

A TIMEPIECE WITH A LIGHT EMITTING DEVICE

This invention relates to timepieces, for example electronic timepieces, with light emitting devices.

There exists in the prior art a timepiece with a light emitting device in which a light emitting element such as an EL (electro-luminescence) element is mounted on a display portion (e.g. time indicating hands, letters or a clock face) of the timepiece so that it may be easily observed even when the surroundings are dark as at night time. However, the brightness of the light emitting element has to be as low as possible so that the power consumption from a battery of the timepiece may be minimised.

In the aforementioned prior art timepiece, the illumination of the light emitting element cannot be seen when the surroundings are bright, e.g. in day time. If the brightness of the light emitting element is increased so that it can be seen even in day time, the power consumption from the battery is accordingly increased with the consequence that the life of the battery is even shorter.

In view of these problems, the present invention seeks to provide a timepiece with a light emitting device in which the illumination of the light emitting element can be seen even when the surroundings are bright.

According to the present invention there is provided a timepiece comprising: a light emitting element mounted on a display portion; light detecting means for detecting the brightness around said

timepiece; and switching means for selectively switching between a first mode in which said light emitting element is caused to illuminate with a given brightness when the brightness of the light detected by said light detecting means is lower than a predetermined brightness and is not illuminated when the brightness detected by the light detecting means is higher than the predetermined brightness, and a second mode in which said light emitting element is caused to illuminate with a brightness greater than the given brightness in the first mode.

In one embodiment the second mode further comprises when said light emitting element is caused to illuminate with a brightness greater than the given brightness in the first mode when the brightness detected by the light detecting means is greater than a predetermined brightness, and is caused to illuminate at the given brightness when the brightness detected by the light detecting means is less than the predetermined brightness.

The timepiece may include means for varying the frequency of an AC signal applied to the light emitting element to vary the brightness thereof. Alternatively the timepiece may include means for varying the amplitude of a signal applied to the light emitting element to vary the brightness thereof.

Means may be provided for causing the light emitting element to flash when energised.

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

Figure 1 is a circuit diagram of a first embodiment of a timepiece according to the present invention with a light emitting device;

Figure 2 is a circuit diagram of a second

embodiment of a timepiece according to the present invention with a light emitting device; and

Figure 3 is a circuit diagram of a third embodiment of an electronic timepiece according to the present invention with a light emitting device.

Referring first to Figure 1, there is illustrated a first embodiment of an electronic timepiece according to the present invention. A light emitting element 1 is disposed on a display portion (not shown) of the timepiece such as time indicating hands, letters or numerals indicating the time, or a face of the timepiece. The light emitting element 1 is composed of EL elements, EL1, EL2, EL3. A light detecting device 2 detects the brightness around the timepiece. This light detecting device is composed of a photo-conductive cell such as a CdS (cadmium sulphide) cell. A switching element 3 switches between a first mode in which the light emitting element 1 is caused to illuminate with a given brightness when the brightness around the timepiece detected by the light detecting device 2 is less than a predetermined brightness and is not caused to illuminate when the brightness detected by the light detecting device is higher than the predetermined brightness, and a second mode in which the light emitting element 1 is caused to illuminate with a brightness greater than the given brightness in the

first mode.

The EL elements EL1, EL2, EL3 of the light emitting element 1 have to be driven with an AC voltage of several tens of volts or more so that they may be caused to produce light. In the present embodiment of Figure 1, resistors R1, R2, capacitors C1, C2, Ca, Cp, a transformer TR, a transistor T1 and the EL elements EL1, EL2, EL3 constitute a blocking oscillator for driving the EL elements with an AC voltage of the required level. In one practical embodiment, a DC voltage of about 3 V from a power source DC, e.g. a battery, is converted into an AC voltage of an effective value of 40 to 80 V and having a frequency of several hundred Hz and is applied to the EL elements.

The capacitor Ca, connected between the transformer TR and the EL elements EL1, EL2, EL3, causes the blocking oscillator to oscillate stably even if there is current leakage between the two electrodes of each of the EL elements EL1, EL2, EL3. The capacity of the capacitor Ca is preferably five or more times as large as the parallel capacity of the EL elements EL1, EL2, EL3. However, the capacitor Ca may be omitted if there is no fear of leakage between the two electrodes of each of the EL elements.

