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[54] **ELECTRONIC TIMEPIECE**

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

[51] **Int. Cl.**[2] **G04B 19/30**; G04C 3/00; G04B 19/06

[58] **Field of Search** ..... 58/23 R, 50 R, 127 R; 340/324 FE

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[57] **ABSTRACT**

An electronic timepiece is provided wherein the time is displayed on a transmissive ceramic material by electrically transforming the signal from a standard signal source such as a crystal oscillator. The display is characterized by a driving circuit secured to a surface which is opposite the surface to which the transmissive ceramic material is secured.

6 Claims, 4 Drawing Figures

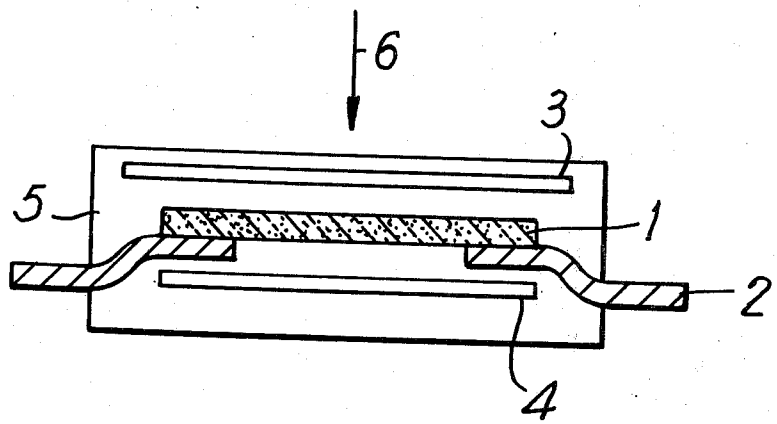


FIG. 1

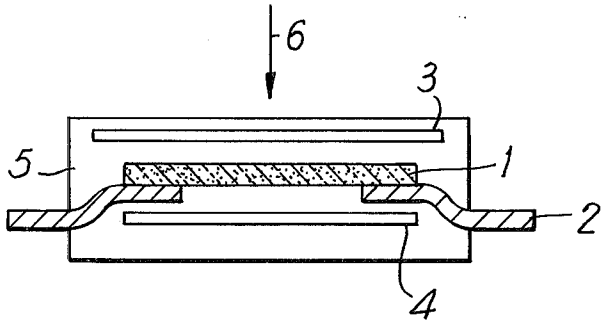


FIG. 2

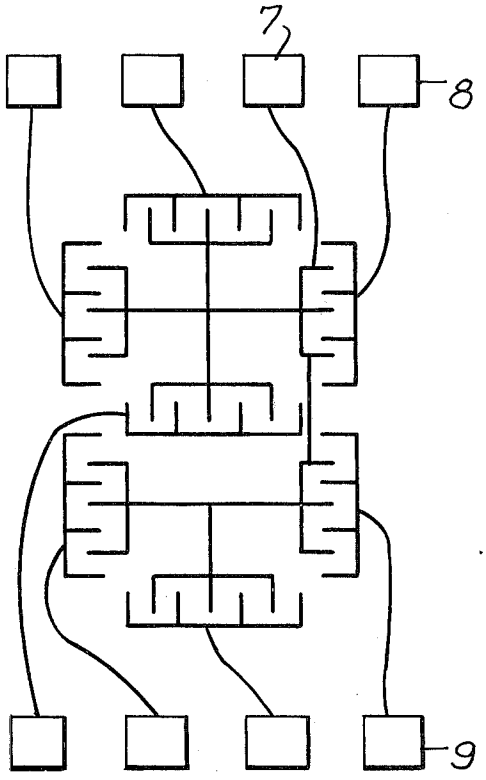


FIG. 3

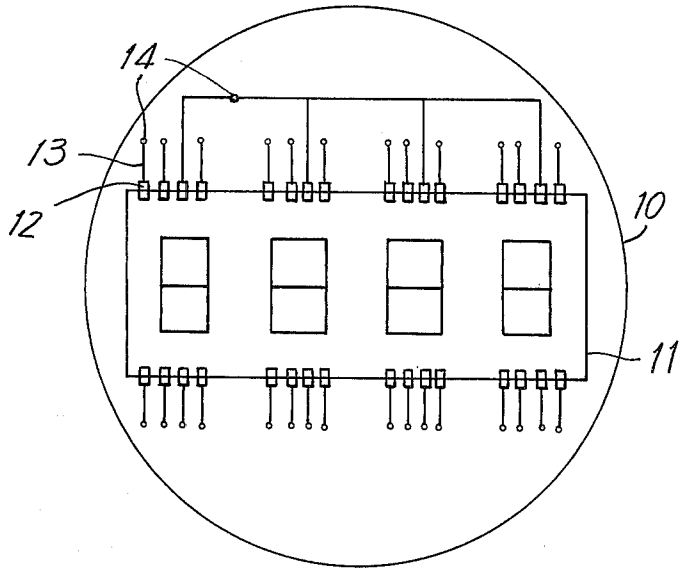
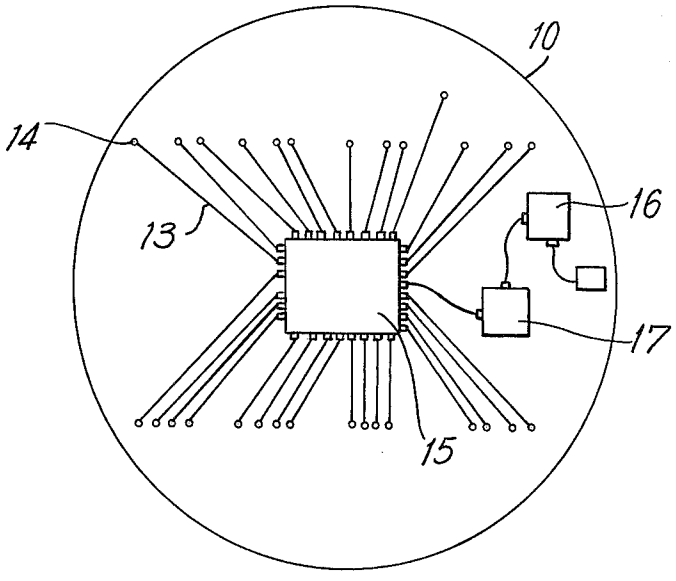


FIG. 4



ELECTRONIC TIMEPIECE

BACKGROUND OF THE INVENTION

This invention relates to an electronic timepiece of the type including, for instance, a crystal oscillator in the standard signal source. More particularly, the instant invention relates to an electronic timepiece wherein the time is displayed on a transmissive ceramic plate and a driving circuit therefor which is secured to the reverse surface of the base plate carrying the transmissive ceramic plate.

A transmissive ceramic display is found to be reliable, have a long useful life and generally avoid problems inherent in liquid crystal displays.

SUMMARY OF THE INVENTION

