

PATENT SPECIFICATION (11)

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(54) IMPROVEMENTS IN OR RELATING TO ELECTRIC TIMEPIECES

(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

5 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:—

10 This invention relates to electric timepieces and has for its object to provide improved electric watches or other timepieces wherein time is displayed by solid state electronic means instead of by the more usual mechanically driven hands.

15 More specifically, the invention seeks to provide improved electric timepieces of relatively simple construction and arrangement and in which time is displayed electronically by solid state means which are of such construction that there is a clearly visible display in any condition of ambient lighting over a wide range of different strengths of light. In its preferred embodiments the invention achieves the foregoing object by means which require a minimum of electric power consumption for display.

25 As will be seen later timepieces in accordance with this invention have two display means, namely a passive one for conditions (such as daylight) of good ambient lighting and an active one for poor lighting conditions. In this specification and in the claims the words "passive" and "active" as applied to display means are employed to distinguish between display means which are dependent upon ambient light to produce a display (passive) and display means which are self luminous (active).

30 According to this invention an electric timepiece has a solid state digital time display arrangement comprising passive (as above defined) display means for time display in conditions of substantial relatively high incident ambient light levels; active (as above defined) display means for time display in conditions of relatively low and zero incident ambient light levels; and means for selecting one or other of said display means for utilisation.

[Price 25p]

50 Preferably the active display means is of the Gallium-arsenide (GaAs) type and the passive display means is of the liquid crystal type.

55 Preferably the two display means are arranged one behind the other; the radiation from the active display means passing through the passive display means from the rear.

60 Preferably also an electronic circuit arrangement for driving the two display means is mounted together with the two display means on a common semi-conductor base plate in a monolithic structure.

65 Preferably the aforesaid selection means comprise a photo-sensitive element subjected to ambient light and arranged to produce a control signal dependent on the level of said light and means for utilising said control signal to interrupt the drive to the active display means when said level is above a pre-determined value and to interrupt the drive to the passive display means when said level is below said value.

75 When used as a display element responsive to electric signals a liquid crystal device reflects incident light to an extent, i.e. with a reflection ratio which is changed according to the electric signal changes. In conditions of relative darkness therefore, i.e. inside an ill-lit room or in some other dark place, a liquid crystal display device will not give a satisfactorily good display because of the small amount of incident light. On the other hand a display element such as a self-luminous Gallium-arsenide device is very effective in the dark but not so in daylight or bright lighting.

80 Another characteristic of the liquid crystal element type of display device is that it requires several tens of micro-watts to display time by means of figures (numeric display) of a practical size for a wrist watch, whereas a Gallium-arsenide display device requires several milli-watts for figures of the same size. A display device of the Gallium-arsenide type, if in continuous use, would therefore require more electric power than is ordinarily available in a wrist watch.

Even if a switch were provided to switch on the display only when the watch user wants to know the time, the electric power required would still be inconveniently high because a large amount of electric current would have to be supplied for the display to be clearly visible when the watch face is exposed to bright sunlight or strong daylight. Moreover, the self-luminous element of a Gallium-arsenide display device has considerable electric resistance so that substantial heat is generated by the electric current and, if the temperature of the display element is not to be increased inadmissibly, this heat must be dissipated externally — which it is by no means easy and convenient to achieve.

In carrying out the present invention, a display device which effects display by reflection of incident light, i.e. by changing the refractive index (a liquid crystal device) is provided for use in the daytime when there is plenty of incident light, and a display element such as self-luminous Gallium-arsenide device is provided for use in the night time or in other situations when there is little incident light. Such a self-luminous display device can give a clear display with only a small electric power consumption when there is little incident light. Preferably a manually operable switch is provided on the timepiece for preventing the active display from coming into operation except when said switch is operated. This provision has the advantage that, during periods in which the user is not likely to want to read the time frequently — for example during the night — the active display will be held out of use, and will therefore consume no power, except when the switch is operated.

This invention is illustrated in the accompanying drawings, in which:—

Figure 1 is a schematic face view of a watch in accordance with the invention.

Figure 2 is a simplified schematic cross-sectional view of one arrangement for liquid crystal (passive) display and Gallium-arsenide (active) display, which can be used in the watch of Figure 1.

Figure 3 is a simplified schematic cross-sectional view on line III—III of Figure 1 showing another form of Gallium-arsenide display and crystal display which can be used in the watch of Figure 1, and

Figure 4 is a block diagram of the circuit arrangement of the watch.

