

[54] **SOLID STATE ELECTRONIC WATCH**
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[56] **References Cited**
UNITED STATES PATENTS

3,505,804 4/1970 Hofstein.....58/23 R
3,516,242 6/1970 Lehovec.....58/23 R
3,576,099 4/1971 Walton.....58/23 R
3,613,351 10/1971 Walton.....58/23 R

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[57] **ABSTRACT**

A watch is provided with a liquid crystal display system operable at high levels of ambient illumination and a solid state display system operable at low levels of ambient illumination. A photo-transistor selects the display system appropriate to the ambient light level.

10 Claims, 4 Drawing Figures

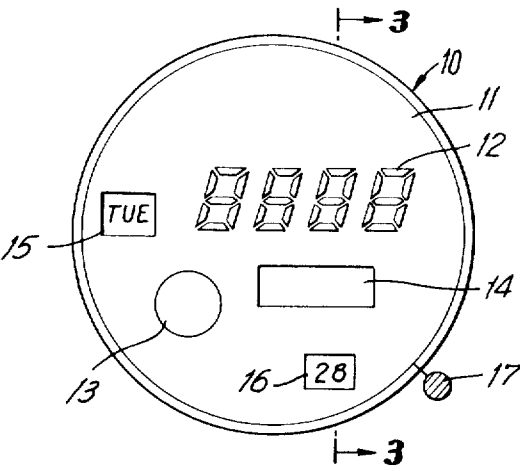


FIG. 1

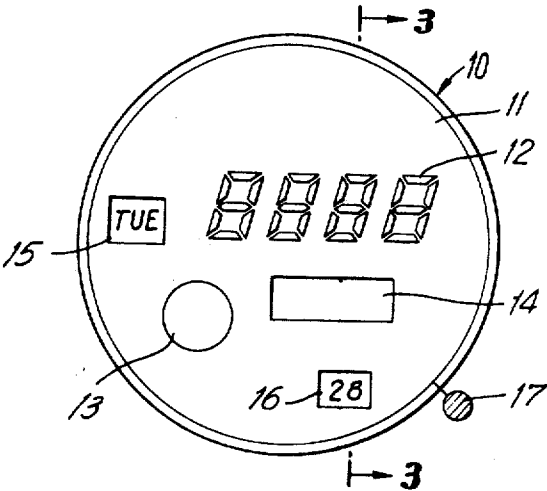


FIG. 2

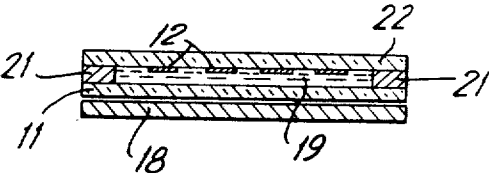


FIG. 3

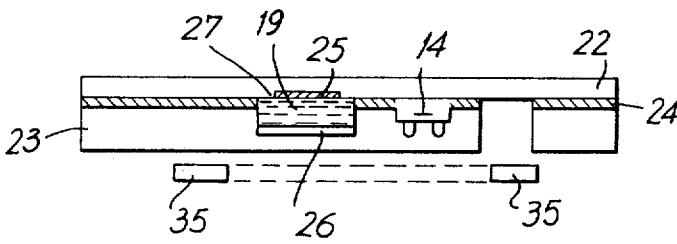
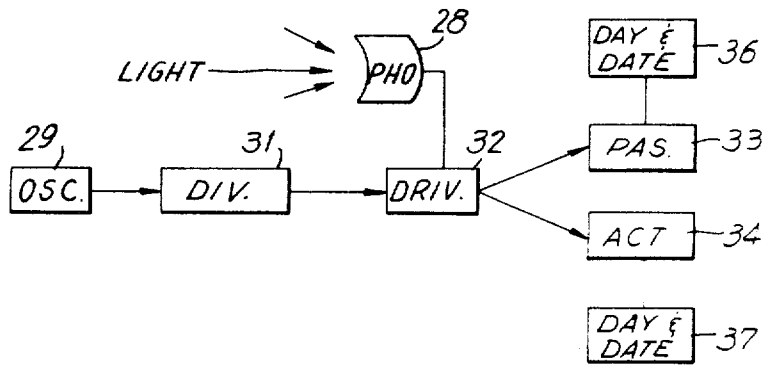


FIG. 4



SOLID STATE ELECTRONIC WATCH

BACKGROUND OF THE INVENTION

Liquid crystal display devices depend upon the fact that the imposition of a sufficient electric field on a liquid crystal material causes the liquid crystal material to disperse light and thus to appear to be luminous. However, the light to be dispersed must be provided from outside the device. Consequently, even though the amount of electrical energy required is very small, such a device is unsuitable for use where the level of ambient illumination is low.

