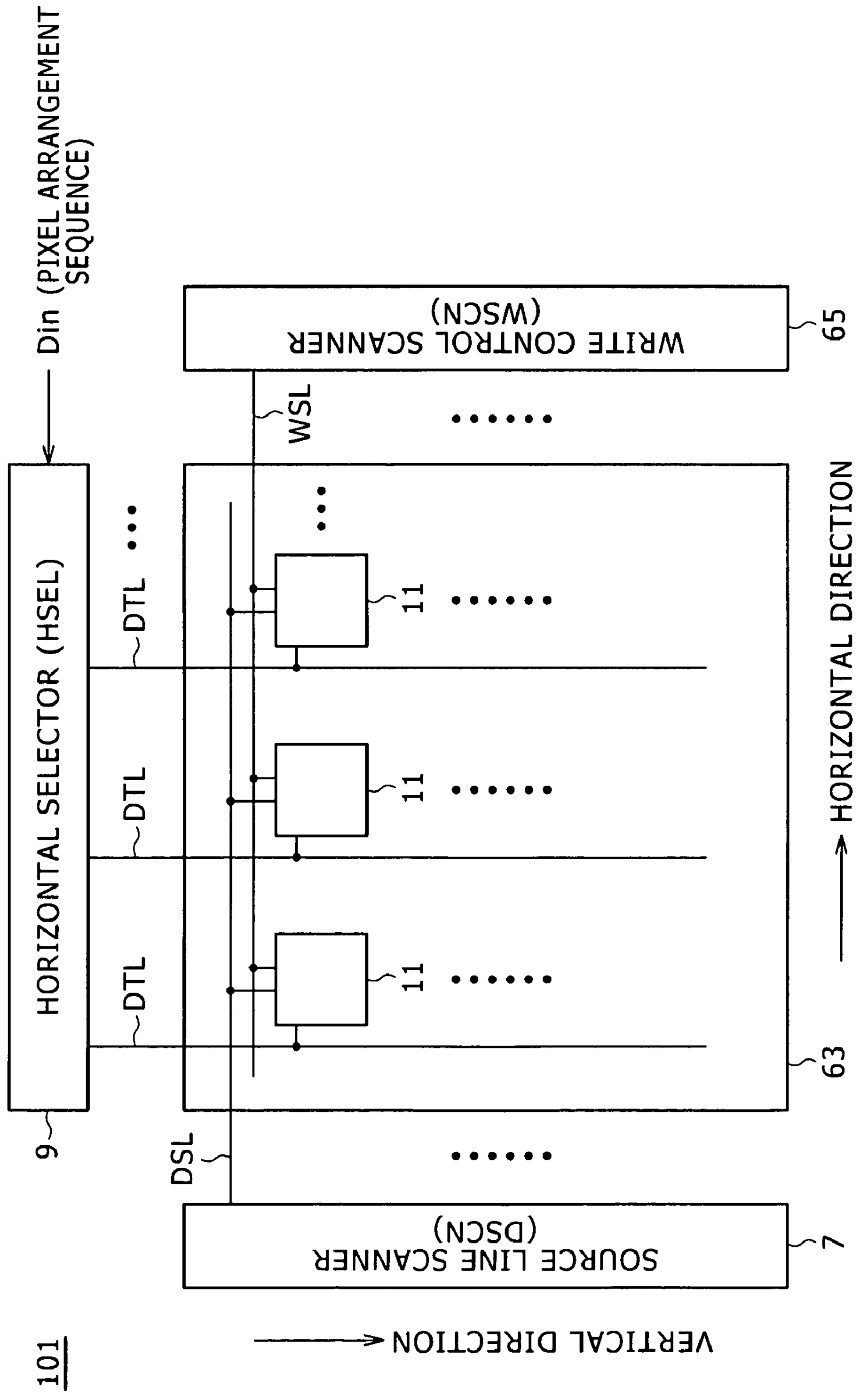

Din (PIXEL ARRANGEMENT SEQUENCE)
HORIZONTAL SELECTOR (HSEL)
9
DTL
DTL
DTL
WSL
DSL
11
11
11
WRITE CONTROL SCANNER (WSCN)
65
63
SOURCE LINE SCANNER (DSCN)
7
HORIZONTAL DIRECTION
VERTICAL DIRECTION
101

FIG. 25

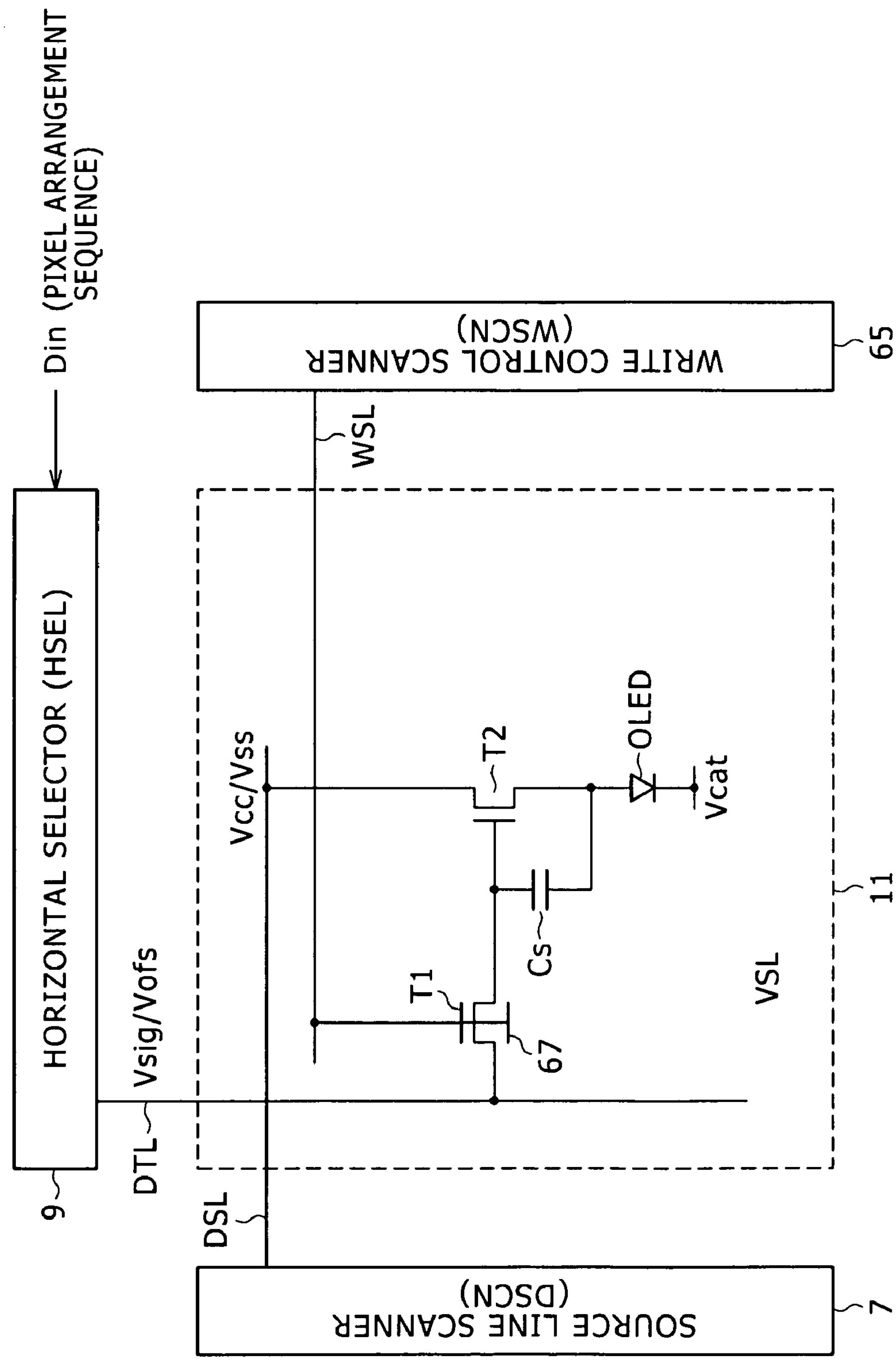

Din (PIXEL ARRANGEMENT SEQUENCE)
HORIZONTAL SELECTOR (HSEL)
9
WRITE CONTROL SCANNER (WSCN)
65
WSL
Vcc/Vss
T2
OLED
Vcat
Cs
T1
67
VSL
11
Vsig/Vofs
DTL
DSL
SOURCE LINE SCANNER (DSCN)
7

