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Tam

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(54) **CIRCUIT, DRIVER CIRCUIT, ORGANIC ELECTROLUMINESCENT DISPLAY DEVICE, ELECTRO-OPTICAL DEVICE, ELECTRONIC APPARATUS, METHOD OF CONTROLLING THE CURRENT SUPPLY TO AN ORGANIC ELECTROLUMINESCENT PIXEL, AND METHOD FOR DRIVING A CIRCUIT**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.⁷** **G09G 3/30**

(52) **U.S. Cl.** **345/76; 345/82; 315/169.3**

(58) **Field of Search** **345/76-82, 204; 315/169.1-169.4**

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,519,288 A 5/1996 Tatsumi et al.
5,684,368 A 11/1997 Wei et al.
5,714,968 A 2/1998 Ikeda
5,903,246 A 5/1999 Dingwall
5,952,789 A 9/1999 Stewart et al.
6,091,203 A 7/2000 Kawashima et al.
6,229,506 B1 5/2001 Dawson et al.
6,351,078 B1 2/2002 Wang et al.
6,356,029 B1 * 3/2002 Hunter 315/169.1
6,373,454 B1 * 4/2002 Knapp et al. 345/76
6,498,438 B1 * 12/2002 Edwards 315/169.3
6,501,449 B1 12/2002 Huang

6,501,466 B1 12/2002 Yamagishi et al.
6,535,185 B2 * 3/2003 Kim et al. 345/76
6,580,408 B1 * 6/2003 Bae et al. 345/76

FOREIGN PATENT DOCUMENTS

EP 0 365 445 A2 4/1990
EP 0 895 219 A1 2/1999
EP 0 917 127 A1 5/1999
GB 2 337 354 A 11/1999
JP A-11-282419 10/1999
WO WO 99/65011 12/1999
WO WO 99/65012 12/1999

OTHER PUBLICATIONS

Dawson, R.M.A., et al., "The Impact of the Transient Response of Organic Light Emitting Diodes on the Design of Active Matrix OLED Displays", *IEEE*, 1998, IEDM 98, pp. 895-878.

* cited by examiner

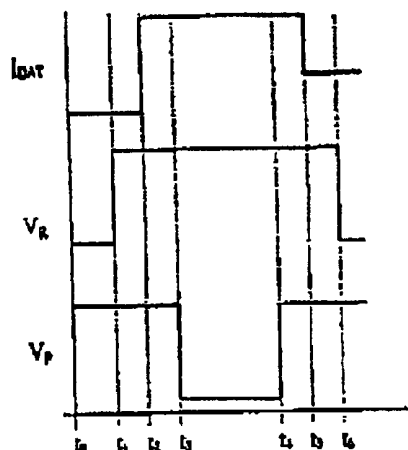
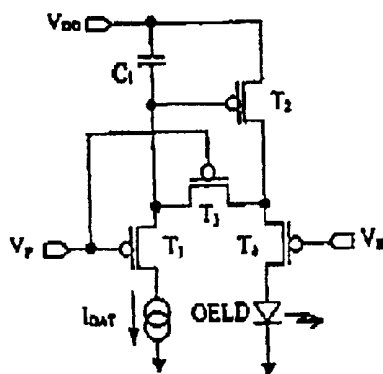
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(57) **ABSTRACT**

A driver circuit operating in stages that comprise a programming stage and a reproduction stage, the circuit comprising: a plurality current paths each of which passes through the circuit, a current driven element, a transistor connected so as operatively to control the current supplied to the said element, a capacitor connected for storing an operating voltage of the transistor during the programming stage, and switching means which control the current paths, the arrangement being such that one of the current paths does not include the said element. No current is applied to the current driven element by the current controlling transistor during the programming stage and thus the overall power consumption is reduced. Furthermore, the circuit can be operated from a normal supply voltage rather than requiring a high bias voltage. During the programming stage, the circuit uses a current sink rather than a current source. Preferably, the current driven element is an electroluminescent element.

