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 5E



(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 the present invention there is provided a timepiece comprising a vibrator for generating a time standard, a driving means including complementary-symmetry type metal oxide semiconductor means, and liquid crystal display means driven by said driving means.

The timepiece preferably includes a DC step-up transformer for obtaining from a relatively low voltage source a relatively high voltage required to drive said liquid crystal display means.

Thus the transformer may be connected so that, in operation, the relatively high voltage is supplied to the vibrator and to the driving means.

Said driving means may include a frequency divider and decoder and an amplifier means.

The liquid crystal display means preferably has a plurality of segments each of which is directly connected to a complementary-symmetry type metal oxide semiconductor inverter of the driving means.

The vibrator may be a quartz crystal vibrator.

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

Figure 1 is a block diagram of one embodiment of a timepiece according to the present invention;

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

Figure 3 is an explanatory diagram of a complementary-symmetry type metal oxide semiconductor inverter;

Figure 4 is an explanatory diagram of a binary counter for use with a timepiece according to the present invention;

Figure 5 illustrates a DC step-up transformer for use with a timepiece according to the present invention;

Figure 6 shows a conventional driving circuit for a liquid crystal display device;

Figure 7(a) shows a driving circuit for a liquid crystal display device of a timepiece according to the present invention; and

Figure 7(b) shows a liquid crystal display device of a timepiece according to the present invention.

Referring to the drawings and in particular to Figure 1, there is illustrated a block diagram of one embodiment of a timepiece, for example a wrist watch, according to the present invention. The timepiece comprises a battery or cell B which may be the same type of cell as currently used in conventional wrist watches, for example it may be a mercury oxide cell, a silver oxide cell or a nickel-cadmium cell, and one or two cells may be employed but it will be appreciated that under certain circumstances more than two cells may be required. The cell B supplies a relatively low voltage, for example between 1.2 volts and 3.5 volts, to circuit blocks 1, 2, 5 via a line LV.

The circuit block 1 comprises a quartz crystal oscillator and a frequency divider and generates a time standard which is either a one second time signal, i.e. a time signal with a frequency of 1 Hz, or a one minute time signal, i.e. a time signal with a frequency of 1/60 Hz. In the embodiment illustrated in Figure 1 the circuit block 1 generates a one minute time signal since a liquid crystal display device 4 has no provision for displaying seconds. The time signal from the circuit block 1 is transmitted to the display device 4 in the direction indicated by the thick black lines.

The circuit block 2 comprises a frequency divider and a decoder for generating a one

hour time signal, i.e. a time signal with a frequency of 1/3600 Hz and a decoder signal therefrom.

5 The circuit block 3 comprises buffer amplifiers for amplifying the decoded signal, which amplified decoded signal drives the display device.

10 A relatively high voltage of, for example, between 10 volts and 30 volts is necessary to drive the display device and this relatively high voltage is supplied to the circuit block 3 from a line HV. The relatively high voltage is obtained from the circuit block 5 which includes a DC step-up transformer; the time-
15 piece, therefore, does not require a separate relatively high voltage cell to drive the display device.

Referring now to Figure 2 there is shown a block diagram of a second embodiment of a timepiece according to the present invention. The same reference numerals are used in Figure 2 as in Figure 1, the difference between the timepiece of Figure 1 and the timepiece of Figure 2 being the connections between the various circuit blocks. Thus, in the timepiece of Figure 2, the cell B is connected only to the circuit block 5 and the relatively high voltage obtained therefrom is applied to the other circuit blocks.

30 Figure 3(a) is an explanatory circuit diagram of a complementary-symmetry type metal oxide semiconductor (hereinafter referred to as a COS-MOS) inverter. The inverter is a fundamental unit of COS-MOS integrated circuits. The inverter comprises a P-channel MOS transistor T_1 of the enhancement type and an N-channel MOS transistor T_2 also of the enhancement type. The voltage of a power source driving the inverter is V_{DD} . The COS-MOS inverter consumes only leakage current in the stable state and, therefore, a COS-MOS integrated circuit composed of a plurality of such inverters has a very low power consumption. Thus COS-MOS integrated circuits are especially useful for use in timepieces such as wrist watches where the power available is very limited.