FIG.26

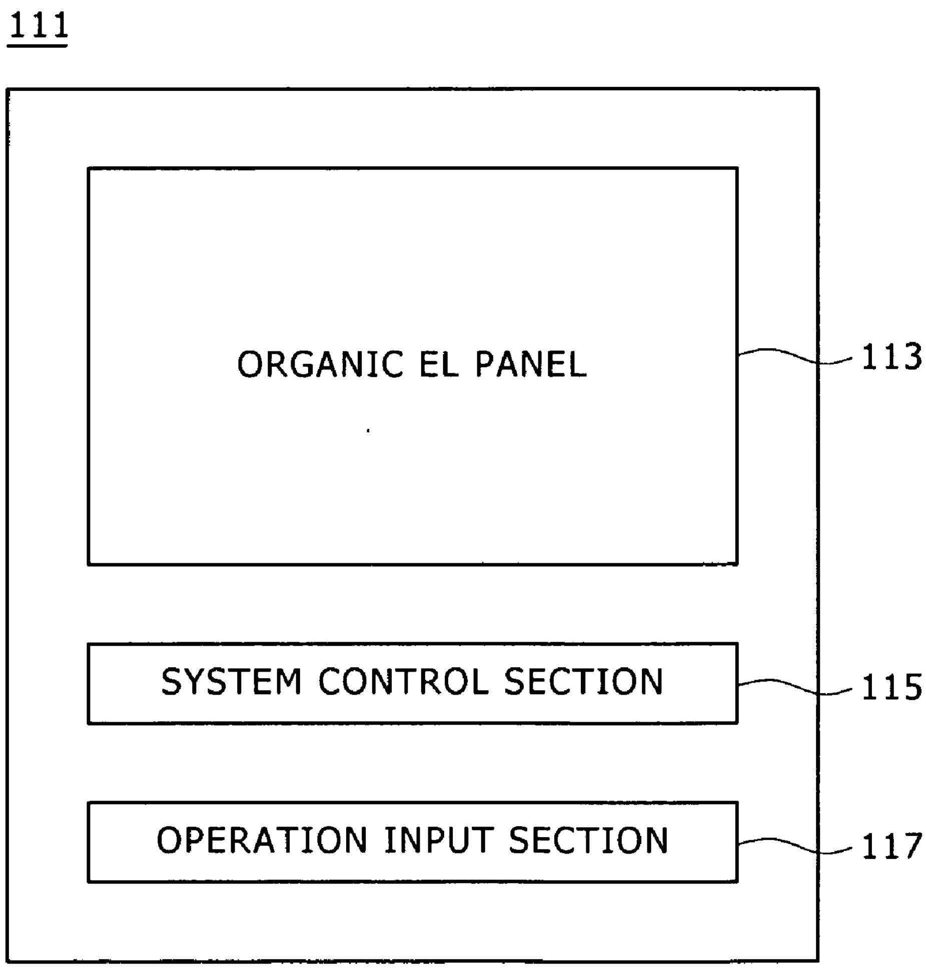

111
ORGANIC EL PANEL
113
SYSTEM CONTROL SECTION
115
OPERATION INPUT SECTION
117

FIG.27

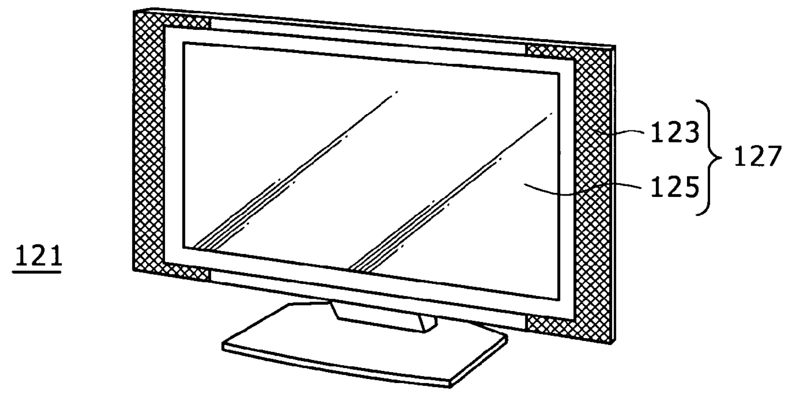


FIG.28A

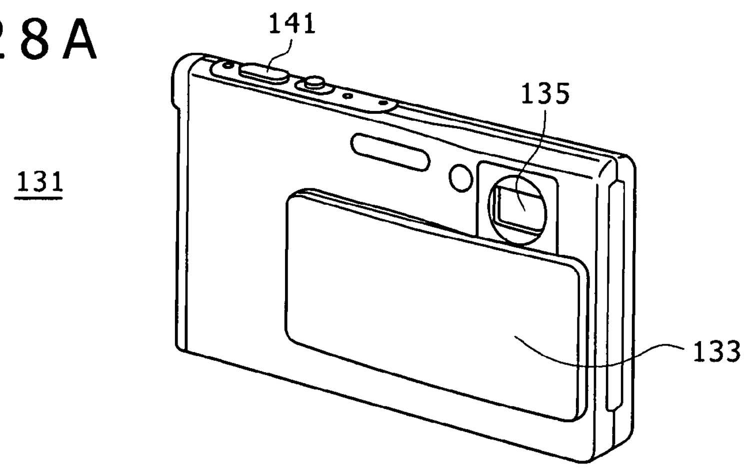


FIG.28B

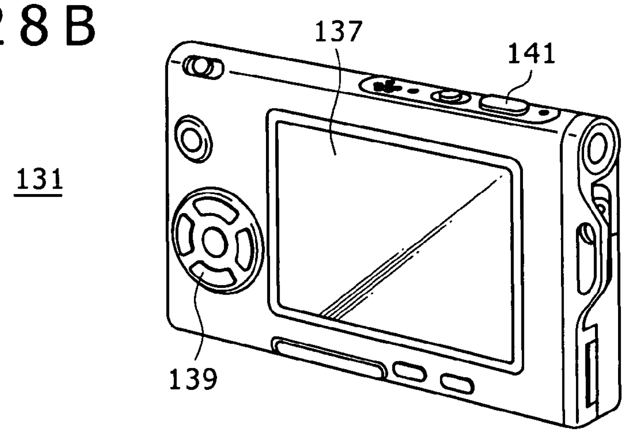
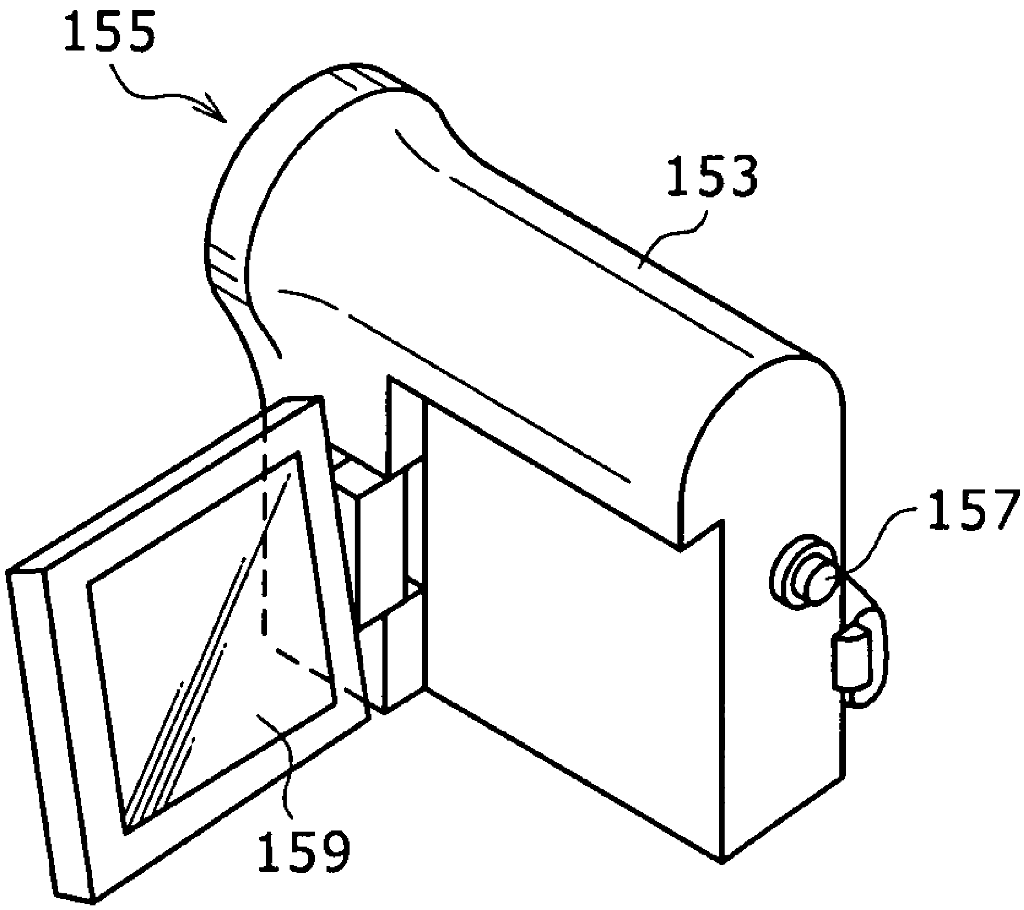