22 Claims, 8 Drawing Sheets



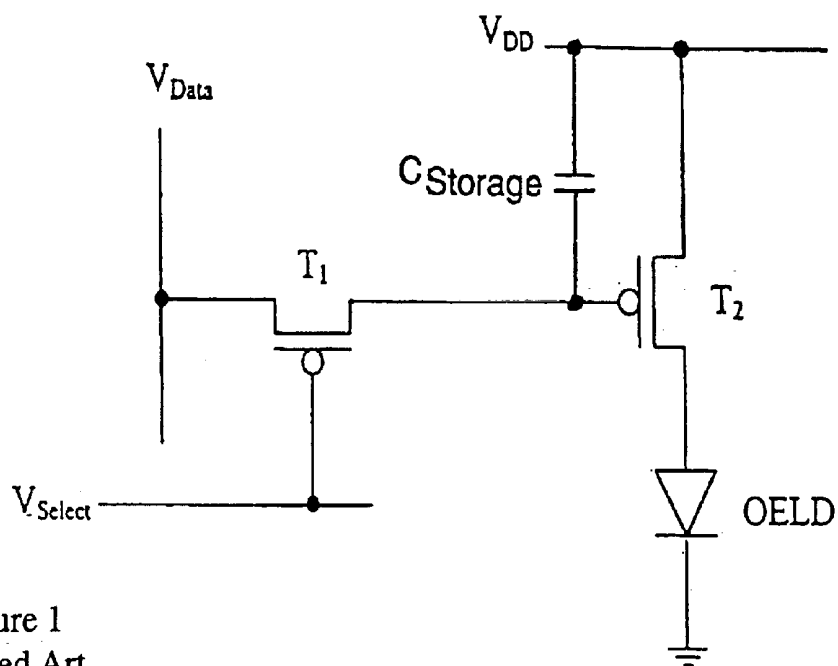


Figure 1
Related Art

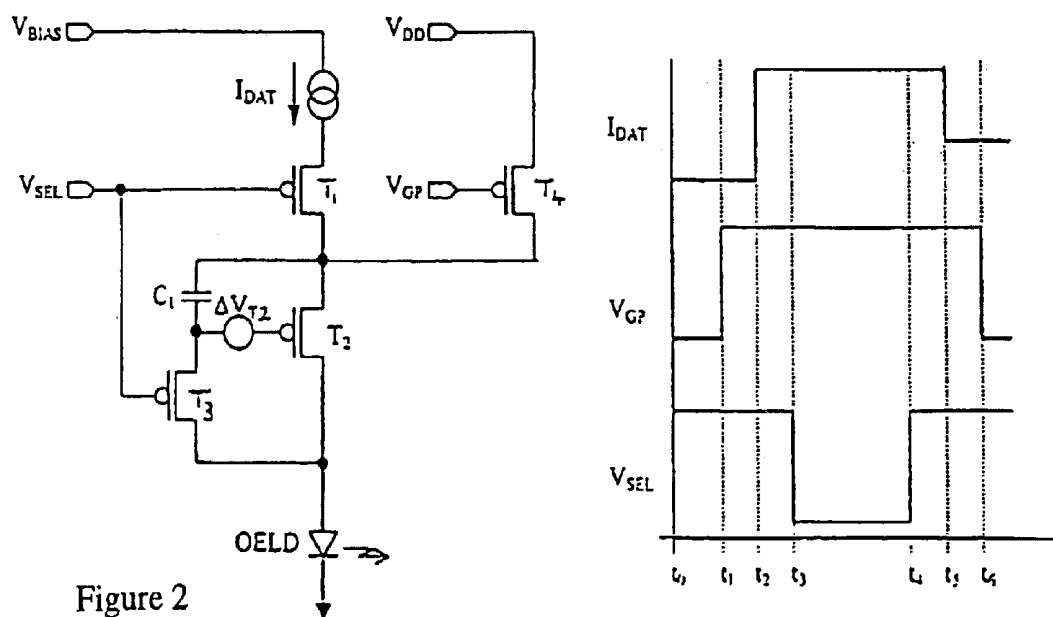


Figure 2
Related Art

Figure 3

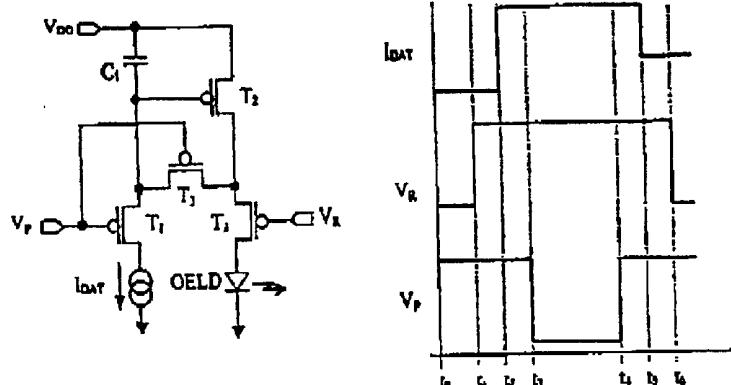


Figure 4

