

PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) DISPLAY DEVICE

(71) We, KABUSHIKI KAISHA SUWA SEIKOSHA, a Japanese company, of 3-4, 4-chome, Ginza, Chuo-ku, Tokyo, Japan, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to display devices and, in particular, although not so restricted, to delay devices for watches or other timepieces.

There are three categories of liquid crystal materials, namely, nematic, smectic cholesteric. Liquid crystal materials scatter light when they are influenced by an electric field. Thus, a display device may be constructed utilizing this light scattering property. Such a cell may, for example, comprise transparent electrodes which hold liquid crystal material therebetween. When a strong electric field is applied between the electrodes the liquid crystal material will scatter light incident thereon.

It is, therefore, necessary to provide a circuit for applying the electric field to the display cell. In the past, such circuits have been proposed including bipolar transistors. The impedance of the display cell is however, very high compared with, say, the impedance of a light emitting diode. For instance, the impedance of the display cell may be in the region of 500 megohms to 1000 megohms. For this reason a normal transistor cannot be used for applying the electric field to a display cell and, further, the light scattering property will gradually disappear when the transistor goes into its non-conducting state.

This defect can be avoided by connecting a load element in parallel with the display cell. This, however, has the disadvantage that when a display cell is used, for example, in a wrist watch, the power consumption is relatively high.

According to one aspect of the present invention there is provided a display device

comprising: a display cell containing a liquid crystal material and an electronic circuit for establishing an electric field across the display cell, said electronic circuit being such as to apply a relative high voltage electric field across the display cell in response to a relatively low voltage switching signal, the circuit including at least one metal oxide semiconductor device.

According to another aspect of the present invention there is provided a display device comprising a display cell containing a liquid crystal material and an electronic circuit for establishing an electric field across the display cell, the circuit including at least one metal oxide semiconductor device.

Said display cell may be connected between the drain and source electrodes of a P-channel metal oxide semiconductor device.

Alternatively, said display cell may be connected between the drain and source electrodes of an N-channel metal oxide semiconductor device.

Thus, said N-channel metal oxide semiconductor device may be part of a COS-MOS inverter device.

According to a further aspect of the present invention, there is provided a display device comprising a display cell containing a liquid crystal material and an electronic circuit for establishing a high voltage electric field across the display cell, the electronic circuit including a pair of COS-MOS inverter devices each arranged to be connected across a high voltage source, the input of each inverter device being connected to the output of the other inverter device, the display device being arranged to be connected between a point common to the input of one inverter device and the output of the other inverter device, and a terminal of a power supply, each inverter device having a control metal oxide semiconductor transistor, and inverter means for causing said inverter devices to

apply a high voltage electric field across the display device in response to a low voltage switching signal applied to the inverter means.

5 According to a still further aspect of the present invention there is provided a timepiece, for example, a wrist watch, provided with a display device as recited above.

10 The invention is illustrated, merely by way of example, in the accompanying drawings, in which:—

Figure 1 illustrates diagrammatically a conventional display device; Figure 2 illustrates diagrammatically a second conventional display device;

Figure 3 is a circuit diagram of one embodiment of a display device according to the present invention; and

20 Figure 4 is a circuit diagram of a further embodiment of a display device according to the present invention.

Referring first to Figure 1, a conventional display device comprises a display cell 1 containing a liquid crystal material, the display cell being connected in series with a transistor 2 across a high voltage supply. When a switching signal, shown in the form of a positive pulse, is applied to the base of the transistor 2, the latter goes into the conducting state and an electric field is established across the display cell.

The conventional display device illustrated in Figure 2 is similar to that illustrated in Figure 1 except that a load resistor 3 is provided in parallel with the display cell. The load resistor 3, however, increases the power consumption and so the display device of Figure 2 cannot be conveniently used in a wrist watch.

Referring now to Figure 3 there is illustrated a circuit diagram of one embodiment of a display device according to the present invention. The circuit comprises an N-channel metal oxide semiconductor transistor (N-MOST) 5 and a P-channel metal oxide semiconductor transistor (P-MOST) 6 connected in series with a high voltage supply and having the configuration of a complementary symmetry circuit (COS), that is to say, the transistors 5, 6 form a COS-MOS inverter device. When a switching signal, shown in the form of a positive pulse, is applied to the transistor 5 the latter goes into the conducting state whereas the transistor 6 goes into the non-conducting state, whereby an electric field is established across a display cell containing a liquid crystal material and connected between the source and drain electrodes of the transistor 6. It will be appreciated that the power consumed by such a display device is very small.

The transistor 6 goes into the conducting state when the potential at its gate electrode

falls to zero. This short circuits the display cell 4 and causes the transistor 5 to go into the non-conducting state and thus there is no electric field across the display device.

Referring now to Figure 4, there is illustrated a circuit diagram of a second display device according to the present invention. This circuit comprises a P-channel metal oxide semiconductor transistor (P-MOST) 8, an N-channel metal oxide semiconductor transistor (N-MOST) 9, a P-channel metal oxide semiconductor transistor (P-MOST) 10, and an N-channel metal oxide semiconductor transistor (N-MOST) 11. The transistors 8, 9 form one COS-MOS inverter device, and the transistors 10, 11 form another COS-MOS inverter device. The gate electrodes of the transistors 8, 9 are connected with the drain electrodes of the transistors 10, 11 and the drain electrodes of the transistors 8, 9 are connected with the gate electrodes of the transistors 10, 11. The source electrodes of the transistors 8, 10 are connected to a high voltage supply. The drain and source electrodes of the transistor 9 are respectively connected to the drain and source electrodes of an N-channel metal oxide semiconductor transistor (N-MOST) 12 and the transistor 11 is similarly connected to an N-channel metal oxide semiconductor transistor (N-MOST) 13. The transistors 12, 13 are connected so as to act as control transistors so their gate electrodes are respectively connected to the input and output terminals of an inverter circuit 14. The inverter circuit 14 is connected across a low voltage supply.