Figure 3(b) shows a timing chart of the input voltage (1) and the output voltage (2) of the COS-MOS inverter. The inverter has an extremely small leakage current and a charging loss of:

$$1/2 C \cdot V_{DD}^2 \cdot f$$

55 where: C is the capacity of the inverter and f is the frequency of the input voltage. Since C is relatively small and f is relatively low, the power consumption of the inverter is correspondingly reduced.

60 Figure 4(a) shows a binary counter including complementary-symmetry type metal oxide semiconductors and Figure 4(b) is a timing chart of the input and output voltages of the binary counter. It is convenient in a

timepiece according to the present invention to use the counter as the frequency dividers, because the binary counter consumes only a few nanowatts of power.

Figure 5 is a circuit diagram of the circuit block 5 of either Figure 1 or Figure 2. The circuit block 5 comprises two inverters I_1 , I_2 , a resistor R_1 , and a capacitor C_1 arranged as an astable multivibrator. The output signal from the multivibrator is amplified by an inverter I_3 , the output of which is applied to step-up transformer T. The inverters I_1 , I_2 , I_3 are supplied with power from the cell B, and the relatively high voltage required to drive the display device is obtained from a diode D which rectifies the pulsiform output of the transformer T. The rectified output voltage from the diode D is filtered by a capacitor C_2 . It will be appreciated that the output signal from the circuit block 1 or the circuit block 2 may be used in place of the output signal of the multivibrator.

Figure 6 shows a conventional driving circuit for the liquid crystal display device. The driving circuit comprises an enhancement type MOS transistor T' for driving a liquid crystal display element indicated by the equivalent RC circuit from a relatively high voltage. It is very difficult to switch perfectly the liquid crystal display element with this conventional driving circuit because it has an extremely high impedance, for example, R may be 500 M Ω or more and the transistor T' has a very low leakage current.

A driving circuit for a liquid crystal display of a timepiece according to the present invention is shown in Figure 7(a). The output impedance of a COS-MOS inverter is low at all times as one MOS transistor is ON and the other is OFF. Furthermore, the power consumption of a COS-MOS inverter is very low as previously discussed. Therefore, the leakage current from the inverter is sufficient to switch the liquid crystal display element. That is to say, a liquid crystal display element having a high impedance can be positively switched by the driving circuit described above.

Figure 7(b) shows a liquid crystal display device of a timepiece according to the present invention. The liquid crystal display device has seven segments E_1 — E_7 . The relatively high voltage is applied to seven driving inverters P_1 — P_7 from separate driving circuits as in Figure 7(a) and respective first electrodes of the segments are connected directly to respective output terminals of the inverters. The other electrodes of the display device are connected in common and are earthed.

The above described timepieces according to the present invention are highly accurate and have no moving parts. Furthermore, they may be powered by either one or two conventional cells.

WHAT WE CLAIM IS:—

1. A timepiece comprising a vibrator for generating a time standard, a driving means including complementary-symmetry type metal oxide semiconductor means, and liquid crystal display means driven by said driving means.
2. A timepiece as claimed in claim 1 including a DC step-up transformer for obtaining from a relatively low voltage source a relatively high voltage required to drive said liquid crystal display means.
3. A timepiece as claimed in claim 2 in which the transformer is connected so that, in operation, the relatively high voltage is supplied to the vibrator and to the driving means.
4. A time piece as claimed in claim 1 or 2 in which said driving means includes a frequency divider and decoder and an amplifier means.

5. A timepiece as claimed in any preceding claim in which the liquid crystal display means has a plurality of segments each of which is directly connected to a complementary-symmetry type metal oxide semiconductor inverter of the driving means.

6. A timepiece as claimed in any preceding claim in which the vibrator is a quartz crystal vibrator.

7. A timepiece substantially as herein described with reference to and as shown in Figures 1 to 5 and 7 of the accompanying drawings.

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