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# (54) ORGANIC EL DISPLAY DEVICE

(76) Inventors: **Hironori Toyoda**, Mobara (JP); **Naruhiko Kasai**, Yokohama (JP); **Hajime Murakami**, Shinjuku (JP)

Correspondence Address:
**ANTONELLI, TERRY, STOUT & KRAUS, LLP**
**1300 NORTH SEVENTEENTH STREET, SUITE 1800**
**ARLINGTON, VA 22209-3873 (US)**

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(57) **ABSTRACT**

The present invention provides an organic EL display device with high detection accuracy which can enhance both of light emission efficiency and light reception efficiency. In an organic EL display device which includes organic thin film elements, a power source line is connected to the organic thin film elements via drive TFTs, a signal line is connected to a gate of the drive TFT to supply a potential corresponding to a gray scale signal, a switch is provided for connecting the signal line and the organic thin film element, and the switch is controlled to allow an electric current which is obtained by photoelectric conversion with the organic thin film element to flow in the signal line and the organic thin film element during a period in which a gray scale signal is not applied to the signal line.

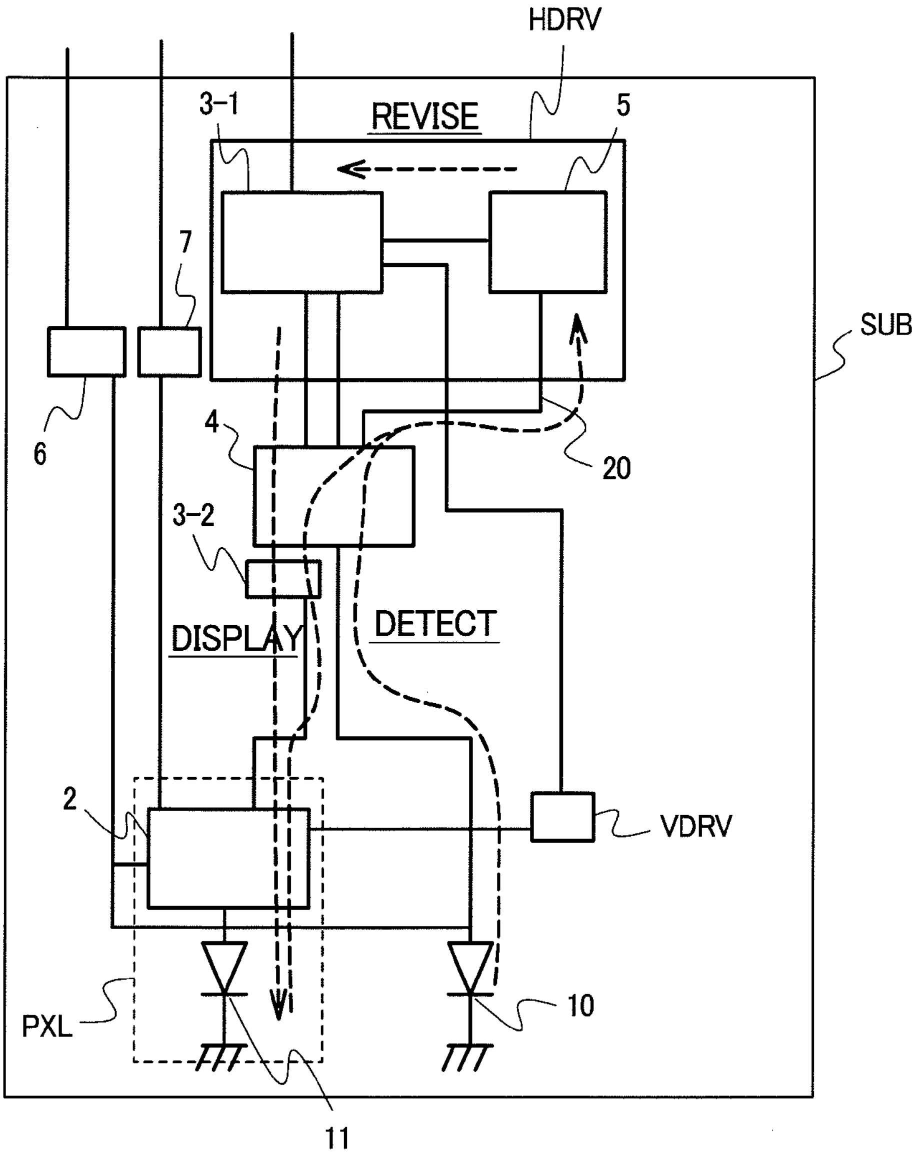


FIG. 1

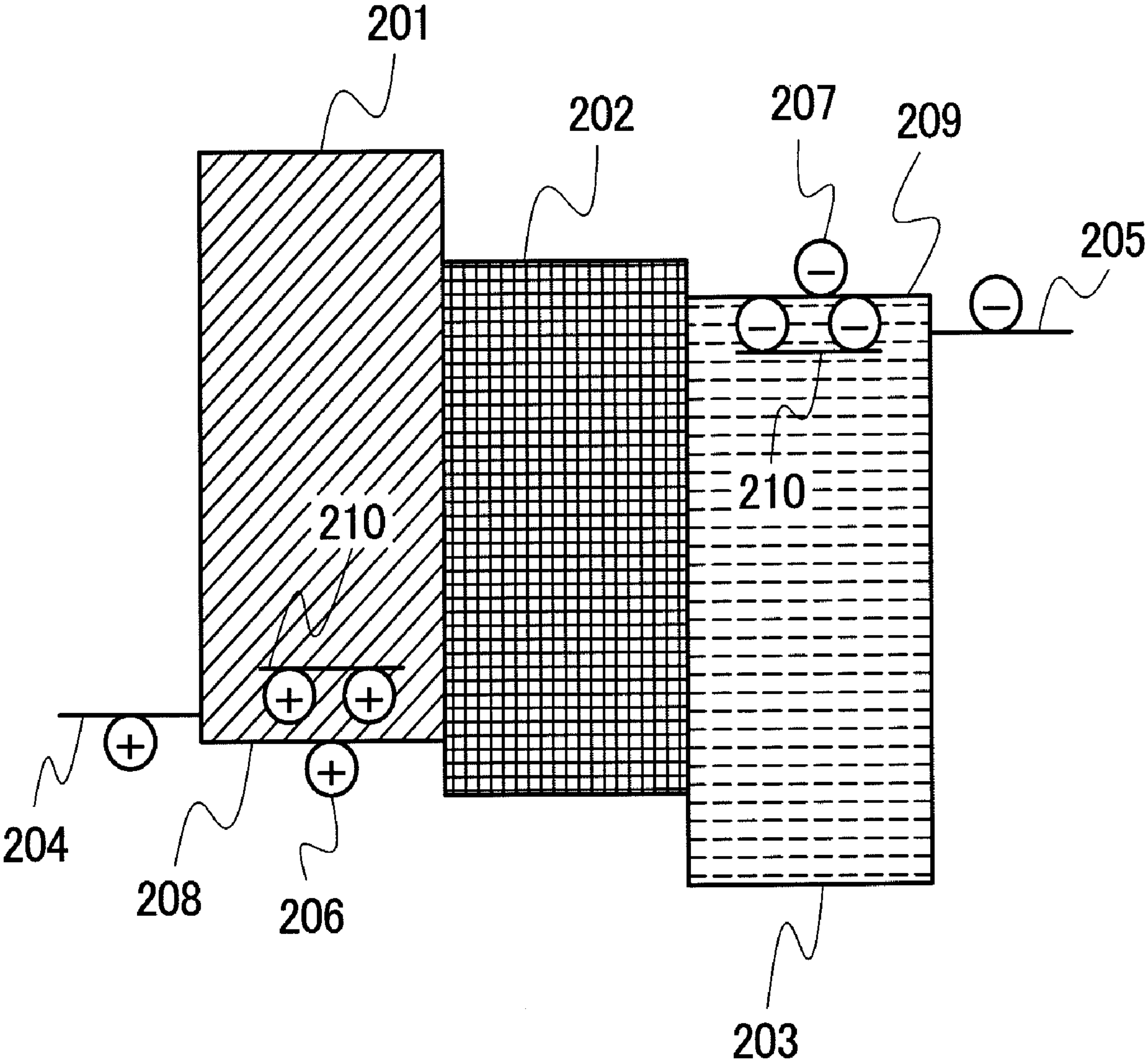


FIG. 2

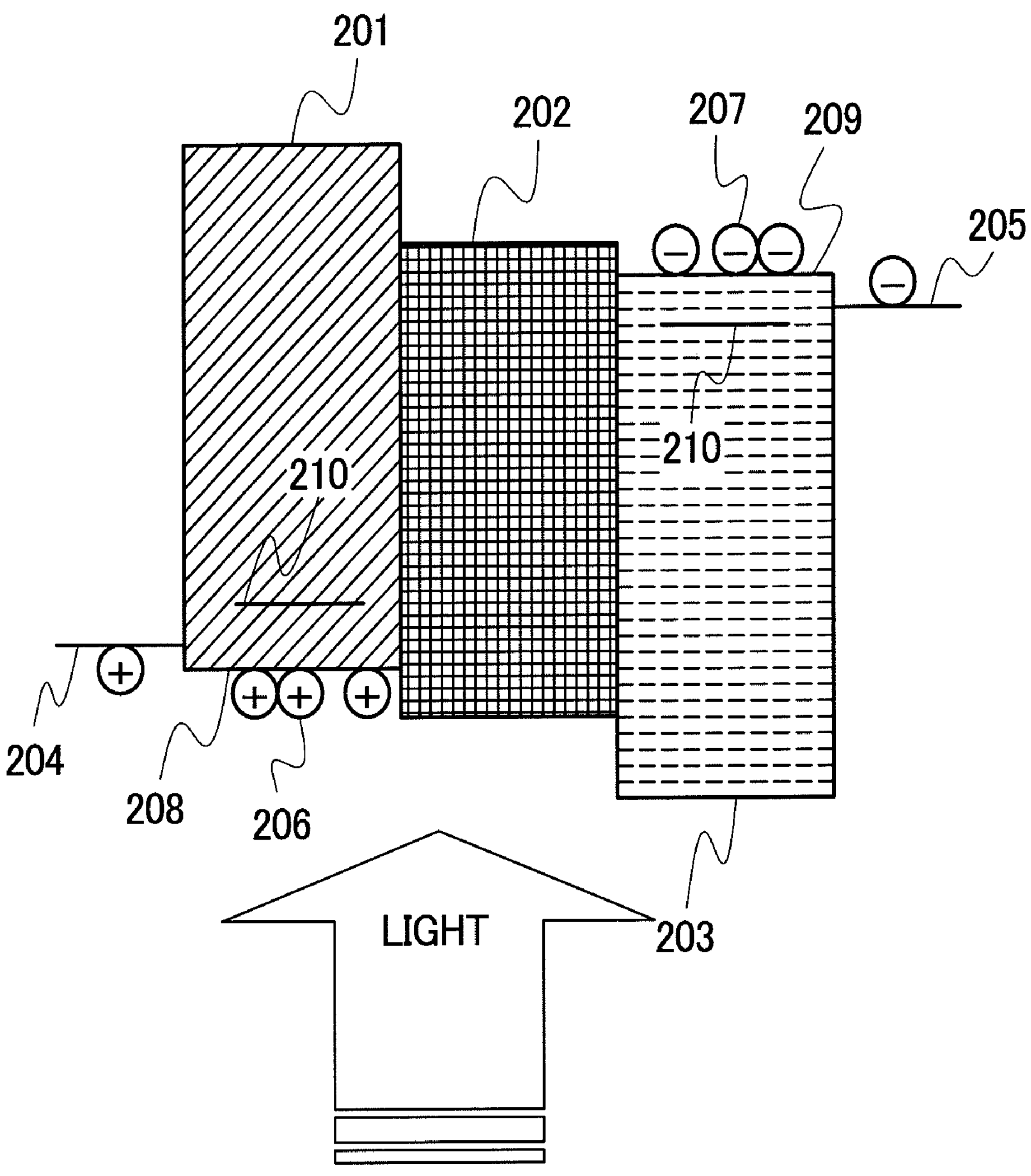


FIG. 3

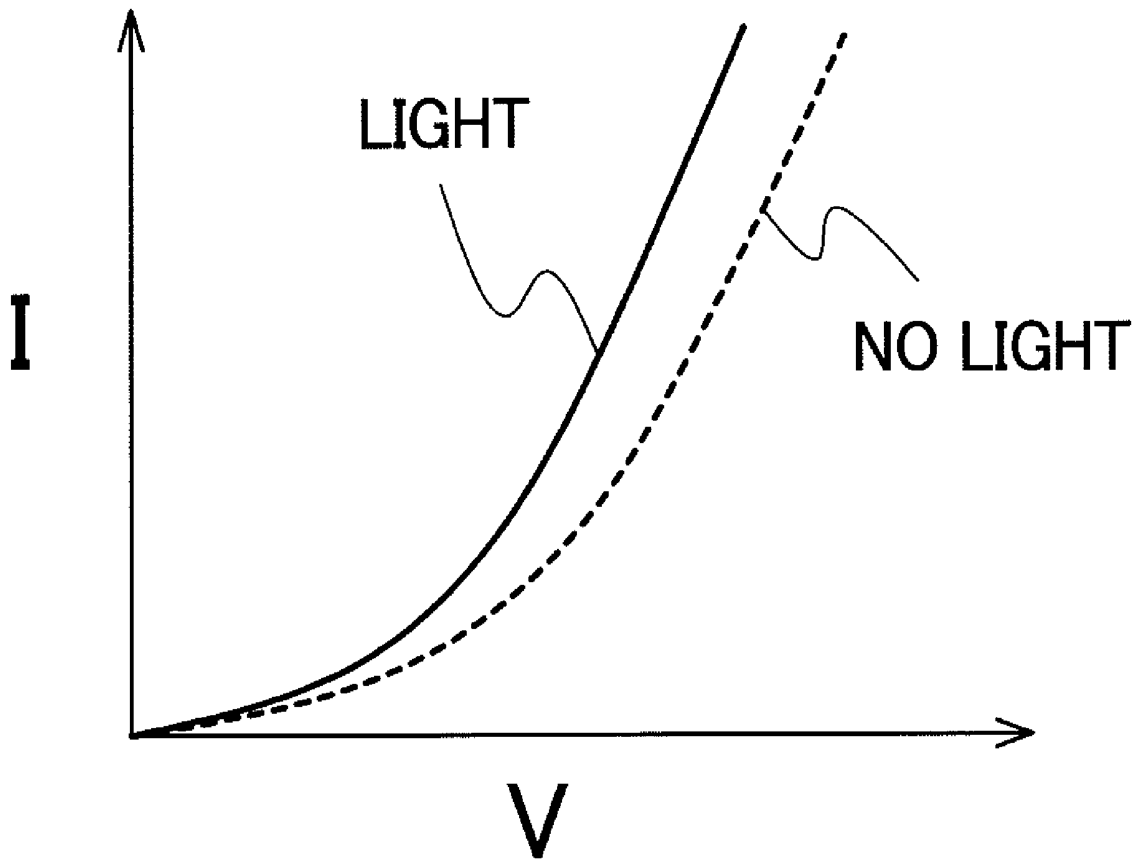


FIG. 4

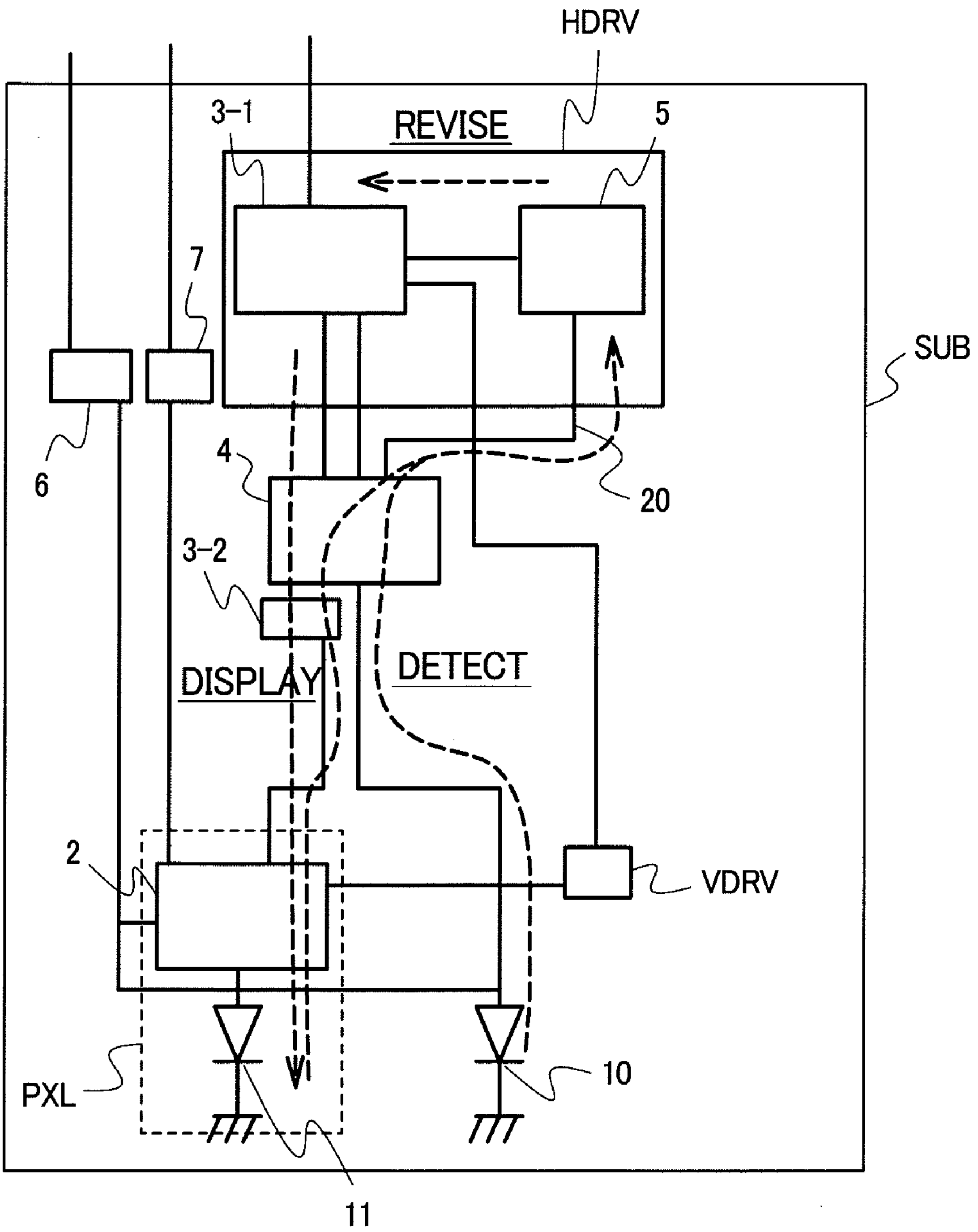
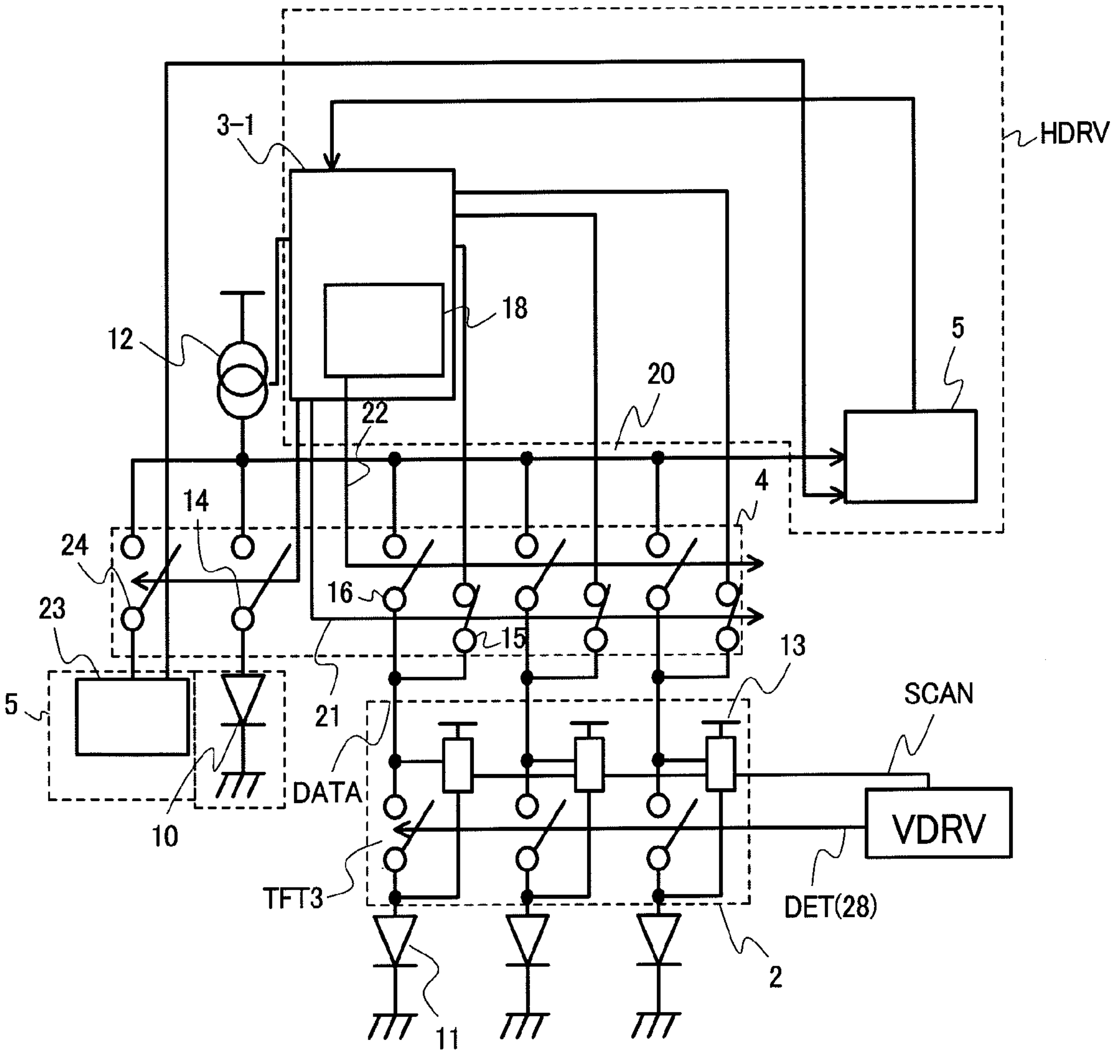


FIG. 5



HDRV
3-1
18
12
5
20
22
4
14
24
16
23
15
13
5
21
SCAN
DATA
VDRV
10
TFT3
DET(28)
2
11

FIG. 6

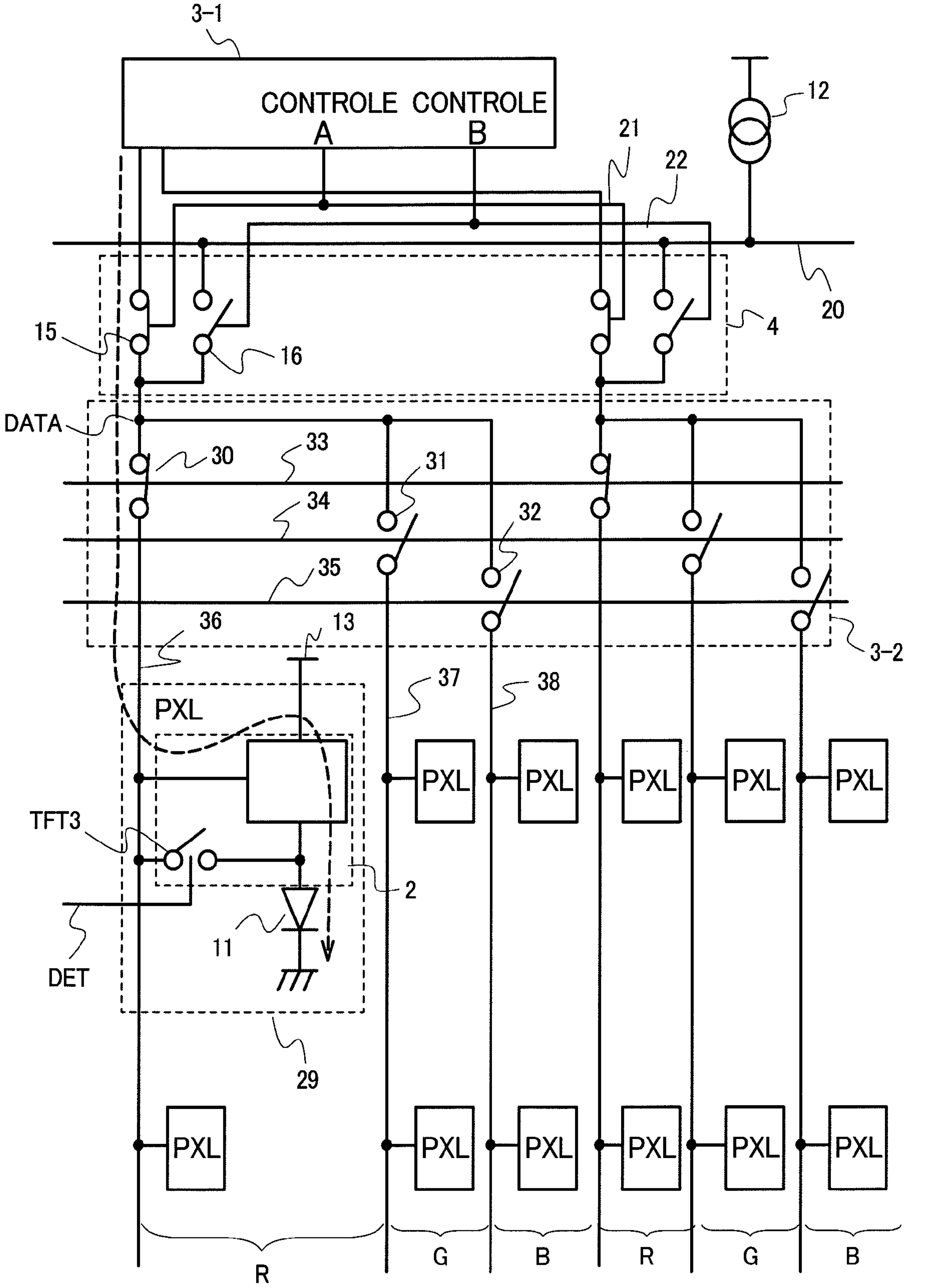
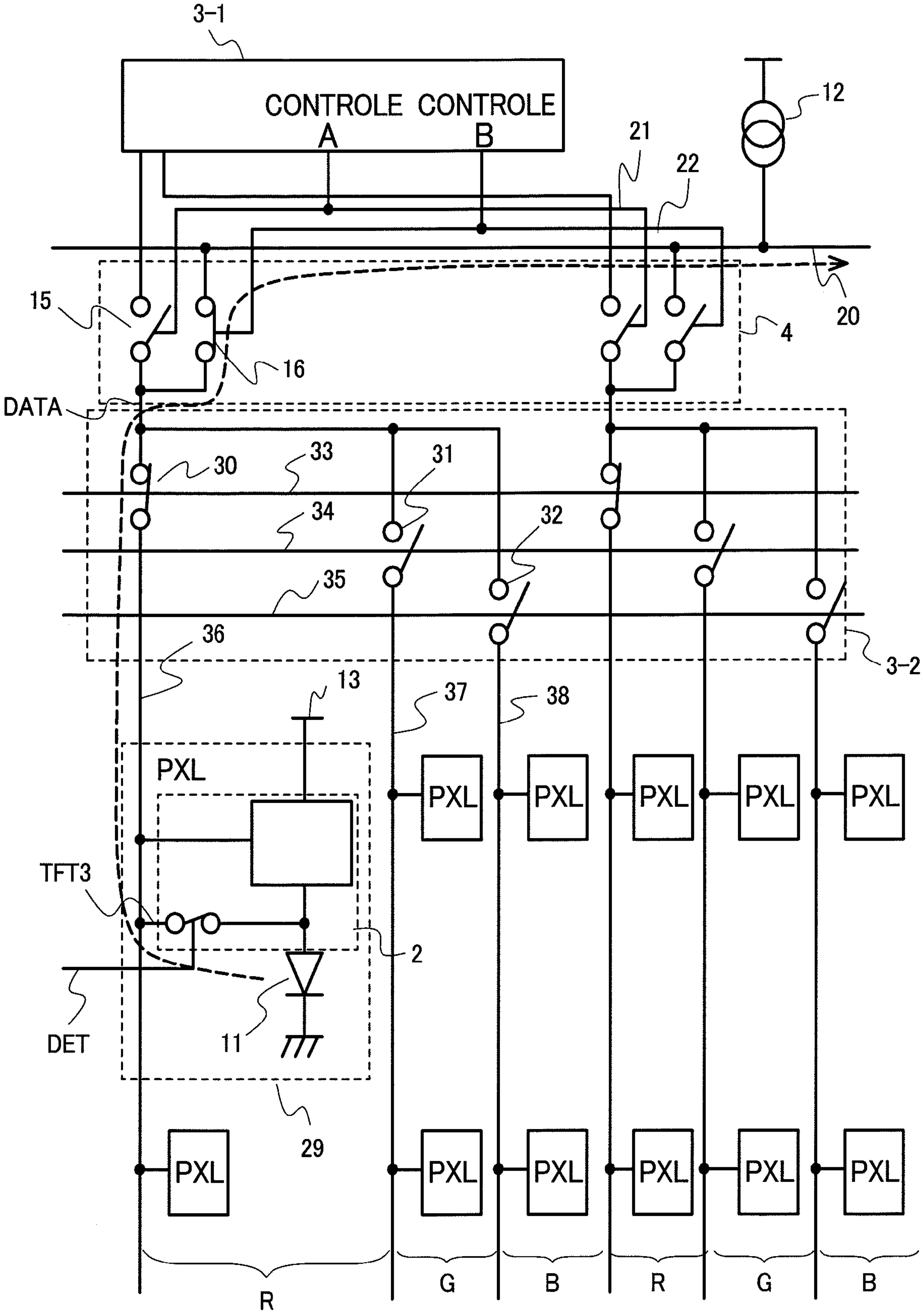

3-1
CONTROLE
A
CONTROLE
B
12
21
22
20
15
16
4
DATA
30
33
31
34
32
35
36
13
3-2
37
38
PXL
PXL
PXL
PXL
PXL
PXL
TFT3
2
11
DET
29
PXL
PXL
PXL
PXL
PXL
PXL
R
G
B
R
G
B

