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| [54] ELECTROOPTICAL TIMEPIECE DISPLAY WITH CONVENTIONAL HOUR AND MINUTE HANDS | 3,626,410 12/1971 deKoster 58/126 R X 3,823,549 7/1974 Feldman 58/127 R X 3,839,857 10/1974 Berets et al. 58/23 R |
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[75] Inventor: Leo Wiesner, Kew Gardens, N.Y.

Primary Examiner—Joseph W. Hartary
Assistant Examiner—U. Weldon

[73] Assignee: Timex Corporation, Waterbury, Conn.

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[57] ABSTRACT

[21] Appl. No.: 547,277

An electronic watch having an electrochromic display in which the transparent electrode pattern of minute hands is formed on one plate of the display, while the pattern for the hour hands is formed on the other plate of the display. A counter electrode to the hour and minute hands is provided outside the field of vision. In this way realistic simulation of the passage of one hand over the other is obtained. A control logic system is provided for sequentially activating and setting the hands to a particular indication of time information.

[52] U.S. Cl. 58/50 R; 58/126 R; 58/127 R; 58/23 R; 340/324 R

[51] Int. Cl.²..... G04B 19/34; G04B 19/06; G08B 23/00

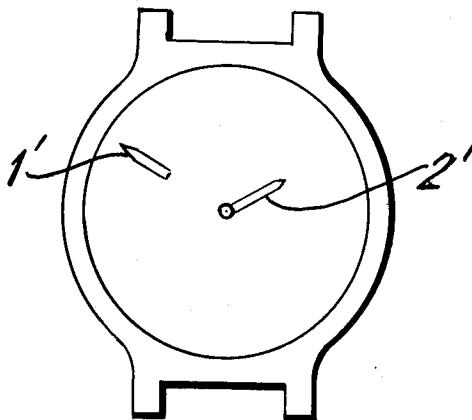
[58] Field of Search .. 58/23 R, 50 R, 126 R, 127 R; 340/324 R, 335; 350/160 R

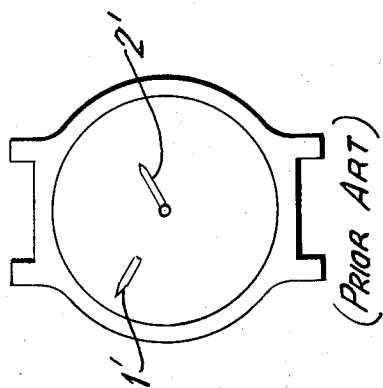
[56] References Cited

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|-----------|---------|--------------------|-----------|
| 3,451,741 | 6/1969 | Manos..... | 350/160 R |
| 3,540,209 | 11/1970 | Zatsky et al. | 58/50 R |

