

PATENT SPECIFICATION

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(54) TIMEPIECE

(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:

The present invention relates to timepieces.

According to one aspect of the present invention there is provided a timepiece having a liquid crystal display device which, when a driving voltage is applied thereto scatters light incident thereon, a timing structure for producing a time indication to be displayed by the liquid crystal display device, voltage means for producing the driving voltage and applying the same to the liquid crystal display device, and switch means for selectively operating the voltage means independently of the timing structure.

According to another aspect of the present invention there is provided a timepiece having a liquid crystal display device which, when a driving voltage is applied thereto scatters light incident thereon, a timing structure for producing a time indication to be displayed by the liquid crystal display device, and voltage means for producing the driving voltage and applying the same to the liquid crystal display device, said voltage means including a transistor pair connected in push-pull configuration and a transformer having a toroidal ferrite core.

Preferably, the timing structure comprises an oscillator for producing a relatively high frequency signal, a divider circuit for producing from the relatively high frequency signal a relatively low frequency signal and a counter circuit for producing the time indication by counting the cycles of the relatively low frequency signal, the voltage means including a driving circuit for applying the driving voltage to the liquid crystal

display device in response to an output from the counter circuit.

Thus, the oscillator may include a quartz crystal oscillator.

Said counter circuit, preferably, includes metal oxide semiconductor transistor means. Said driving circuit may include transistorised inverter means.

The timepiece may include a power source the voltage of which is arranged to drive the timing structure directly and from which a higher voltage is derived by the voltage means to produce the driving voltage.

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

Figure 1 is a cross-sectional view showing a liquid crystal display element for use in a timepiece according to the present invention;

Figure 2 is a block diagram of a timepiece according to the present invention;

Figure 3 is a circuit diagram of a boosting circuit for a timepiece according to the present invention; and

Figure 4 is a circuit diagram of a driving circuit for a timepiece according to the present invention.

Referring now to the drawings and in particular to Figure 1, there is shown a cross-sectional view of a liquid crystal display element for use in a timepiece according to the present invention. The liquid crystal display element comprises a transparent base plate 1 which may be made of glass and whose inside surface is coated with a transparent conductive electrode film 2. An insulating spacer 3 and a liquid crystal material 4 are sandwiched between the base plate and a further base plate 5 which may be made of glass and whose inside surface has a transparent conductive electrode film 6 thereon. The thickness of the insulating spacer 3 and hence the thickness of the liquid crystal material 4 may be between 1μ

[Price 25p]

and 30μ . The outside surface of the base plate 5 is provided with a mirror surface 7 which may be a coating of aluminium or nickel. Lead terminals 8, 8' are connected at one end to a power source (not shown) which may be a direct current or alternating current of between 10 volts and 30 volts and at the other end to the electrode films 2, 6 respectively. Thus a voltage can be applied across the liquid crystal material.

The mirror surface 7 intensifies the light scattered by the liquid crystal display element. Light which enters the liquid crystal display element from various directions and which is reflected by the mirror surface 7 is scattered by the liquid crystal material rather than passing through the base plate 5 only to the lost. Thus, the light scattered by this liquid crystal display element may be twice that scattered by an identical liquid crystal display element but not provided with the mirror surface 7.

The thickness of the base plates 1, 5 may, for example, be between 0.1 mm and several millimetres. The electrode films 2, 6 and the mirror surface 7 are preferably less than 1μ in thickness. The liquid crystal material 4 is between 1μ and 30μ in thickness as mentioned previously. Therefore, the liquid crystal display element can be made with a thickness between 0.2 and 0.3 mm. Thin liquid crystal display elements of this type are especially suitable for use in wrist-watches where the watch movement (not shown) may be between 2 and 7 mm in thickness and so there is a requirement for as thin a liquid crystal display element as possible.

As an alternative construction, the mirror surface 7 may be dispensed with if the electrode film 6 is polished to a mirror finish.

The liquid crystal display element has the following disadvantages: in order for the liquid crystal material to scatter light, the voltage applied may be as high as 10 to 30 volts but the watch movement may only need 1.5 volts to drive it; furthermore, the power consumption of a liquid crystal display element is relatively high although it is low when compared with the power consumption of other display devices.