FIG. 7



3-1
CONTROLE A
CONTROLE B
12
21
22
15
16
4
20
DATA
30
33
31
34
32
35
36
3-2
13
37
38
PXL
TFT3
2
DET
11
29
R
G
B
R
G
B

FIG. 8

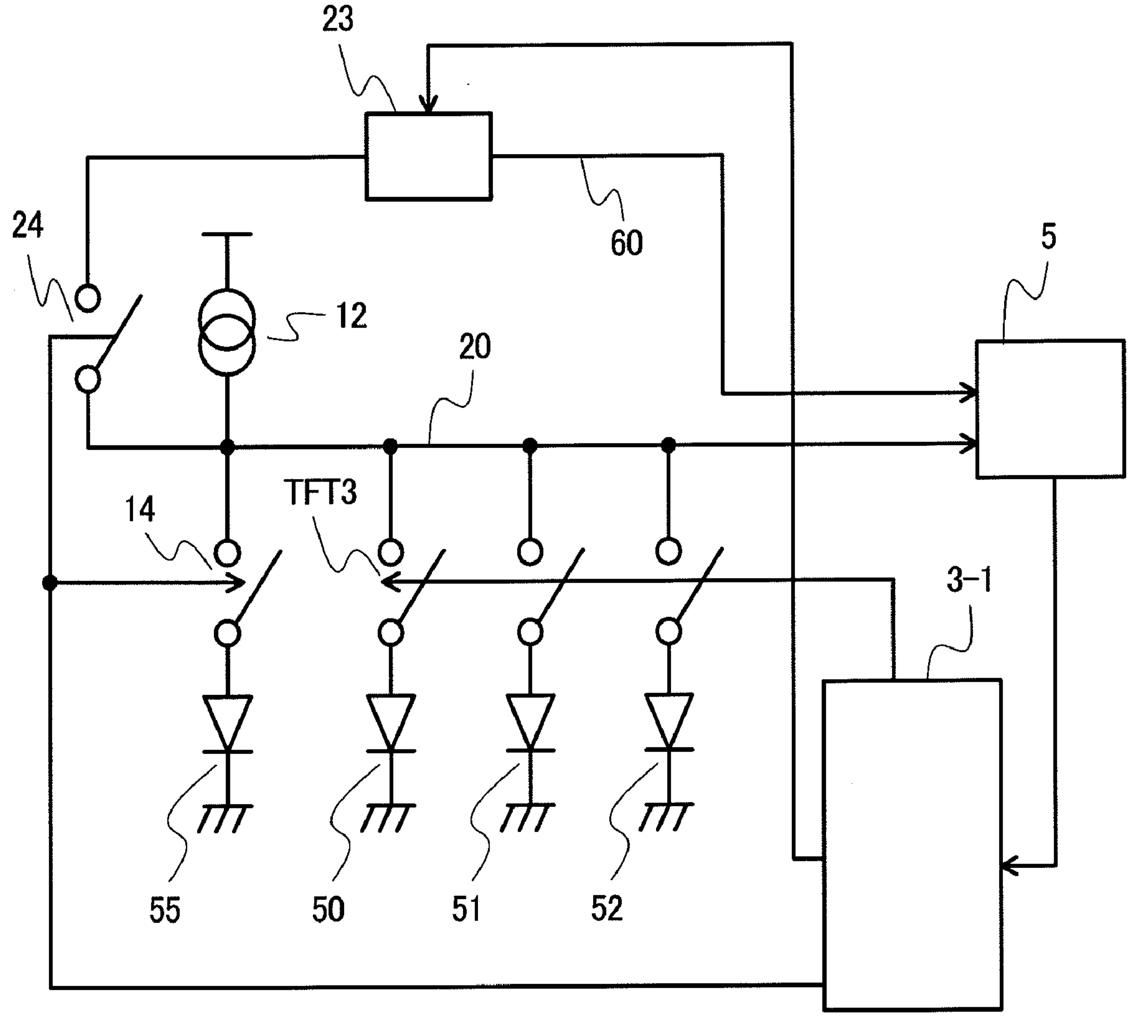


FIG. 9

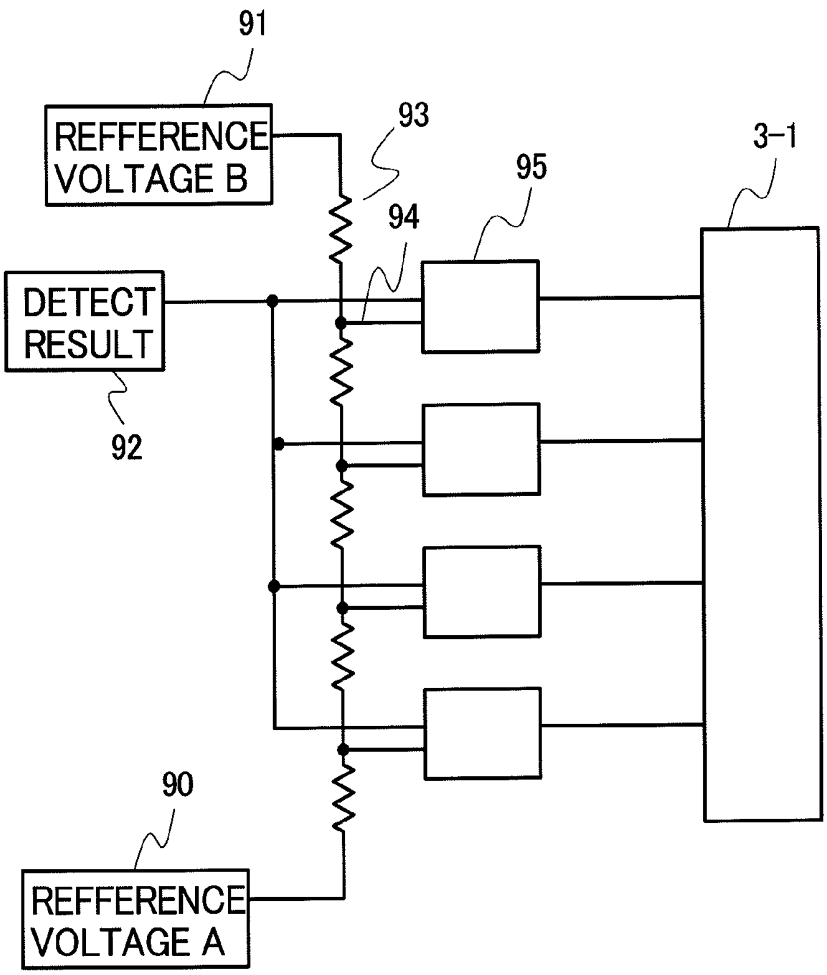

91
REFFERENCE VOLTAGE B
93
95
3-1
94
DETECT RESULT
92
90
REFFERENCE VOLTAGE A

FIG. 10

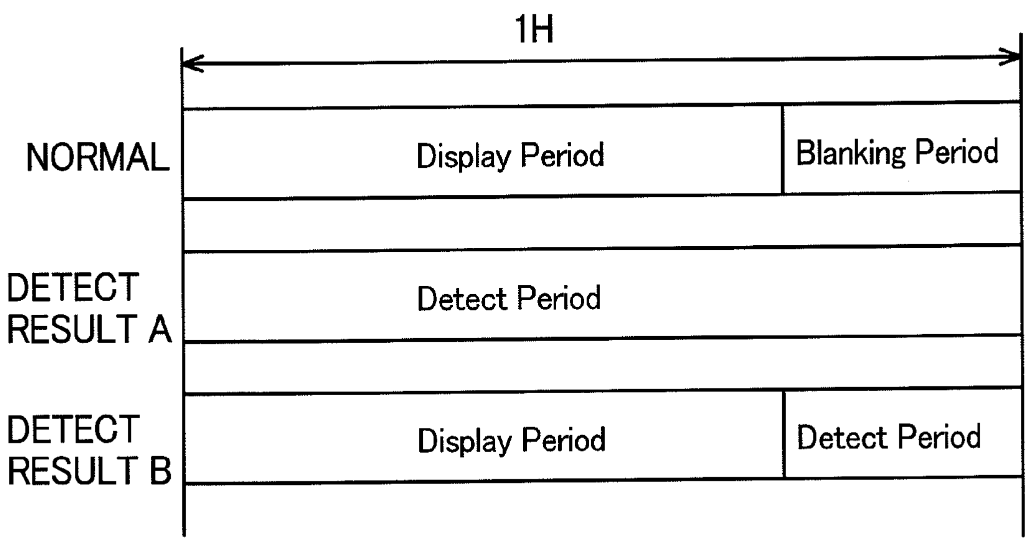

1H
NORMAL
Display Period
Blanking Period
DETECT RESULT A
Detect Period
DETECT RESULT B
Display Period
Detect Period