The capacitor Cp, connected in parallel with the EL elements EL1, EL2, EL3, is used to reduce the frequency of the AC voltage thereby to increase the life time of the EL elements (it is generally believed that the life time of an EL element is inversely proportional to the drive frequency).

In the transformer TR, a connection a - c or b - c constitutes a primary side, a connection c - d constitutes a secondary side, and a connection e - f constitutes a tertiary side.

Next, the switching operation of the switching element 3 and the light emitting states of the light emitting element 1 accompanying the changes in the amount of light detected by the light detecting device 2 will be described:

OPERATION (A) - FIRST MODE

The switching element 3 is set in the first mode (i.e. when the switching element is set at position AT1):

When the switching element 3 is set in the first mode (or automatic mode) in which the light emitting state of the light emitting element 1 is automatically set in accordance with the brightness around the time-piece, the following operations are accomplished in accordance with the brightness of the light detected by the light detecting device 2.

First, the following operations are accomplished when the brightness of the light detected by the light detecting device 2 is lower than a predetermined brightness (of several luxes in the present embodiment). The photo-conductive cell used as the light detecting device 2 has its resistance raised to a relatively high value to turn ON a transistor T2 so that a transistor T3 is accordingly turned ON. As a result, the transformer TR has its primary side constituted by the connection a - c to apply the predetermined AC voltage (e.g. 50 V) to the EL elements EL1, EL2, EL3 so that the light emitting element 1 illuminates with a relatively low luminance.

Next, the following operations are accomplished when the brightness of the light detected by the light detecting device 2 is higher than a predetermined brightness. The photo-conductive cell used as the

light detecting device 2 has its resistance reduced to a relatively low level to turn OFF the transistor T2 so that the transistor T3 is also turned OFF. As a result, no current flows to the primary side of the transformer TR and so no AC voltage is provided to the EL elements EL1, EL2, EL3 so that the light emitting element 1 does not illuminate.

OPERATION (B) - SECOND MODE

The switching element 3 is set in the second mode (i.e. when the switching element is set at position DM1):

When the switching element 3 is set in the second mode (i.e. a demonstration mode) in which the light emitting element is caused to illuminate with high luminance, the following operations are accomplished.

The transformer TR has its primary side constituted by the connection b - c. Since the number of turns of the primary side is smaller than that during the foregoing Operation (A), the EL elements EL1, EL2, EL3 are fed with a higher AC voltage (e.g. 75 V) than that during Operation (A) so that the light emitting element 1 illuminates with a high luminance. In the present embodiment, as is apparent from Figure 1, the light emitting element 1 illuminates with high luminance independently of the brightness of the light detected by the light detecting device 2.

Since in this second mode, the light emitting element 1 illuminates brightly even if the surroundings are bright, as during day time, the illumination of the light emitting element 1 can be seen without fail. This highly bright emission of light is effective especially when it is desired to demonstrate the light emitting element 1 when the surroundings are also

bright.

Generally speaking, it is known that the emission luminance of an EL element is proportional to the frequency of the AC drive. Thus, when the switching element 3 is set in the first mode a connection x - y is electrically shorted to connect the capacitor Cp in parallel with the EL elements EL1, EL2, EL3 so that the EL elements may be driven with an AC voltage of relatively low frequency. When, on the other hand, the switching element 3 is set in the second mode the connection x - y of Figure 1 is electrically opened to disconnect the capacitor Cp so that the EL elements EL1, EL2, EL3 are driven with an AC voltage of a relatively high frequency. In this way also it is possible to control the low- and high-luminance illuminations by the EL elements EL1, EL2, EL3. In this case, it is not always necessary to increase or decrease the number of turns of the primary side of the transformer TR for each mode.

In the present embodiment, the modes may be suitably switched as follows. The switching element 3 is usually set at the first mode so that the EL elements may automatically illuminate with low luminance when the surroundings are dark. When the surroundings are bright, the switching element 3 may be set in the second mode, so that the EL elements may illuminate with high luminance. As a result, in normal operation, the EL elements illuminate automatically with low luminance only when the light detecting device 2 detects that the brightness around the timepiece is less than a predetermined brightness with the result that power consumption is reduced. If necessary the switching element 3 can be set in the second mode so that the EL elements may illuminate with high luminance. Thus, the

so called "demonstration function" can be performed so that the illumination of the EL elements can be clearly seen even when the surroundings are bright.