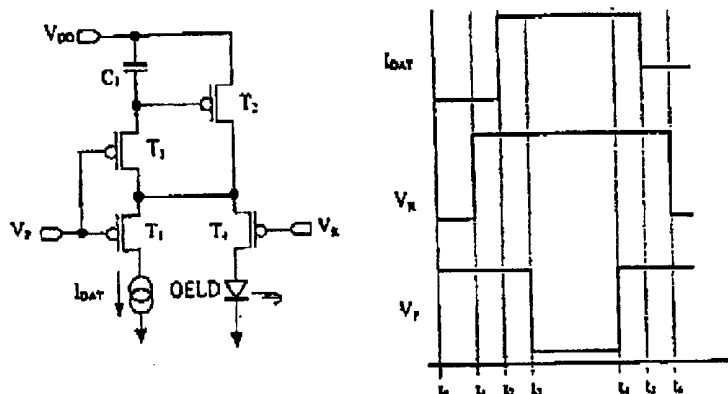


Figure 5

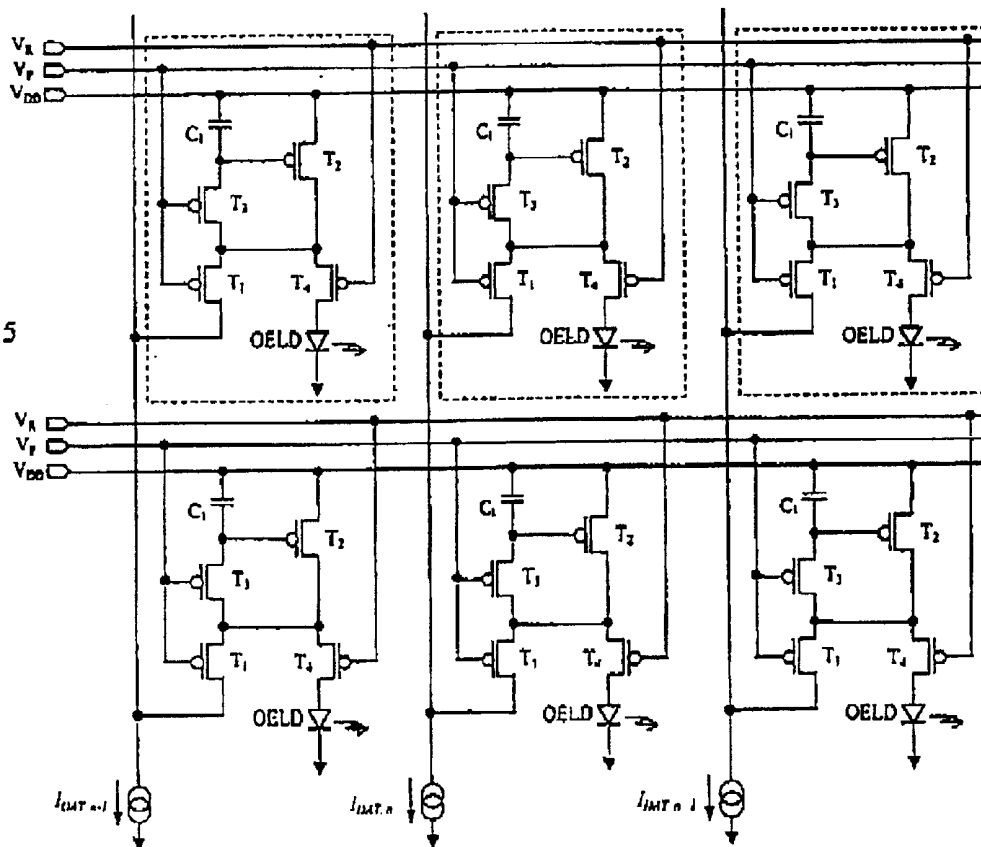


Figure 6

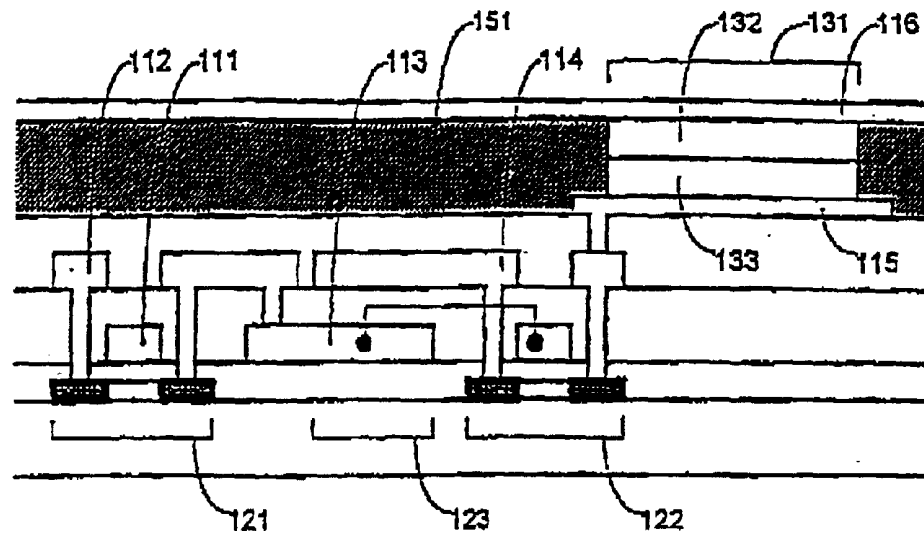


Figure 7

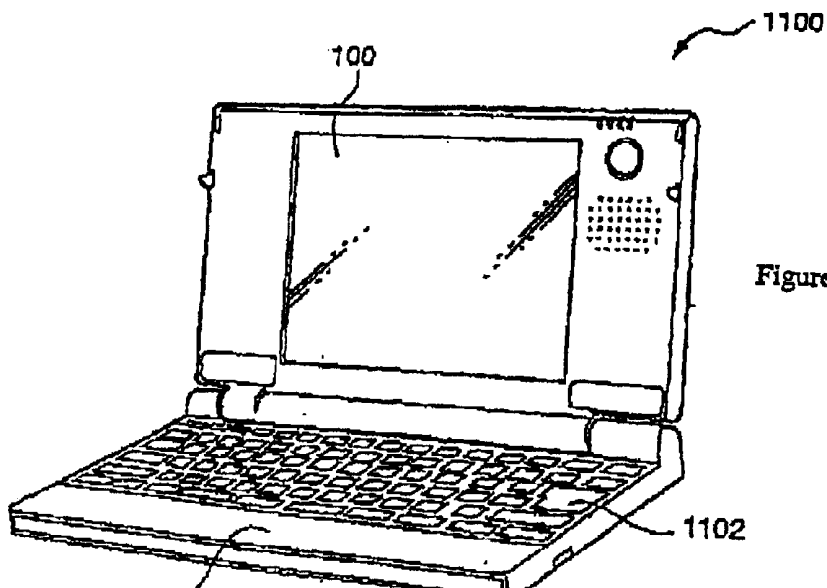
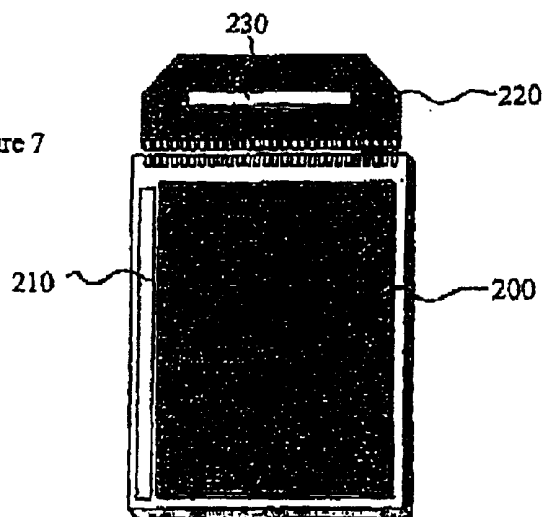