Referring to Figures 1 and 2, the watch includes a transparent base plate 1; a time display arrangement 2 of the numeric display type wherein the figures displayed are made up of a plurality of segments; a frequency divider, oscillation and driving circuit arrangement 3 of the crystal vibrator type using a MOS transistor (Metal-Oxide-

Semiconductor transistor); and display elements 4 and 5 for indicating the name of the day in the week (Monday, Tuesday and so forth) and the date of the day in the month (1, 2, 3 and so forth). In Figure 1 the former is indicated by the word "week" (short for weekday) and the latter by the word "day". These last elements 4 and 5 may be of the mechanical display type as the relevant time intervals they have to deal with are long. For example names of the days and the dates may be printed on rings or discs which are advanced across the appropriate viewing windows once a day by means of electro-magnets or the like. The watch also has a photo resistor 14 responsive to incident light and a push-button switch 15. Means (not shown) may be provided for manually adjusting the light reaching the photo resistor 14. As will be explained more in detail with reference to Figure 2 the watch has two display modes namely a passive mode in which a liquid crystal layer is utilised and an active or self-luminous mode in which Gallium-arsenide is utilised. The switch 15 has to be pressed to bring the active mode display into use. In this way power is taken to display in this mode only when the switch is pressed. The selection of the display mode is effected by the photo-resistor 14 but the level of incident light at which the change from one mode to the other occurs can be manually adjusted by the means (not shown) for adjusting the light reaching the photo-resistor 14.

Referring to Figure 2, the liquid crystal display device therein represented comprises a layer of liquid crystal 10 which is situated between a transparent plate 1 and a transparent cover 7 and is confined at its edges by spacing means 6 between the plate 1 and the cover 7. The reference 2 is used in Figure 2 for segment electrodes of the numeric display 2 of Figure 1. 8 is a self-luminous Gallium-arsenide display arrangement which also includes numeric display segment electrodes (not shown). The whole display arrangement is thus a layered display device incorporating a passive display responsive to incident light (the liquid crystal display) and an active self-luminous display (the Gallium arsenide display). The liquid crystal material 10 is normally transparent but when a sufficiently high voltage is applied between appropriate segments 2 and the transparent base plate 1 a desired numeral is displayed because of dispersion of incident ambient light; the brighter the light the brighter the display. This mode of display is therefore satisfactory when the level of illumination is high and is accordingly selected by the photo-resistor 14. When the light level is low or zero the photo resistor 14 passes current through appropriate

display elements (not shown) of the Gallium-arsenide arrangement 8. The lower the ambient incident light level the brighter will be the display in this mode.

5 In the embodiment represented in Figure 3 a Gallium-arsenide display, an MOS transistor and a liquid crystal device are mounted on the same semi-conductor base plate. The arrangement of Figure 3 includes a display
10 cell generally designated 20 in which is incorporated a liquid crystal (passive) display arrangement 10 and a light emitting diode (active) display arrangement 21. In order not to complicate Figure 3 these display
15 arrangements are not shown in detail and the cell 20 is only schematically generally indicated. The active and passive display arrangements in the cell 20 are, however, as already described with reference to Figure 2. 11 is a sapphire or a spinel base
20 plate. 2 is an electrode associated with a liquid crystal 10. 3 is a frequency divider, oscillation and driving circuit using an MOS transistor and 4 is a ring or disc for display of the day or date. Alternatively day and/
25 or date display, if required may be effected by solid state display means. 12 is an apertured layer or spacer between the base plate 11 and a transparent cover plate 13, and serves as a sealing spacer preventing deterioration or loss of the liquid crystal material. 21 is a self-luminous element of Gallium-arsenide mounted on the semi-conductor base
30 plate 11. In this way there is obtained a display cell in which each segment of the liquid crystal display can be lighted from the back by the infra-red radiation from the Gallium-arsenide element. In an ordinary display device using only liquid crystal
35 effects the visibility of the display provided depends on the amount of incident light. However, in the display device shown in Figure 3 in which visibility can be produced by dull red light passed through the liquid
40 crystal device from the rear, visibility in darkness can be achieved with only a small amount of electric power consumption because the liquid crystal device will appear red when there is only a small amount of
45 lighting from the rear. The illustrated arrangements of Figures 2 and 3 are particularly advantageous for very small watches because the self-luminous display portion and the liquid crystal display portion overlap and occupy virtually the same total area. In Figure 3 "N" is an N-type semi-conductor
50 substrate, but in the case of a P-channel MOS transistor it is necessary to provide p+ islands on the N-type substrate.
55 Figure 4 is an electrical block circuit diagram. The signal from the time standard crystal oscillator OSC incorporated in unit 3 is frequency divided by the divider circuit DIV (using MOS transistors) and the divided
60 frequency is fed to a driving circuit DRIV