8 Claims, 5 Drawing Figures





(PRIOR ART)
FIG. 1

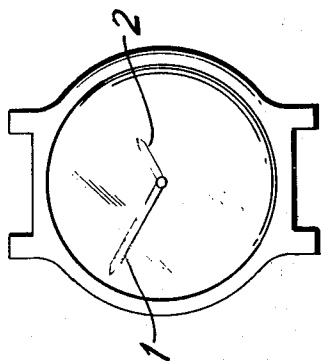


FIG. 2

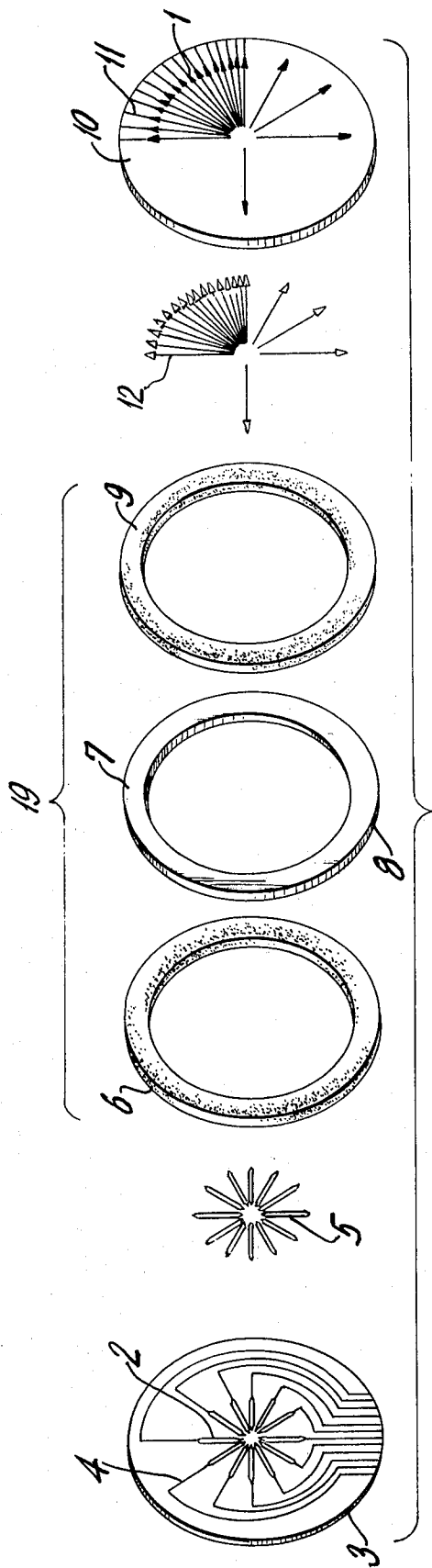


FIG. 3

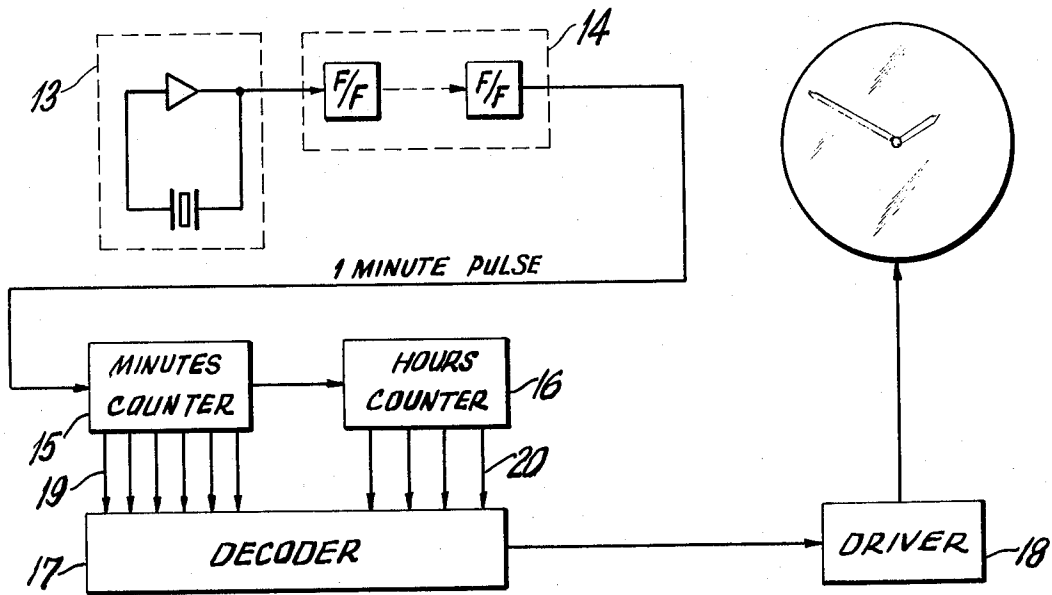


FIG. 4

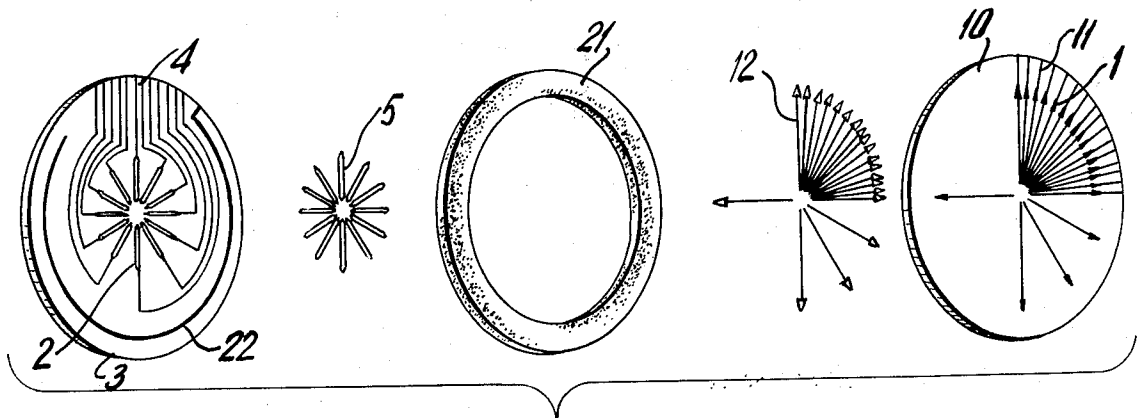


FIG. 5

ELECTROOPTICAL TIMEPIECE DISPLAY WITH CONVENTIONAL HOUR AND MINUTE HANDS

BACKGROUND OF THE INVENTION

This application relates to solid state electronic timepieces with electrooptical displays which present time information in a substantially conventional format of hour and minute hands and in particular to an electrochromic watch display having the hour and minute hands formed on opposite plates of the display thereby presenting a realistic simulation of the passage of one hand over the other.

In recent years electronic watch displays have been suggested which attempt to simulate the movement of conventional watch hands. In such watches, the simulated watch hands are formed on one substrate or plate of a liquid crystal type display. Typically, the minute hands are formed on an outer circle and the hour hands on an inner circle such as in U.S. Pat. Nos. 3,823,549 issued July 16, 1974 to Bernard Feldman and 3,540,209 issued Nov. 17, 1970 to Norman C. Zatsky and Eugene R. Keeler. To provide the equivalent of the analog function of continuously moving watch hands with selectively energizable fixed position electrically conductive segments on a watch surface, has, in such cases, produced a watch display which does not permit the minute and hour hands to extend to the center of the dial or the simulation of passage of one hand over the other.

SUMMARY OF THE INVENTION

In accordance with the present invention, a fully electronic watch is provided having a substantially conventional appearing hour and minute hand movement. The hour and minute hands each extend to the center of the dial and are formed on opposite plates of an electrochromic display such that a realistic simulation of the passage of one hand over the other is obtained.

Accordingly, it is an object of the present invention to provide a wholly electronic watch, i.e., without any moving parts, which simulates the watch face of a traditional mechanical watch.

These and other objectives and features of the present invention will be apparent from the description of a preferred embodiment of the invention, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a top plan view of a prior art wristwatch;

FIG. 2 is a top plan view of the wristwatch of the present invention;

FIG. 3 is an exploded view of the display;

FIG. 4 is a general block diagram of the logic circuitry employed in the invention to provide selective display of portions of the pattern shown in FIGS. 2 and 3.

FIG. 5 is an exploded view of an alternative embodiment of the display.