Figure 10

Figure 8

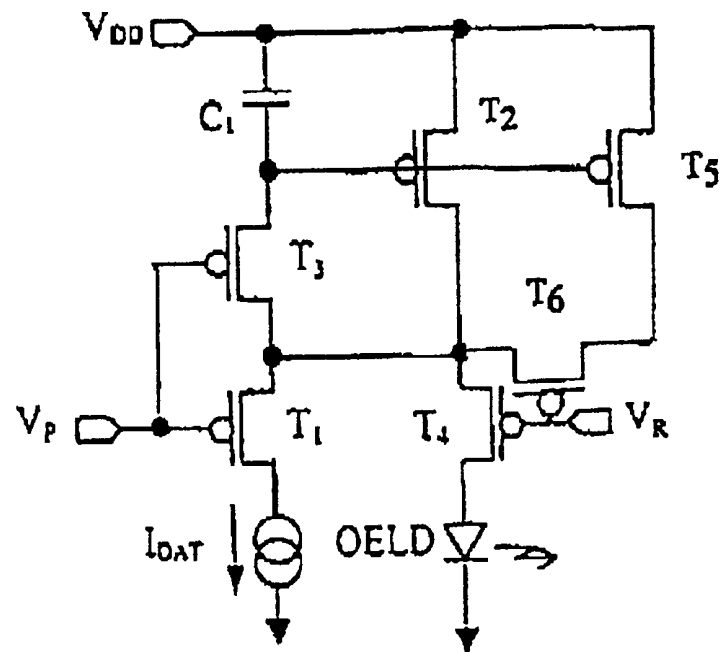


Figure 9

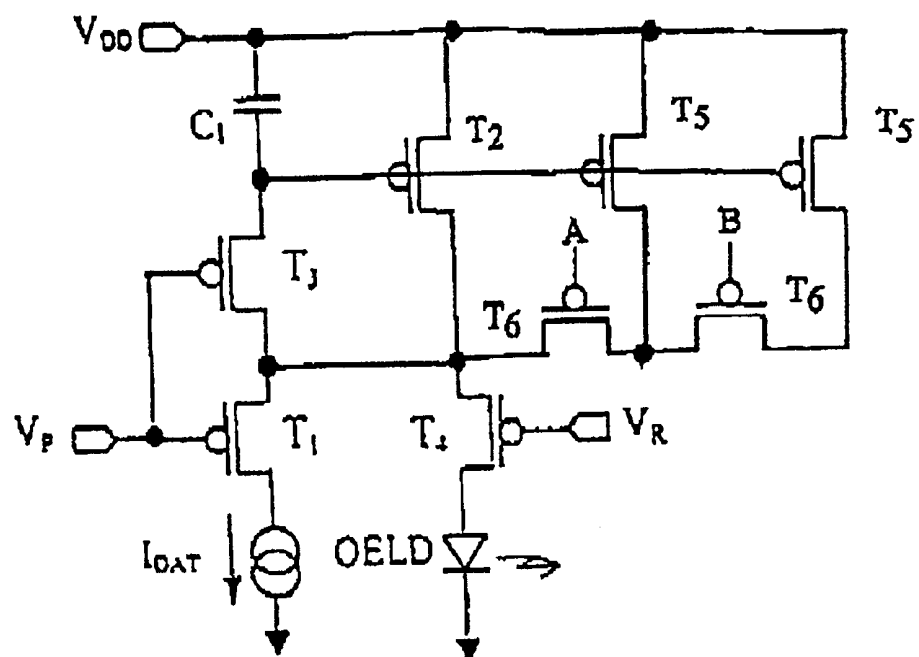


Figure 11

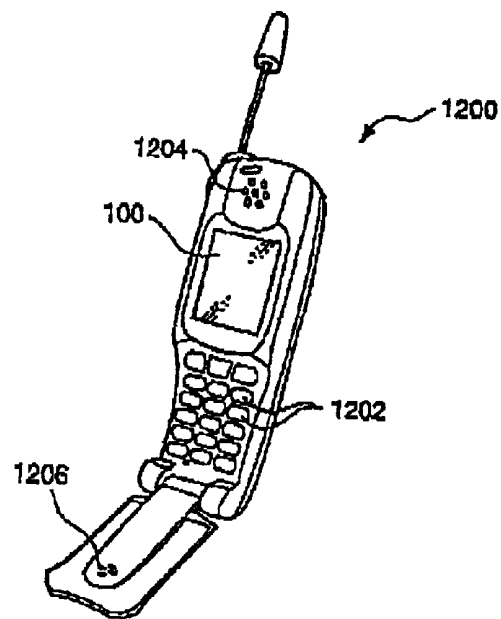


Figure 12

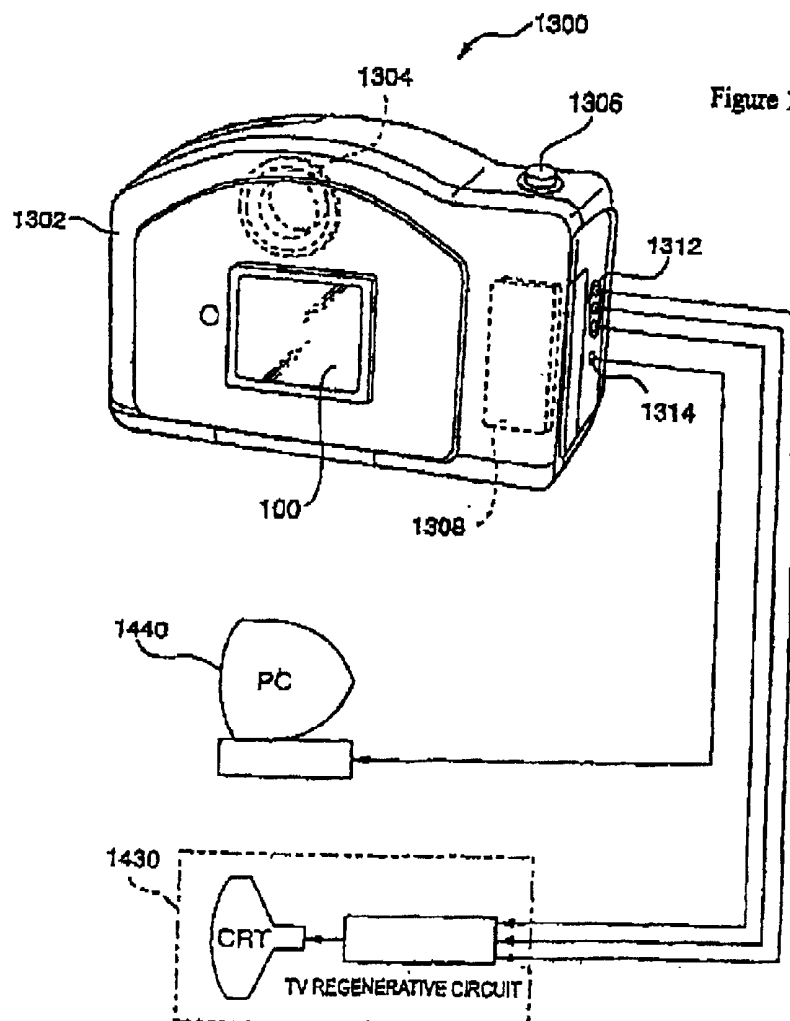


Figure 13

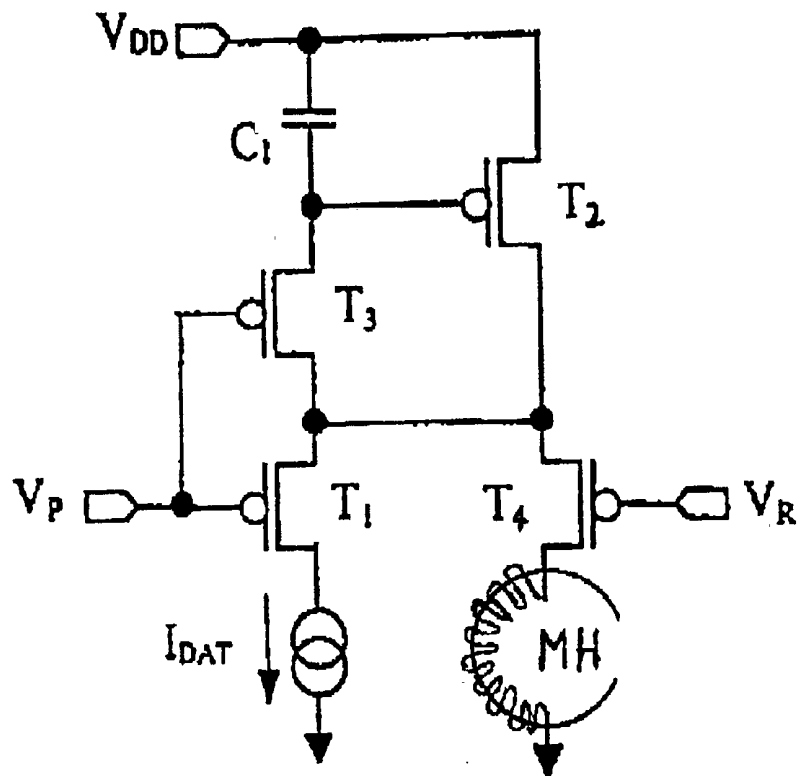
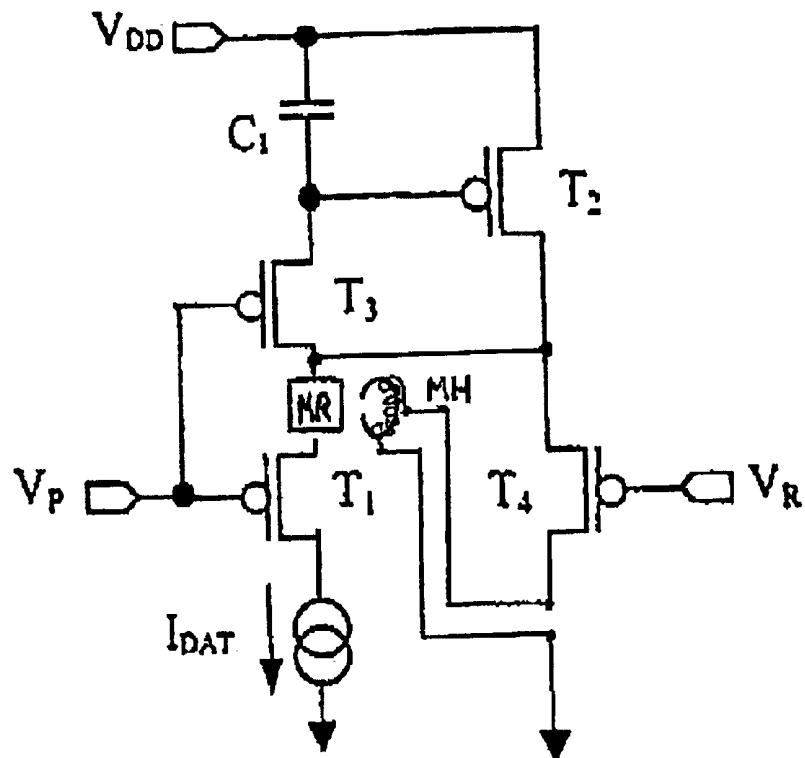