FIG.29



151

FIG.30A

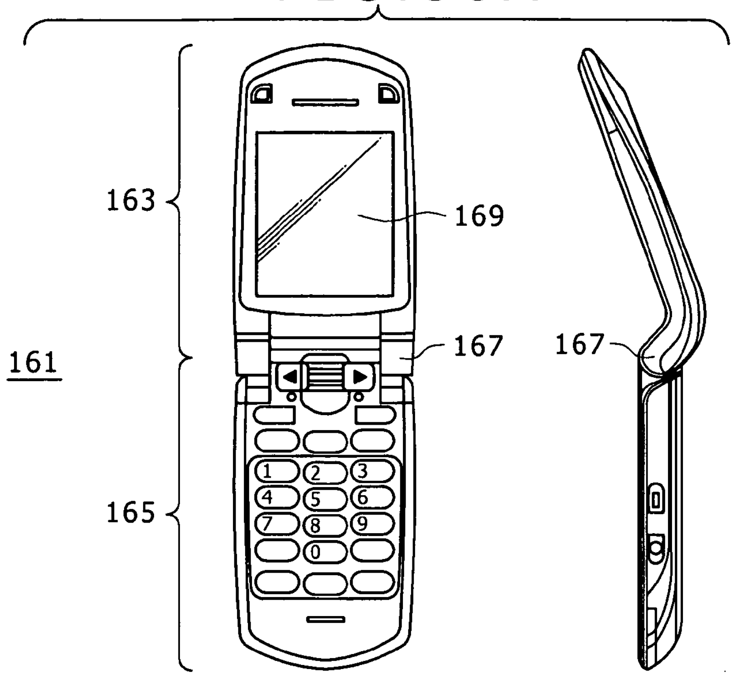


FIG.30B

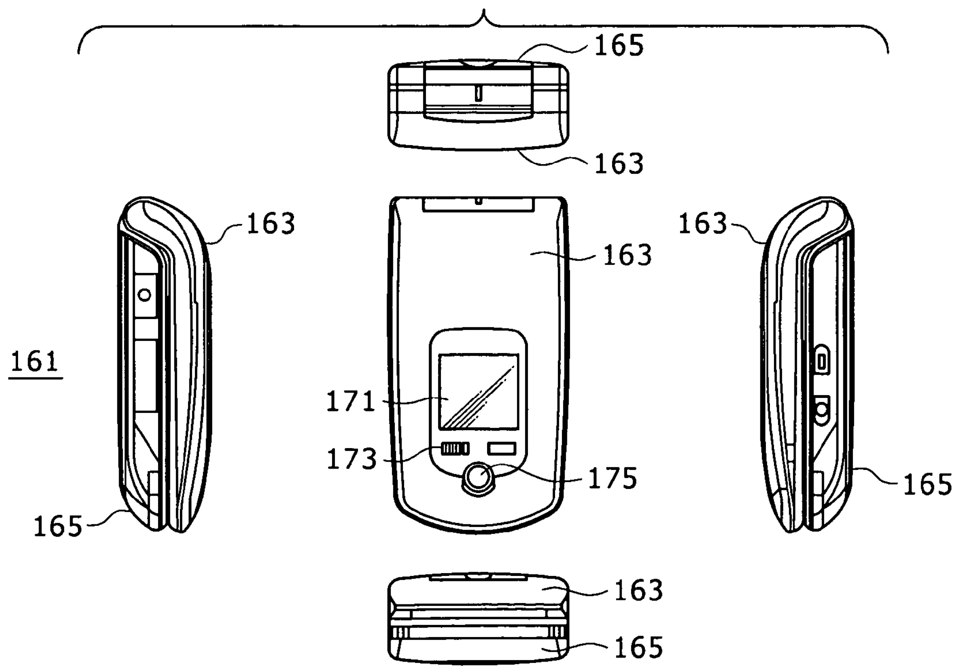
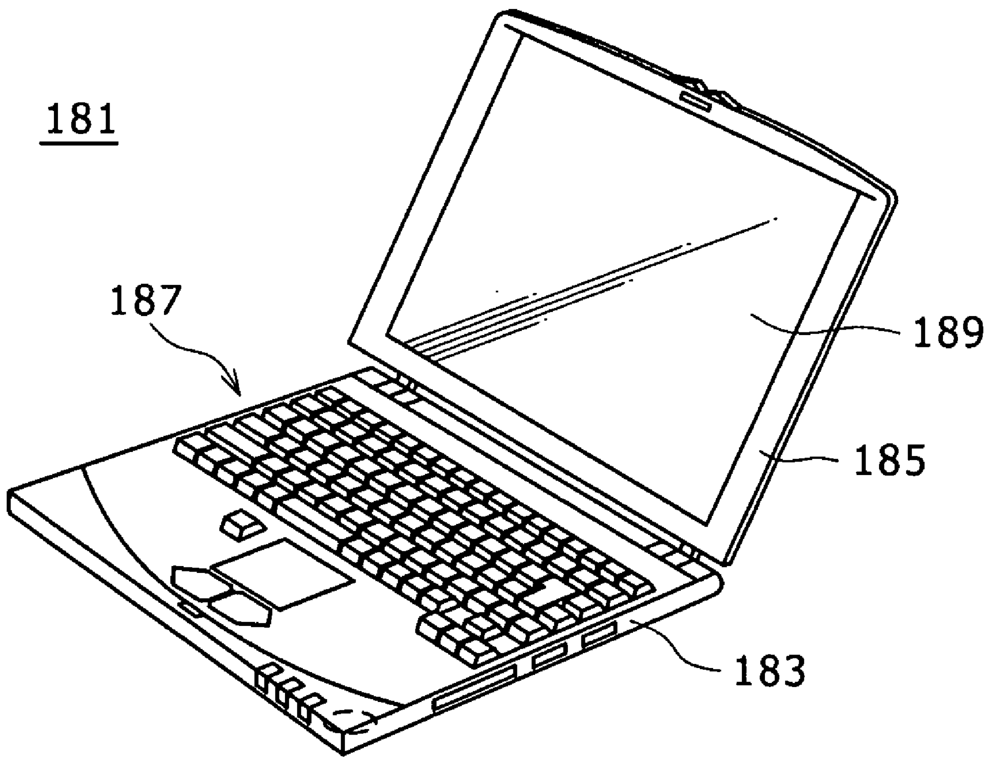


FIG.31



ELECTROLUMINESCENT DISPLAY PANEL AND ELECTRONIC APPARATUS

CROSS REFERENCES TO RELATED APPLICATIONS

[0001] The present invention contains subject matter related to Japanese Patent Application JP 2008-011004, filed in the Japan Patent Office on Jan. 21, 2008, the entire contents of which being incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to an electroluminescent (EL) display panel that works under control by the active matrix driving system. The present invention relates also to a variety of electronic apparatus provided with said EL display panel.