for driving the display device which is controlled by a photo detecting element PHO (14 in Figure 1) which selectively controls the supply of electric driving power to the
70 passive (liquid crystal) or active (Gallium arsenide) parts of the display in response to the amount of the incident light and so that, when the ambient light is insufficient to provide a clearly visible display from the passive part, display is provided by the active
75 part. The passive display part is referenced PAS in Figure 4 and the active display part is referenced ACT. By virtue of the control by the photo detector PHO electric power consumption is reduced to a minimum consistent with the maintenance of a clearly
80 visible display in darkness or poor ambient lighting. If the base plate is a semi-conductor base plate 11 in Figure 3, the photo resistor may be mounted thereon.
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As will now be appreciated, a timepiece in accordance with this invention has a solid state display arrangement which is simple in nature, of high reliability, and incorporates active and passive displays which are used to best advantage whatever the conditions of ambient lighting.

WHAT WE CLAIM IS:—

1. An electric timepiece having a solid
95 state digital time displaying arrangement comprising passive (as herein defined) display means for time display in conditions of relatively high incident ambient light levels; active (as herein defined) display
100 means for time display in conditions of relatively low or zero incident ambient light levels; and means for selecting one or other of said display means for utilisation.
2. A timepiece as claimed in claim 1
105 wherein the active display means is of the Gallium-arsenide type and the passive display means is of the liquid crystal type.
3. A timepiece as claimed in claim 1
110 wherein the two display means are arranged one behind the other, the radiation from the active display means passing through the passive display means from the rear.
4. A timepiece as claimed in any of
115 claims 1 to 3 wherein an electronic circuit arrangement for driving the two display means is mounted together with the two display means on a common semi-conductor base plate in a monolithic structure.
5. A timepiece as claimed in any of the
120 preceding claims wherein a manually operable switch is provided on the timepiece for preventing the active display coming into operation except when said switch is operated.
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6. A timepiece as claimed in any of the
preceding claims and wherein said selection means comprise a photo-sensitive element subjected to ambient light and arranged to produce a control signal dependent on the
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display elements (not shown) of the Gallium-arsenide arrangement 8. The lower the ambient incident light level the brighter will be the display in this mode.

5 In the embodiment represented in Figure 3 a Gallium-arsenide display, an MOS transistor and a liquid crystal device are mounted on the same semi-conductor base plate. The arrangement of Figure 3 includes a display
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60 p+ islands on the N-type substrate.

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for driving the display device which is controlled by a photo detecting element PHO (14 in Figure 1) which selectively controls the supply of electric driving power to the passive (liquid crystal) or active (Gallium
70 arsenide) parts of the display in response to the amount of the incident light and so that, when the ambient light is insufficient to provide a clearly visible display from the passive part, display is provided by the active
75 part. The passive display part is referenced PAS in Figure 4 and the active display part is referenced ACT. By virtue of the control by the photo detector PHO electric power consumption is reduced to a minimum consistent with the maintenance of a clearly
80 visible display in darkness or poor ambient lighting. If the base plate is a semi-conductor base plate 11 in Figure 3, the photo resistor may be mounted thereon. 85

As will now be appreciated, a timepiece in accordance with this invention has a solid state display arrangement which is simple in nature, of high reliability, and incorporates
90 active and passive displays which are used to best advantage whatever the conditions of ambient lighting.

WHAT WE CLAIM IS:—

1. An electric timepiece having a solid
95 state digital time displaying arrangement comprising passive (as herein defined) display means for time display in conditions of relatively high incident ambient light levels; active (as herein defined) display
100 means for time display in conditions of relatively low or zero incident ambient light levels; and means for selecting one or other of said display means for utilisation.

2. A timepiece as claimed in claim 1
105 wherein the active display means is of the Gallium-arsenide type and the passive display means is of the liquid crystal type.

3. A timepiece as claimed in claim 1
110 wherein the two display means are arranged one behind the other, the radiation from the active display means passing through the passive display means from the rear.

4. A timepiece as claimed in any of
115 claims 1 to 3 wherein an electronic circuit arrangement for driving the two display means is mounted together with the two display means on a common semi-conductor base plate in a monolithic structure.

5. A timepiece as claimed in any of the
120 preceding claims wherein a manually operable switch is provided on the timepiece for preventing the active display coming into operation except when said switch is operated. 125

6. A timepiece as claimed in any of the
preceding claims and wherein said selection means comprise a photo-sensitive element subjected to ambient light and arranged to produce a control signal dependent on the
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level of said light and means for utilising
said control signal to interrupt the drive to
the active display means when the said level
is above a predetermined value and to inter-
rupt the drive to the passive display means
when said level is below said value.
7. Timepieces having solid state time
displaying arrangements substantially as

herein described and illustrated in the ac-
companying drawings.

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