Figure 14



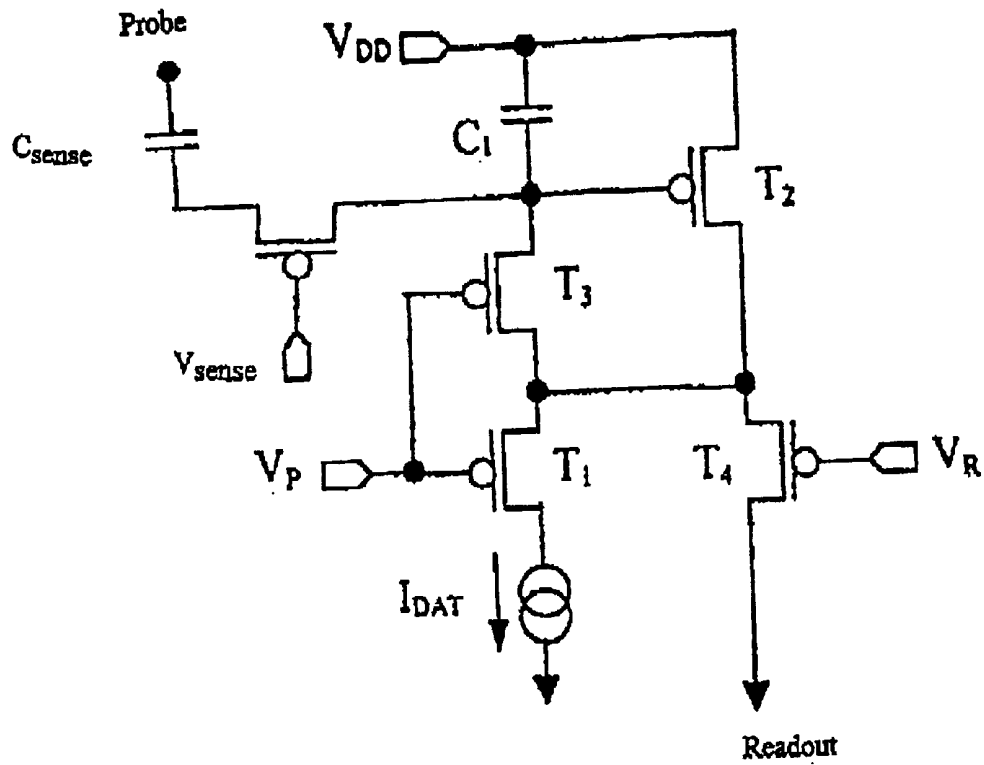


Figure 15

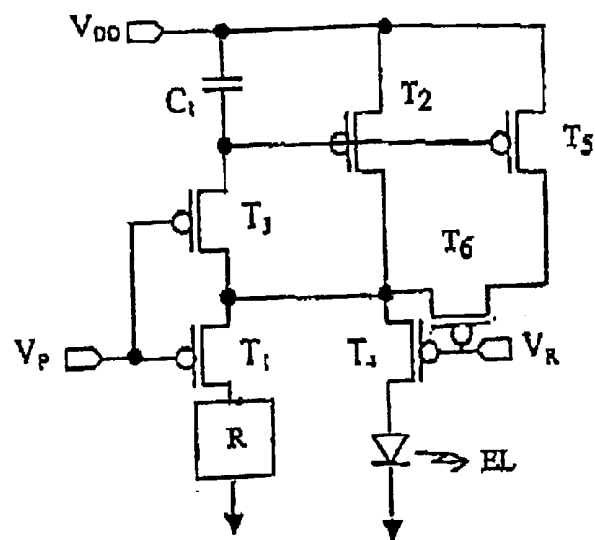


Figure 16

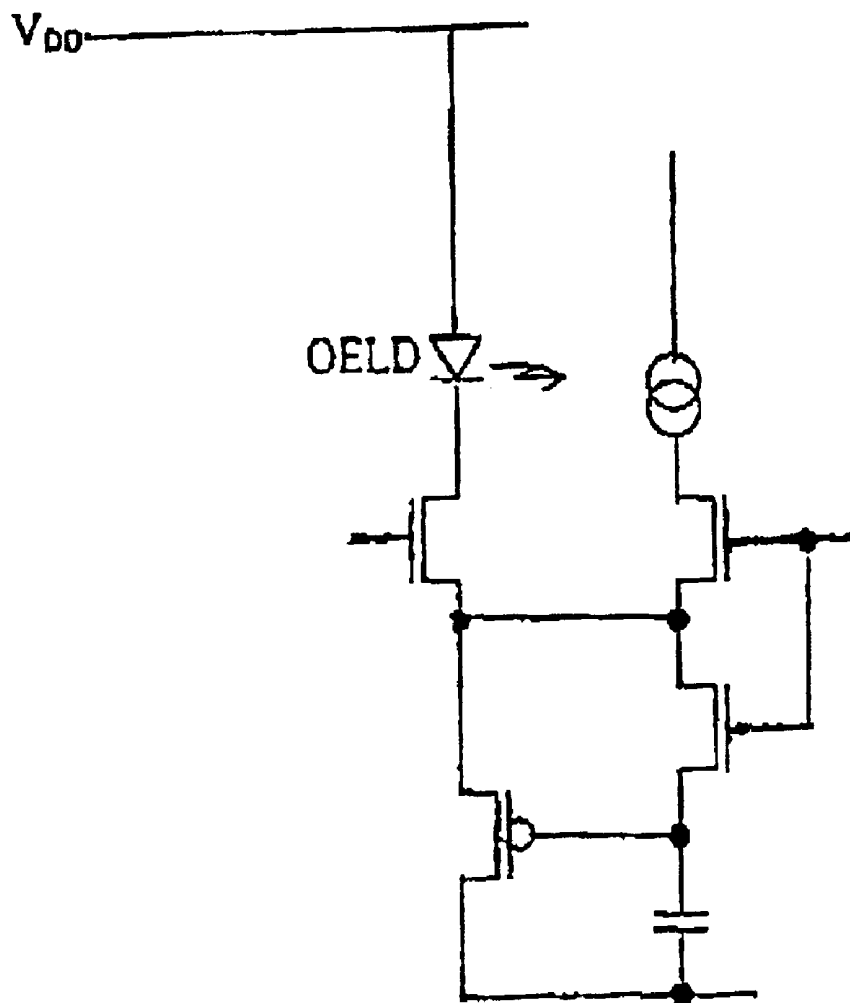


Figure 17

**CIRCUIT, DRIVER CIRCUIT, ORGANIC
ELECTROLUMINESCENT DISPLAY DEVICE
ELECTRO-OPTICAL DEVICE, ELECTRONIC
APPARATUS, METHOD OF CONTROLLING
THE CURRENT SUPPLY TO AN ORGANIC
ELECTROLUMINESCENT PIXEL, AND
METHOD FOR DRIVING A CIRCUIT**

BACKGROUND OF INVENTION

1. Field of Invention

The present invention relates, inter alia, to a driver circuit. One particular application of such a driver circuit is for driving a pixel of an organic electroluminescent device.

2. Description of Related Art

An organic electro-luminescent (OEL) element comprises a light emitting material layer sandwiched between an anode layer and a cathode layer. Electrically, this element operates like a diode. Optically, it emits light when forward biased and the intensity of the emission increases with the forward bias current. It is possible to construct a display panel with a matrix of OEL elements fabricated on a transparent substrate and with at least one of the electrode layers being transparent. One can also integrate the driving circuit on the same panel by using low temperature polysilicon thin film transistor (TFT) technology.

In a basic analog driving scheme for an active matrix OEL display, a minimum of two transistors are required per pixel (FIG. 1): T_1 is for addressing the pixel and T_2 is for converting the data voltage signal into current which drives the OEL element at a designated brightness. The data signal is stored by the storage capacitor $C_{storage}$ when the pixel is not addressed. Although p-channel TFTs are shown in the figures, the same principle can also be applied for a circuit with n-channel TFTs.

There are problems associated with TFT analog circuits and OEL elements do not act like perfect diodes. The light emitting material does, however, have relatively uniform characteristics. Due to the nature of the TFT fabrication technique, spatial variation of the TFT characteristics exists over the entire panel. One of the most important considerations in a TFT analog circuit is the variation of threshold voltage, ΔV_T , from device to device. The effect of such variation in an OEL display, exacerbated by the non perfect diode behaviour, is the non-uniform pixel brightness over the display panel, which seriously effects the image quality. Therefore, a built-in circuit for compensating a dispersion of transistor characteristics is required.

A circuit shown in FIG. 2 is proposed as one of built-in for compensating a variation of transistor characteristics. In this circuit T_1 is for addressing the pixel. T_2 operates as an analog current control to provide the driving current T_3 connects between the drain and gate of T_2 and toggles T_2 to be either a diode or in saturation. T_4 acts as a switch. Either T_1 or T_4 can be ON at any one time. Initially, T_1 and T_3 are OFF, and T_4 is ON. When T_4 is OFF, T_1 and T_3 are ON, and a current of known value is allowed to flow into the OEL element, through T_2 . This is the programming stage because the threshold voltage of T_2 is measured with T_2 operating as a diode (with T_3 turned ON) while the programming current is allowed to flow through T_1 , through T_2 and into the OEL element. T_3 shorts the drain and gate of T_2 and turns T_2 in to a diode. The detected threshold voltage of T_2 is stored by the capacitor C_1 connected between the gate and source terminals of T_2 when T_3 and T_1 are switched OFF. Then T_4 is turned ON, the current is now provided by V_{DD} . If the

slope of the output characteristics were flat, the reproduced current would be the same as the programmed current for any threshold voltage of T_2 detected. By turning ON T_4 , the drain-source voltage of T_2 is pulled up, so a flat output characteristic will keep the reproduced current the same as the programmed current. Note that ΔV_{T2} shown in FIG. 2 is imaginary, not real.

A constant current is provided, in theory, during the active programming stage, which is t_2 to t_5 in the timing diagram shown in FIG. 2. The reproduction stage starts at t_6 .

The circuit of FIG. 2 is advantageous but there is an on-going desire to reduce power consumption. In particular, implementation of the current-source in the circuit of FIG. 2 requires a bias voltage (V_{BIAS}) in addition to the supply voltage (V_{DD}). Although the supply voltage (V_{DD}) could be increased to cover the required bias voltage (V_{BIAS})—which would have the advantage of reducing the component count, there is still an overall increase in system power consumption to program with any value of data current (I_{DAT}).