FIG. 11

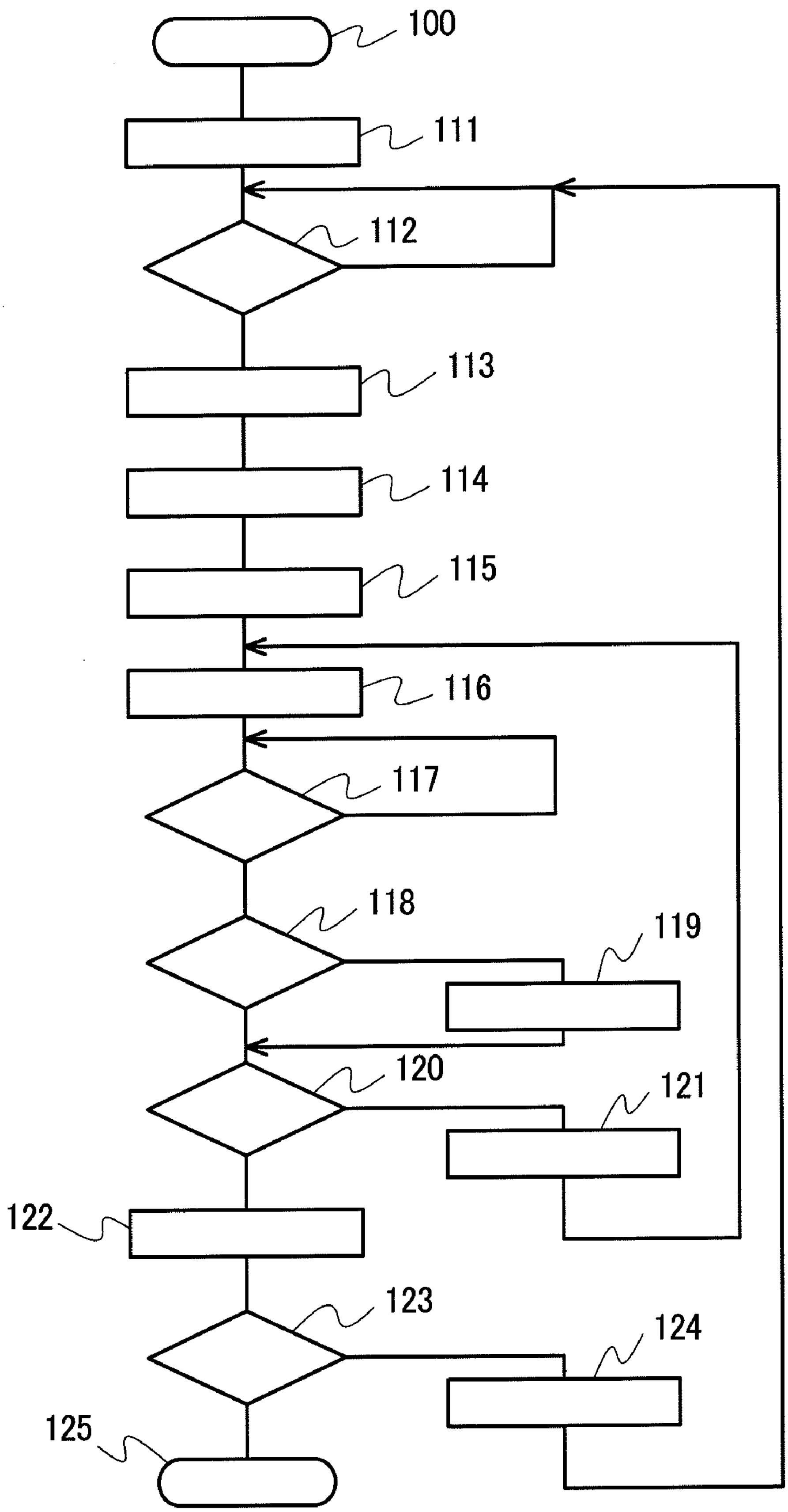


FIG. 12

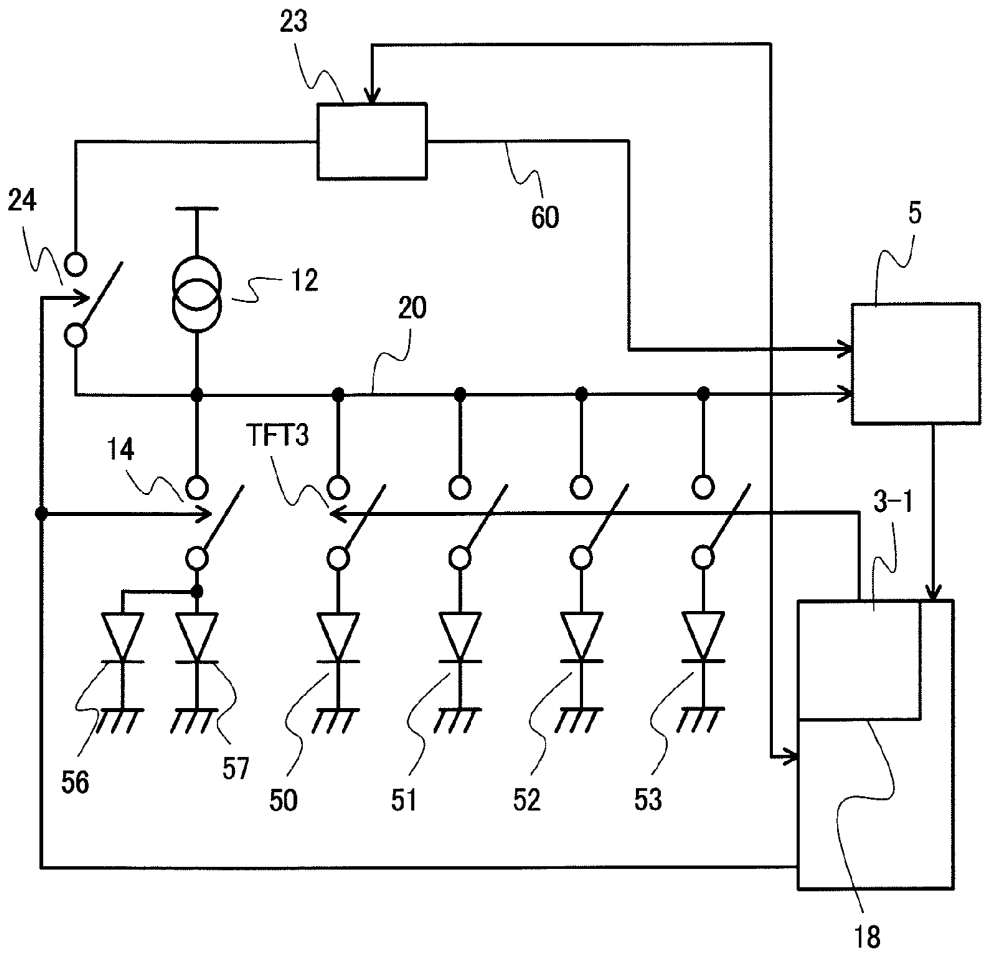

23
60
24
12
5
20
14
TFT3
3-1
56
57
50
51
52
53
18

FIG. 13

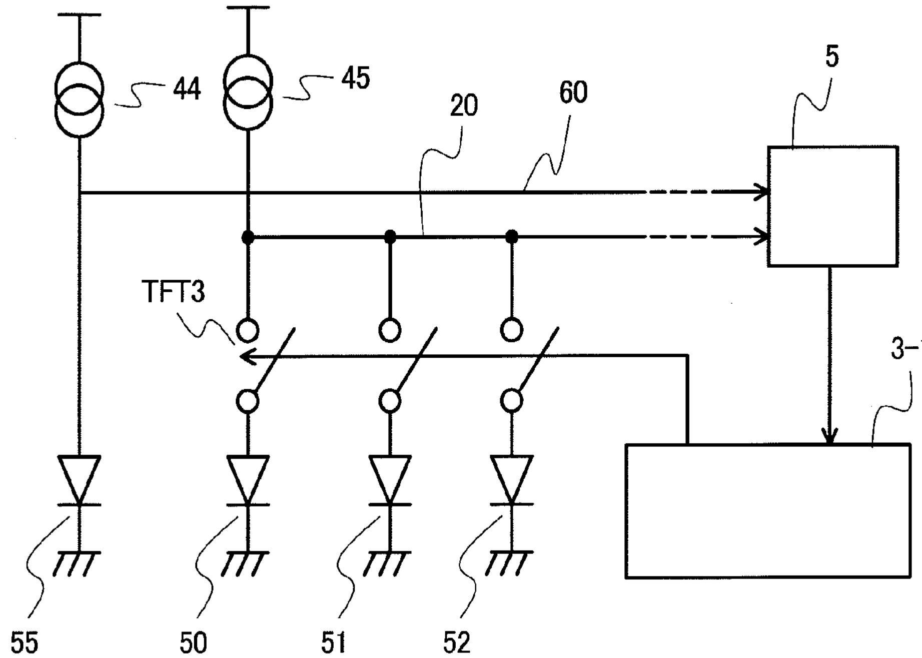

44
45
5
20
60
TFT3
3-1
55
50
51
52

FIG. 14

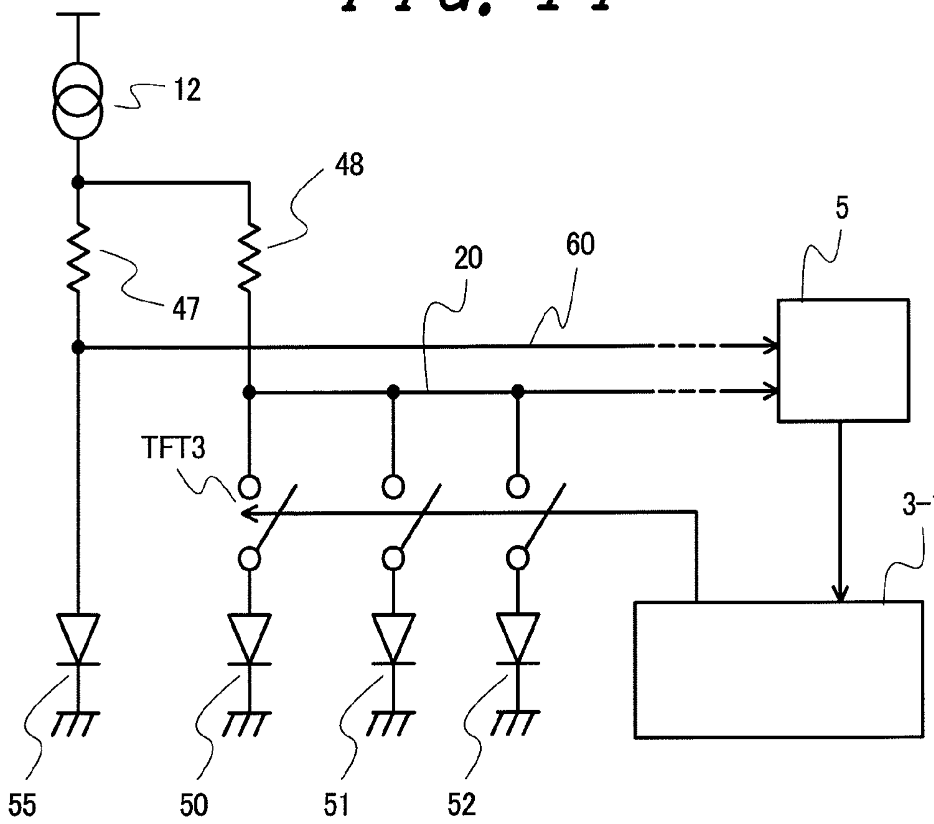



FIG. 15

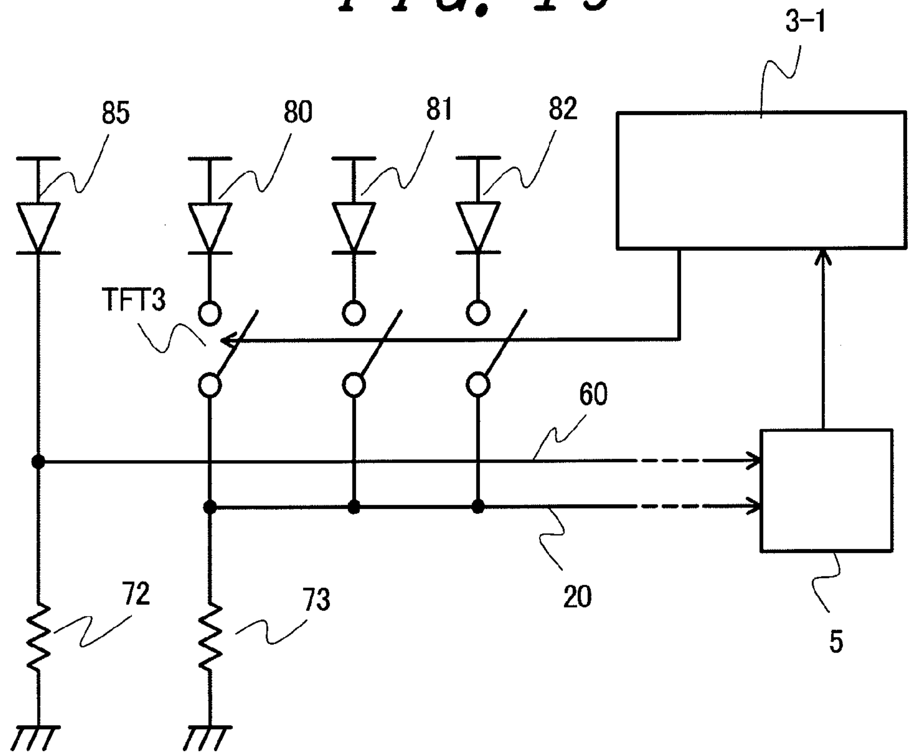


FIG. 16

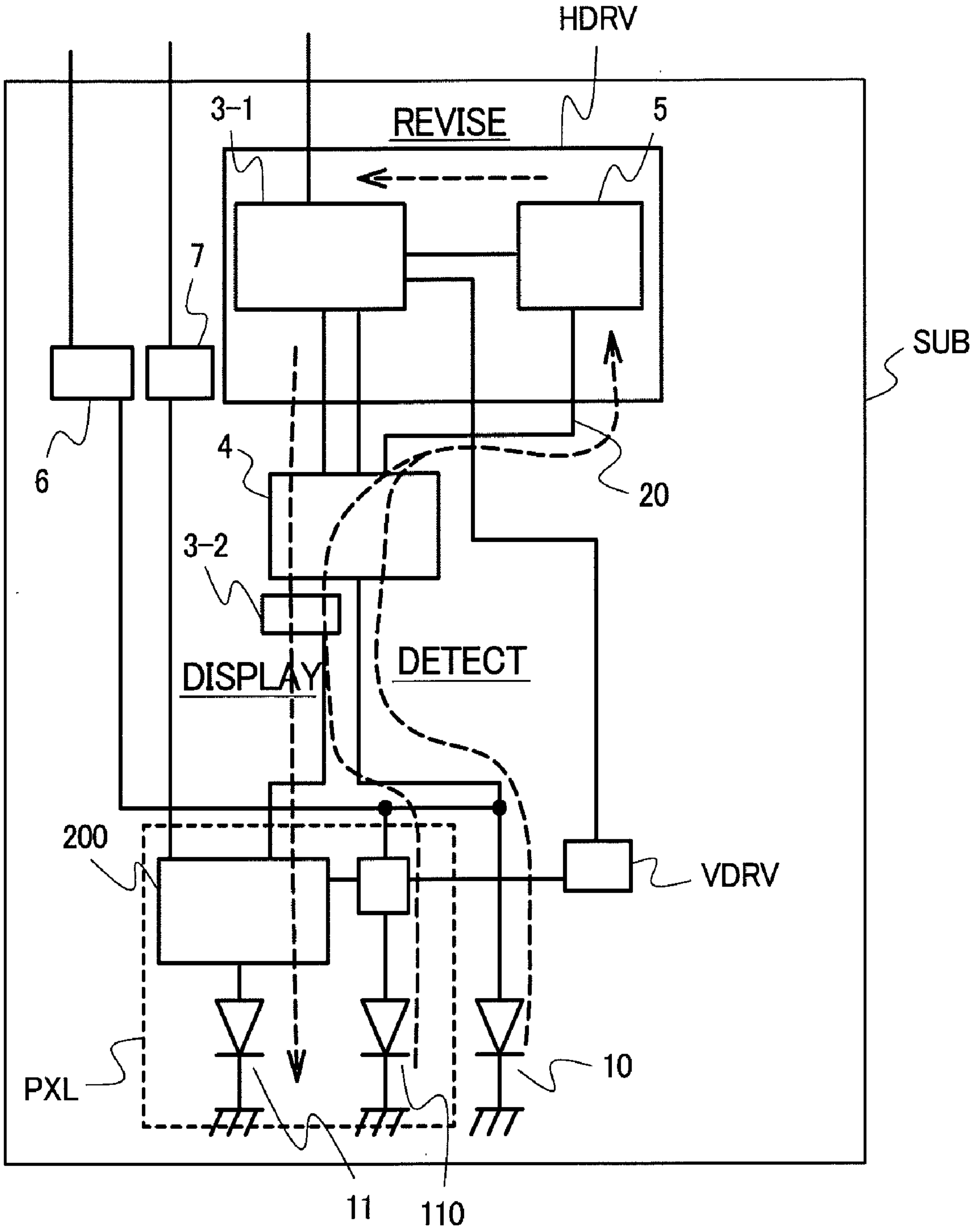

HDRV
3-1
REVISE
5
7
SUB
6
4
20
3-2
DISPLAY
DETECT
200
VDRV
PXL
10
11
110

FIG. 17

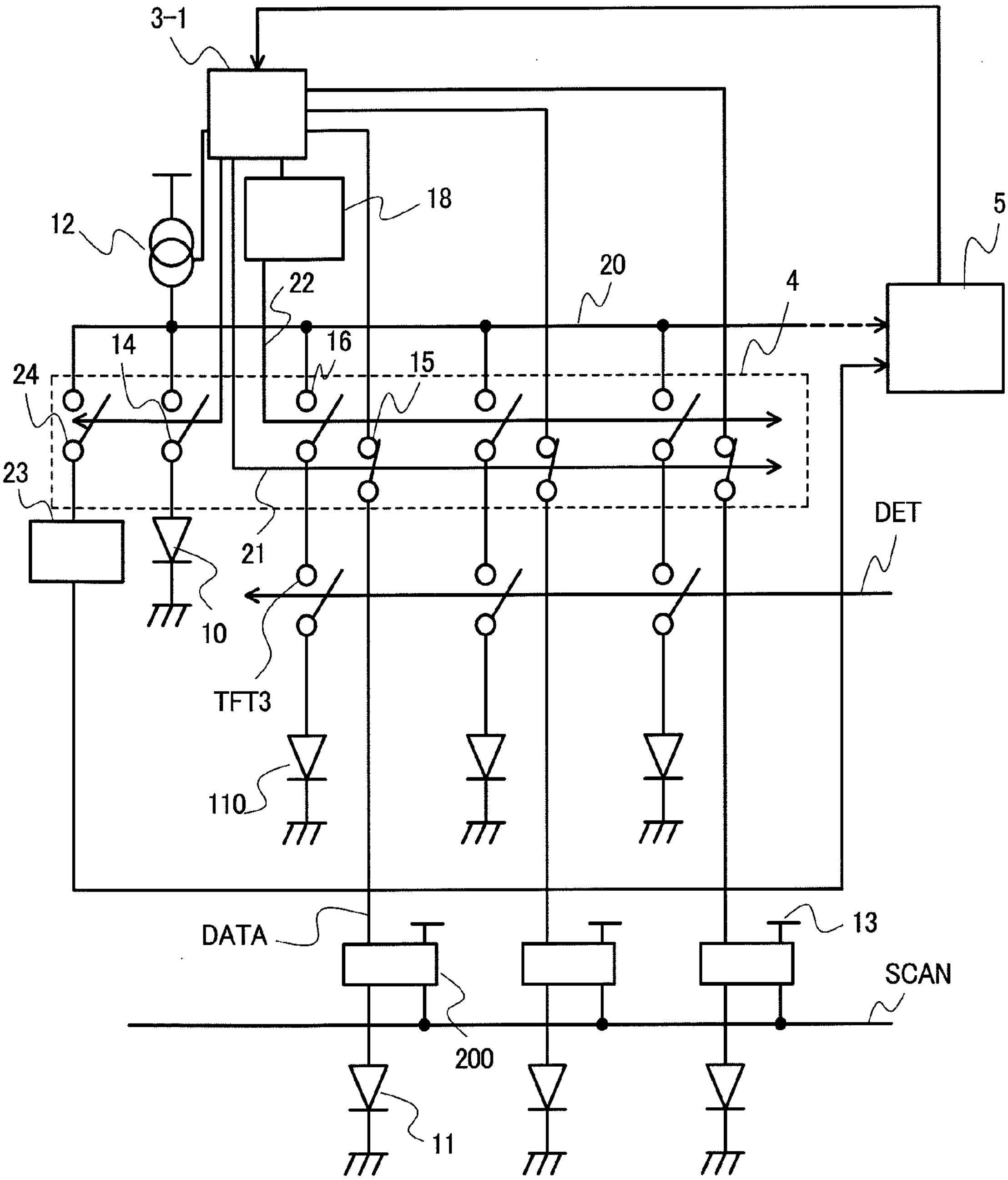
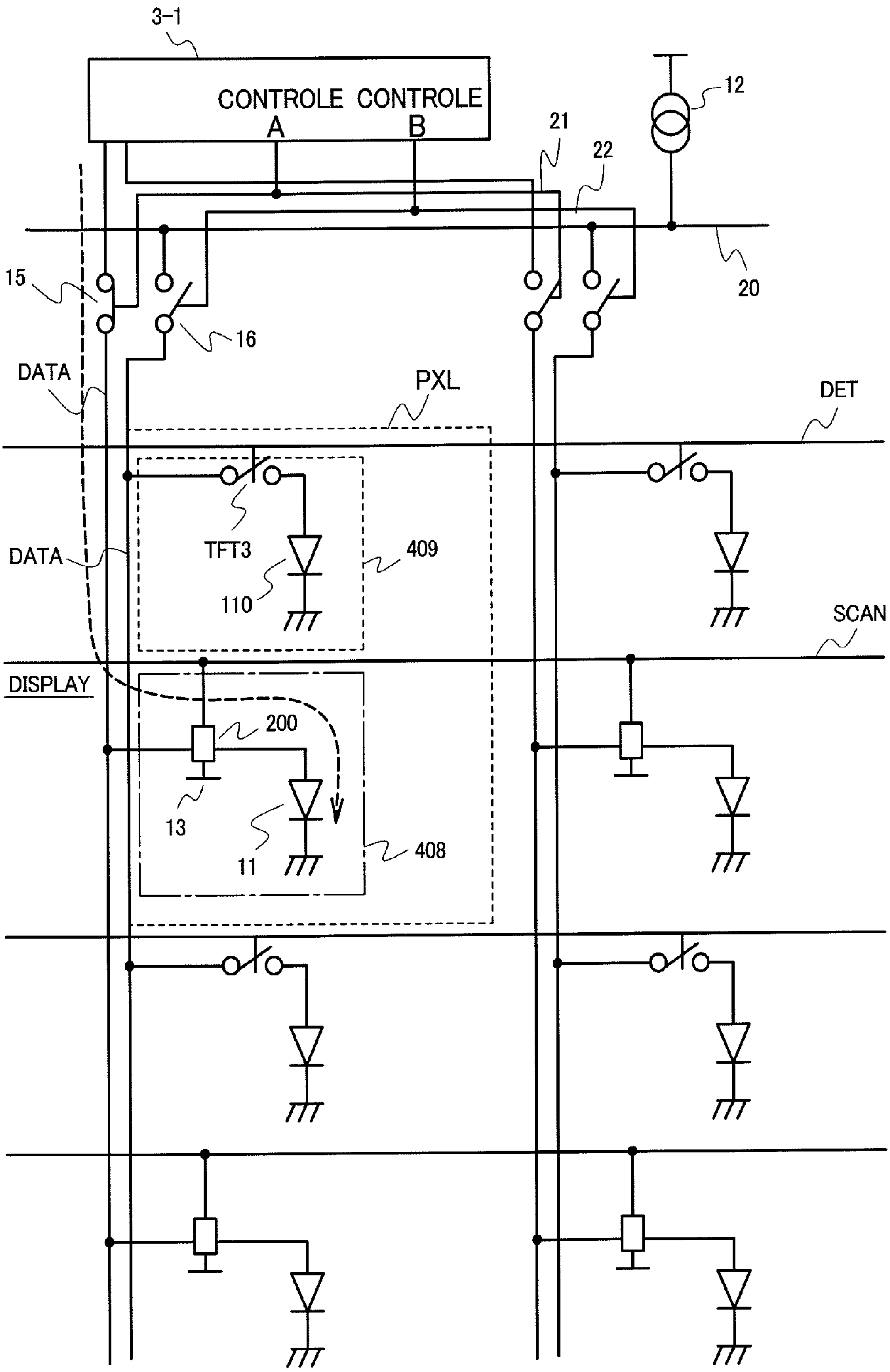