In contrast, electroluminescent, i.e., self-luminous devices such as those based on gallium-arsenide require substantially greater amounts of energy since the temperature of the display element must be increased. Also the heat produced must be rejected to the exterior of the device. When an attempt is made to use such a device in regions of high ambient illumination, a high level of luminescence is required for the light produced to be perceptible, resulting in a considerable energy drain from the energy source.

SUMMARY OF THE INVENTION

Incorporated in a watch are a liquid crystal display device and a self-luminous display device. The former is a passive device and is suitable for use at high ambient light levels. The latter is an active device and utilizes an electrically powered self-luminous solid state material such as gallium-arsenide; it is suitable for use at low ambient light levels or in complete darkness. In this device, a photo-transistor senses the ambient light level, and, in accordance with the light level, either imposes an electric field on the liquid crystal material or powers the self-luminous solid state material. In order to decrease the total energy consumed, the photo-transistor, its associated circuitry and the selected display device are energized only when the user wishes to note the time.

Accordingly, an object of the present invention is to provide an improved watch having an electrically powered display system suitable for use at all levels of illumination, including total darkness.

Another object of the invention is to provide an improved electrically powered display system comprising a liquid crystal material for use at high levels of illumination and a solid state self-luminous material for low levels of illumination.

A further object of the invention is to provide an improved electrically powered display system incorporating a device for determining the level of illumination and selecting an appropriate display means.

Yet another object of the invention is to provide an improved electrically powered display system which functions only when energized by an exterior signal.

Still other objects and advantages of the invention will in part be obvious and will in part be apparent from the specification.

The invention accordingly comprises an article of manufacture possessing the features, properties, and the relation of elements which will be exemplified in the article hereinafter described, and the scope of the invention will be indicated in the claims.

BRIEF DESCRIPTION OF THE DRAWING

For a fuller understanding of the invention, reference is had to the following description taken in connection with the accompanying drawing, in which:

FIG. 1 is a plan view of an electrically powered digital display system constructed in accordance with a preferred embodiment of the present invention;

FIG. 2 is a cross-sectional elevational view of the device of FIG. 1;

FIG. 3 is a sectional view at an enlarged scale, taken along line 3-3 of FIG. 1; and

FIG. 4 shows schematically the arrangement of the components of the display device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A solid state electronic watch in accordance with the present invention is generally indicated by the reference numeral 10. The watch has a transparent base plate 11. The display portion of the watch is made up of segments 12; in the embodiment shown in FIG. 1 each of the indicia has seven segments. Photo-transistor 13 which is responsive to incident light controls a divider, oscillation and driving circuit and crystal vibrator portion 14, using an MOS (metal oxide-semiconductor) transistor. Day and date display elements 15 and 16 are preferably mechanically activated. In a preferred form, the day and the date are printed on planar, ring-shaped disks which are advanced once a day by means of electric plungers, for instance; it is not uneconomical of electrical energy to advance these disks in this way because the electro-mechanical activation elements need be energized only for a short time.

While the advancement of the day and date disks 15 and 16 occurs automatically, the time display consisting of the segments 12 is activated only on pressing a switch 17. The selection of the display mode is, of course, controlled by the photo-transistor 13, but the level of incident light at which the choice changes can be set manually. This adjustment is not shown. Similarly, the current fed to self-luminous element 18 (FIG. 2) may also be adjusted by means not shown.

A cell for holding liquid crystal material is formed by spacers 21 between cover 22 and transparent base plate 11. Liquid crystal material 19 normally is transparent, but when a sufficiently high voltage transverse to the cell is impressed between appropriate segments 12 and transparent base plate 11, a desired numeral becomes visible by reason of dispersion of incident light from the surroundings. It should be noted that the brighter the incident light, the more light is dispersed, and consequently the brighter the indicia appear. Consequently, indication of the time by this method is eminently satisfactory where the level of illumination is high.