When a voltage is applied across the electrode films 2, 6 the orientation of the molecules of the liquid crystal material is disturbed and so it scatters light incident thereon. Compared with other display devices such as luminous diodes, nixy tubes, Braun tubes, and digitrons, the liquid crystal display element described above has the following advantages:

1. The brighter the surroundings the clearer the display.
2. Power consumption per unit area of display is less than 1 mW/cm^2 ; this is very small when compared with the power

consumption of other display devices.

3. The liquid crystal material is about 20μ in thickness and so a very flat liquid crystal element may be constructed.
4. The cost per unit area of display is very low.

low.

Figure 2 is a block diagram of a timepiece, for example, a watch, according to the present invention and having a liquid crystal display device 34. The timepiece includes a quartz crystal vibrator 31, which controls an oscillator circuit having a relatively low power consumption, a frequency divider circuit employing metal oxide semiconductor transistors (herein referred to as MOSTs) and a counter or decoder circuit, the oscillator, divider and decoder circuits being indicated at 32. The output from the oscillator circuit is a relatively high frequency signal which is divided in the divider circuit to produce a relatively low frequency signal, the decoder circuit counting the cycles of the relatively low frequency signal. A driving circuit 33 using a transistorised inverter is provided to apply a driving voltage to the liquid crystal display device 34 in response to the output of the decoder circuit. A voltage boosting circuit 35, which may employ a transistorised inverter, increases the voltage of a power source 36 and supplies a driving voltage to the driving circuit 33. On receipt of an output from the decoder circuit the driving circuit supplies the driving voltage to the liquid crystal display device. The power source 36 may be a silver oxide battery or a primary cell or a secondary cell in combination with a solar battery.

In timepieces, especially in wristwatches, it is desirable that the size of each component such as the electric circuits and the liquid crystal display device is as small as possible as the space available is limited. For example, it is desirable to increase the life of the power source without increasing its size. The present arrangement also seeks to minimise the power consumption of each circuit of the timepiece to ensure optimum efficiency. Thus the quartz crystal oscillator 31 oscillates at between 8 kHz and 2 MHz to ensure high precision in the time-keeping. MOSTs which have a low power consumption, preferably, complementary-symmetry metal oxide semiconductor transistors are used in the oscillator, divider and decoder circuits 32. Particularly, transistorised inverters may be used in parts of the oscillator circuit in order to minimise its power consumption. The oscillator, divider and decoder circuits 32 are driven directly from the power source 36. Usually however, two batteries can be used so that the voltage produced by the power source is between 2.6 volts and 3.2 volts. The voltage from the power source

which, therefore, may be between 1.2 volts and 3.2 volts is converted to about 20 volts in the boosting circuit 35. It is also necessary to minimise the power consumption in the boosting circuit 35.

Figure 3 is a circuit diagram of one embodiment of a voltage boosting circuit for use with a timepiece according to the present invention. The boosting circuit has a switch 7' for selectively supplying power from the power source 36 thereto. Since display of the liquid crystal display device is dependent upon the ambient light conditions the power consumption of the power source can be reduced by switching the boosting circuit off when a display from the liquid crystal display device is not required, for example when the timepiece is in dark surroundings. Even though when the switch 7' is open there is no display by the liquid crystal display device the timepiece still keeps time because the oscillator, divider and decoder circuits are always connected to the power source and their operation is not affected by the switch 7'. Therefore when the switch 7' is closed, the driving voltage is supplied once more to the liquid crystal display device and the correct time indication is displayed.

The booster circuit includes a pair of transistors 8, 9 connected in push-pull configuration as a transistorised inverter. A boosting transformer has a core 10 which, because the oscillator frequency at the time of boosting may be as high as 500 Hz to 100 kHz is a ferrite core, preferably, a toroidal ferrite core. Such a core has a high permeability and consequently improves the efficiency of the boosting circuit. A primary coil 11 is wound on the core 10 and the ends of the primary coil are connected to the collectors of the transistors 8, 9 respectively. A centre tap of the primary coil is connected to the switch 7'. A detecting coil 12 is provided on the core 10 and the ends of the detecting coil are connected to the bases of the transistors 8, 9 respectively. A resistor 13 and a condenser 14 are connected in parallel between a centre tap of the detecting coil 12 and the centre tap of the primary coil. A secondary coil 15 is also provided on the core 10 and the centre tap of the secondary coil is earthed whilst the ends are connected *via* fullwave rectifying diodes 16, 17 to an output terminal at which there is provided a grounded smoothing condenser 18.