A second embodiment of an electronic timepiece according to the present invention is illustrated in Figure 2.

In Figure 2, numerals and symbols identical to those of Figure 1 have the same functions and so further description will be omitted.

The switching of the switching element 3 and the light emitting states of the light emitting element 1 accompanying the changes in the amount of light detected by the light detecting device 2 will be described in the following:

OPERATION (C) - FIRST MODE

When the switching element 3 is set in the first mode (i.e. when the switching element is set at position AT2):

The functions and operations are similar to those of Operation (A) of the first embodiment, and their descriptions will be omitted.

OPERATION (D) - SECOND MODE

The switching element 3 is set in the second mode (i.e. when the switching element is set at position DM2):

The following operations are accomplished when the switching element 3 is set at the second mode (i.e. a demonstration mode) in which the light emitting element 1 is caused to illuminate with a high or low brightness.

First of all, the following operations are accomplished when the brightness of the light detected by the light detecting device 2 is higher than a pre-

determined brightness (e.g. several luxes in the present embodiment).

Since the photo-conductive cell used as the light detecting device 2 has its resistance reduced to a relatively low level, the transistor T2 is turned OFF so that the transistor T3 is also turned OFF. Since, moreover, a transistor T4 is also OFF, a transistor T5 is turned ON by the actions of the resistors R8, R9. As a result, the transformer TR has its primary side constituted by the connection b - c and the number of turns of the primary side is smaller than that in Operation (C) so that the EL elements EL1, EL2, EL3 are fed with a higher AC voltage (e.g. 75 V) than that during Operation (C). Thus the light emitting element 1 is caused to illuminate with a high luminance.

Next, the following operations are accomplished when the brightness of the light detected by the light detecting device 2 is lower than a predetermined brightness.

The photo-conductive cell used as the light emitting device 2 has its resistance raised to a relatively high level to turn ON the transistor T2 so that the transistor T3 is turned ON. As a result, the transformer TR has its primary side constituted by the connection a - c to apply a predetermined AC voltage (e.g. 50 V) to the EL elements EL1, EL2, EL3 so that the light emitting element 1 illuminates with a low luminance.

Since in this mode, the light emitting element 1 illuminates with high luminance when the surroundings are bright (as in day time), the illumination of the light emitting element 1 can be easily seen. This highly bright emission is effective especially when it is desired to demonstrate the light emitting element 1

in bright surroundings. When, on the other hand, the surroundings are dark (as at night), the illumination of the EL elements can also be easily seen even though their luminance is low. Thus, the power consumption can be reduced by causing the light emitting element 1 to illuminate with a low luminance.

OPERATION (E) - THIRD MODE

The switching element 3 is normally set in the illuminating mode (i.e. when the switching element is set at ON):

In this third mode, the light emitting element 1 is always caused to illuminate with a low luminance independently of the brightness of the light detected by the light detecting device 2.

In this mode, as is apparent from Figure 2, the transformer TR has its primary side constituted by the connection a - c independently of the brightness of the light detected by the light detecting device 2. As a result, a predetermined AC voltage (e.g. 50 V) is applied to the EL elements EL1, EL2, EL3 so that the light emitting element 1 illuminates with a low luminance.

OPERATION (F) - FOURTH MODE

The switching element 3 is normally set in the non-illuminating mode (i.e. when the switching element is set OFF):

In this fourth mode, as is apparent from Figure 2, no current flows to the primary side of the transformer TR and therefore no AC voltage is applied to the EL elements EL1, EL2, EL3 so that the light emitting element 1 does not illuminate at all.

In this second embodiment of the present invention, it

is not essential to provide the third, (the normal illuminating mode) or fourth mode, (the normally non-illuminating mode).