Attention is, by the present invention, drawn to the fact that all currents passing through the circuit of FIG. 2 pass through the OEL element. The significance of this to the present invention will be apparent from the description given hereinafter.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention there is provided a driver circuit operating in stages that comprise a programming stage and a reproduction stage, the circuit comprising: a plurality of current paths each of which passes through the circuit, a current driven element, a transistor connected so as operatively to control the current supplied to the said element, a capacitor connected for storing an operating voltage of the transistor during the programming stage, and switching means which control the current paths, the arrangement being such that one of the current paths does not include the said element.

According to a second aspect of the present invention there is provided a driver circuit for driving a pixel of an electroluminescent device, the pixel including an electroluminescent element and the circuit comprising: a transistor connected so as operatively to control the current supplied to the electroluminescent element, a capacitor connected for storing an operating voltage of the transistor during a programming stage, a first switching means connected so as to establish when operative a current path through the transistor during the programming stage, and a second switching means connected so as to establish when operative a current path through the transistor and the electroluminescent element during a reproduction stage, wherein the first switching means is connected such that the current path during the programming stage does not pass through the electroluminescent element.

According to a third aspect of the present invention there is provided a driver circuit for driving a pixel of an electroluminescent device, the pixel including an electroluminescent element and the circuit comprising: a transistor connected so as operatively to control the current supplied to the electroluminescent element, a capacitor connected for storing an operating voltage of the transistor during a programming stage, a first switching means connected so as to establish when operative a current path through the transistor during the programming stage, a second switching means connected so as to establish when operative a current path through the transistor and the electroluminescent element during a reproduction stage, and a current sink, the first

switching means being connected such that the current path during the programming stage is through the transistor to the current sink.

According to a fourth aspect of the present invention there is provided a method of controlling the current supply to an electroluminescent element comprising the steps of providing a current path during a programming stage which path does not pass through the electroluminescent element and of providing a current path during a reproduction stage which path does pass through the electroluminescent element.

According to a fifth aspect of the present invention there is provided a method of controlling the current supply to an electroluminescent element comprising the steps of providing a current path during a programming stage which path connects to a current sink and of providing a current path during a reproduction stage which path passes through the electroluminescent element.

According to a sixth aspect of the present invention there is provided an electroluminescent display device comprising one or more driver circuits according to any of the first to third aspects of the present invention.

According to a seventh aspect of the present invention there is provided an electronic apparatus incorporating an electroluminescent display device according to the sixth aspect of the present invention.

According to an eight aspect of the present invention there is provided a circuit comprising a current driven element the circuit providing a first current path including the current driven element and a second current path not including the current driven element.

According to a ninth aspect of the present invention there is provided a circuit comprising a current driven element, the circuit providing a first current path flowing a current through the current driven element, and a second current path not flowing current through the current driven element.

According to a tenth aspect of the present invention there is provided a method for driving a circuit comprising a current driven element and a transistor that controls a current supplied to the current driven element, comprising a step of determining a gate voltage of the transistor based on a predetermined current.

It will be noted that according to the present invention no current is applied to the current driven element by the current controlling transistor during the programming stage. In accordance with the invention in an electroluminescent device a pixel driver circuit can be implemented without degrading the perceived image presented by the electroluminescent device. It has the benefit of reducing the overall power consumption compared with the prior art in which the same current is supplied to the OEL element during both the programming and the reproduction stage. Furthermore, the circuit can be operated from a normal supply voltage rather than requiring a high bias voltage as in the prior art. In effect, the present invention provides for separation of the programming and the reproduction current paths. This enables a number of advantages to be achieved. For example, if there is no current flow through the OEL element during the programming stage then the programming stage operates more quickly—since the arrangement avoids the slow down caused by the parasitic capacitance of the OEL element.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will now be described by way of further example only and with reference to the accompanying drawings, in which:

FIG. 1 shows a conventional OEL element pixel driver circuit using two transistors,

FIG. 2 shows a known current programmed OEL element driver with threshold voltage compensation,

FIG. 3 shows a pixel driver circuit according to a first embodiment of the present invention,

FIG. 4 shows a pixel driver circuit according to a second embodiment of the present invention,

FIG. 5 shows several pixels in a matrix display wherein each pixel uses the circuit of FIG. 4,

FIG. 6 is a schematic sectional view of a physical implementation of an OEL element and pixel driver according to an embodiment of the present invention,

FIG. 7 is a simplified plan view of an OEL display panel incorporating the present invention,

FIG. 8 shows another embodiment of a pixel driver circuit according to the present invention,

FIG. 9 shows another embodiment of a pixel driver circuit according to the present invention,

FIG. 10 is a schematic view of a mobile personal computer incorporating a display device having a pixel driver according to the present invention,

FIG. 11 is a schematic view of a mobile telephone incorporating a display device having a pixel driver according to the present invention,

FIG. 12 is a schematic view of a digital camera incorporating a display device having a pixel driver according to the present invention,

FIG. 13 illustrates the application of the driver circuit of the present invention to a magnetic RAM,

FIG. 14 illustrates the application of the driver circuit of the present invention to a magnetoresistive element,

FIG. 15 illustrates the application of the driver circuit of the present invention to a capacitance sensor or a charge sensor,

FIG. 16 illustrates the application of the driver circuit of the present invention to a night vision camera, and

FIG. 17 is a brief outline of an alternative implementation of the circuit of FIG. 4.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

A pixel driver circuit according to a first embodiment of the present invention is shown in FIG. 3. Transistor T_2 operates as an analog current control to provide the driving current to the OEL element. Also, the storage capacitor C_1 is connected between the gate and the source of transistor T_2 . In the circuit of FIG. 2, a current source is operatively connected to the source of transistor T_2 by transistor T_1 , during the programming stage, and current is thus applied to the OEL element. In the embodiment of the present invention, transistor T_1 operatively connects transistor T_2 to a current sink during the programming stage. That is, according to the present invention, during the programming stage no current is supplied through transistor T_2 to the OEL element. In the circuit of FIG. 3, the drain of transistor T_2 is connected to the source of transistor T_1 via the source/drain path of transistor T_3 . The source of transistor T_1 is connected to the gate of transistor T_2 and the gates of transistors T_2 and T_3 are connected together. The programming voltage V_P is applied to the gates of T_1 and T_3 . Transistor T_4 , which is switched off during the programming stage, connects the drain of T_2 and the source of T_3 to the OEL element. During the programming stage, transistor T_1 operatively connects transistor T_2 to a current sink which is tied to ground or a reference voltage.

The circuit of FIG. 3 operates in the programming stage with T_4 switched off and T_1 and T_3 switched on. T_3 being

switched on has the effect of making T_2 act as a diode and T_1 connects this diode to the data current sink. As a result, capacitor C_1 charges (or discharges, depending on the voltage stored during the previous frame). Capacitor C_1 charges to the gate/source voltage of transistor T_2 and thus stores the voltage (V_{GS2} , corresponding to the data current I_{DAT}) which will control the current supply to the OEL element during the reproduction stage. At the end of the programming stage, T_1 and T_3 are switched off. The voltage V_{GS2} is stored on C_1 for the remainder of the frame period. As will be readily apparent from the circuit diagram and this description, in accordance with the present invention there is no requirement for a bias voltage to provide a current source. That is, the supply voltage (V_{DD}) in FIG. 3 is determined by T_2 and by the OEL element and there is no requirement for a high voltage to power a current source. The maximum voltage required by the circuit is thus significantly less than that required by the circuit of FIG. 2.