[0004] 2. Description of the Related Art

[0005] FIG. **1** shows a configuration example of circuit blocks constituting an organic EL panel **1** of active matrix driving type, which is composed of a pixel array part **3**, a write control scanner **5** as a driving circuit therefor, a source line scanner **7**, and a horizontal selector **9**.

[0006] The pixel array part **3** has a matrix structure in which each subpixel **11** is at the intersection of the signal line DTL and the write control line WSL. The subpixel **11** is a minimum unit for one pixel. For example, one pixel for white color is composed of three subpixels, representing R (red), G (green), and B (blue), generated by different organic EL materials.

[0007] The subpixel **11** described in this specification is compatible with the active driving system, so that it is composed of a light-emitting region (organic EL element) and a pixel circuit. Incidentally, the organic EL element constituting the light-emitting region is a light-emitting element to be excited by current. Therefore, the organic EL panel has its brightness gradient controlled by the amount of current flowing through the organic EL element in each pixel. It is the pixel circuit that maintains the current supply for a prescribed period of time.

[0008] For the purpose of reference, there is given patent documents concerning the organic EL display panels that work under control by the active matrix driving system. The documents are Japanese Patent Laid-open Nos. 2003-255856, 2003-271095, 2004-133240, 2004-029791, and 2004-093682.

SUMMARY OF THE INVENTION

[0009] FIG. **2** shows one of the simplest pixel circuits constituting the subpixel **11**, which consists of thin-film transistors T**1** and T**2** and a storage capacitor Cs. The thin-film transistors T**1** and T**2** will be referred to as "sampling transistor T**1**" and "driving transistor T**2**," respectively, hereinafter.

[0010] The sampling transistor T**1** is a thin-film transistor of N-channel type which controls writing of the signal potential Vsig to be applied to the storage capacitor Cs according to the tone of the corresponding pixel. The driving transistor T**2** is also a thin-film transistor of N-channel type which supplies the organic EL element OLED with the driving current Ids according to the gate-source voltage Vgs to be determined by the signal potential Vsig held in the storage capacitor Cs.

[0011] The write control scanner **5** is a circuit device which controls the on-off action of the sampling transistor T**1**. The source line scanner **7** is a circuit device which drives the source line DSL at a high potential Vcc and a low potential Vss. The horizontal selector **9** is a circuit device which drives the signal line DTL at a signal potential Vsig corresponding to the pixel data Din and at a reference potential Vofs for correction of the threshold value.

[0012] Incidentally, in the light emission period, the source line DSL is driven at a high potential Vcc and the driving current Ids is supplied to the organic EL element OLED from the source line DSL through the driving transistor T**2**. Incidentally, the driving transistor T**2** operates in the saturation region at all times in the light emission period. That is, the driving transistor T**2** functions as a constant-current source that supplies the organic EL element OLED with the driving current Ids of a certain magnitude corresponding to the signal potential Vsig.

[0013] The driving current Ids is defined as follows.

$$Ids=k\cdot\mu\cdot(Vgs-Vth)^2 \tag{1}$$

where, μ denotes the mobility of majority carriers in the driving transistor T**2**, Vth denotes the threshold voltage of the driving transistor T**2**, and k denotes a coefficient defined as (W/L)·Cox/2 (where W is the channel width, L is the channel length, and Cox is the gate capacity per unit area).

[0014] Meanwhile, the pixel circuit **11** may be formed not only by the high-temperature polysilicon process but also by the low-temperature polysilicon process or amorphous silicon process. The latter methods, however, tend to give thin-film transistors vulnerable to variation in characteristic properties such as threshold voltage (Vth) and mobility μ.

[0015] Particularly, the driving transistor T**2** with variation in characteristic properties directly affects the magnitude of the driving current Ids. In other words, it causes the organic EL element to vary in brightness gradation even though the signal potential Vsig remains the same. The variation in brightness becomes visible in the screen when it exceeds a certain limit.

[0016] Therefore, the pixel circuit of this type has seen technologies to correct the threshold voltage Vth and mobility μ.

[0017] FIGS. **3**A to **3**E show the driving action with a function to correct characteristic properties, which has been proposed by the present applicant. The driving action represents one of the horizontal lines constituting the vertical resolutions of the pixel array **3**. One frame period consists of a non-emitting period and an emitting period, and it is in the non-emitting period that the above-mentioned action to correct characteristic properties is executed.

[0018] FIG. **3**A represents the waveform of the signal line DTL, FIG. **3**B represents the waveform of the write control line WSL, FIG. **3**C represents the waveform of the source line DSL, FIG. **3**D represents the waveform of the gate potential Vg of the driving transistor T**2**, and FIG. **3**E represents the waveform of the source potential Vs of the driving transistor T**2**.

[0019] The driving action shown in FIGS. **3**A to **3**E will be briefly described below. The driving action works such that the potential of the source line DSL is switched to the low potential Vss at the timing for start of the non-emitting period. As the result, the source potential Vs of the driving transistor T**2** falls to the lower potential Vss. Incidentally, the organic EL element OLED goes out automatically when the source potential Vs falls below Vcat plus Vthel (or the sum of the cathode potential Vcat and the threshold voltage Vthel of the organic EL element OLED).

[0020] At the time of this action, the gate electrode of the driving transistor T**2** is open and hence the gate potential Vg also falls as the source potential Vs falls.

[0021] The following explains the action to correct the threshold value of the driving transistor T**2**. The action to correct the threshold value of the driving transistor T**2** starts when the source line DSL rises again to the high potential Vcc. The high potential Vcc is maintained until the next emission period ends.

[0022] The sampling transistor T**1** it turned on before the source line DSL rises to the high potential Vcc, and the gate potential Vg of the driving transistor T**2** is fixed at the offset potential Vofs. In this way, the gate-source voltage Vgs of the driving transistor T**2** is preset to the voltage Vofs−Vss, which is wider than the threshold voltage Vth.

[0023] When the source line DSL is switched to the high potential Vcc in this present state, a current flows through the driving transistor T**2** and the source potential Vs rises as shown in FIG. **4**.

[0024] This current flows in such a way as to charge the storage capacitor Cs and the capacitance parasitic on the organic EL element OLED. As the parasitic capacitance is charged, the source potential Vs of the driving transistor T**2** rises. When the source potential Vs reaches the voltage Vofs−Vth, the driving transistor T**2** becomes off automatically. In this way, the correction of the threshold value is completed. Incidentally, at this point of time, the organic EL element OLED does not emit light because the voltage Vofs−Vth is smaller than the voltage Vcat+Vthel.

[0025] Then, the sampling transistor T**1** is turned off temporarily. After that, the sampling transistor T**1** is turned on again when the signal potential Vsig is applied to the signal wire DTL. As the result, the gate-source voltage Vgs of the driving transistor T**2** rises again above the threshold voltage Vth and a current corresponding to the signal potential Vsig begins to flow. This is the action for writing and mobility correction.

[0026] In this case, too, the current flows in such a way as to charge the storage capacitor Cs and the capacitance parasitic on the organic EL element OLED. Incidentally, the current that flows through the driving transistor T**2** depends largely on the mobility μ; the larger the mobility μ, the larger the current that flows through the driving transistor T**2**, and the smaller the mobility μ, the smaller the current that flows through the driving transistor T**2**.