In this embodiment, the switching element 3 may normally be set to the first mode so that the EL elements may illuminate with low luminance when the surroundings become dark. When the surroundings are bright, the switching element 3 may be set, if necessary, to the second mode to cause the EL elements to illuminate with high luminance. As a result, in normal operation, the EL elements illuminate automatically with low luminance only when the light detecting device 2 detects that the brightness surrounding the timepiece is less than the predetermined brightness with the result that power consumption is reduced. If necessary the switching element 3 can be set in the second mode so that the EL elements illuminate with high luminance. Thus, the so called "demonstration function" can be performed so that the illumination of the EL elements can be clearly seen even when the surroundings are bright. Furthermore, the switching element 3 may be set to the third mode (i.e. the illumination mode) when the surroundings are dark (as at night) and the EL elements illuminate with low luminance so that the power consumption can be reduced to a lower value than that of the first embodiment in which the EL elements always illuminate with high luminance in the demonstration mode independently of the brightness of the surroundings.

Incidentally, the switching element can be set to the fourth or "non-illuminating mode" at night (e.g. bed time) and to the third mode, when the time is to be confirmed at bed time, so that the EL elements illuminate with low luminance.

A third embodiment of an electronic timepiece according to the present invention is illustrated in Figure 3.

In Figure 3, the numerals and symbols identical to those of Figure 1 have the same functions as those of Figure 11 and so further description will be omitted.

The switching of the switching element 3 and the light emitting states of the light emitting element 1 accompanying the changes in the amount of light detected by the light detecting device 2 will be described in the following:

OPERATION (G) - FIRST MODE

The switching element 3 is set in the first mode (i.e. when the switching element is set at AT3):

When the switching element 3 is set in the first mode in which the light emitting state of the light emitting element 1 is automatically set in accordance with the brightness around the timepiece, the following operations are accomplished in accordance with the brightness of the light detected by the light emitting device 2.

First of all, the following operations are accomplished when the brightness of the light detected by the light detecting device 2 is lower than a predetermined brightness (of several luxes in the present embodiment).

In accordance with the brightness of the light detected by a light detecting device 2', the resistance of its photo-sensitive cell is changed such that it has a larger value for lower brightness. In accordance with the magnitude of the resistance, the bias voltage of a transistor T6 is changed. As will be apparent from Figure 3, the transformer TR has its primary side constituted by the connection a - c and the current

thereto is a function of the conductivity of the transistor T6. Specifically, the current flowing through the primary side of the transformer TR is reduced as the brightness of the light detected by the light detecting device 2 is reduced, so that the AC voltage applied to the EL elements EL1, EL2, EL3 is reduced so reducing the brightness of the light emitting element 1.

Since, in this mode, the light emitting element 1 is set to illuminate with lower luminance in darker surroundings of the timepiece, it can be caused to illuminate with the optimum brightness in bright surroundings so that the display of the timepiece can become clearly visible.

Next, the following operations are accomplished when the brightness of the light detected by the light detecting device 2 is higher than a predetermined brightness.

The photo-conductive cell used as the light detecting device 2 has its resistance reduced to turn OFF the transistor T2 so that the transistor T6 is also turned OFF. As a result, no current flows to the primary side of the transformer TR, and no AC voltage is applied to the EL elements EL1, EL2, EL3 so that the light emitting element 1 does not illuminate.

OPERATION (H) - SECOND MODE

The switching element 3 is set in the second mode (i.e. when the switching element is set at position DM3):

The following operations are accomplished when the switching element 3 is set in the second mode (i.e. the demonstration mode) where the light emitting element 1 is caused to illuminate with a high luminance.

The transformer TR has its primary side consti-

tuted by connection b - c. Since the number of turns of the primary side in consequence becomes less than that in Operation (G), the EL elements EL1, EL2, EL3 are fed with an AC voltage (e.g. 75 V) higher than the highest AC voltage (e.g. 50 V) supplied in Operation (G) so that the light emitting element 1 illuminates with high luminance. In this embodiment, as is apparent from Figure 3, the light emitting element 1 illuminates with high luminance independent of the brightness of the light detected by the light detecting device 2.

In the present mode, the light emitting element 1 illuminates with high luminance even when the surroundings are bright as in day time, so that the illumination of the light emitting element 1 can be seen clearly. This illumination is effective especially if the light emitting element 1 is operated when the surroundings are bright.