3-1
18
12
5
20
4
22
16
15
14
24
23
21
DET
10
TFT3
110
DATA
13
SCAN
200
11

FIG. 18



3-1
CONTROLE A
CONTROLE B
21
22
12
20
15
16
DATA
PXL
DET
DATA
TFT3
409
110
SCAN
DISPLAY
200
13
11
408

FIG. 19

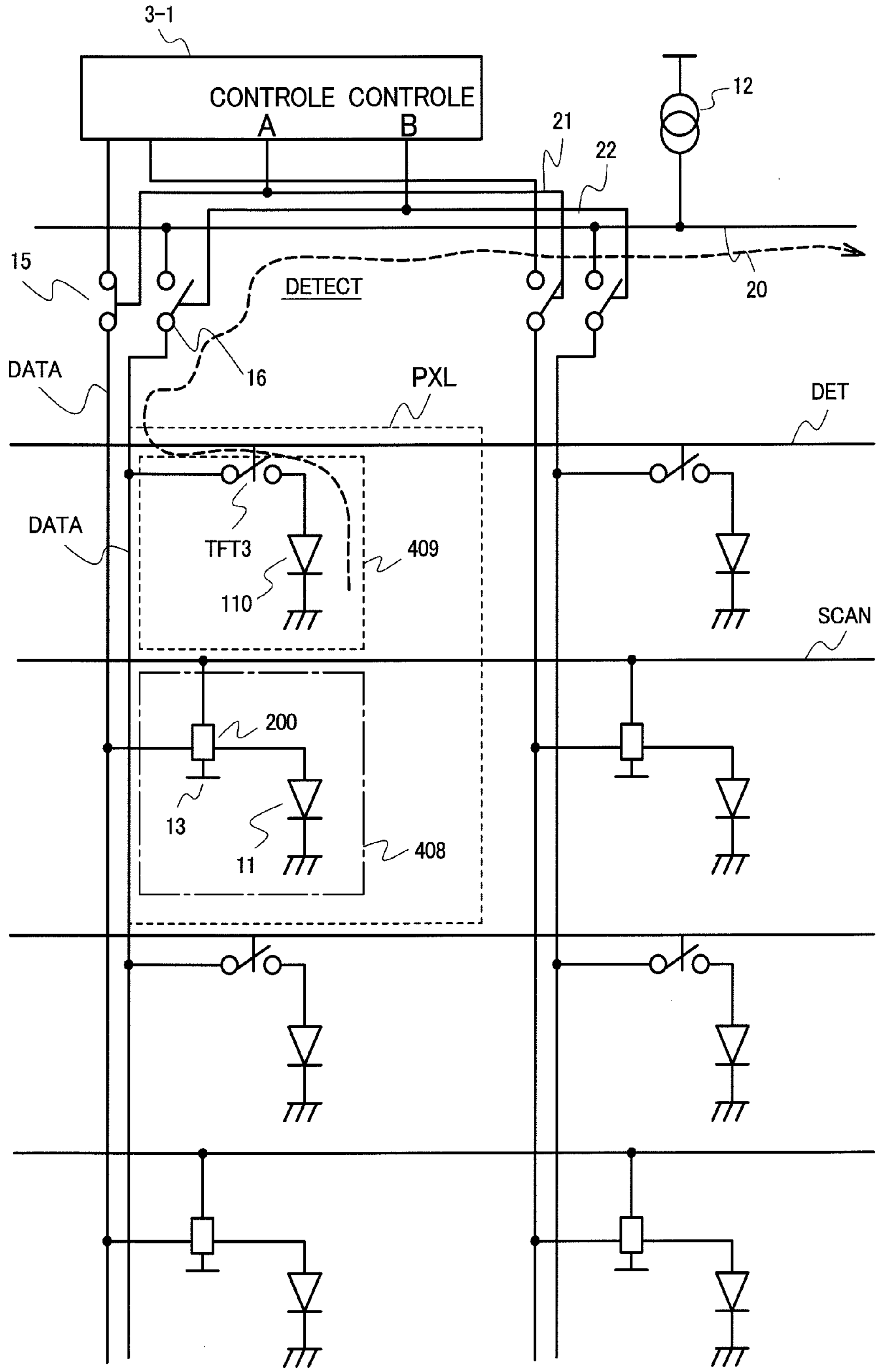

3-1
CONTROLE A
CONTROLE B
12
21
22
15
DETECT
20
16
DATA
PXL
DET
DATA
TFT3
409
110
SCAN
200
13
11
408

FIG. 20

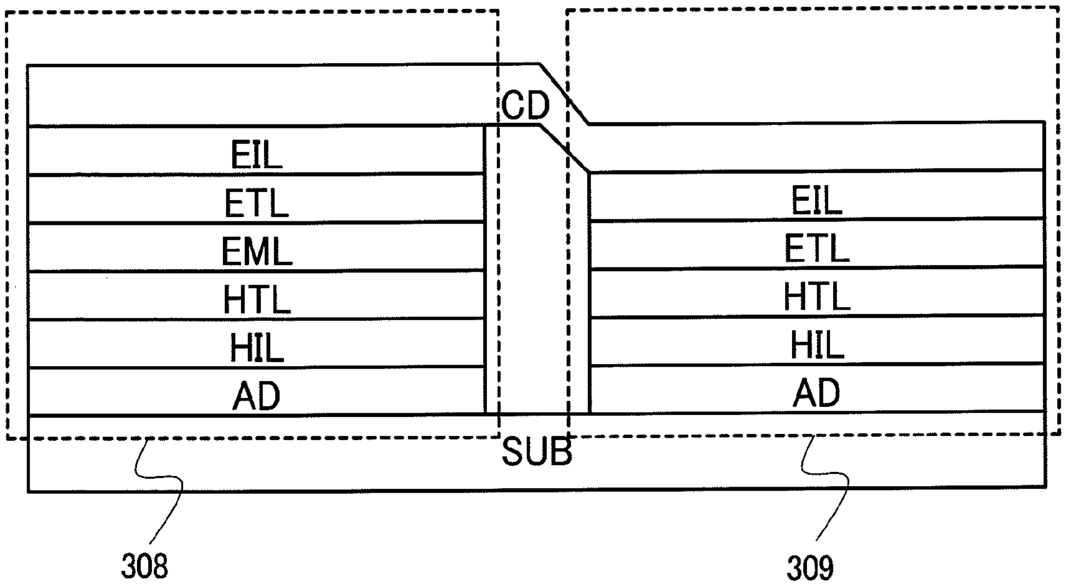

CD
EIL
ETL
EML
HTL
HIL
AD
EIL
ETL
HTL
HIL
AD
SUB
308
309

FIG. 21

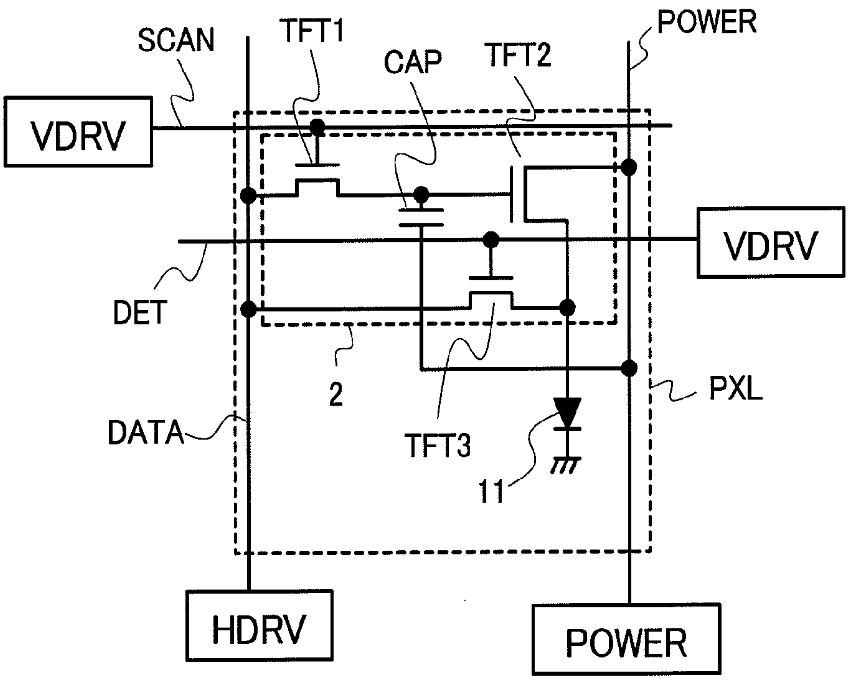

SCAN
TFT1
CAP
TFT2
POWER
VDRV
VDRV
DET
2
PXL
DATA
TFT3
11
HDRV
POWER

FIG. 22

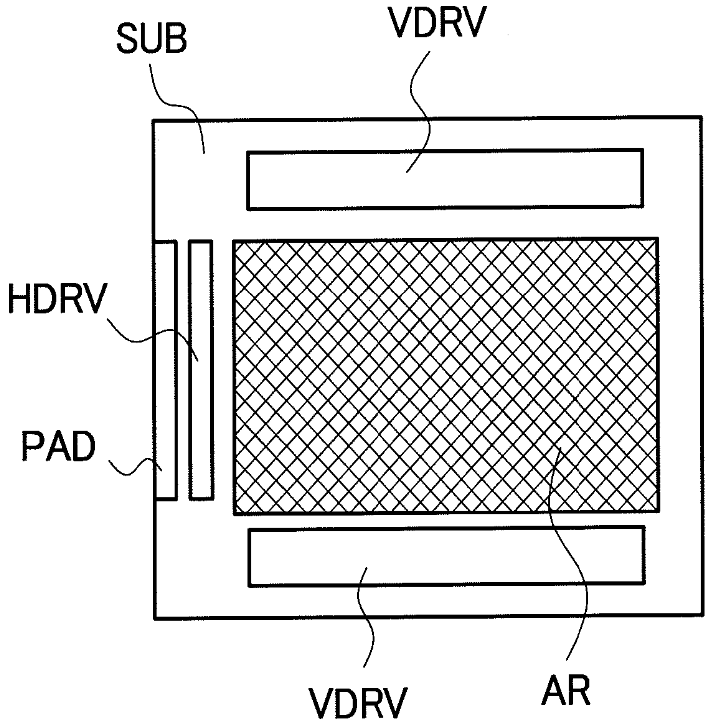
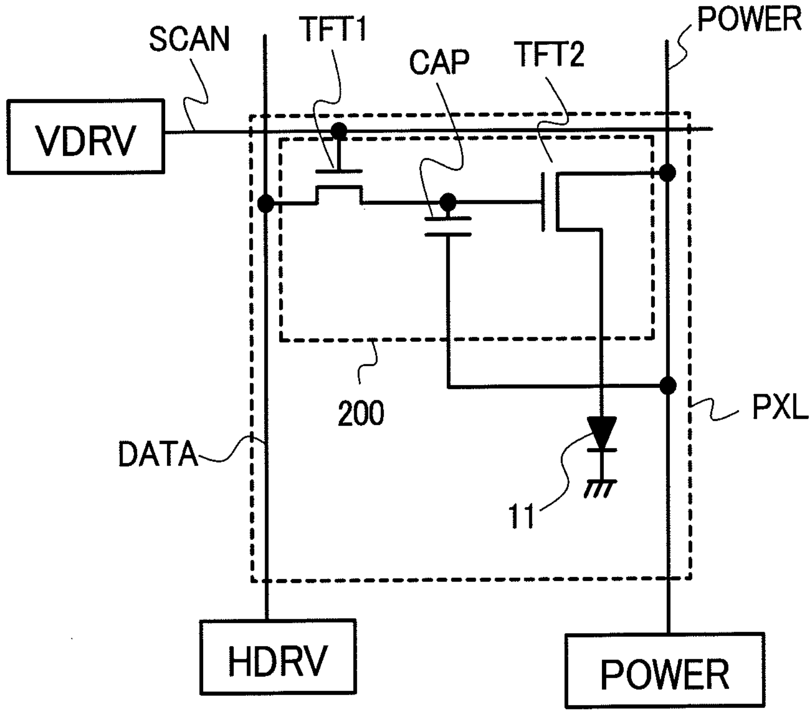

SUB
VDRV
HDRV
PAD
VDRV
AR

FIG. 23


SCAN
TFT1
CAP
TFT2
POWER
VDRV
200
PXL
DATA
11
HDRV
POWER

# ORGANIC EL DISPLAY DEVICE

## CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The disclosure of Japanese Patent Application No. 2007-068695 filed on 2007/Mar./16 (yyyy/mm/dd) including the claims, the specification, the drawings and the abstract is incorporated herein by reference in its entirety.

## BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to an organic EL display device including light receiving elements, and more particularly to an organic EL display device in which a light receiving element is constituted of an organic thin film element.

[0004] 2. Description of the Related Art

[0005] Patent document 1 (JP-A-11-75115) discloses a conventional technique relating to an organic EL display device in which a light receiving element is constituted of an organic thin film element.

[0006] The patent document 1 discloses the structure in which first organic thin film elements are vertically arranged parallel to each other in the planar direction, a second organic thin film element having the same stacked structure as the first organic thin film element is arranged between the first organic thin film elements, and the first organic thin film elements and the second organic thin film element are respectively connected to signal lines different from each other.

[0007] The display device described in patent document 1 is configured to be controlled in three modes, that is, a mode which uses both of the first organic thin film elements and the second organic thin film element as a light emitting element, a mode which uses one of the first organic thin film elements and the second organic thin film element as a light receiving element and uses another as a light emitting element, and a mode which uses both of the first organic thin film elements and the second organic thin film element as a light receiving element.

## SUMMARY OF THE INVENTION

[0008] In the patent document 1, a pixel circuit is configured such that a so-called drive TFT is arranged between a power source line and an organic thin film element. By outputting an electromotive force generated due to the photoelectric conversion of the organic thin film element to the outside of a display region using the power source line, a magnitude of the electromotive force is detected outside the display region. When the power source line is used as a detection path for detecting the electromotive force as described above, a load capacitance is increased thus lowering the detection accuracy.

[0009] Although the patent document 1 also discloses the structure in which the power source line also functions as a detection signal line, such structure makes a light emission control difficult.

[0010] Further, it is substantially impossible to design the structure which can suppress a voltage drop of the power source line by allowing the power source line to be used in common by a plurality of lines. This is because that, when the power source line is used in common by all lines, the parasitic capacitance corresponding to all lines, that is, the parasitic capacitance several hundred times as large as the parasitic capacitance corresponding to 1 line is generated.

[0011] Accordingly, the first object of the present invention is to provide an organic EL display device which can increase external light detection accuracy.

[0012] Further, in patent document 1, the first organic thin film element and the second organic thin film element have the same layered structure. In using the first organic thin film element as the light emitting element and the second organic thin film element as the light receiving element, materials and layer thicknesses preferable to the respective elements completely differ from each other. Accordingly, in case of patent document 1 where the first organic thin film element and the second organic thin film element have the same layered structure, in display, there exists the possibility that either one of the light emission characteristic and the light reception characteristic is sacrificed. For example, when the light emission characteristic is sacrificed as a result of enhancing the light reception characteristic, a lifetime of the organic EL display device is shortened.

[0013] It is another object of the present invention to provide an organic EL display device which can realize both of the enhancement of the light emission characteristic and the light reception characteristic.

[0014] As means for achieving the above-mentioned first object, the present invention provides following modes.

(First Means)

[0015] In an organic EL display device which includes a first switch for controlling a quantity of electric current which flows between a power source line and an organic thin film element in response to a gray scale signal from a signal line, the organic EL display device includes a second switch which is controlled to connect the signal line and the organic thin film element during a period in which the gray scale signal is not supplied to the signal line.

(Second Means)

[0016] In an organic EL display device which includes a switch for controlling a quantity of electric current which flows between a power source line and an organic thin film element in response to a gray scale signal from a signal line, the gray scale signal is supplied to the signal line from a drive circuit during a first period, and a voltage corresponding to an external light which is generated by the organic thin film element is supplied to the signal line during a second period different from the first period.

[0017] As means for achieving the above-mentioned another object, the present invention provides following modes.

(Third Means)

[0018] The layered structure of an organic layer which constitutes a light emitting element and the layered structure of an organic layer which constitutes a light receiving element are made different from each other.

(Fourth Means)

[0019] The light emitting element and the light receiving element include an organic layer, and the organic layer of the light receiving element is made of a material which does not emit light with a natural light.

[0020] By adopting either one of the third means and the fourth means, it is possible to provide an organic EL display device which exhibits both of high light emitting efficiency and high light receiving efficiency.

**[0021]** Not only by simply making the layered structure of the light emitting element and the layered structure of the light receiving element different from each other but also by using a portion of the organic layer which constitutes the light emitting element as a portion of the light receiving element, the light receiving element can be simultaneously formed in a portion of the manufacturing process of the light emitting element thus realizing the efficient manufacture of the organic EL display device.

**[0022]** According to the present invention, it is possible to provide the organic EL display device with high detection accuracy.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0023]** FIG. **1** is a schematic view of energy levels of organic thin film elements at a dark place;

**[0024]** FIG. **2** is a view showing behaviors of holes **206** and electrons **207** when an external light (a light radiated from the outside of the substrate, that is, from the outside of an organic EL display device) is radiated to the organic thin film element;

**[0025]** FIG. **3** is a view showing a detection result of a current/voltage characteristic of the organic thin film element;

**[0026]** FIG. **4** is a view showing the basic constitution of a display panel of an embodiment 1;

**[0027]** FIG. **5** is a view showing the further detailed system constitution of the display panel shown in FIG. **4**;

**[0028]** FIG. **6** is a constitutional view of a panel system showing a signal path between a display element and another system in a display mode;

**[0029]** FIG. **7** is a constitutional view of a panel system showing a signal path between a display element and another system in a detection mode;

**[0030]** FIG. **8** is a constitutional view of a panel system which also includes a reference element **10**;

**[0031]** FIG. **9** is a constitutional example of a detection circuit **5**;

**[0032]** FIG. **10** is a detection timing chart;

**[0033]** FIG. **11** is a flowchart of a detection flow of a display control part **3-1** and a detection circuit **5**;

**[0034]** FIG. **12** is a view showing one constitutional example relating to the reference element, the detection line and the display element;

**[0035]** FIG. **13** is a view showing one constitutional example relating to the reference element, the detection line and the display element;

**[0036]** FIG. **14** is a view showing one constitutional example relating to the reference element, the detection line and the display element;

**[0037]** FIG. **15** is a view showing one constitutional example relating to the reference element, the detection line and the display element;

**[0038]** FIG. **16** is a basic constitutional view of a display panel in which one pixel is formed by using a light receiving element and a light emitting element as a set;

**[0039]** FIG. **17** is a view showing one example of the system constitution of the display panel shown in FIG. **16**;

**[0040]** FIG. **18** is a view showing a constitutional example of a periphery of a signal line DATA;

**[0041]** FIG. **19** is a view showing a constitutional example of the periphery of the signal line DATA;

**[0042]** FIG. **20** is a view showing the layered structure of the organic thin film element;

**[0043]** FIG. **21** is a view showing an equivalent circuit of a pixel circuit of a display pixel;

**[0044]** FIG. **22** is a view showing the basic constitution of the display panel; and

**[0045]** FIG. **23** is a view showing the constitution of the pixel circuit controlling a light emitting of the display element **11**.

## DETAILED DESCRIPTION OF THE INVENTION

**[0046]** First of all, a light detection mechanism used in the present invention is explained. Although the explanation is made hereinafter on the premise of an organic thin film element of a so-called bottom-emission-type or top-cathode-type active organic EL display device, the present invention is not limited to such an organic thin film element.

**[0047]** The structure which becomes a premise of this embodiment includes a pixel electrode (an anode **204**) made of ITO which is connected to an active element on a substrate. Further, on the anode **204**, a hole injection layer **201**, a light emitting layer **202**, an electron transport layer **203**, and an aluminum counter electrode (cathode **205**) are sequentially stacked.

**[0048]** FIG. **1** is a schematic view showing an energy level of the organic thin film element in a dark place. By applying a voltage between the anode **204** and the cathode **205** of the organic thin film element, holes **206** are injected into the hole injection layer **201** from the anode **204**, and electrons **207** are injected into the electron transport layer **203** from the cathode **205**. The holes **206** are transported to the light emitting layer **202** through a highest occupied trajectory **208** of each layer, while the electrons **207** are transported to the light emitting layer **202** through a lowest empty trajectory **209** of each layer. In such a transport step, when a trap level **210** is present in the hole injection layer **201** and the electron transport layer **203**, the holes **206** and the electrons **207** are trapped so that a quantity of electric current which flows in the whole element is lowered. Although the trap level **210** is generated, in general, due to impurities such as decomposed materials, a similar phenomenon can be observed by intentionally mixing trapping-property molecules in the organic layer.

**[0049]** FIG. **2** shows behaviors of the holes **206** and the electrons **207** when an external light (a light radiated from the outside of the substrate, that is, from the outside of the organic EL display device) is radiated to the organic thin film element. When the external light is radiated to the organic thin film element, the holes **206** and the electrons **207** trapped at the trap level **210** respectively transit to the highest occupied trajectory **208** of the hole injection layer **201** and the lowest empty trajectory **209** of the electron transport layer **203**. This is because that the holes **206** and the electrons **207** acquire, due to the radiation of the external light, the energy larger than the energy difference between the highest occupied trajectory **208** of the hole injection layer **201** and the trap level **210** or the energy difference between the lowest empty trajectory **209** of the electron transport layer **203** and the trap level **210**.

**[0050]** FIG. **3** shows a detection result of a current/voltage characteristic of the organic thin film element. The detection result indicated by "NO LIGHT" is a detection result (current/voltage characteristic) in a dark place. The detection result indicated by "LIGHT" is a detection result (current/voltage characteristic) when the external light is radiated. As can be understood from the drawing, when the external light is radiated, a large quantity of electric current is detected. That is, it is found that the organic thin film element of the organic EL display device possesses a photoelectric conversion function attributed to the external light.

**[0051]** In FIG. **1** to FIG. **3**, the explanation is made by taking the case in which the hole injection layer **201**, the light emitting layer **202**, the electron transport layer **203**, and the anode **205** are stacked on the anode **204** as an example. However, as a result of an experiment, it is found that the substantially equal advantageous effect is obtainable provided that the organic thin film element includes at least one layer which has the trap level **210** between the anode **204** and the cathode **205**. Hereinafter, the explanation is made with respect to an embodiment of an organic EL display device exhibiting the detection accuracy higher than the detection accuracy of the display device disclosed in patent document 1 from such an experimental result.

**[0052]** Before explaining the embodiment 1, the basic constitution of the display panel applied to an active-matrix-type organic EL display device which becomes the premise of the embodiment 1 is explained.

**[0053]** FIG. **22** shows the basic constitution of the display panel. On a glass substrate SUB, a signal line drive circuit HDRV, a scanning line drive circuit VDRV, an effective display region AR, and an external connection terminal PAD are formed.

**[0054]** The signal line drive circuit HDRV is constituted of a semiconductor IC chip referred to as a driver IC in general, and is mounted between the effective display region AR and the external connection terminal PAD arranged on one side of the glass substrate SUB**1** by COG (Chip on Glass) mounting. The scanning line drive circuit VDRV is a circuit constituted of a low-temperature poly-silicon layer and metal lines, and is arranged on two sides of the glass substrate SUB**1** which sandwich one side of the glass substrate SUB**1** on which the signal line drive circuit HDRV is arranged. Display pixels PXL are arranged in the effective display region AR. Further, although a reference pixel is not shown in the drawing, the reference pixel is arranged in a light blocking region outside the effective display region AR.

**[0055]** FIG. **21** shows an equivalent circuit of the display pixel PXL. The pixel PXL includes a display element **11** which functions as a light emitting/receiving element, a signal line DATA to which a gray-scale signal or a detection voltage is supplied, a scanning line SCAN to which a control signal is supplied, a power source line POWER to which an electric current is supplied, a detection control line DET to which a control signal is supplied, a data latch switch TFT**1** connected to the signal line DATA and one terminal of a capacitor CAP and controlled by the control signal of the scanning line SCAN, the capacitor CAP having one terminal thereof electrically connected to the data latch switch TFT**1** and another terminal thereof connected to the power source line POWER, a drive switch TFT**2** connected to one terminal of the capacitor CAP and controlled with a potential of the capacitor CAP, the display element **11** electrically connected to the power source line POWER via the drive switch TFT**2**, and a pixel detection switch TFT**3** electrically connected between the display element **11** and the signal line DATA. The pixel circuit **2** is constituted of the data latch switch TFT**1**, the capacitor CAP, the drive switch TFT**2**, and the pixel detection switch TFT**3**. The data latch switch TFT**1**, the drive switch TFT**2**, and the pixel detection switch TFT**3** are respectively formed of a thin film transistor made of low-temperature poly-silicon.

**[0056]** The pixel circuit **2** is driven as follows. In a display mode, the data latch switch TFT**1** is turned on in response to a control signal supplied to the scanning line SCAN from the scanning line drive circuit VDRV, and fetches the gray-scale signal from the signal line DATA. The capacitor CAP holds a potential difference (the potential difference between a potential of the gray-scale signal and a potential of the power source line POWER) corresponding to the fetched gray-scale signal. The drive switch TFT**2** is controlled to supply a quantity of electric current corresponding to a voltage including the holding potential difference to the display element **11** from the power source line POWER. Next, in a detection mode, a control signal is supplied to the detection control line DET connected to the control terminal of the pixel detection switch TFT**3**, and a voltage generated in the display element **11** is supplied to the signal line DATA at the timing that a gray-scale signal is not supplied to the signal line DATA. In the display mode, a potential of a display-use power source (voltage) **7** is supplied to the power source line POWER. In the detection mode, a detection-use power source (current) **6** is connected to the data line DATA.