In the boosting circuit described above the centre taps of the primary and detecting coils are connected through the resistor 13 and the capacitor 14 and magnetically linked through the core 10 and so the circuit will oscillate. The collector currents of the transistors 8, 9 can be adjusted by changing the value of the resistor 13 and at the same

time changing the value of the condenser 14 to maximise efficiency. The transistors 8, 9 are arranged so that the oscillation can be started with a low voltage and a high current amplification rate β is achieved.

Experiments have indicated that transistorised inverters have a higher efficiency than MOSTs. The transistors 8, 9 are connected in a push-pull configuration to prevent direct current from overlapping on the core 10. A toroidal ferrite core fully utilises the magnetic fluxes from the various coils thereby increasing efficiency and enabling the size of the boosting circuit to be reduced. A boosting circuit such as that described above will increase an input voltage of 1.2 volts to 3.2 volts up to an output voltage of 20 volts very efficiently. As is clear from the above discussion, this boosting circuit is ideally suited to small timepieces such as wristwatches. When applied to a pocket watch, it enables the size of the watch to be reduced.

In the booster circuit illustrated in Figure 3 the transistors 8, 9 are of the NPN type and a rectified positive output is obtained but it will be appreciated that PNP type transistors may be used and a rectified negative output can be obtained.

Figure 4 illustrates a circuit diagram of a driving circuit for a timepiece according to the present invention. The driving circuit includes a transistor 19 and a liquid crystal display device 20. A resistor 21 is connected in series with the liquid crystal display device in order to give protection when it is short-circuited. A resistor 22 is provided for the transistor 19. When a positive signal, as shown, from the oscillator, divider and decoder circuits is applied to the base of the transistor 19 the latter goes into the conductive state so that the driving voltage from the booster circuit is applied to the liquid crystal display device so a time indication may be displayed. Again it will be appreciated that PNP transistor may be used.

The timepiece described above may be made at a reasonable cost and has a relatively low power consumption.

WHAT WE CLAIM IS:—

1. A timepiece having a liquid crystal display device which, when a driving voltage is applied thereto, scatters light incident thereon, a timing structure for producing a time indication to be displayed by the liquid crystal display device, voltage means for producing the driving voltage and applying the same to the liquid crystal display device, and switch means for selectively operating the voltage means independently of the timing structure.

2. A timepiece having a liquid crystal display device which, when a driving voltage is applied thereto scatters light incident thereon, a timing structure for producing a



which, therefore, may be between 1.2 volts and 3.2 volts is converted to about 20 volts in the boosting circuit 35. It is also necessary to minimise the power consumption in the boosting circuit 35.

Figure 3 is a circuit diagram of one embodiment of a voltage boosting circuit for use with a timepiece according to the present invention. The boosting circuit has a switch 7' for selectively supplying power from the power source 36 thereto. Since display of the liquid crystal display device is dependent upon the ambient light conditions the power consumption of the power source can be reduced by switching the boosting circuit off when a display from the liquid crystal display device is not required, for example when the timepiece is in dark surroundings. Even though when the switch 7' is open there is no display by the liquid crystal display device the timepiece still keeps time because the oscillator, divider and decoder circuits are always connected to the power source and their operation is not affected by the switch 7'. Therefore when the switch 7' is closed, the driving voltage is supplied once more to the liquid crystal display device and the correct time indication is displayed.

The booster circuit includes a pair of transistors 8, 9 connected in push-pull configuration as a transistorised inverter. A boosting transformer has a core 10 which, because the oscillator frequency at the time of boosting may be as high as 500 Hz to 100 kHz is a ferrite core, preferably, a toroidal ferrite core. Such a core has a high permeability and consequently improves the efficiency of the boosting circuit. A primary coil 11 is wound on the core 10 and the ends of the primary coil are connected to the collectors of the transistors 8, 9 respectively. A centre tap of the primary coil is connected to the switch 7'. A detecting coil 12 is provided on the core 10 and the ends of the detecting coil are connected to the bases of the transistors 8, 9 respectively. A resistor 13 and a condenser 14 are connected in parallel between a centre tap of the detecting coil 12 and the centre tap of the primary coil. A secondary coil 15 is also provided on the core 10 and the centre tap of the secondary coil is earthed whilst the ends are connected via fullwave rectifying diodes 16, 17 to an output terminal at which there is provided a grounded smoothing condenser 18.