In the present embodiment, the switching element is normally set in the first mode (automatic mode) only in darkness, so that the EL elements may illuminate with low luminance in accordance with the brightness of the surroundings, and in the second mode (i.e. a demonstration mode) if necessary, when the surroundings are bright, so that the EL elements may illuminate with high luminance. As a result, in normal operation, the EL elements can illuminate with low luminance only in the dark in accordance with the brightness of the surroundings to reduce the power consumption. If necessary, the EL elements can be set to illuminate with high luminance so that the so called "demonstration function" can be performed with excellent visibility even if the surroundings are bright.

The present invention has been described above in connection with three embodiments but is not limited

thereto and the following modifications are possible.

For example, the brightness of the EL elements can be controlled by changing not only the amplitude of the AC voltage applied to the EL elements but also the frequency of the AC voltage applied to the EL elements and changing the duty ratio.

Moreover, the following functions can be effectively added to a timepiece according to the present invention. For example, the light emitting element may flash with an arbitrary period. When the surroundings are so dark that the display of the timepiece cannot be seen, the light emitting element is caused to illuminate as has been described hereinbefore. However, for time recognition, it is not always necessary to cause the light emitting element to be illuminated continuously, but the recognition can also be achieved by causing the illumination to flash with a suitable period. Thus, the energy consumed by the light emitting element can be reduced by up to an order of magnitude. Incidentally, the flashing period preferably is one to two seconds and can be achieved in an analog timepiece by using motor driving pulse signals.

In the first embodiment of the present invention described above the light emitting element is normally enabled to illuminate automatically with low luminance only in the dark thereby to reduce power consumption and, if necessary, to illuminate with high luminance so that the so called "demonstration function" can be achieved even if the surroundings are bright.

In the second embodiment of the present invention described above the light emitting element is normally enabled to illuminate automatically with low luminance only in the dark thereby to reduce the power consumption

and, if necessary, to illuminate with high lumiance so that the so called "demonstration function" can be achieved even in daylight. In this case, in the second mode (i.e. a demonstration mode) when the surroundings are dark, the light emitting element illuminates with low luminance so the power consumption can be reduced to a lower value than that in the foregoing first embodiment in which the light emitting element in the second mode always illuminates with high luminance independently of the brightness of the surroundings.

In the third embodiment described above, the light emitting element is normally enabled to illuminate with low luminance only in the dark in accordance with the brightness of the surroundings thereby to reduce the power consumption and, if necessary, to illuminate with a high luminance so that the so called "demonstration function" can be achieved even if the surroundings are bright.

C L A I M S

1. A timepiece comprising: a light emitting element mounted on a display portion; light detecting means for detecting the brightness around said timepiece; and switching means for selectively switching between a first mode in which said light emitting element is caused to illuminate with a given brightness when the brightness of the light detected by said light detecting means is lower than a predetermined brightness and is not illuminated when the brightness detected by the light detecting means is higher than the predetermined brightness, and a second mode in which said light emitting element is caused to illuminate with a brightness greater than the given brightness in the first mode.

2. A timepiece as claimed in claim 1 in which the second further comprises when said light emitting element is caused to illuminate with a brightness greater than the given brightness in the first mode when the brightness detected by the light detecting means is greater than a predetermined brightness, and is caused to illuminate at the given brightness when the brightness detected by the light detecting means is less than the predetermined brightness.

3. A timepiece as claimed in claim 2, in which the switching means is arranged to switch selectively between the first, the second and a third mode in which said light emitting element is caused to illuminate with the given brightness irrespective of the brightness of the light detected by said light detecting means.

4. A timepiece as claimed in claim 3, in which the switching means is arranged to switch selectively



between the first, the second, the third and a fourth mode in which said light emitting element is caused not to illuminate at any brightness irrespective of the brightness of the light detected by said light detecting means.

5. A timepiece as claimed in any one of the preceding claims, including means for varying the frequency of an AC signal applied to the light emitting element to vary the brightness thereof.

6. A timepiece as claimed in any one of claims 1 to 4 including means for varying the amplitude of a signal applied to the light emitting element to vary the brightness thereof.

7. A timepiece as claimed in any preceding claim in which means are provided for causing the light emitting element to flash when energised.

8. A timepiece as claimed in claim 1 in which said given brightness in said first mode is lowered in accordance with decreasing of the brightness around said timepiece.

9. A timepiece substantially as herein described with reference to Figure 1 or Figure 2 or Figure 3 of the accompanying drawings.