The display device illustrated in Figure 4 operates in the following manner:

When a switching signal, shown in the form of a positive pulse, is applied to the input terminal of the inverter device 14, the transistors 11, 13 go into the conducting state and the transistors 9, 12 go into the non-conducting state. This causes the transistor 8 to go into the conducting state whereby an electric field is established across a display cell 7 containing a liquid crystal material. The display cell 7 is connected between the drain electrodes of the transistors 8, 9 and the gate electrodes of the transistors 10, 11 (that is to say between the output of one inverter device and the input of the other inverter device) on the one hand and one terminal of the high voltage supply on the other hand. The transistors 9, 12 go into the conducting state when the voltage of the input terminal of the inverter circuit 14 falls to zero. This short-circuits the display cell 7 and causes the transistor 8 to go into the non-conducting state and thus there is no electric field across the display device.

It is a simple matter to produce an in-

egrated circuit incorporating MOS transistors and so the display device illustrated in Figures 3 and 4 may be made of small size and with a very low power consumption.

- 5 These display devices are, therefore, suitable for use in wrist watches especially as such wrist watches operate at a low voltage. To provide the necessary high voltage supply for the display device a transformer means (not shown) may be provided to produce the high voltage supply from the relatively low voltage supply. The display devices illustrated in Figures 3 and 4 have the advantage, therefore, that the construction of a wrist watch incorporating a quartz crystal and one of these display devices can be very much simplified.

- 10 The display devices illustrated above are operated by a switching signal in the form of a positive pulse. However, it will be appreciated that the switching signal may be in the form of a negative pulse in which case it is merely necessary to reverse the connection of the display cell from those illustrated.

WHAT WE CLAIM IS:—

1. A display device comprising a display cell containing a liquid crystal material and an electronic circuit for establishing an electric field across the display cell, said electronic circuit being such as to apply a relatively high voltage electric field across the display cell in response to a relatively low voltage switching signal, the circuit including at least one metal oxide semiconductor device.

2. A display device comprising a display cell containing a liquid crystal material and an electronic circuit for establishing an electric field across the display cell, the circuit including at least one metal oxide semiconductor device.

3. A display device as claimed in claim 1 or 2 in which said display cell is connected between the drain and source electrodes of

a P-channel metal oxide semiconductor device.

4. A display device as claimed in claim 1 or 2 in which said display cell is connected between the drain and source electrodes of an N-channel metal oxide semiconductor device.

5. A display device as claimed in claim 4 in which said N-channel metal oxide semiconductor device is part of a COS-MOS inverter device.

6. A display device comprising a display cell containing a liquid crystal material and an electronic circuit for establishing a high voltage electric field across the display cell, the electronic circuit including a pair of COS-MOS inverter devices each arranged to be connected across a high voltage source, the input of each inverter device being connected to the output of the other inverter device, the display device being arranged to be connected between a point common to the input of one inverter device and the output of the other inverter device, and a terminal of power supply, each inverter device having a control metal oxide semiconductor transistor, and inverter means for causing said inverter devices to apply a high voltage electric field across the display device in response to a low voltage switching signal applied to the inverter means.

7. A display device substantially as herein described with reference to and as shown in Figures 3 or 4 of the accompanying drawings.

8. A timepiece provided with a display device as claimed in any preceding claim.

9. A wrist watch provided with a display device as claimed in any of claims 1 to 7.

J. MILLER & CO.,
Agents for the Applicants,
Chartered Patent Agents,
262 High Holborn.
London WC1V 7EF.

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2. A display device comprising a display cell containing a liquid crystal material and an electronic circuit for establishing an electric field across the display cell, the circuit including at least one metal oxide semiconductor device.

3. A display device as claimed in claim 1 or 2 in which said display cell is connected between the drain and source electrodes of

a P-channel metal oxide semiconductor device.

4. A display device as claimed in claim 1 or 2 in which said display cell is connected between the drain and source electrodes of an N-channel metal oxide semiconductor device.

5. A display device as claimed in claim 4 in which said N-channel metal oxide semiconductor device is part of a COS-MOS inverter device.

6. A display device comprising a display cell containing a liquid crystal material and an electronic circuit for establishing a high voltage electric field across the display cell, the electronic circuit including a pair of COS-MOS inverter devices each arranged to be connected across a high voltage source, the input of each inverter device being connected to the output of the other inverter device, the display device being arranged to be connected between a point common to the input of one inverter device and the output of the other inverter device, and a terminal of power supply, each inverter device having a control metal oxide semiconductor transistor, and inverter means for causing said inverter devices to apply a high voltage electric field across the display device in response to a low voltage switching signal applied to the inverter means.

7. A display device substantially as herein described with reference to and as shown in Figures 3 or 4 of the accompanying drawings.

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J. MILLER & CO.,

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London WC1V 7EF.