At the start of the programming stage, with T_4 switched off, it is found that the OEL element exhibits a parasitic capacitance which discharges through the device. The rate of charging of C_1 determines the time taken for the programming stage. In accordance with circuits embodying the present invention, the capacitance of C_1 can be relatively small and thus the charging can be very rapid. As a consequence, the period for which no current is applied to the OEL element by T_2 is very short compared with the whole frame. These factors, together with the persistence of vision of the human eye means that there is no perceptible degradation of a displayed image.

The off resistance of T_3 can be important, because after C_1 has been charged and T_3 is switched off, the off resistance of T_3 can affect the voltage across C_1 for the rest of the frame period. Thus, the gate/source capacitance of T_3 should preferably be small compared with C_1 .

The reproduction voltage V_R is applied to the gate of transistor T_4 . At the beginning of the reproduction stage, in the circuit of FIG. 3, T_4 is switched on and T_1 and T_3 switched off. As a result, T_2 acts as a current source with V_{GS2} biased by C_1 , thus supplying current to the OEL element. At the end of the reproduction stage T_4 is switched off, T_1 and T_3 remain switched off and completes one cycle. The driving waveform is indicated in FIG. 3.

FIG. 4 illustrates a second embodiment according to the present invention. The circuit of FIG. 4 differs from that of FIG. 3 in the connection of transistor T_3 . In the circuit of FIG. 4, T_1 is connected to C_1 through the drain/source path of T_3 . The circuit of FIG. 4 is preferred to that of FIG. 3 because T_3 is not in the current path during the programming stage. Otherwise the operation and effects of the second embodiment are similar to those of the first embodiment.

FIG. 5 is a circuit diagram showing a number of pixels in an active matrix display, with each pixel implemented in accordance with the circuit of FIG. 4. To simplify the illustration, a monochrome display device is shown. Since the circuit is of an active matrix, pixels on the same row are addressed at the same time. Transistor T_3 is responsible for pixel addressing, so its source terminal is connected to the current data line shared by a column of pixels. Because of this the leakage current of T_3 should be kept to a minimum. This can be ensured by using a multi-gate structure for T_1 . In addition to a multi-gate structure, a lightly doped drain (LDD) structure can also reduce the leakage current.

FIG. 6 is a schematic cross-sectional view of the physical implementation of the pixel driver circuit in an OEL element structure. In FIG. 6, numeral 132 indicates a hole injection

layer, numeral 133 indicates an organic EL layer, and numeral 151 indicates a resist or separating structure. The switching thin-film transistor 121 and the n-channel type current-thin-film transistor 122 adopt the structure and the process ordinarily used for a low-temperature polysilicon thin-film transistor, such as are used for example in known thin-film transistor liquid crystal display devices such as a top-gate structure and a fabrication process wherein the maximum temperature is 600° C. or less. However, other structures and processes are applicable.

The forward oriented organic EL display element 131 is formed by: the pixel electrode 115 formed of Al, the opposite electrode 116 formed of ITO, the hole injection layer 132, and the organic EL layer 133. In the forward oriented organic EL display element 131, the direction of current of the organic EL display device can be set from the opposite electrode 116 formed of ITO to the pixel electrode 115 formed of Al.

The hole injection layer 132 and the organic EL layer 133 may be formed using an ink-jet printing method employing the resist 151 as a separating structure between the pixels. The opposite electrode 116 formed of ITO may be formed using a sputtering method. However, other methods may also be used for forming all of these components.

The typical layout of a full display panel employing the present invention is shown schematically in FIG. 7. The panel comprises an active matrix OEL element 200 with analogue current program pixels, an integrated TFT scanning driver 210 with level shifter, a flexible TAB tape 220, and an external analogue driver LSI 230 with an integrated RAM/controller. Of course, this is only one example of the possible panel arrangements in which the present invention can be used.

The structure of the organic EL display device is not limited to the one described here. Other structures are also applicable.

With reference for example to the circuit of FIG. 3, it will be appreciated that the invention provides a data current source in this case for the OEL element. The circuit is readily extended so as to provide an amplified and/or multiple level (current) output. The principle of such a circuit can be understood with reference to FIG. 8. The circuit of FIG. 8 comprises the circuit of FIG. 3 with an additional drive transistor T_5 and an additional switching transistor T_6 added. The source of T_5 is connected to V_{DD} and its gate receives the same drive voltage signal as is applied to the gate of transistor T_2 . The drain of transistor T_5 is series connected to the drain of transistor T_6 and the source of T_6 is connected to the common point of connection of transistors T_2 , T_3 and T_4 . The gate of transistor T_6 is connected to the gate of transistor T_4 . If it is assumed that the characteristic of transistor T_2 is W/L and that the characteristic of transistor T_5 is selected to be $(N-1)W/L$ then a current amplification of:

$$I_{out} = I_{in} \times N$$

is achieved. I_{in} is the current which flows through the current sink, i.e. I_{DAT} in FIGS. 3 and 4. I_{out} is the current which flows through the OEL element. Thus the circuit of FIG. 8 can be used to reduce the value of I_{DAT} compared with the circuit of FIGS. 3 and 4, while maintaining the same current through the OEL element. Lowering the value of I_{DAT} has the advantage of enabling the operating speed of the circuit to be increased. Lowering the value of I_{DAT} also has the advantage of lowering the transmission loss experienced across a matrix of pixels, which is particularly important with respect to large scale display panels.

Of course, additional stages—each adding their own circuit of additional transistors T_5 and T_6 —can be added. With the switching transistors T_6 series connected and each receiving its own gate drive signal—as shown in FIG. 9 (A,B etc)—different current values can be selected to pass through the OEL element, resulting in different intensities of light output.

Preferably the circuits shown in FIGS. 3 to 9 are implemented using thin film transistor (TFT) technology, most preferably in polysilicon.

The present invention is particularly advantageous for use in small, mobile electronic products such as mobile phones, computers, CD players, DVD players and the like—although it is not limited thereto.

Several electronic apparatuses using the above organic electroluminescent display device will now be described.

<1: Mobile Computer>

An example in which the display device according to one of the above embodiments is applied to a mobile personal computer will now be described.

FIG. 10 is an isometric view illustrating the configuration of this personal computer, in the drawing, the personal computer 1100 is provided with a body 1104 including a keyboard 1102 and a display unit 1106. The display unit 1106 is implemented using a display panel fabricated according to the present invention, as described above.

<2: Portable Phone>

Next, an example in which the display device is applied to a display section of a portable phone will be described. FIG. 11 is an isometric view illustrating the configuration of the portable phone. In the drawing, the portable phone 1200 is provided with a plurality of operation keys 1202, an earpiece 1204, a mouthpiece 1206, and a display panel 100. This display panel 100 is implemented using a display panel fabricated according to the present invention, as described above.

<3: Digital Still Camera>

Next, a digital still camera using an OEL display device as a finder will be described. FIG. 12 is an isometric view illustrating the configuration of the digital still camera and the connection to external devices in brief.

Typical cameras sensitize films based on optical images from objects, whereas the digital still camera 1300 generates imaging signals from the optical image of an object by photoelectric conversion using, for example, a charge coupled device (CCD). The digital still camera 1300 is provided with an OEL element 100 at the back face of a case 1302 to perform display based on the imaging signals from the CCD. Thus, the display panel 100 functions as a finder for displaying the object. A photo acceptance unit 1304 including optical lenses and the CCD is provided at the front side (behind in the drawing) of the case 1302.

When a cameraman determines the object image displayed in the OEL element panel 100 and releases the shutter, the image signal from the CCD are transmitted and stored to memories in a circuit board 1308. In the digital still camera 1300, video signal output terminals 1312 and input/output terminals 1314 for data communication are provided on a side of the case 1302. As shown in the drawing, a television monitor 1430 and a personal computer 1440 are connected to the video signal terminals 1312 and the input/output terminals 1314, respectively, if necessary. The imaging signals stored in the memories of the circuit board 1308 are output to the television monitor 1430 and the personal computer 1440, by a given operation.