[0027] As the result, the driving transistor T**2** with a large mobility μ rises in the source potential Vs higher than the one with a small mobility μ. FIG. **5** shows how the driving transistor T**2** varies in the source potential Vs depending on the mobility μ.

[0028] After the action for mobility correction is completed, the sampling transistor T**1** becomes off and the driving current Ids' of the driving transistor T**2** begins to flow into the organic EL element OLED. This starts a new emission period of the organic EL element OLED.

[0029] The action for correction to be executed at the time of driving as mentioned above is intended to correct the variation of characteristics of the driving transistor T**2**. In other words, there is no action to correct the variation of characteristics of the sampling transistor T**1**. One reason for this is that the sampling transistor T**1** is driven by switching and is affected little by the variation of its characteristics.

[0030] However, the sampling transistor T**1** may vary in the threshold voltage Vth (or in the on period) to fluctuate the working point for correction of the mobility of the driving transistor T**2**. This affects the accuracy of mobility correction or causes the fluctuation of brightness level.

[0031] One factor to fluctuate the threshold voltage Vth is a reverse (negative) bias that occurs during the emission period. FIG. **6** shows the potentials in the emission period, with the signal potential Vsig being at a potential for the white tone. Incidentally, the anode potential Vel of the organic EL element OLED (or the source potential Vs of the driving transistor T**2**) is 5 V, and the gate potential Vg of the driving transistor T**2** is 10 V.

[0032] On the other hand, the gate potential Vg of the sampling transistor T**1** is −3 V, which means that the sampling transistor T**1** is continuously given a reverse (negative) bias. Biasing in this manner lowers the threshold voltage Vth of the sampling transistor T**1**. Moreover, the fluctuation of the threshold voltage Vth is amplified as the scattered light in the panel enters the sampling transistor T**1**.

[0033] FIG. **7** shows the exemplary sectional structure of an organic EL panel of top emission type. "Top emission" means that light emerges from the sealing substrate, which corresponds to the glass substrate **21** in FIG. **7**. The sealing substrate may be any transparent material such as plastic film.

[0034] The lower surface of the sealing substrate **21** is coated with a highly transparent sealant **23**. Under the sealant **23** are sequentially arranged the cathode electrode **25**, the organic layer **27**, and the anode electrode **29**, all of which constitute the organic EL element OLED. The cathode electrode **25** is made of a transparent material and the anode electrode **29** is made of a metallic material.

[0035] In the case shown in FIG. **7**, an auxiliary wiring **31** is arranged in the gap between the anode electrode **29** and the anode electrode **29**. The auxiliary wiring **31** supplies a cathode potential to the cathode electrode **25**, and it is formed from the same metallic material as the anode electrode **29**. It is used often in large panels but is not so common in small panels. Under the organic EL element OLED is formed the pixel circuit. FIG. **7** shows an example of the thin-film transistor of bottom gate type.

[0036] In the case shown in FIG. **7**, the pixel circuit is composed of the source electrode **33**, the drain electrode **35**, the interlayer film **37**, the polysilicon layer (channel layer) **39**, the gate oxide film **41**, and the gate electrode **43**. The pixel circuit is formed on the surface of the glass substrate **45**, which is a so-called circuit substrate on which are formed driving elements. The interlayer film **47** is formed between the glass substrate **45** and the anode electrode **29** (which is a lower electrode layer of the organic EL element OLED).

[0037] The following describes the internally scattered light indicated by a thick line with an arrow. The light generated by the organic EL element OLED is emitted theoretically from the inside of the panel to the outside of the sealing substrate. In actual, however, part of the scattered light is reflected repeatedly in the panel and eventually enters the channel region of the sampling transistor T**1** of the adjacent pixel.

[0038] FIG. **8** shows the fluctuation of the threshold voltage Vth that occurs when the internally scattered light enters and the application of reverse (negative) bias persists. It is noted from FIG. **8** that the threshold voltage Vth gradually falls in proportion to the stress time and it falls significantly after the stress time exceeds about 1000 seconds.

[0039] The experiments showed that the threshold voltage Vth falls in the same way as mentioned above regardless of the color of emitted light and that the threshold voltage Vth falls more significantly as the emitted light decreases in wavelength. In other words, the internally scattered light is most influential when the subpixel **11** emits blue light.

[0040] The decrease of the threshold voltage Vth of the sampling transistor T**1** extends the on period of the sampling transistor T**1** as shown in FIG. **9**, which exaggerates the transient characteristics. The extended on period of the sampling transistor T**1** results in an increase of the mobility correction time or the fluctuation of the working point of the mobility correction.

[0041] The mobility correcting action is accompanied by the increase of the source potential Vs of the driving transistor T**2**. Therefore, as the correction time extends, the gate-source potential Vgs decreases accordingly. The magnitude of the driving current Ids after mobility correction is expressed by the formula (2) below.

$$Ids=k\cdot\mu\cdot\{(Vsig-Vofs)/[1+(Vsig-Vofs)\cdot k\cdot\mu\cdot t/C]\}^2 \quad (2)$$

It is noted from Formula (2) that the longer the correction time t, the smaller the driving current Ids.

[0042] In other words, the great fluctuation in the threshold voltage Vth of the sampling transistor T**1** makes the driving current Ids smaller than its original value. In view of the foregoing, it is believed that it is necessary to develop a new technology for protection of the sampling transistor T**1** against the internally scattered light that accelerates the fluctuation of the threshold voltage Vth.

[0043] Incidentally, the formula 2 above contains "C" which represents the sum of individual capacitances in the subpixel **11**. In other words, "C" represents the sum of the capacitance Cs of the storage capacitor, the capacitance Coled of the organic EL element OLED itself, and the capacitance Csub connected in parallel to the organic EL element OLED, as shown in FIG. **10**. In fact, the subpixel **11** may not have the capacitance Csub in the thin-film transistor structure.

[0044] Also, the formula 2 above contains "t" which is defined by the formula (3) below.

$$t=C/(k\cdot\mu\cdot Vsig) \quad (3)$$

[0045] What is proposed herein is an EL display panel having pixel circuits for the active matrix driving system, said EL display panel being characterized by an additional structure to shield internally scattered light.

[0046] That is, what is proposed herein is an EL display panel having pixel circuits for the active matrix driving system, having the following configuration: each pixel circuit has a thin-film transistor in which a portion of the metal wiring material above the channel layer thereof is so arranged as to shield the channel region thereof. This additional structure shields the thin-film transistor from internally scattered light.

[0047] Incidentally, "a portion of the metal wiring material" mentioned above should preferably be connected to the constant potential line for which the maximum voltage applied across the main electrodes of the thin-film transistor is below the cut-off voltage. However, it may also be connected to the pulse signal line for which the maximum voltage applied across the main electrodes of the thin-film transistor is below the cut-off voltage or to the control line for the gate electrode of the thin-film transistor.

[0048] Meanwhile, the shield against internally scattered light is not necessarily restricted to the metal wiring material. Any light-shielding material will reduces the amount of internally scattered light entering the thin-film transistor so long as it has a pattern which shields light (light-shielding pattern).

[0049] The light shield may be formed from any semiconducting material doped with metal atoms or any organic material including black filters. Such semiconducting materials or organic materials are inferior to the metal wiring material in light-shielding performance; however, they surely reduce the entry of internally scattered light and hence lower the rate at which the threshold voltage Vth falls.

[0050] What is further proposed herein is an electronic apparatus equipped with the EL display panel constructed as mentioned above.

[0051] The electronic apparatus is composed of an EL display panel, a system control section to control the operation of the entire system, and an operation input section to accept input operation for the system control section.

[0052] The invention proposed herein produces the effect of shielding the channel region from internally scattered light or reducing the amount of internally scattered light reaching the channel region, thereby eliminating the cause of decrease in the threshold voltage Vth of the thin-film transistor. In this way it is possible to minimize the fluctuation in the timing of mobility-correction (or increase in the length of time for mobility correction).