DETAILED DESCRIPTION OF THE INVENTION

In order to give better understanding of the present invention, a brief description will first be made of one type of prior art electronic watch having a so-called "analog" display reference to FIG. 1.

Typically, the time indicating hands 1', 2' are formed as electrodes on a single layer or substrate, i.e., bounding on one side of a liquid crystal layer. The minute hands 1' are formed on an outer circle and the hour hands 2' formed on an inner circle.

The display hands 1', 2', therefore, appear in one plane which does not permit the hands 1' on the outer circle to extend to the center of the dial or the perception of a depth relationship between the hands 1', 2', or the simulation, for example, of the passage of the minute hand 1' over the hour hand 2'.

With reference now to FIG. 2, the display illustrated is in accordance with the present invention. The display is preferably an electrochromic device using a well-known phenomenon such as is described in U.S. Pat. Nos. 3,704,057 issued Nov. 28, 1972 to Lindley Clair Beegle, 3,708,220 issued Jan. 2, 1973 to M. Meyers and T. Augurt and 3,807,832 issued Apr. 30, 1974 to George Castellion.

Briefly stated, if a layer of an electrochromic material is disposed between, on or over at least one of a pair of electrodes and/or forms a part thereof, across which a potential is applied, the light reflective and transmitting characteristics of the material will change. If the electrodes and the electrochromic film are provided on a surface of a transparent glass plate, the light transmitting ability of the combination can be varied by the application of an electric field across the electrochromic material turning it darker, for example, decreasing its light transmitting ability over the area of the electrode and electrodes activated.

The display shown in FIG. 2 consists of two such substrates, for example, NESA glass, on which transparent selectively energizable electrodes are formed representative of minute 1 and hour 2 hands. The minute hands 1 are formed on the inner surface of the upper substrate, i.e., transparent glass, and the hour hands 2 are formed on the inner surface of the lower substrate. The outer surface of the lower substrate may, for example, be coated with a mirror or reflective material or with a light colored opaque material. Thus, minute and hour hands 1, 2 are provided on the inner surfaces of the two opposite electrochromic plates or substrates such that when the hands 1, 2 are sequentially actuated they will give the appearance of a mechanical watch face movement of hands, i.e., hands that extend to the center of the dial on two planes which, thereby, enables the appearance of the passage of one hand, for example, the minute hand 1, over the other.