**[0057]** As described above, in the display mode, in each pixel, the gray-scale signal is supplied to the signal line via the data latch switch TFT**1** and the capacitor CAP for controlling the drive switch TFT**2**. Further, due to the control of the drive switch TFT**2**, a quantity of electric current corresponding to the gray-scale signal is supplied to the display element **11** from the power source line POWER.

**[0058]** Further, in the detection mode, the pixel detection switch TFT**3** arranged between the signal line DATA and the power source line POWER is controlled to connect a line which electrically connects the power source line POWER and the display element **1** with the signal line DATA in a period that the gray-scale signal is not supplied to the signal line DATA. Accordingly, a voltage corresponding to an external light is outputted to the signal line DATA from the display element **11** via the pixel detection switch TFT**3**. Further, the detection circuit **5** is mounted on the driver IC and hence, the detection circuit **5** is connected to the signal line DATA and the signal line drive circuit HDRV using lines different from the signal line DATA and, further, the detection circuit **5** is connected to a terminal of the signal line drive circuit HDRV different from the terminal of the signal line drive circuit HDRV to which the signal line DATA is connected.

## EMBODIMENT 1

**[0059]** FIG. **4** shows the basic constitution of a display panel of the embodiment 1. The display panel of the embodiment 1 includes a pixel circuit **2**, a display control part **3-1**, a color selection circuit **3-2**, a detection switch **4**, the detection circuit **5**, a detection-use power source **6**, a display-use power source **7**, a reference element **10**, a display element **11**, and the scanning line drive circuit VDRV.

**[0060]** The display control part **3-1**, the detection circuit **5** and the detection-use power source **6** are incorporated in the signal line drive circuit HDRV shown in FIG. **22**.

**[0061]** A first terminal of the signal line drive circuit HDRV is directly connected to the detection switch **4**, and a second terminal which differs from the first terminal is connected to the detection switch **4** via the detection circuit **5**.

**[0062]** The pixel circuit **2** is, as described above, connected to the signal line DATA, the scanning line SCAN, the power source line POWER, and the detection control line DET. The signal line DATA is connected to the first terminal of the signal line drive circuit HDRV and, further, is electrically connected to the display control part **3-1** in the driver IC.

**[0063]** An analog power source, a digital power source, a clock, and a video signal are inputted to the display control part **3-1** from the outside, and the display control part **3-1** outputs a gray-scale signal to the color selection circuit **3-2** via the signal line DATA in a display mode. Further, in a detection mode, when a correction signal is inputted to the display control part **3-1** from the detection circuit **5**, the display control part **3-1** corrects a gray-scale signal in response to a correction signal after the detection of the correction signal. Further, by controlling the detection-use power source **6** and the detection switch **4**, the display control part **3-1** controls the connection between the detection-use power source **6** and the power source line POWER.

**[0064]** The pixel circuit **2**, the color selection circuit **3-2**, the scanning line drive circuit VDRV, and the detection switch **4** are respectively constituted of a thin film transistor, a low-temperature poly-silicon line, a gate metal line, a source drain metal line, and an interlayer insulation film which are formed on the grass substrate SUB**1**.

**[0065]** The color selection circuit **3-2** is arranged between the effective display region AR and the signal line drive circuit HDRV shown in FIG. **22**. The color selection circuit **3-2** selects the signal line DATA of any one of colors to which the gray scale signal supplied from the display control part **3-1** is supplied. The color selection circuit **3-2** selects the detection voltage of the signal line DATA of any one of pixels to be supplied to the detection circuit **5**.

**[0066]** The detection switch **4** changes over the connection between the display control part **3-1** and the pixel circuit **2** and the connection between the detection circuit **5** and the pixel circuit **2**. Such changeover is performed by the display control part **3-1**.

**[0067]** The detection circuit **5** detects a magnitude of a voltage supplied to the detection circuit **5** due to the connection between the detection circuit **5** and the pixel circuit **2** by the detection switch **4**, generates a correction signal based on the detection result, and supplies the correction signal to the display control part **3**.

**[0068]** The detection-use power source **6** is a power source for supplying a drive current to the pixel circuit **2** at the time of detection, and the light-emitting-use power source **7** is a power source for supplying a drive current to the pixel circuit **2** at the time of light emission.

**[0069]** Next, the manner of operation of the display panel shown in FIG. **4** is explained. A path of a signal is roughly classified into three paths, that is, a display path DISPLAY, a detection path DETECT, and a correction path REVISE. These paths are sequentially changed with time. Here, in this specification, a behavior which reflects a light detection result in a display state based on an arbitrary mode is referred to as "correction".

**[0070]** The display control part **3-1** outputs the gray-scale signal to the signal line DATA in a first display period during which display is performed. In parallel with such outputting of the gray-scale signal, the detection switch **4** is controlled to supply the gray-scale signal to the color selection circuit **3-2**. Further, the color selection circuit **3-2** is controlled to supply the gray-scale signal to the desired signal line DATA. The display control part **3-1** controls the scanning line drive circuit VDRV so as to allow the scanning line drive circuit VDRV to transmit the control signal to the scanning line SCAN of a specified pixel and turns on the data latch switch TFT**1** to allow the supply of the gray-scale signal to the pixel circuit **2** of the specified pixel. Here, the detection switch **4** cuts off the connection between the detection circuit **5** and the detection-use power source **6**. The pixel circuit **2** performs a control such that a quantity of electric current which flows in the display element **11** via the power source line POWER from the display-use power source **7** assumes a quantity of electric current corresponding to the supplied gray-scale signal. That is, a path which allows the display element **11** to emit light with a gray scale expressed by the gray-scale signal forms the path DISPLAY of the electric current and the gray-scale signal at the time of display.

**[0071]** In a blanking period which is the second period different from the first period, the detection voltage flows through two paths, that is, the detection path DETECT and the correction path REVISE. First of all, the display control part **3-1** does not supply the gray-scale signal. Then, the display control part **3-1** controls the detection switch **4** so as to electrically connect the detection circuit **5** and the detection-use power source **6** to the signal line DATA. Here, a drive current is supplied to the pixel circuit **2** from the detection-use power source **6**. Further, a voltage obtained by the photoelectric conversion in the display element **11** which is constituted of a display element which does not emit light by an external light is outputted to the detection switch **4** via the pixel detection switch TFT**3** of the pixel circuit **2** and the signal line DATA. By inputting a pulse to the detection control line DET, the pixel detection switch TFT**3** of the pixel circuit **2** is turned on, and the detection voltage supplied to the detection switch **4** is inputted into the detection circuit **5**. This path forms the detection path DETECT. Further, the reference element **10** is connected to the detection-use power source so that the detection voltage is supplied to the detection circuit **5**.

**[0072]** The detection circuit **5** generates a correction signal in response to the detection voltage and supplies the correction signal to the display control part **3-1**. The display control part **3-1** corrects the gray-scale signal in response to the inputted correction signal. This path forms the correction path REVISE.

**[0073]** As described above, the display path (DISPLAY) which is the supply path of the gray-scale signal from the display control part **3-1** to the pixel circuit **2**, the supply path (DETECT) of the detection voltage from the pixel circuit **2** to the detection circuit **4**, and the supply path (REVISE) of the correction signal from the detection circuit **4** to the display control part **3-1** use the same path on the signal line DATA in common between the detection switch **4** and the pixel circuit **2**. However, these three paths differ from each other with respect to the path from the detection switch **4** to the display control part **3-1** as well as input/output terminals toward the signal drive circuit HDRV. Further, in this embodiment, the number of power source is set to two, that is, the display-use power source (voltage) **7** and the detection-use power source (current) **6**. However, depending on the constitution of the organic EL display device, the number of power sources may be increased or decreased. Also with respect to a kind of power sources, either one of the current source and the voltage source may be selected.

**[0074]** FIG. **5** shows the system constitution of the display panel shown in FIG. **4** in more detail. The organic EL display device includes the reference element **10** which is used as the light receiving element, and the display elements **11** which are used as the light emitting element/light receiving elements. FIG. **20** shows the layered structures of these organic thin film elements. The reference element **10** is an organic thin film element having the light receiving element structure **309** shown in FIG. **20**, and the display element **11** is an organic thin film element having the light emitting/receiving element structure **308** shown in FIG. **20**.

**[0075]** The light receiving element structure **309** is constituted by forming an anode AD, a hole injection layer HIL, a hole transport layer HTL, an electron transport layer ETL, an electron injection layer EIL, and a cathode CD on the glass substrate SUB**1** in this order. The light emitting/receiving element structure **308** is constituted by forming an anode AD, a hole injection layer HIL, a hole transport layer HTL, an organic light emitting layer EML, an electron transport layer ETL, an electron injection layer EIL, and a cathode CD on the glass substrate SUB**1** in this order. As shown in FIG. **2** and FIG. **3**, the hole transport layer HTL may be omitted.

**[0076]** When the organic thin film element used only as the light receiving element and the organic thin film element used not only as the light receiving element but also as the light emitting element are formed on the same substrate in this manner, although it is preferable that these two organic thin film elements adopt the same layered structure in view of the manufacturing process, it is not always necessary for these two organic thin film elements to have the same structure and hence, the organic thin film element used only as the light receiving element may be constituted of layers completely different from layers of the organic thin film element used not only as the light receiving element but also as the light emitting element. However, for simplifying the manufacturing process, it is preferable that the organic thin film element used only as the light receiving element may adopt some of the organic layers which constitute the organic thin film element used not only as the light receiving element but also as the light emitting element. Further, even when the organic thin film element used only as the light receiving element adopts the absolutely same material layers as the organic thin film element used not only as the light receiving element but also as the light emitting element, by making film thicknesses of the material layers different from each other, it is possible to enhance the photoelectric conversion efficiencies of both light emitting element and light receiving element. Further, when the organic thin film element is used only as the light receiving element, it is preferable that the organic thin film element adopts an organic layer which does not emit light with an external light. It is especially preferable for the organic thin film element used not only as the light receiving element but also as the light emitting element to eliminate a material layer corresponding to the light emitting layer, to use a material different from the light emitting element, or to change a film thickness thereof.

**[0077]** The reference element **10** is a light receiving element used only at the time of detection, and is not used for every frame different from the display element **11**. That is, the reference element **10** is configured to detect the reference voltage in a state that a frequency of use of the reference element **10** is decreased thus suppressing the deterioration of the pixel. Further, the reference element **10** is arranged in a region where an external light is not incident.

**[0078]** The display elements **11** are arranged in the effective display region AR in a matrix array. The detection circuit **5** of this embodiment compares detection voltages of two kinds of the organic thin film elements, that is, the reference element **10** and the display element **11**, and calculates the influence attributed to an external light based on the difference between the detection voltages. Further, the detection circuit **5** transmits the calculation result of the influence to the display control part **3-1** as a correction signal, and the display control part **3-1** calculates a correction quantity of the gray-scale signal and feedbacks the correction quantity of the gray-scale signal for display. Here, although the reference element **10** is provided to the constitution shown in the drawing, depending on the detection constitution, the display element **11** may be allocated to the reference element **10** and the reference voltage may be preliminarily held without providing the reference element **10**.

**[0079]** The detection-use drive power source and the display-use drive power source are configured independently from each other. At the time of detection, a detection-use current source **12** (corresponding to the detection-use power source **6** shown in FIG. **4**) is used, while at the time of display, a display-use voltage source **13** (corresponding to the display-use power source **7** shown in FIG. **4**) is used. The detection-use current source **12** is not limited to the current source but may be also formed of a voltage source. The connection between the detection-use current source **12** and the reference element **10** is controlled by a switch **14**. The switch **14** is configured to be turned on at the time of detection in response to a control signal of the display control part **3-1**. The connection between the pixel circuit **2** and the display control part **3-1** is controlled by a switch **15**. The switch **15** is configured to be turned on at the time of display in response to a control signal of the display control part. The connection between the detection-use current source **12** and the display element **11** is controlled by a switch **16**. The switch **16** is configured to be turned on at the time of detection in response to a control signal of the display control part.

**[0080]** The switch **15** and the switch **16** correspond to the detection switch **4** shown in FIG. **4**, and there is no possibility that the switch **15** and the switch **16** are simultaneously turned on. That is, the switch **15** and the switch **16** are alternatively operated. The display control part **3-1** performs controls, detections and corrections of the respective switches and power sources. A shift register **18** which controls the switch **16** is incorporated in the display control part **3-1**. Here, although the shift register **18** may be arranged on the glass substrate SUB**1** as an independent control part, the control of the shift register **18** is performed by the display control part **3-1**. The switch **15** is controlled in response to a control signal **21** outputted from the display control part **3-1**. The switch **16** is controlled in response to a control signal **22** outputted from the display control part **3-1**. The detection-use current source **12** and the switch **14** are connected to each other via a detection line **20**.

**[0081]** The signal line DATA is a common-use line to which a gray-scale signal is supplied from the display control part **3-1** at the time of display and through which a detection voltage is applied to the detection circuit **5** at the time of detection. A holding part **23** is connected to the detection line **20** via a switch **24**. When the switch **14** and the switch **24** are turned on, the holding part **23** holds a voltage applied to the reference element **10**, and sets a value of the holding voltage as the reference voltage. The switch **14** and the switch **24** are controlled in response to a control signal outputted from the display control part **3-1**.

**[0082]** The detection circuit **5** compares a reference voltage of the holding part **23** and the detection voltage of the display element **11** supplied via the detection line **20**, generates a correction signal based on a comparison result, and outputs the correction signal to the display control part **3-1**. Since the output data of the holding part **23** is a voltage, the comparison can be performed using a comparator or the like. Further, when the voltage difference is minute, the detection voltage may be amplified by providing an amplifier to the detection circuit **5** thus increasing the detection accuracy. The display-use voltage sources **13** and the display elements **11** are connected with each other in the pixel circuit **2**. Although the power sources are separately provided as the detection-use current source **12** and the display-use voltage sources **13** in the drawing, depending on the detection constitution, these sources may be merged into either one of current source or the voltage source. The signal lines DATA and the display element **11** are connected with each other via pixel detection switches TFT**3**. The pixel detection switches TFT**3** are controlled in response to a control signal **28** supplied to a detection control line DET from the scanning line drive circuit DRV.

**[0083]** FIG. **6** is a constitutional view of a panel system which shows a signal path between the display elements and other systems in a display mode. The pixel PXL is constituted of the display element **11** and the pixel circuit **2**. The pixel detection switch TFT**3** of the pixel circuit **2** is controlled in response to a control signal supplied to the detection control line DET. In this embodiment, the selection of pixels PXL of

R, G, B is configured to be controlled based on time division. The signal lines DATA of respective pixels are connected to a color selection circuit **3-2** (an R selection switch **30**, a G selection switch **31**, a B selection switch **32**). The R selection switch **30** is controlled in response to an R selection signal **33**. The G selection switch **31** is controlled in response to a G selection signal **34**. The B selection switch **32** is controlled in response to a B selection signal **35**. The respective pixels of R and the R selection switches **30** are connected with each other by signal lines **36**. The respective pixels of G and the G selection switches **31** are connected with each other by signal lines **37**. The respective pixels of B and the B selection switches **32** are connected with each other by signal lines **38**. Although the control signals (R selection signal **33**, G selection signal **34**, B selection signal **35**) of the color selection circuit **3-2** are controlled by the display control part **3-1** in this embodiment, these control signals may be controlled by other independent circuit.

**[0084]** Next, the manner of operation of the panel system shown in FIG. **6** is explained. In the display mode, in response to the control signal **21** and the control signal **22** from the display control part **3-1**, the switches **15** are turned on and the switches **16** are turned off. In this state, a gray-scale signal from the display control part **3-1** is supplied to the signal line DATA. Then, at the time of performing the display of R pixels, the R selection switches **30** which are subject to a time-division control are turned on, the G selection switches **31** which are subject to the time-division control are turned off, the B selection switches **32** which are subject to the time-division control are turned off, and the pixel detection switches TFT**3** of all pixels assume an OFF state. Here, the pixel circuit **2** controls a quantity of electric current which flows into the display element **11** from the display-use voltage source **13** based on a gray-scale signal from the display control part **3-1**. As the result, the display pixels emit light with brightness corresponding to the gray-scale signal of R.

**[0085]** In the same manner, at the time of performing the display of G pixels, the G selection switches **31** which are subject to a time-division control are turned on, the R selection switches **30** which are subject to the time-division control are turned off, the B selection switches **32** which are subject to the time-division control are turned off, and the pixel detection switches TFT**3** of all pixels assume an OFF state. Here, the pixel circuit **2** controls a quantity of electric current which flows into the display element (light emitting element/light receiving element) **11** from the display-use voltage source **13** based on a gray-scale signal from the display control part **3-1**. As the result, the G pixels emit light with brightness corresponding to the gray-scale signal of G. Further, at the time of performing the display of B pixels, the B selection switches **32** which are subject to a time-division control are turned on, the R selection switches **30** which are subject to the time-division control are turned off, the G selection switches **31** which are subject to the time-division control are turned off, and the pixel detection switches TFT**3** of all pixels assume an OFF state. Here, the pixel circuit **2** controls a quantity of electric current which flows into the display element **11** from the display-use voltage source **13** based on a gray-scale signal from the display control part **3-1**. As the result, the display elements **11** emit light with brightness corresponding to the gray-scale signal of B. In this manner, the respective switches are controlled so that the display elements **11** sequentially emit light.

**[0086]** FIG. **7** is a constitutional view of the panel system which shows a signal path between the display elements and other systems in the detection mode. In this detection mode, in response to a control signal **21** and a control signal **22** from the display control part **3-1**, the switches **15** are turned off and the switches **16** are turned on. In this state, the signal line DATA of the pixel to be detected and the detection line **20** are connected with each other. The pixel to be detected is selected in response to a control signal supplied from the detection control line DET.