BRIEF DESCRIPTION OF THE DRAWINGS

[0053] FIG. **1** is a block diagram illustrating the function of the organic EL panel;

[0054] FIG. **2** is a diagram illustrating connection between the pixel circuit and the driving circuit;

[0055] FIGS. **3**A to **3**E are diagrams illustrating the driving action of the pixel circuit shown in FIG. **2**;

[0056] FIG. **4** is a diagram illustrating the change in source potential of the driving transistor that takes place when the threshold value is corrected;

[0057] FIG. **5** is a diagram illustrating the change in source potential of the driving transistor that takes place when the mobility is corrected;

[0058] FIG. **6** is a diagram illustrating potentials in the pixel circuit during the emission period;

[0059] FIG. **7** is a diagram illustrating the passage through which internally scattered light propagates;

[0060] FIG. **8** is a diagram illustrating the fluctuation in the threshold voltage of the sampling transistor;

[0061] FIG. **9** is a diagram illustrating the relation between the fluctuation in the threshold voltage and the time for mobility correction;

[0062] FIG. **10** is a diagram illustrating the capacitances that affect the driving current;

[0063] FIG. **11** is a diagram showing an appearance of the organic EL panel;

[0064] FIG. **12** is a diagram illustrating connection between the pixel circuit and the driving circuit;

[0065] FIG. **13** is a diagram illustrating the passage through which internally scattered light propagates in the case where the light shield is used;

[0066] FIG. **14** is a diagram showing the structure of the pixel circuit pertaining to an embodiment;

[0067] FIG. **15** is a diagram illustrating the relation between the gradation brightness and the time for mobility correction;

[0068] FIG. **16** is a diagram illustrating the waveform of the write control signal to be used to optimize the time for mobility correction according to the gradation brightness;

[0069] FIG. **17** is a diagram illustrating the circuit structure of the write control scanner pertaining to the embodiment;

[0070] FIG. **18** is a diagram illustrating the waveform of the source voltage pulse pertaining to the embodiment;

[0071] FIG. **19** is a diagram illustrating the circuit to generate the source voltage pulse;

[0072] FIG. **20** is a diagram illustrating the exemplary internal structure of the driving source generator;

[0073] FIGS. **21**A and **21**B are diagrams illustrating the effect which is produced when the light shield pattern is combined with the write control signal shown in FIG. **16**;

[0074] FIG. **22** is a diagram illustrating another power supply system;

[0075] FIG. **23** is a diagram illustrating connection in the pixel circuit;

[0076] FIG. **24** is a diagram illustrating another power supply system;

[0077] FIG. **25** is a diagram illustrating connection in the pixel circuit;

[0078] FIG. **26** is a conceptual diagram illustrating the structure of the electronic apparatus;

[0079] FIG. **27** is a diagram illustrating a commercial electronic apparatus;

[0080] FIGS. **28**A and **28**B are diagrams illustrating a commercial electronic apparatus;

[0081] FIG. **29** is a diagram illustrating a commercial electronic apparatus;

[0082] FIGS. **30**A and **30**B are diagrams illustrating a commercial electronic apparatus; and

[0083] FIG. **31** is a diagram illustrating a commercial electronic apparatus.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0084] This section is concerned with the organic EL panel of active matrix driving type to which the present invention is applied.

[0085] Not all parts are graphically shown or described in this specification so long as they are known in the relevant technical field. The embodiment explained below is merely one of the embodiments according to the present invention, and it is not intended to restrict the scope of the present invention.

(A) Exterior Structure

[0086] The term "organic EL panel" used in this specification embraces not only the display panel composed of a substrate and pixel arrays and driving circuits (such as write control scanner and source line scanner) formed thereon by semiconductor process but also a display panel composed of a substrate and pixel arrays formed thereon and driving circuits mounted thereon in the form of IC manufactured for specific applications.

[0087] FIG. **11** shows an exterior structure of the organic EL panel. The organic EL panel **51** is composed of the supporting substrate **53** and the opposed substrate **55** which are bonded together such that the latter fits into the pixel array part of the former.

[0088] The supporting substrate **53** is made of glass, plastics, or the like. In the case of top emission structure, the supporting substrate **53** has pixel circuits formed on the surface thereof. That is, the supporting substrate **53** corresponds to the circuit substrate. In the case of bottom emission structure, the supporting substrate **53** has organic EL elements formed on the surface thereof. That is, the supporting substrate **53** corresponds to the sealing substrate.

[0089] The opposed substrate **55** is made of glass, plastics, or any other transparent materials. The opposed substrate **55** seals the surface of the supporting substrate **53**, with a sealant interposed between them. In the case of top emission structure, the opposed substrate **55** corresponds to the sealing substrate. In the case of bottom emission structure, the opposed substrate **55** corresponds to the circuit substrate.

[0090] Incidentally, the organic EL panel **51** is provided with the FPC (flexible printed circuit) **57** for introduction of external signals and driving power.

(B) Embodiment

(B-1) System Structure

[0091] FIG. **12** shows the exemplary system structure of the organic EL panel **61**. The corresponding parts in FIGS. **1** and **12** are identified by the same symbols.

[0092] The organic EL panel **61** shown in FIG. **12** is composed of the pixel array part **63**, the write control scanner **65** (as the driving circuit for the pixel array part **63**), the source line scanner **7**, and the horizontal selector **9**.

(1) Structure of the Pixel Array Part

[0093] The pixel array part **63** has the same structure as shown in FIG. **1**. That is, it has the matrix structure consisting of signal lines DTL and write control lines WSL, with each subpixel **11** placed at the intersection of the two lines. The difference in structure is that the light shield pattern **67** is arranged above the channel layer in such a way that it entirely covers the channel layer of the sampling transistor T**1**.

[0094] The light shield pattern **67** corresponds to "a portion of a pattern of the metal wiring material" or "light shield pattern" as used in the claims.

[0095] FIG. **13** shows the positional relationship of the light shield pattern **67** and the channel layer of the sampling transistor T**1**. The light shield pattern **67** is arranged above the channel layer of the sampling transistor T**1** such that it entirely covers the channel layer. Incidentally, the light shield pattern **67** is independent of or separate from the neighboring patterns.

[0096] The light shield pattern **67** is formed from the same metallic material (e.g., aluminum and molybdenum) as the signal wire DTL.

[0097] Consequently, the light shield pattern **67** reflects the internally scattered light which has been reflected by the anode electrode **29** and returned into the panel inside, thereby preventing the internally scattered light from entering the channel layer.

[0098] The light shield pattern **67** can be formed at the same time as the metal wiring layers (source electrode **33** and drain electrode **35**) are formed. Therefore, it can be formed without the necessity of additional processes and hence it does not add to the production cost. However, there should be a sufficient distance between the light shield pattern **67** and the main electrodes to avoid short-circuiting between them.

[0099] Incidentally, the light shield pattern **67** should preferably be so arranged as to cover the sampling transistor T**1** as well as the entire channel layer of the driving transistor T**2**.

However, the light shield pattern **67** may be so arranged as to cover only the entire channel layer of the sampling transistor T**1** as in this embodiment, because the driving transistor T**2** has a function to correct the threshold value.

[0100] Also, in this embodiment, the light shield pattern **67** can be formed at the same time as the main electrodes (source electrode **33** and drain electrode **35**) of the sampling transistor T**1** are formed. Therefore, it can be formed without the necessity of additional processes and hence it does not raise the production cost.

[0101] In the meantime, the light shield pattern **67** is kept at a constant potential Vcnst through the constant source line CVL. The constant potential Vcnst is supplied from a source arranged anywhere on the panel.

[0102] The constant potential Vcnst should be kept below a potential (cut-off potential) which does not activate the sampling transistor T**1** into on state except the period in which it is turned on by the write control line WSL. In other words, the constant potential Vcnst should be set such that it is not higher by the threshold voltage than all the potentials to be applied to the main electrodes of the sampling transistor T**1** except the period in which the sampling transistor T**1** is activated by the write control line WSL.