Examples of electronic apparatuses, other than the personal computer shown in FIG. 10, the portable phone shown

in FIG. 11, and the digital still camera shown in FIG. 12, include OEL element television sets, view-finder-type and monitoring-type video tape recorders, car navigation systems, pagers, electronic notebooks, portable calculators, word processors, workstations, TV telephones, point-of-sales system (POS) terminals, and devices provided with touch panels. Of course, the above OEL device can be applied to display sections of these electronic apparatuses.

The driver circuit of the present invention can be disposed not only in a pixel of a display unit but also in a driver disposed outside a display unit.

In the above, the driver circuit of the present invention has been described with reference to various display devices. The applications of the driver circuit of the present invention are much broader than just display devices and include, for example, its use with a magnetoresistive RAM, a capacitance sensor, a charge sensor, a DNA sensor, a night vision camera and many other devices.

FIG. 13 illustrates the application of the driver circuit of the present invention to a magnetic RAM. In FIG. 13 a magnetic head is indicated by the reference MH.

FIG. 14 illustrates the application of the driver circuit of the present invention to a magnetoresistive element. In FIG. 14 a magnetic head is indicated by the reference MH, and a magnetic resistor is indicated by the reference MR.

FIG. 15 illustrates the application of the driver circuit of the present invention to a capacitance sensor or a charge sensor. In FIG. 15 a sense capacitor is indicated by the reference C_{sense} . The circuit of FIG. 15 is also applicable to other applications, such as a fingerprint sensor and a DNA sensor.

FIG. 16 illustrates the application of the driver circuit of the present invention to a night vision camera. In FIG. 16 a photoconductor is indicated by reference R.

In the embodiments illustrated with reference to the above specific description the transistors have been shown as p-channel type transistors. This is not limiting of the invention. For example, FIG. 17 is a brief outline of an alternative implementation of the circuit of FIG. 4. In FIG. 17 n-channel transistors are used throughout the circuit, except for the drive transistor which is retained as a p-channel transistor.

It will be apparent to persons skilled in the art that other variations and modifications can be made to the arrangements described with respect to FIGS. 3 to 16 without departing from the scope of the invention.

What is claimed is:

1. A driver circuit to drive a pixel of an electroluminescent device, the pixel including an electroluminescent element, the circuit comprising:

a transistor of which a conducting state is set according to a data current that determines a current level of a driving current supplied to the electroluminescent element;

a first switching device connected so as to establish a first current path through which the data current flows during a programming stage, the data current flowing through the transistor and the first switching device to a data line during the programming stage; and

a second switching device connected so as to establish a second current path through the transistor and the electroluminescent element during a reproduction stage,

the first and second switching devices being controlled by respective control signals supplied from separate signal lines.

2. The driver circuit according to claim 1, further comprising a third switching device, the third switching device

being connected to bias the transistor to act as a diode during the programming stage.

3. The driver circuit according to claim 2, wherein the third switching device connects the first switching device to the gate of the transistor.

4. The driver circuit according to claim 1, wherein the circuit is implemented with polysilicon thin film transistors.

5. An electroluminescent display device comprising the driver circuit according to claim 1.

6. An electronic apparatus incorporating an electroluminescent display device as claimed in claim 5.

7. The circuit according to claim 1, wherein the transistor is a p-channel thin film transistor.

8. A method of controlling a supply of a driving current to an electroluminescent element, the method comprising:

providing a first current path through which a data current that determines a current level of the driving current flows during a programming stage by using a first switching device connected so as to establish the first current path that allows the data current to flow through the first switching device to a data line; and

providing a second current path during a reproduction stage by controlling a second switching device connected so as to establish the second current path, the second current path passing through the electroluminescent element,

the first switching device and the second switching device being controlled by respective control signals supplied from separate signal lines.

9. A method of controlling a current supply to an electroluminescent element, the method comprising:

providing a first current path including a transistor during a programming stage; and

providing a second current path including the transistor during a reproduction stage, the second current path passing through the electroluminescent element,

providing a data current that determines a conduction state of the transistor, the data current flowing from a power-supply line to a data line through the first current path,

supplying a driving current to the electroluminescent element, the driving current flowing through the second current path, and

providing a current level of the driving current corresponding to the conduction state of the transistor.

10. A circuit comprising a current driven element, the circuit providing a first current path through which a data current, that determines a current level of a driving current supplied to the current driven element, flows through the first switching device to a data line by controlling a first switching means;

the circuit providing a second current path through which the driving current flows by controlling a second switching means, the driving current flows through the current driven element, and

the first switching means and the second switching means being controlled by respective control signals supplied from separate signal lines.

11. The circuit according to claim 10, wherein the first and second switching means are n-channel thin film transistors.

12. The circuit according to claim 10, wherein the first current path and the second current path include a transistor.

13. An electro-optical device comprising a plurality of pixels, each of the plurality of pixels including a circuit that controls a driving current supplied to a current driven element,

the circuit providing a first current path that excludes the current driven element by controlling a first switching

device, and a data current that determines a current level of the driving current, the data current flowing through the first current path and the first switching device to a data line,

the circuit further providing a second current path that includes the current driven element by controlling a second switching device, and

the first and second switching devices being controlled by respective control signals supplied from separate signal lines.

14. An electronic apparatus including the electro-optical device according to claim 13.

15. A circuit comprising a current driven element, the circuit providing:

a first current path during a first period and a second current path during a second period,

a data current that determines a conduction state of a transistor included in the circuit, the data current flowing through the first current path,

a driving current of which a current level corresponds to the conduction state of the transistor, the driving current flowing through the second current path,

the data current flowing to a current sink and a data line through the transistor, and

the driving current flowing to the current driven element through the transistor.

16. A method for driving a circuit comprising a current driven element and a transistor that controls a current supplied to the current driven element, the method comprising:

determining a gate voltage of the transistor by flowing a data current from a voltage supply to a current sink through the transistor and a data line; and

providing a driving current to the current driven element, the driving current corresponding to the gate voltage determined according to the data current.

17. The method according to claim 16, no current is the data current being supplied to the current driven element during the determining of the gate voltage of the transistor.

18. A driver circuit to drive a pixel of an electroluminescent element, the driver circuit comprising:

a transistor connected so as operatively control the current supplied to the electroluminescent element;

a first switching device connected so as to establish a first current path including the transistor during the programming stage;

a second switching device connected so as to establish a second current path including the transistor and the electroluminescent element during a reproduction stage; and

a current sink,

the first switching device being connected such that the first current path during the programming stage is connected through a data line to the current sink.

19. The driver circuit according to claim 18, the first and second switching devices being controlled by respective control signals supplied from separate signal lines.

20. An electroluminescent display device comprising the driver circuit according to claim 18.

21. The driver circuit according to claim 18, the transistor being a p-channel transistor.

22. The driver circuit as claimed in claim 18, the first and the second switching devices being formed of respective

专利名称(译)	电路，驱动电路，有机电致发光显示装置，电光装置，电子设备，控制向有机电致发光像素的电流供应的方法，以及用于驱动电路的方法		
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摘要(译)

一种驱动电路，其包括编程级和再现级，所述电路包括：多个电流路径，每个电流路径通过所述电路，电流驱动元件，晶体管连接以便可操作地控制提供给所述电路的电流。所述元件，连接用于在编程阶段期间存储晶体管的工作电压的电容器，以及控制电流路径的开关装置，该布置使得电流路径之一不包括所述元件。在编程阶段期间，电流控制晶体管没有电流施加到电流驱动元件，因此降低了总功耗。此外，该电路可以从正常电源电压操作，而不需要高偏置电压。在编程阶段，电路使用电流吸收器而不是电流源。优选地，电流驱动元件是电致发光元件。