**[0087]** Further, in the detection mode, it is necessary to read a state of the display element **11** of the pixel to be detected and hence, the display control part **3-1** interrupts the supply of the voltage from the display-use voltage source **13** to the pixel circuit **2**. By turning on the pixel detection switch TFT**3** thus connecting the display element **11** with the signal line DATA in this state, an electric current is supplied from the detection-use current source **12** thus allowing the detection of a voltage by photoelectric conversion.

**[0088]** To be more specific, in detecting a received light quantity of the R pixel, the R selection switch **30** is turned on, and the pixel detection switch TFT**3** of the display element (light emitting element/light receiving element) **11** of the pixel to be detected is turned on. The detection-use current source **12** is connected to the detection line **20**, and a fixed voltage is generated in the signal line **36** due to the photoelectric conversion characteristic of the display element **11** of the pixel to be detected and hence, a state (voltage) of the display element **11** appears in the detection line **20**. Here, when the display element **11** emits light, a contrast is lowered and hence, display quality of the panel is lowered. Accordingly, a current value of the electric current from the detection-use current source **12** is set to a value which prevents the light emitting element from emitting light.

**[0089]** In the same manner, in detecting the G pixel, the G selection switch **31** is turned on and the pixel detection switch of the pixel to be detected is turned on and hence, a state of the display element **11** of the pixel to be detected appears in the detection line **20** via the signal line **37**. Further, in detecting the B pixel, the B selection switch **32** is turned on and the pixel detection switch of the pixel to be detected is turned on and hence, a state of the display element **11** of the pixel to be detected appears in the detection line **20**.

**[0090]** FIG. **8** is a constitutional view of a panel system which also includes a reference element **10**. The manner of detecting operation is explained in conjunction with the constitutional view of the panel system. In the described constitution, the detection switch **4** and the like are omitted. Here, one current source is used, a reference element **55** (corresponding to the reference element **10** shown in FIG. **4**) and a detection voltage of the reference element **55** and a detection voltage of a display elements **50**, **51**, **52** (corresponding to the display element **11** shown in FIG. **4**) are compared to each other. A reference line **60** is connected to a holding part **23** for holding a reference voltage. A detection-use current source **12** used in common is connected to the detection line **20** and, further, the display element **50**, the display element **51**, the display element **52** and all other display elements are respectively connected to the detection line **20** via the respective pixel detection switches TFT**3**. The reference element **55** is connected to the detection line **20** via a switch **14**, and the holding part **23** is connected to the detection line **20** via a switch **24**. The pixel detection switches TFT**3**, the switch **14** and the switch **24** are controlled in response to a control signal from the display control part **3-1**.

**[0091]** Next, the manner of operation of the panel system constitution shown in FIG. **8** is explained. The display control part **3-1** turns on the switch **14** and the switch **24** and turns off all pixel detection switches TFT**3**. In this state, the detection-use current source **12** and the reference element **55** are connected with each other, and a voltage at the time is held in the holding part **23**. Thereafter, with a control performed by the display control part **3-1**, the holding part **23** holds this value and continues outputting of the value to the reference line **60**. When the processing of the reference element **55** is finished, using a shift register **18** in the display control part **3-1**, the display element **50** is connected to the detection line **20** via the pixel detection switch TFT**3**. The detection circuit **5** performs a comparison of the detection voltages supplied from the reference line **60** and the detection line **20** and generates a correction signal, and outputs the correction signal to the display control part **3-1**. Upon inputting of the correction signal to the display control part **3-1** from the detection circuit **5**, the display control part **3-1** connects the display element **51** to the detection line **20** via the pixel detection switch TFT3 using the shift register **18**. Then, the detection circuit **5** performs a comparison of the reference line **60** and the detection line **20**, generates a correction signal, and outputs the correction signal which is a result of the comparison to the display control part **3-1**. In this manner, the voltage detected from the reference element **55** is sequentially compared with the voltages detected from all display elements **50**, **51**, **52**.

**[0092]** FIG. **9** shows a constitutional example of the detection circuit **5**. In the detection circuit **5**, a reference voltage **90** and a reference voltage **91** detected from the reference line **60** are compared with a detection result **92** (detection voltage) of the display element detected from the detection line **20**. One of the reference voltage **90** and the reference voltage **91** is assumed to have a value of a reference line, and another is assumed to have a value which is obtained by adding an offset value to the value or by subtracting the offset value from the value. A reference value **94** used in comparison is assumed to be a value which is obtained by dividing the reference voltage **90** and the reference voltage **91** with a resistance ladder **93**. Comparators **95** compare the detection result **92** and the reference value **94**.

**[0093]** Although four comparators **95** are used in this embodiment, the number of comparators **95** and the division number of the resistance ladder **93** are increased or decreased depending on the accuracy of comparison. The detection result obtained by the comparators **95** is processed by the display control part **3-1**, and is fed back by correcting voltage values allocated in response to gray-scale signals of the display element **1110**.

**[0094]** FIG. **10** shows timing of detection. A 1 horizontal period of an organic EL display device NORMAL having no light receiving elements is formed of a display period and a blanking period. In the detection method A (DETECT RESULT A), all period including the display period and the blanking period is used as a detection period. In this case, no display is performed during detection. In the detection method B (DETECT RESULT B), the display period remains as it is and all or part of the blanking period is allocated to the detect period. In this case, the detection is performed while continuing the display and hence, although the detection of one whole screen takes time compared to the detection method A, the display period is not influenced.

**[0095]** FIG. **11** is a flowchart of detection flow in the display control part **3-1** and the detection circuit **5**. When the detection process is started in step **100**, the display control part **3-1** resets a vertical counter (step **111**). The display control part **3-1** determines whether or not the detection period has arrived (step **112**), turns on the switches **23**, **24** when the detection period has arrived, allows the detection circuit **5** to measure the reference voltage (step **113**), and allows the holding part **23** to hold the reference voltage which is a result of processing in step **113** (step **114**). The display control part **3-1** sets the shift register for changing over the respective pixels, turns off the switch **15**, turns on the switch **16** thus supplying a control signal to the detection control line DET from the scanning line drive circuit VDRV to turn on the pixel detection switch TFT**3** (step **115**). The detection circuit **5** detects a voltage generated by the display element **10** which constitutes the pixel to be detected (step **116**). The display control part **3-1** waits for a response from the detection circuit **5** (step **117**). The display control part **3-1** determines a detection state when the voltage is detected by the detection circuit **5** (step **118**), while the display control part **3-1** performs error processing when the voltage is not detected by the detection circuit **5** (step **119**).

**[0096]** The display control part **3-2** determines whether or not the detection of 1 line is finished when the detection in step **118** is determined to be normal (step **120**), and the display control part **3-2** moves the shift register when the detection is in the midst of 1 line and detects a remaining line of 1 line (step **121**). When the detection of 1 line is finished by repeating steps ranging from step **116** to step **120**, the detection circuit **5** generates a correction signal, and the display control part **3-1** executes correction processing (step **122**). The display control part **3-1** determines whether or not the detection of the screen is finished (step **123**), and counts up the vertical counter when the detection of the screen is in the midst of 1 screen, and detects a remaining portion of the screen (step **124**). The display control is executed by repeating steps up to step **124**, and the detection is finished when the detection of 1 screen is finished (step **125**).

**[0097]** Due to the above-mentioned constitution and manner of operation, it is possible to manufacture an organic EL display device having a light detection function without separately adding an expensive optical system, an expensive mechanical system, expensive sensors, expensive lighting devices or the like. In this manner, with the provision of the external light detection system per coordinates, it is also possible to provide a highly-value-added application referred to as an OLED module which incorporates a touch panel function, a handwriting inputting function or a function of automatically adjusting light emitting brightness by external illumination.

EMBODIMENT 2

**[0098]** FIG. **12** shows one constitutional example relating to the reference element, the detection line and the display element. In this constitution, one current source is used, a plurality of reference elements is used, and the reference elements and the display elements are compared with each other. Further, this embodiment also provides the constitution which detects the plurality of elements collectively. Assuming the number of elements to be detected simultaneously as n pieces, n pieces of reference pixels are prepared and a current supply quantity of the current source is increased n times with respect to one-piece detection.

**[0099]** A reference line **60** is connected to a holding part **23** for holding a reference voltage. A detection-use current source **12** used in common is connected to the detection line **20** and, further, the display element **50** (corresponding to the display element **11** shown in FIG. **4**), the display element **51** (corresponding to the display element **11** shown in FIG. **4**), the display element **52** (corresponding to the display element **11** shown in FIG. **4**), the display element **53** (corresponding to the display element **11** shown in FIG. **4**) and all other display elements are respectively connected to the detection line **20** via the separately-provided pixel detection switches TFT3. The reference element **56** (reference element **10** in FIG. **4**) and a reference element **57** (reference element **10** in FIG. **4**) are connected to the detection line **20** via a switch **14**, and the holding part **23** is connected to the detection line **20** via a switch **24**. The pixel detection switches TFT**3**, the switch **14** and the switch **24** are controlled by the display control part **3-1**.

**[0100]** Next, the manner of operation of the panel system constitution shown in FIG. **12** is explained. The display control part **3-1** turns on the switch **14** and the switch **24** and turns off all pixel detection switches TFT**3**. In this state, the detection-use current source **12** is connected with the reference element **56** and the reference element **57**, and a voltage at the time is held in the holding part **23**. Thereafter, with a control performed by the display control part **3-1**, the holding part **23** holds this value until the detection of 1 cycle is finished, and continues outputting of the value to the reference line **60**. This constitutional example uses two reference elements and hence, provided that these reference elements have the substantially same characteristic, an electric current of the detection-use current source **12** flows into the reference elements in halves whereby the detection quantity becomes substantially equal to the detection quantity when one reference element is used. Further, when the reference elements differ from each other in the characteristics, an average characteristic is adopted.

**[0101]** When the detection processing using the reference elements **56**, **57** is finished, the pixel detection switch TFT**3** is turned on using the shift register **18** in the display control part **3-1** so as to connect the display element **50** and the display element **51** to the detection line **20**. The detection quantity becomes an average quantity of the respective pixels. The detection circuit **5** performs a comparison of the detection voltage of the reference line **60** and the detection voltage of the detection line **20** and generates a correction signal from the comparison result, and outputs the correction signal to the display control part **3-1**. Upon inputting of the correction signal to the display control part **3-1** from the detection circuit **5**, the display control part **3-1** connects the display element **52** and the display element **53** to the detection line **20** via the pixel detection switch TFT**3** using the shift register **18**. Then, the detection circuit **5** performs a comparison of the detection voltage of the reference line **60** and the detection voltage of the detection line **20**, and outputs the result (correction signal) to the display control part **3-1**. In this manner, the comparison detection is collectively performed with respect to the plurality of pixels.

EMBODIMENT 3

**[0102]** FIG. **13** shows one constitutional example relating to the reference element, the detection line and the display element. In this constitution, a reference element is used in addition to the display elements, and the detection voltage of the reference element and the detection voltages of the display elements are compared with each other. A reference element **55** (corresponding to the reference element **10** shown in FIG. **4**) and a detection-use current source **44** (corresponding to the detection-use current source **6** shown in FIG. **6**) are connected to the reference line **20**. Although only one kind of reference pixel is connected to the reference line **60** in this constitutional example, a plurality of reference elements may preferably be selectively connected to the reference line using a switch. The display element **50** (corresponding to the display element **11** shown in FIG. **4**), the display element **51** (corresponding to the display element **11** shown in FIG. **4**), the display element **52** (corresponding to the display element **11** shown in FIG. **4**) are respectively connected to the detection line **20** via the pixel detection switches TFT**3**. Further, a detection-use current source **45** is connected to the detection line **20**. The significant technical feature of this constitutional example lies in that the detection-use current source **12** used in the previous embodiments is divided in two, and these divided detection-use current sources are separately used for the reference element and the display elements respectively.

**[0103]** Next, the manner of operation of the panel system constitution shown in FIG. **13** is explained. The detection is performed by comparing the detection voltage of the reference element **55** and the detection voltage of the display element **50**, the detection voltage of the reference element **55** and the detection voltage of the display element **51**, and the detection voltage of the reference element **55** and the detection voltage of the display element **52** in this order. The reference element **55** is fixedly connected to the reference line **60**, and the display elements **50**, **51**, **52** are connected to the detection line **20** via the pixel detection switches TFT**3**. The detection circuit **5** performs a comparison of the detection voltages which are results of the detection of the reference line **60** and the detection line **20**, and outputs the correction signal which is a result of the comparison to the display control part **3-1**. Upon inputting of the result to the display control part **3-1** from the detection circuit **5**, the display control part **3-1** connects the display element **51** to the detection line **20** via the pixel detection switch TFT**3**. Then, the detection circuit **5** performs a comparison of the detection voltage of the reference line **60** and the detection voltage of the detection line **20**, and outputs the result to the display control part **3-1**. In this manner, the correction signals are sequentially generated from the detection voltages of the respective display elements using the detection voltage of the reference element **55** as the reference.

EMBODIMENT 4

**[0104]** FIG. **14** shows one constitutional example relating to the reference element, the detection line and the display elements. In this constitution, the reference element is used in addition to the display elements, and the detection voltage of the reference element and the detection voltages of the display elements are compared with each other. Further, one current source is used in this constitution, and the reference line **60** and the detection line **20** use the detection-use current source **12** in common. The reference element **55** (corresponding to the reference element **10** shown in FIG. **4**) is connected to the reference line **60**, and a current source **46** is connected to the reference line **60** via a resistance **47**. Although only one kind of reference element is connected to the reference line **60** in this constitutional example, a plurality of reference pixels may preferably be selectively connected to the reference line using a switch. The display element **50** (corresponding to the display element **11** shown in FIG. **4**), the display element **51** (corresponding to the display element **11** shown in FIG. **4**), the display element **52** (corresponding to the display element **11** shown in FIG. **4**) are respectively connected to the detection line **20** via the pixel detection switches TFT**3**. Further, a detection-use current source **12** is connected to the detection line **20** via a resistance **48**. Next, the manner of operation of the panel system constitution shown in FIG. **14** is explained. The detection is performed by comparing the detection voltage of the reference element **55** with the detection voltage of the display element **50**, the detection voltage of the reference element **55** with the detection voltage of the display element **51**, and the detection voltage of the reference element **55** with the detection voltage of the display element **52** in this order. The reference element **55** is fixedly connected to the reference line **60**, and the display element **50** is connected to the detection line **20** via the pixel detection switches TFT**3**. Since the detection-use current source **12** is used in common, when the electric characteristic of the reference element **55** and the electric characteristic of the display element **50** are not equal, the minute voltage difference is generated between the reference line **60** and the detection line **20**. When the electric characteristic of the reference element **55** and the electric characteristic of the display element **50** are equal, the voltage difference is not generated between the reference line **60** and the detection line **20**. The detection circuit **5** performs a comparison of the detection voltage of the reference line **60** and the detection voltage of the detection line **20**, and outputs the correction signal which is a result of the comparison to the display control part **3-1**. Upon inputting of the result (correction signal) to the display control part **3-1** from the detection circuit **5**, the display control part **3-1** connects the display element **51** to the detection line **20** via the pixel detection switch TFT**3**. Then, the detection circuit **5** performs a comparison of the detection voltage of the reference line **60** and the detection voltage of the detection line **20**, and outputs the comparison result to the display control part **3-1**. In this manner, the reference element is compared with the display elements sequentially.

EMBODIMENT 5

**[0105]** FIG. **15** shows one constitutional example relating to the reference element, the detection line and the display elements. In this constitutional example, the display elements are connected with a power source (voltage source) by a node grounding. Further, the reference element and the display elements are operated using the voltage source and a fixed resistance in place of the current source. The reference element **85** (corresponding to the reference element **10** shown in FIG. **4**) and a resistance **72** are connected to the reference line **60**. A resistance **73** is connected to the detection line **20** and, further, the display element **80** (corresponding to the display element **11** shown in FIG. **4**), the display element **81** (corresponding to the display element **11** shown in FIG. **4**), the display element **82** (corresponding to the display element **11** shown in FIG. **4**), and all other display elements are connected to the detection line **20** via the pixel detection switches TFT**3**. The pixel detection switches TFT**3** are controlled by the display control part **3-1**.

**[0106]** Next, the manner of operation of the panel system constitution shown in FIG. **15** is explained. A reference voltage appears in the reference line **60** due to the provision of the reference element **85** and the resistance **72**. The detection is performed by comparing the detection voltage of the reference element **85** with the detection voltage of the display element **80**, the detection voltage of the reference element **85** with the detection voltage of the display element **81**, and the detection voltage of the reference element **85** with the detection voltage of the display element **82** in this order. The display control part **3-1** connects the display element **80** to the detection line **20** via the pixel detection switch TFT**3**. The detection circuit **5** performs a comparison of the detection voltage of the reference line **60** and the detection voltage of the detection line **20**, and outputs the correction signal formed of a gray-scale signal which is a result of the comparison to the display control part **3-1**. Upon inputting of the correction signal formed of the gray-scale signal which is a result of the comparison to the display control part **3-1** from the detection circuit **5**, the display control part **3-1** connects the display element **81** to the detection line **71** via the pixel detection switch TFT**3**. Then, the detection circuit **5** performs a comparison of the detection voltage of the reference line **60** and the detection voltage of the detection line **20**, and outputs the correction signal formed of the gray-scale signal which is a result of the comparison to the display control part **3-1**. In this manner, the respective display elements are sequentially compares with the reference element **85** which constitutes the reference.

EMBODIMENT 6

**[0107]** FIG. **16** is a basic constitutional view of a display panel which forms one pixel using a light receiving element and a light emitting element as a set. In FIG. **16**, parts identical with the parts in the embodiment 1 are, unless otherwise specified, given the same symbols.

**[0108]** A display panel of the embodiment 6 includes a reference element **10**, light-receiving-use elements **110**, display elements **11**, a pixel circuit **200**, a display control part **3-1**, a color selection circuit **3-2**, a detection switch **4**, a detection circuit **5**, a detection-use power source **6**, a display-use power source **7**, and a scanning line drive circuit VDRV on a glass substrate SUB**1**.