[0103] Needless to say, the constant potential Vcnst should be established by taking it into consideration that the threshold voltage Vth of the sampling transistor T**1** changes with time. In other words, it should have a sufficient margin in anticipation of fluctuation. In this way it is possible to prevent the sampling transistor T**1** from becoming on at unexpected timing and the storage capacitor Cs from changing in potential.

(2) Structure of the Write Control Scanner

[0104] FIG. **14** shows the connection relation between the pixel circuit **11** and the driving circuits. The connection relation shown in FIG. **14** is identical with that shown in FIG. **2**. That is, the write control line WSL, which is driven and controlled by the write control scanner **65**, is connected to the gate electrode of the sampling transistor T**1**, and the source line DSL, which is driven and controlled by the source line scanner **7**, is connected to one of the main electrodes of the driving transistor T**2**.

[0105] The embodiment is differentiated by the write control scanner **65**, which optimizes the time for mobility correction according to the gradation brightness.

[0106] FIG. **15** shows the relation between the gradation brightness and the time for mobility correction. In FIG. **15**, the abscissa represents the time for mobility correction, and the ordinate represents the gradation brightness (signal potential Vsig).

[0107] It is noted from FIG. **15** that, in the case of high brightness (white tone), the brightness level of the driving transistor T**2** having a high mobility μ coincides with the brightness level of the driving transistor T**2** having a low mobility μ at the time t**1** for mobility correction. In other words, the time for mobility correction should desirably be t**1** in the case of high brightness pixels.

[0108] It is also noted from FIG. **15** that, in the case of low brightness (gray tone), the brightness level of the driving transistor T**2** having a high mobility μ coincides with the brightness level of the driving transistor T**2** having a low mobility μ at the time t**2** for mobility correction. In other words, the time for mobility correction should desirably be t**2** in the case of low brightness pixels.

[0109] In the case of the driving system in which the time for mobility correction is fixed, the time for mobility correction may be longer or shorter than necessary for the pixel circuit at the brightness level other than specific ones. This causes visual confirmation as luminance irregularity or stripes, at worst.

[0110] Consequently, the write control scanner **65** is provided with the function to adjust automatically the time for mobility correction of each pixel circuit according to the brightness level of each pixel.

[0111] This is achieved by the driving function which makes the time for mobility correction shorter automatically for the pixel circuit corresponding to the high brightness level, and also makes the time for mobility correction longer automatically for the pixel circuit corresponding to the low brightness level.

[0112] Incidentally, the time for mobility correction is the time for on action for the sampling transistor T**1**.

[0113] The write control scanner **65** in this embodiment is provided with the function that causes the write control signal for the sampling transistor T**1** to have the waveform shown in FIG. **16** during the period of mobility correction. The write control signal shown in FIG. **16** has a waveform region in which potential drops abruptly and a waveform region in which potential drops gradually.

[0114] The effect produced by this write control signal is that the gate-source voltage Vgs of the sampling transistor T**1** becomes smaller (for automatic cutoff) than the threshold voltage Vth in the region where the waveform changes abruptly in the case of high brightness pixels and that the gate-source voltage Vgs of the sampling transistor T**1** becomes smaller (for automatic cutoff) than the threshold voltage Vth in the region where the waveform changes gradually in the case of low brightness pixels.

[0115] This means that the time for mobility correction for each pixel is automatically adjusted according to the magnitude of the signal potential Vsig and the optimal action for mobility correction is ensured even though the signal potential Vsig varies.

[0116] FIG. **17** shows the partial structure of the write control scanner **65** which generates the write control signals mentioned above. The partial structure corresponds to one horizontal line. Therefore, one screen contains in the vertical direction as many circuits (shown in FIG. **17**) as the number of vertical resolution.

[0117] This partial circuit is also referred to as the write control scanner **65** hereinafter. The write control scanner **65** is composed of the shift register **71**, the buffer circuit composed of the two-stage inverter circuits **73** and **75**, the level shifter **77**, and the output buffer circuit composed of the one-stage inverter circuit **79**. It is characterized in that the waveform level of the source voltage pulse WSP supplied to the inverter circuit **79** falls as shown in FIG. **16**.

[0118] Needless to say, the timing for the waveform level to fall should be implemented in synchronism with the period for mobility correction of each horizontal line, as shown in FIG. **18**.

[0119] FIG. **19** shows the structure of the circuit device that generates the source voltage pulse WSP to be supplied to the write control scanner **65**.

[0120] The source voltage pulse WSP is generated by the timing generator **81** and the driving source generator **83**. The timing generator **81** is a circuit device to supply driving pulses (rectangular wave) to the write control scanner **65** as well as the source line scanner **7** and the horizontal scanner **9**. Incidentally, the fall timing of the driving pulse is so established as to lag for a prescribed time behind the timing to start mobility correction.

[0121] The drive power source generator **83** is a circuit device which generates the driving voltage pulse WSP (FIG. **18**) whose waveform bends in two steps at the fall time according to the drive pulse in rectangular waveform.

[0122] FIG. **20** shows a circuit for the drive power source generator **83**, which is composed of two transistors, one capacitor, three fixed resistors, and two variable resistors.

[0123] The drive power source generator **83** generates, through analogue processing of driving pulse, the driving voltage pulse WSP whose waveform bends in two steps at the fall time. That is, it generates the source voltage pulse WSP whose fall waveform has a steep slope in the first step and a gentle slope in the second step.

(B-2) Driving Action and Effect

[0124] In this embodiment, the driving action is identical with that shown in FIG. **3** except for action in the period for mobility correction. Incidentally, the light beam emitted from each subpixel **11** toward the panel surface partly remains inside the glass substrate **21** as the result of internal scattering.

[0125] However, in this embodiment, the entry of internally scattered light into the channel layer is blocked by the light shield pattern **67** arranged above the channel layer of the sampling transistor T**1**.

[0126] This mechanism prevents the threshold voltage Vth of the sampling transistor T**1** from fluctuation and maintains the time for mobility correction in its optimal condition.

[0127] The shielding of internally scattered light produces its better effect when employed in combination with the driving system that works at the time of mobility correction, as proposed in this embodiment.

[0128] As mentioned above, this embodiment employs the source voltage pulse WSP whose waveform falls in two steps after a certain period of time from the start for mobility correction so that the time of mobility correction is automatically optimized according to the magnitude of the signal potential Vsig.

[0129] Consequently, as the fluctuation of the threshold voltage Vth becomes larger, the time for mobility correction greatly changes, as shown in FIG. **21**A. This is true particularly in the case of the signal potential Vsig for which the region where the source voltage pulse WSP steeply falls is the optimal time for mobility correction. In this case, as the threshold voltage Vth falls, the on time of the sampling transistor T**1** greatly changes. This is a problem inherent in the driving system which makes dull in two steps the waveform of the source voltage pulse WSP of the time for mobility correction.

[0130] However, in this embodiment, which is so designed as to minimize the fluctuation of the threshold voltage Vth by shielding the internally scattered light, it is possible to prevent the actual time for mobility correction from greatly shifting from the optimized time for mobility correction for each signal potential Vsig as shown in FIG. **21**B.

[0131] Thus, the shielding of internally scattered light stabilizes by itself the working point of the time for mobility correction, and it produces a better effect when combined with the technique of optimizing the time for mobility correction.

(C) Other Embodiments

(C-1) Electric Supply to the Light Shield Pattern

[0132] The foregoing embodiment has demonstrated the instance in which the light shield pattern **67** is supplied with the constant potential Vcnst. However, another instance is also possible in which the light shield pattern **67** is driven by a pulse power source. The panel may have the same sectional structure as shown in FIG. **13**.

[0133] FIG. **22** shows the structure of the organic EL panel, and FIG. **23** shows the connection in the pixel circuit. In the case of the organic EL panel **91** shown in FIGS. **22** and **23**, the light shield pattern **67** is connected to the pulse voltage source **93** through the variable source line VSL. Incidentally, although the pulse voltage source **93** is depicted in FIG. **22** as being connected to all the pixel circuits **11**, it may be provided for each horizontal line. The action timing of the pixel circuit **11** may be controlled for each horizontal line.