Reference will now be made to FIG. 3, in which is shown an exploded view of the display. The lower substrate 3, as hereinbefore noted, is formed for example from an opaque ceramic or a transparent material such as NESA glass coated with a reflective or light opaque finish on its outside surface. The inner surface is coated or overlaid with a transparent conductive layer, for example of tin oxide, to form a pattern of electrodes in the form of 12 hour hands 2. The 12 hour hands 2 are electrically insulated from each other and are each separately connected to hour drive signals from the timepiece by means of transparent conductors 4, deposited on or over the hour hands 2 is a layer of electrochromic material 5. The deposited material 5 is formed for example by vacuum evaporating tungsten oxide to form a film to a desired optimum thickness, for example, in the range of about 1 micron. Overlaying and in contact with the periphery of the inner surface of substrate 3 is a first gasket 6 formed from electrically insulating material which, for example, has a washer or ring-like shape. Overlaying and in contact with the first gasket 6 is a counter electrode 7, for example formed from tungsten or other suitable material. It should be recog-

nized also that the counter electrode, alternatively, could be formed on either substrate as, for example, a tungsten ring outside the field of vision. The counter electrode 7 is formed such that an electrical connection or contact is possible to a conductive substance, for example, a liquid conductive electrolyte, which is sealed within the display 19. An electrical connection 8 is made to the counter electrode 7 for applying an electrical potential to the counter electrode 7 by the electric timepiece. Overlaying and in contact with the counter electrode 7 is a second gasket 9 which is formed similarly as was the first gasket 6, hereinbefore described.

The inner surface of the upper substrate 10 has formed thereon 60 electrodes, for example, formed from tin oxide, in a pattern of 60 minute hands 1. The 60 minute hands 1 are not connected together electrically, but are each connected to minute drive signals from the electric timepiece by means of conductors 11. Deposited on or over the minute hands 1 is a layer of electrochromic material 12, for example, of tungsten oxide. The two substrates 3, 10, are assembled in a sandwich-like arrangement in which the tungsten oxide layers are positioned opposite and in face-to-face arrangement in a cell cavity provided by the spacer effect of the insulators 6, 9 and the counter electrode 7. A conductive electrolyte is provided within the cavity, for example, of dilute sulfuric acid. The electrolyte is transparent and provides electrical coupling between the counter electrode 7 and the electrochromic materials 5, 12, such that the electrochromic material darkens, for example, to a blue color, over the area of an actuated or activated hand 1, 2. The hands 1, 2 are sequentially actuated to visibility by the application of a potential on the selected hand and positive potential on the counter electrode 7. The voltage potential applied across a hand and the counter electrode needs to be maintained only for a short period of time, for example, a fraction of a second, since the electrochromic material 5, 12 will maintain in a memory-like manner the darkened area until a signal of reverse polarity is applied across the hand activated and the counter electrode 7.

Thus, the electrochromic material, as used herein, is defined as a material which is responsive to the application of an electric field having a first polarity to change from a first state in which it is substantially transparent to a second state in which it is non-transparent, and will substantially remain in the second state until an electric field of the opposite polarity is applied to return it to the first state.

Referring now to FIG. 4, a block diagram of the electronic circuitry for applying voltage potentials to the display to selectively actuate the time indicating hands thereof is shown. The display is actuated by electronic circuitry which generally consists of a frequency standard 13, frequency dividing unit 14, a minutes counter 15, an hours counter 16, a decoder 17 and driver circuitry 18. Since circuitry for performing these functions is well known to those skilled in the art such as described in U.S. Pat. No. 3,754,392 issued Aug. 28, 1973 to R. Gary Daniels, exhaustive details thereof are omitted to avoid prolixity.