**[0109]** The display element **11** has the same structure as the element structure **308**. That is, the display element **11** is constituted by stacking an anode AD, a hole injection layer HIL, a hole transport layer HTL, an organic light emitting layer EML, an electron transport layer ETL, an electron injection layer EIL, and a cathode CD on the substrate SUB**1** in this order. On the other hand, the reference element **10** and the light-receiving-use element **110** have the same structure as the element structure **309**. That is, the reference element **10** and the light-receiving-use element **110** are respectively constituted by stacking an anode AD, a hole injection layer HIL, a hole transport layer HTL, an electron transport layer ETL, an electron injection layer EIL, and a cathode CD on the glass substrate SUB**1** in this order.

**[0110]** The large difference between the element structure **308** and the element structure **309** lies in that the element structure **309** uses some of organic layers which constitute the element structure **308** but do not use remaining organic layers which also constitute the element structure **308**. To be more specific, the element structure **309** includes the hole injection layer HIL, the hole transport layer HTL, the electron transport layer ETL, and the electron injection layer EIL which constitute the element structure **308** but does not include the organic light emitting layer EML. By constituting the element structure **309** using one or more layers other than the organic light emitting layer in this manner, it is possible to simplify a manufacturing process. Further, the organic light emitting layer is not used and hence, it is possible to prevent the emission of light attributed to an electric current generated by the photoelectric conversion of an external light. Further, even when the organic light emitting layer EML used in the element structure **308** is used in the element structure **309**, it is preferable to make a film thickness of the organic light emitting layer EML used in the element structure **309** different from a film thickness of the organic light emitting layer EML used in the element structure **308**. This is because that the light receiving efficiency can be enhanced due to such a constitution.

**[0111]** Further, also when the organic light emitting layer EML used in the element structure **308** is used in the element structure **309**, to prevent the reference element **10** and the light-receiving-use element **110** from emitting light attributed to an external light, especially, a natural light, it is preferable to control respective materials and respective film thicknesses of the hole injection layer HIL, the hole transport layer HTL, the organic light emitting layer EML, the electron transport layer ETL, and the electron injection layer EIL. Further, when some of the organic layers constituting the element structure **308** are used in the element structure **309**, it is preferable to use a layer formed of a so-called matted film which is used in common by all pixels in place of layers formed in the same pattern as the organic light emitting layer EML.

**[0112]** FIG. **23** shows the constitution of the pixel circuit **200** for controlling the light emission of the display element **11**.

**[0113]** The pixel circuit **200** is constituted of a data latch switch TFT**1**, a capacitor CAP and a pixel drive switch TFT**2**. A control line of the data latch switch TFT**1** is constituted of a scanning line SCAN, and is configured to control the connection between the signal line DATA and one end of the capacitor CAP. One end of the capacitor CAP is also connected to a control end of the pixel drive switch TFT**2**. Another end of the capacitor CAP is connected between the pixel drive switch TFT**2** and the display element **11**. The pixel drive switch TFT**2** controls the connection between a power source line POWER and the display element **11**.

**[0114]** When a control signal supplied from a scanning line drive circuit VDRV is applied to the scanning line SCAN and the data latch switch TFT**1** is turned on, a voltage corresponding to a gray-scale signal is fetched in the capacitor CAP. The pixel drive switch TFT**2** is turned on in response to a voltage held by the capacitor, and a quantity of electric current which flows into the light emitting element **308** from the power source line POWER is controlled. The power source line POWER is connected to the display-use power source **7**, and the signal line DATA is connected to the detection switch **4** via the color selection circuit **3-2**. The scanning line SCAN is connected to the scanning drive circuit VDRV.

**[0115]** The display control part **3-1** is provided to a signal line drive circuit HDRV shown in FIG. **22**. A display panel shown in FIG. **22** performs a display mode in which the display control part **3-1** controls the detection switch **4** so as to bring the color selection circuit **3-2** and the display element into a conductive state and to bring the detection-use power source **6** and the light-receiving-use element **110** into a non-conductive state, and a detection mode in which the display control part **3-1** controls the detection circuit **4** so as to bring the color selection circuit **3-2** and the display element **11** into a non-conductive state and to bring the detection-use power source **6** and the light-receiving-use element **110** into a conductive state.

**[0116]** In the display mode, the display control part **3-1** also performs a control of the color selection circuit **3-2** to supply the gray-scale signal to a predetermined pixel. Further, in the detection mode, the display control part **3-1** applies a voltage from the predetermined pixel to the detection circuit **5**. Further, in the detection mode, when a correction signal is inputted to the display control part **3-1** from the detection circuit **5**, the display control part **3-1** corrects a gray-scale signal based on the correction signal.

**[0117]** The color selection circuit **3-2** is connected to the detection switch **4** and the pixel circuit **200**. The color selection circuit **3-2**, in the display mode, selects the signal line DATA into which the gray-scale signal flows.

**[0118]** The display control part **3-1**, the detection circuit **5** and the detection-use power source **6** are provided to the signal line drive circuit HDRV shown in FIG. **22**. A first terminal of the signal line drive circuit HDRV is connected to the color selection circuit **3-2** via the detection switch **4**, while a second terminal which differs from the first terminal is connected to the detection switch **4** via the detection circuit **5**.

**[0119]** The pixel circuit **200**, the color selection circuit **3-2**, the detection switch **4**, the display-use power source **7**, and the scanning line drive circuit VDRV, are respectively constituted of a thin film transistor, a low-temperature poly-silicon line, a gate metal line, a source drain metal line, and an interlayer insulation film which are formed on the grass substrate SUB**1**.

**[0120]** The detection switch **4** is controlled in response to a control signal from the display control part **3-1**, and changes over the connection between the display control part **3-1** and the color selection circuit **3-2** and the connection of the light-receiving-use element **110** with the detection circuit **5** and the detection-use power source **6**. The detection circuit **5** detects a magnitude of a voltage inputted into the detection circuit **5** due to the connection between the detection circuit **5** and the light-receiving-use element **110** by the detection switch **4**, generates a correction signal based on the detection result, and supplies the correction signal to the display control part **3-1**. The display-use power source **7** supplies a drive current to the pixel circuit **200**.

**[0121]** Next, the manner of operation of the panel system shown in FIG. **16** is explained. A path of a signal is roughly classified into three paths, that is, a display path DISPLAY, a detection path DETECT, and a correction path REVISE. These paths are sequentially changed with time. Here, in this specification, a behavior which reflects a light detection result on a display state based on an arbitrary mode is referred to as "correction". The gray-scale signal which is outputted from the display control part **3-1** in a first display period in which display is performed is inputted into the pixel circuit **200** through the detection switch **4**, the color selection circuit **3-2**, and the signal line DATA. The pixel circuit **200** performs a control such that a quantity of electric current which flows in the display element **11** from the display-use power source **7** assumes a quantity of electric current corresponding to the gray-scale signal. That is, a path which allows the display element **11** to emit light with a gray scale expressed by the gray-scale signal forms the path DISPLAY of the electric current and the gray-scale signal at the time of display. A path in which the electric current and the gray-scale signal flow into the detection circuit **5** from the reference element **10** and the light-receiving-use element **110** (via the detection switch **4**) during a second detection period in which the detection of voltages generated in the reference element **10** and the light-receiving-use element **110** and the correction of the gray-scale signal are performed forms the detection path DETECT. A path in which the electric current and the gray-scale signal flow into the display control part **3-1** from the detection circuit **5** for forming the gray-scale signal forms the correction path REVISE. A drive power source of the display element **11** in the first period is the light-emitting-use voltage source **7**, and drive power sources of the reference element **10** and the light-receiving-use element **110** in the second period is the detection-use current source **6**. In this embodiment, although the number of power source is set to two, depending on the constitution of the organic EL display device, the number of power sources may be increased or decreased. Also with respect to a kind of power sources, the current source, the voltage source or the like is changed depending on the constitution of the organic EL display device.

**[0122]** FIG. **17** shows one example of the system constitution of the display panel shown in FIG. **16**. In the inside of the display device, the reference element **10**, the display elements **11** and the light-receiving-use elements **110** are present as pixels. The reference element **10** is an element which is used only at the time of performing the detection, and the reference element **10** is used as a reference of the detection comparison in a state that a frequency of use of the reference element **10** is decreased for suppressing the deterioration of the pixel. Further, to achieve the above-mentioned object, it is always necessary to arrange the reference element **10** in a region where an external light is not incident. The display element **11** is an element which is always used at the time of driving. In performing the detection, two pixels, that is, the light-receiving-use element **110** and the reference element **10** are compared to each other, and a state of pixel is obtained based on the difference between two pixels. A correction quantity is calculated by the control part based on the comparison result and the correction quantity is fed back to a display image. Here, in the drawing, although the reference element **10** is provided, depending on the detection constitution, the reference element **10** may be allocated to the light-receiving-use element **110**.

**[0123]** The detection-use drive power source and the display-use drive power source are configured independently from each other. At the time of performing the detection, a detection-use current source **12** (corresponding to the detection-use power source **6** shown in FIG. **16**) is used, while at the time of display, a display-use voltage source **13** (corresponding to the display-use power source **7** shown in FIG. **16**) is used. The detection-use current source **12** is not limited to the current source but may be also formed of a voltage source. The detection-use current source **12** and the reference element **10** are connected to each other using a switch **14**. The switch **15** is configured to be turned on at the time of display. The detection-use current source **12** and the light-receiving-use element **110** are connected to each other using a switch **16** and a pixel detection switch TFT**3**. Here, there is no possibility that the switch **15** and the switch **16** are simultaneously turned on.

**[0124]** The display control part **3-1** performs controls, detections and corrections of the respective switches and power sources. A shift register **18** controls the switch **16**. The shift register **18** may be incorporated in the display control part **3-1** or may be arranged as a control part independent from the display control part **3-1**. However, the control of the shift register **18** is performed by the display control part **3-1**. The signal line DATA is used at the time of display. The switch **15** is controlled in response to a control signal **21** outputted from the display control part **3-1**. The switch **16** is controlled in response to a control signal **22** outputted from the display control part **3-1**.

**[0125]** The detection-use current source **12** and the switch **14** are connected to each other using the detection line **20**. The holding part **23** is connected to the detection line **20** using a switch **24**. When the switch **14** and the switch **24** are turned on, the holding part **23** holds a voltage applied to the reference element **10**, and sets a value of the holding voltage as the reference voltage. The detection circuit **5** compares a detection voltage inputted from the holding part **23** and a detection voltage inputted from the detection line **20**, and outputs the comparison result to the display control part **3-1**. Since the detection data is detected as a voltage, the comparison can be performed using a comparator or the like. Further, when a value of the detection result is minute, the detection voltage may be amplified by providing an amplifier to the detection circuit **5** thus increasing the detection accuracy. The display-use voltage sources **13** and the display elements **11** are connected with each other in the pixel circuit **200**. Although the power sources are separately provided as the detection-use current source **12** and the display-use voltage sources **13** in the drawing, depending on the detection constitution, these sources may be merged into either one of the current source or the voltage source. The data latch switch TFT**1** for scanning the display element **11** in the horizontal direction is incorporated in the pixel circuit **200**, and a control of the data latch switch TFT**1** is performed by inputting a control signal **28** controlled by the display control part **3-1** to the scanning line SCAN. Further, a control of the pixel detection switch TFT**3** for scanning the light receiving element **309** in the horizontal direction is performed in response to a control signal controlled by the display control part **3-1**.

**[0126]** FIG. **18** and FIG. **19** show constitutional examples of a periphery of the signal line DATA. FIG. **18** shows a state of the periphery of the signal line DATA at the time of display.

**[0127]** A pixel PIXEL is constituted of a display pixel **408** and a detection pixel **409**. The display pixel **408** is constituted of the display element **11** and the pixel circuit **200**. Here, as explained in conjunction with FIG. **17**, the data latch switch TFT**1** for scanning the display element **11** in the horizontal direction is incorporated in the pixel circuit **200**. The detection pixel **409** is constituted of a light-receiving-use element **110** and the pixel detection switch TFT**3**. The switch **15** is controlled in response to a control signal **21** outputted from the display control part **3-1**. The switch **16** is controlled in response to a control signal **22** outputted from the display control part **3-1**.

**[0128]** Next, the manner of operation of the panel system shown in FIG. **18** is explained. At the time of display, in response to the control signal **21** and the control signal **22** from the display control part **3-1**, the switches **15** are turned on and the switches **16** are turned off. In this state, a gray-scale signal from the display control part **3-1** is supplied to the signal line DATA. Further, in response to the gray-scale signal from the display control part **3-1**, the pixel circuit **200** applies a voltage to the display element **11** by controlling a voltage from the display-use voltage source **13**, and allows the display pixel **408** to emit light. As described above, by controlling the respective switches, the display pixels emit light sequentially.

**[0129]** FIG. **19** shows the manner of operation of the panel system at the time of performing the detection. At the time of performing the detection, in response to the control signal **21** and the control signal **22** from the display control part **3-1**, the switches **15** are turned off and the switches **16** are turned on. The detection-use current source **12** is connected to the detection line **20**, and a fixed voltage is generated in the signal line DATA due to the characteristic of the light-receiving-use element **110** and hence, a state of the light-receiving-use element **110** appears in the detection line **20**. Here, when the light-receiving-use element **110** emits light, a contrast is lowered and hence, display quality of the panel is lowered. Accordingly, it is necessary to set a current value of the electric current from the detection-use current source **12** to a value which prevents the light emitting element from emitting light. With respect to a constitutional example relating to the detection line and the display element, a constitutional example of the detection circuit **5**, detection timing, and a flowchart showing a processing in a display control, the constitutional examples, timing, and the flowchart explained in conjunction with FIG. **8**, FIG. **9**, FIG. **10** and FIG. **11** respectively are applicable in the same manner.

**[0130]** Here, the detection switch **4** described in the above-explained embodiments can be incorporated in the driver IC.

What is claimed is:

**1**. An organic EL display device forming a plurality of pixels in a display region, wherein

the pixel includes a signal line, a capacitor, a first switch, a second switch, a power source line, and an organic thin film element,

the organic thin film element includes a pixel electrode which is separated for every pixel, a counter electrode overlapping with the pixel electrode, and an organic layer sandwiched between the pixel electrode and the counter electrode,

a gray-scale signal is supplied to the signal line, a potential difference corresponding to the gray scale signal is held in the capacitor,

a first switch which controls a quantity of electric current flowing between the power source line and the organic thin film element corresponding to the potential difference held by the capacitance is connected between the power source line and the organic thin film element,

a second switch is connected between the signal line and the power source line, and

the second switch is controlled to connect the signal line and the organic thin film element during a period in which the gray scale signal is not supplied to the signal line.

**2**. An organic EL display device comprising:

a drive circuit arranged outside a display region and outputting a gray-scale signal;

signal lines extending to the inside of the display region from the outside of the display region;

power source lines extending to the inside of the display region from the outside of the display region; and

a plurality of pixels arranged in the inside of the display region, wherein

the pixel includes a first switch and a second switch constituted of a thin film transistor and an organic thin film element,

the organic thin film element includes a pixel electrode which is separated for every pixel, a counter electrode overlapping with a plurality of pixel electrodes, and an organic layer sandwiched between the pixel electrode and the counter electrode,

the power source line is electrically connected with the organic thin film element via the first switch,

the signal line is electrically connected with a control terminal of the first switch,

the signal line is electrically connected with the organic thin film element via the second switch,

a gray scale signal is supplied to the signal line from the drive circuit during a first period, and

the second switch is turned on and a signal corresponding to an external light from the organic thin film element is supplied to the signal line during a second period different from the first period.

**3**. An organic EL display device comprising:

light emitting elements; and

light receiving element, wherein

the light emitting element includes a pair of electrodes and an organic layer sandwiched therebetween,

the light receiving element includes a pair of electrodes and an organic layer sandwiched therebetween, and

the organic layer of the light emitting element and the organic layer of the light receiving element differ from each other in the layered structure.

**4**. An organic EL display device according to claim **5**, wherein the organic layer of the light receiving element is a layer which does not emit light with an external light.

**5**. An organic EL display device according to claim **5**, wherein the organic layer of the light receiving element includes a material layer equal to a portion of the organic layer of the light emitting element.

**6**. An organic EL display device according to claim **5**, wherein the light receiving elements are arranged within a display region surrounded by the light emitting elements in a matrix array.

**7**. An organic EL display device according to claim **5**, wherein the light receiving elements are arranged outside an effective display region surrounded by the light emitting elements.

**8**. An organic EL display device according to claim **5**, wherein the organic layer of the light emitting element includes an organic light emitting layer, and

the organic layer of the light receiving element is constituted of only a material layer different from the organic light emitting layer or includes a material layer made of the same material as the organic light emitting layer and having a layer thickness different from a layer thickness of the organic light emitting layer.

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|---|---|---|---|
| 专利名称(译) | 有机EL显示装置 | | |
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| [标]申请(专利权)人(译) | TOYODA弘典<br>KASAI NARUHIKO<br>村上HAJIME | | |
| 申请(专利权)人(译) | TOYODA弘典<br>KASAI NARUHIKO<br>村上HAJIME | | |
| 当前申请(专利权)人(译) | TOYODA弘典<br>KASAI NARUHIKO<br>村上HAJIME | | |
| [标]发明人 | TOYODA HIRONORI<br>KASAI NARUHIKO<br>MURAKAMI HAJIME | | |
| 发明人 | TOYODA, HIRONORI<br>KASAI, NARUHIKO<br>MURAKAMI, HAJIME | | |
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摘要(译)

本发明提供一种具有高检测精度的有机EL显示装置，其可以提高发光效率和光接收效率。在包括有机薄膜元件的有机EL显示装置中，电源线经由驱动TFT连接到有机薄膜元件，信号线连接到驱动TFT的栅极以提供对应于灰度级的电位。信号，提供用于连接信号线和有机薄膜元件的开关，并且控制开关以允许通过有机薄膜元件的光电转换获得的电流在信号线和有机薄膜中流动。在没有将灰度信号施加到信号线的时段期间的胶片元件。