[0134] Needless to say, it is assumed that the potential generated by the pulse voltage source **93** is lower than the cutoff potential which does not turn on the sampling transistor T**1** except for the period of on control by the write control line WSL. So long as this condition is met, the driving pulse can be switched at any timing. In this case, too, the potential generated by the pulse voltage source **93** should be set in consideration of change with time of the threshold voltage Vth of the sampling transistor T**1**, as a matter of course.

[0135] FIG. **24** shows the structure of the organic EL panel, and FIG. **25** shows the exemplified connection in the pixel circuit. In the case of the organic EL panel **101** shown in FIGS. **24** and **25**, the light shield pattern **67** is connected to the write control line WSL. In other words, the sampling transistor T**1** constitutes a thin-film transistor of double gate structure. This connection corresponds to the electric supply shown in FIGS. **22** and **23**.

(C-2) Material of Light Shield

[0136] In the foregoing embodiment, the light shield pattern **67** is made of the same metallic material as the electrode wiring for the thin-film transistor T**2**. Because of this material, the light shield pattern **67** is expected to reflect all of internally scattered light in the incident direction. However, the light shield pattern **67** may be formed from any metallic material different from the electrode wiring.

[0137] Incidentally, even though the light shield pattern **67** cannot reflect all of internally scattered light in the incident direction. It will produce a certain effect so long as it reduces the amount of light passing through it and it reduces the fluctuation of the threshold voltage. For example, the light shield pattern **67** may be formed from a semiconducting material doped with metallic atoms. Alternatively, it may be a black filter or formed from a dark-colored organic material.

(C-3) Other Pixel Circuits

[0138] The foregoing embodiment has demonstrated the pixel circuit **11** consisting of two thin-film transistors T**1** and T**2** and a storage capacitor Cs.

[0139] However, the present invention is not concerned with the structure of the pixel circuit **11**, and hence it is possible to employ any structure of the pixel circuit **11** and any method for its driving.

[0140] The foregoing embodiment has demonstrated the pixel circuit in which the thin-film transistor T**1** is of bottom gate type; however, it may be replaced by that of top gate type.

(C-4) Other Panel Structures

[0141] The foregoing embodiment has demonstrated the EL display panel of top emission type.

[0142] However, the EL display panel may be of bottom emission type, which is constructed such that light is emitted through the circuit substrate.

(C-5) Product Examples

[0143] Electronic Apparatus

[0144] In the foregoing, the description has been made with reference to the organic EL panel. The organic EL panel mentioned above is mounted on a variety of electronic apparatus as exemplified below.

[0145] FIG. **26** shows a concept of the structure of the electronic apparatus **111**. The electronic apparatus **111** consists of the organic EL panel **113** mentioned above, the system control section **115**, and the operation input section **117**. The system control section **115** performs various processes according to the type of the electronic apparatus **111**. The operation input section **117** is a device to accept operation input for the system control section **115**. The operation input section **117** includes mechanical interfaces (such as switches and buttons) and graphical interfaces.

[0146] Incidentally, the electronic apparatus **111** is not specifically restricted in its application area so long as it has a function to display images or videos generated therein or entered from outside.

[0147] FIG. **27** shows an appearance of the electronic apparatus as a television set. The television set **121** has a display screen **127** (consisting of a front panel **123** and a filter glass **125**) fitted on the front face of the casing thereof. The display screen **127** corresponds to the organic EL panel explained in the embodiment.

[0148] The electronic apparatus **111** includes the digital camera **131** whose appearance is shown in FIGS. **28**A and **28**B. FIG. **28**A is an exemplified front view (facing the object) and FIG. **28**B is an exemplified rear view (facing the photographer).

[0149] The digital camera **131** consists of a protective cover **133**, an image pickup lens **135**, a display screen **137**, a control switch **139**, and a shutter button **141**. The display screen **137** corresponds to the organic EL panel explained in the embodiment.

[0150] The electronic apparatus **111** includes the video camera **151** whose appearance is shown in FIG. **29**.

[0151] The video camera **151** consists of a main body **153**, an image pickup lens **155** attached to the front of the main body **153**, a start/stop switch **157**, and a display screen **159**. The display screen **159** corresponds to the organic EL panel explained in the embodiment.

[0152] The electronic apparatus **111** includes a mobile terminal, for example. The appearance of a mobile phone **161** as a portable remote terminal is shown in FIGS. **30**A and **30**B. The mobile phone **161** shown in FIGS. **30**A and **30**B is a collapsible one. FIG. **30**A is an external appearance, with the casing opened, and FIG. **30**B is an external appearance, with the casing closed.

[0153] The mobile phone **161** consists of an upper casing **163**, a lower casing **165**, a hinge **167** as a connector, a display screen **169**, an auxiliary display screen **171**, a picture light **173**, and an image pickup lens **175**. The display screen **169** and the auxiliary display screen **171** correspond to the organic EL panel explained in the embodiment.

[0154] The electronic apparatus **111** includes a computer, for example. The appearance of a notebook computer **181** as a computer is shown in FIG. **31**. The notebook computer **181** consists of a lower casing **183**, an upper casing **185**, a keyboard **187**, and a display screen **189**. The display screen **189** corresponds to the organic EL panel explained in the embodiment.

[0155] In addition, the electronic apparatus **111** includes audio players, game machines, electronic books, and electronic dictionaries.

(C-6) Other Example of Display Device

[0156] The foregoing embodiment has demonstrated the application of the present invention to the organic EL panel. However, the driving technique mentioned above can also be applied to other EL display devices, such as display devices with LEDs or light-emitting elements of diode structure, which include inorganic EL panels.

(C-7) Others

[0157] The forgoing embodiment may be variously modified within the scope of the present invention, by combining or changing the examples described in this specification.

[0158] While a preferred embodiment of the present invention has been described using specific terms, such description is for illustrative purposes only, and it is to be understood that changes and variations may be made without departing from the spirit or scope of the following claims.

What is claimed is:

1. An electroluminescent display panel having pixel circuits for the active matrix driving system, wherein each pixel circuit has a thin-film transistor in which a portion of a pattern of a metal wiring material above the channel layer of the thin-film transistor is so laid out as to shield the channel region of the thin-film transistor.

2. The electroluminescent display panel as defined in claim **1**, wherein said portion of the pattern is connected to the constant potential line for which the maximum voltage applied across the main electrodes of said thin-film transistor is set below the cutoff voltage.

3. The electroluminescent display panel as defined in claim **1**, wherein said portion of the pattern is connected to the pulse signal line for which the maximum voltage applied across the main electrodes of said thin-film transistor is set below the cutoff voltage.

4. The electroluminescent display panel as defined in claim **1**, wherein said portion of the pattern is connected to the control line of the gate electrode of said thin-film transistor.

5. The electroluminescent display panel as defined in claim **1**, said portion of the pattern is formed from the same metal wiring material as the main electrodes of said thin-film transistor.

6. An electroluminescent display panel having pixel circuits for the active matrix driving system, wherein each pixel circuit has a thin-film transistor in which a light shield is laid out above the channel layer of said thin-film transistor.

7. The electroluminescent display panel as defined in claim **6**, wherein said light shield pattern is formed from a semiconducting material doped with metal atoms.

8. The electroluminescent display panel as defined in claim **6**, wherein said light shield pattern is formed from an organic material.

9. An electronic apparatus comprising:

an electroluminescent display panel;

a system control section to control the operation of the entire system; and

an operation input section to accept input operation for the system control section,

said electroluminescent display panel having pixel circuits for the active matrix driving system, wherein each pixel circuit has a thin-film transistor in which a portion of a pattern of a metal wiring material above the channel layer of the thin-film transistor is so laid out as to shield the channel region of the thin-film transistor.

10. An electronic apparatus comprising:

an electroluminescent display panel;

a system control section to control the operation of the entire system; and

an operation input section to accept input operation for the system control section,

said electroluminescent display panel having pixel circuits for the active matrix driving system, wherein each pixel circuit has a thin-film transistor in which a light shield pattern is laid out above the channel layer of said thin-film transistor.

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