Where the level of illumination is low, or where illumination is completely absent, photo-transistor 13 passes current through appropriate display elements of gallium-arsenide crystal 18. As is evident, the lower the level of the ambient illumination, the more strongly will the self-luminous display elements appear.

Another embodiment is shown in FIG. 3 wherein a gallium-arsenide display element, an MOS transistor and a liquid crystal cell are mounted monolithically on one semiconductor base plate 23. Base plate 23 consisting of a sapphire or a spinel is separated from cover 22 by sealing layer 24. Electrode 25 is provided for driving liquid crystal 19 into the dispersion state. Self-luminous element 26 of gallium-arsenide is mounted on semi-conductor base plate 23. Display cell 27 is so arranged that each desired segment is illuminated from the rear by infra-red radiation emitted by electroluminescent element 26. By using the liquid crystal material in combination with the infra-red radiating self-luminous material, visible light is produced and the power requirement is very low. Where the available space is small as is the case with a watch, it is desirable that the self-luminous display element and the liquid crystal element be combined, but if desired, they may be arranged separately, or one may overlie the other in part only.

The arrangement of the electrical components of the system is shown in the electrical block diagram of FIG. 4 wherein the signal of crystal oscillator 29 which constitutes the time standard for the system is divided by divider 31 which employs an MOS transistor. The output from divider circuit 31 is supplied to driving circuit 32 from which energy is then transferred either to liquid crystal system 33 or self-luminous system 34. The selection is made by the photo-transistor circuit 28. Since the energy expended in operating liquid crystal display system 33 is in the range of microwatts, this display system is termed "passive." The self-luminous display system 34 consumes energy in the range of milliwatts and is therefore termed "ac-

tive." Where the base plate 23 is of semi-conductor material as shown in FIG. 3, then the photo-transistor 13 may be mounted in the base plate.

Although the day and the date displays are more conveniently mounted on separate wheels, they are shown as one wheel 35 in FIG. 3. If desired, however, the day and the date may also be presented by means of display elements similar to those used for indicating time. Such an arrangement is shown diagrammatically in FIG. 4 by boxes 36 and 37.

It will thus be seen that a novel solid state electronic watch of high reliability is provided in which the time can be shown with an extremely small expenditure of energy. Consequently, such a watch will operate for extended periods of time between replacements of a driving battery. By means of the system described, time is displayed where the level of illumination is high with virtually no expenditure of energy, and where the level of illumination is low, at very low expenditure of energy. Operation by these alternate means is made possible by the use of a photo-transistor with associated circuitry, so adjusted that the method of display is changed at a selected level of illumination.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above article without departing from the spirit and scope of the invention, it is intended that all matter contained in the above description and shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

What is claimed is:

1. A solid state electronic watch comprising a passive display element for time display in regions of relatively high incident light intensity, an active display element for time display in regions of relatively low light intensity and means for activating said passive and active display elements.

2. A solid state electronic watch as defined in claim 1,

wherein said passive display element includes a sealed cell having a transparent outer face and liquid crystal material within said cell and said activating means includes means for imposing a voltage transverse to said cell sufficient to cause said liquid crystal material to disperse light.

3. A solid state electronic watch as defined in claim 2, wherein said outer face has thereon segments in an array such that any digit from 0 to 9 may be shown by suitable activation by said activation means.

4. A solid state electronic watch as defined in claim 1, wherein said active display element includes an electroluminescent material activatable by said activation means to emit radiation, said activation resulting from passage of current through said electroluminescent material.

5. A solid state electronic watch as defined in claim 3, wherein said active display element has thereon segments in an array such that any digit from 0 to 9 may be shown by suitable activation by said activation means.

6. A solid state electronic watch as defined in claim 1, wherein said activation means comprises a photo-transistor positioned in said watch to sense the level of said incident light and generate a signal characteristic of said incident light level, and circuit means to activate said passive display element at high incident light levels and to activate said active display element at low incident light levels.

7. A solid state electronic watch as defined in claim 1, wherein said active display element is disposed behind said passive display element so that said active display element, when activated, may be viewed through said passive display element.

8. A solid state electronic watch as defined in claim 6, wherein a portion of said active display element overlies a portion of said passive display element.

9. A solid state electronic watch as defined in claim 1, wherein said watch includes a semi-conductor base plate and said display elements and said activating means are mounted monolithically on said base plate.

10. A solid state electronic watch as defined in claim 3, wherein said electroluminescent material is gallium arsenide.

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