In the boosting circuit described above the centre taps of the primary and detecting coils are connected through the resistor 13 and the capacitor 14 and magnetically linked through the core 10 and so the circuit will oscillate. The collector currents of the transistors 8, 9 can be adjusted by changing the value of the resistor 13 and at the same

time changing the value of the condenser 14 to maximise efficiency. The transistors 8, 9 are arranged so that the oscillation can be started with a low voltage and a high current amplification rate β is achieved.

Experiments have indicated that transistorised inverters have a higher efficiency than MOSTs. The transistors 8, 9 are connected in a push-pull configuration to prevent direct current from overlapping on the core 10. A toroidal ferrite core fully utilises the magnetic fluxes from the various coils thereby increasing efficiency and enabling the size of the boosting circuit to be reduced. A boosting circuit such as that described above will increase an input voltage of 1.2 volts to 3.2 volts up to an output voltage of 20 volts very efficiently. As is clear from the above discussion, this boosting circuit is ideally suited to small timepieces such as wristwatches. When applied to a pocket watch, it enables the size of the watch to be reduced.

In the booster circuit illustrated in Figure 3 the transistors 8, 9 are of the NPN type and a rectified positive output is obtained but it will be appreciated that PNP type transistors may be used and a rectified negative output can be obtained.

Figure 4 illustrates a circuit diagram of a driving circuit for a timepiece according to the present invention. The driving circuit includes a transistor 19 and a liquid crystal display device 20. A resistor 21 is connected in series with the liquid crystal display device in order to give protection when it is short-circuited. A resistor 22 is provided for the transistor 19. When a positive signal, as shown, from the oscillator, divider and decoder circuits is applied to the base of the transistor 19 the latter goes into the conductive state so that the driving voltage from the booster circuit is applied to the liquid crystal display device so a time indication may be displayed. Again it will be appreciated that PNP transistor may be used.

The timepiece described above may be made at a reasonable cost and has a relatively low power consumption.

WHAT WE CLAIM IS:—

1. A timepiece having a liquid crystal display device which, when a driving voltage is applied thereto, scatters light incident thereon, a timing structure for producing a time indication to be displayed by the liquid crystal display device, voltage means for producing the driving voltage and applying the same to the liquid crystal display device, and switch means for selectively operating the voltage means independently of the timing structure.

2. A timepiece having a liquid crystal display device which, when a driving voltage is applied thereto scatters light incident thereon, a timing structure for producing a



- time indication to be displayed by the liquid crystal display device, and voltage means for producing the driving voltage and applying the same to the liquid crystal display device,
- 5 said voltage means including a transistor pair connected in push-pull configuration and a transformer having a toroidal ferrite core.
3. A timepiece as claimed in claim 1 in
- 10 which the voltage means includes a transistor pair connected in push-pull configuration and a transformer having a toroidal ferrite core.
4. A timepiece as claimed in any preceding claim in which the timing structure comprises an oscillator for producing a relatively high frequency signal, a divider circuit for producing from the relatively high frequency signal a relatively low frequency
- 15 signal and a counter circuit for producing the time indication by counting the cycles of the relatively low frequency signal, the voltage means including a driving circuit for applying the driving voltage to the liquid
- 20 crystal display device in response to an out-

put from the counter circuit.

5. A timepiece as claimed in claim 4 in which the oscillator includes a quartz crystal oscillator.

6. A timepiece as claimed in claim 4 or 5 in which said counter circuit includes metal oxide semiconductor transistor means.

7. A timepiece as claimed in any of claims 4 to 6 in which said driving circuit includes transistorised inverter means.

8. A timepiece as claimed in any preceding claim including a power source the voltage of which is arranged to drive the timing structure directly and from which a higher voltage is derived by the voltage means to

35 produce the driving voltage.

9. A timepiece substantially as herein described with reference to and as shown in the accompanying drawings.

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