Briefly stated, however, the frequency standard 13 is a quartz crystal oscillator having an output frequency of f - Hz connected to a series of count-down circuits 14. A suitable count-down circuit is a flip-flop counting circuit of low power consumption which counts down

(divides) by two. The flip-flop circuits are connected in cascade as a counter to provide an electrical output at a predetermined rate, for example, at the normal rate of one pulse per minute. This output is coupled to ring counters 15, 16, which store and provide a binary count of the number of pulses received, for example, as a six bit binary count of minutes 19 and as a four bit binary count of hours 20. The output count of the minutes and hours are coupled to the decoder 17 and driver 18 logic for actuating selective hands 1, 2, on the display which are representative of the binary count stored in the counters 15, 16. Basically, the driver circuitry provides an actuating potential between the desired hand and the counter electrode 7. For example, a source of dc potential is applied between a conductive hand and the counter electrode 7, via metallic connectors 4, 8, 11, by means of electronic switching arrangements which permit dc polarity reversal. In this manner, an actuating potential can be applied to a selected hand causing visibility thereof. The actuating potential is applied to the selected hand and counter electrode only for a small portion of the display period since the electrochromic device will exhibit coloration until potential or reverse (bleaching) polarity is applied. With a change in the output count of the minutes or hours counters 15, 16, the previously actuated minute or hour hand 1, 2 is bleached and a hand or hands representative of the present binary count is activated.

Referring now to FIG. 5, an exploded view of an alternative embodiment of the present invention is shown. The display is an electrochromic device similar to that shown in FIG. 3 with the exception that the counter electrode 22 is formed, i.e., sputtered or evaporated, etc., on one of the substrates, for example, the lower substrate having the hour hands 2 formed thereon. The counter electrode 22 is provided, for example, peripherally around the hour hands on the inner surface of the lower substrate such that it makes electrical contact with a liquid electrolyte which is sealed in the cavity created by the sandwich-like arrangement of the gasket 21 between the substrates 3, 10. The counter electrode 22 is disposed on the substrate such that it does not form part of the visible display, for example it is positioned out of the viewable display area. The electrodes forming the hour and minute hands 1, 2 are coated or overlaid with a thin film of electrochromic material 5, 12.

While certain specific embodiments have been set forth for the invention for the sake of illustration to persons skilled in the art, it is not intended to be limitative. For example, although the specific embodiments are desired as a display having minutes and hours indicated thereon, it should be recognized that the present invention is suited to the display of seconds also.

What is claimed is:

1. An electronic timepiece having an electrochromic display comprising:

- a first substrate having a plurality of conductive hands formed thereon for indicating minutes, said first substrate being coated with electrochromic material at least over the area of the minute indicating hands;
- a second substrate having a plurality of conductive hands formed thereon for indicating hours, said second substrate being coated with electrochromic material at least over the area of the hours indicating hands;

a counter electrode;
 electrolyte means sealed between the first and second substrates such that it is in electrical contact with said counter electrode and the electrochromic material on the first and second substrates; and
 means for selectively applying a potential between one minute indicating hand and the counter electrode and between one hour hand and the counter electrode at a time so as to activate a hand and hands representative of time information in at least hours and minutes.

2. An electronic timepiece as in claim 1 wherein: there are 60 minute hands formed radially on the first substrate which extend substantially to the center of the display; and
 there are at least 12 hour hands formed radially on the second substrate which extend substantially to the center of the display.

3. An electronic timepiece as in claim 1 wherein: the counter electrode being disposed peripherally of the viewable display.

4. An electronic timepiece as in claim 1 wherein: the counter electrode being disposed on a substrate.

5. An electronic timepiece as in claim 4 wherein: the counter electrode being disposed around the hour hands.

6. An electronic timepiece as in claim 1 wherein: the counter electrode being disposed between said first and second substrates and insulated therefrom by insulating means.

7. An electronic watch having an electrochromic display for indicating subdivisions of time in a substantially conventional watch format comprising:
 an oscillator providing an output signal of a pre-

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lected frequency;
 means controlled by said oscillator for providing electrical signals representing time information;
 an upper substrate having formed thereon no more than 60 conductive radial minute hands which extend substantially to the center of the display, said upper substrate being coated with electrochromic material at least over the area of said minute hands;
 a lower substrate having formed thereon at least 12 conductive radial hour hands, said lower substrate being coated with electrochromic material at least over the area of said hour hands;
 a counter electrode located between and electrically insulated from direct connection with the hands on the substrates and disposed peripherally of the viewable display;
 an electrolyte sealed between the upper and lower substrates and in electrical contact with said counter electrode and with the electrochromic material on the upper and lower substrates;
 means for electrically connecting the hour and minute hands and counter electrode to said means providing electrical signals representing time information whereby the hour and minute hands are selectively activated to display the time information in at least hours and minutes.

8. An electronic watch as in claim 3 wherein:
 the counter electrode is insulated from the hands on the upper and lower substrates by insulating means disposed between the upper substrate and the counter electrode and between the lower substrate and the counter electrode.

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