Generally speaking, in accordance with the invention, a transmissive ceramic display for a timepiece is provided which includes a transmissive ceramic plate comprising a hot-pressed admixture of lanthanum oxide, lead titanate and lead zirconate, a linear polarizing plate overlying the transmissive ceramic plate, but in spaced relation therefrom, and a light-reflective plate underlying the transmissive ceramic plate, but in spaced relation therefrom.

Another aspect of the invention includes mounting the transmissive ceramic display on one face of a base plate, for instance a dial disk, and the provision of a driving circuit for the display which is mounted on the other face of the base plate.

Accordingly, it is an object of this invention to provide a highly reliable transmissive ceramic display for a timepiece.

Another object of the invention is to provide a digital timepiece having a prominent display.

A further object of the invention is to provide a compact driving circuit for a transmissive ceramic display.

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 the features of construction, combinations of elements, and arrangement of parts which will be exemplified in the constructions hereinafter set forth, and the scope of the invention will be indicated in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 1 is a schematic representatation of a transmissive ceramic display constructed in accordance with the invention;

FIG. 2 is a schematic representation of an electrode construction employed in connection with the embodiment shown in FIG. 1;

FIG. 3 is a schematic representation of the display face of a dial disc which carries the transmissive ceramic display shown in FIG. 1;

FIG. 4 is a schematic representation of the underside face of the dial disc shown in FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, a transmissive ceramic plate 1 is mounted on a conductive frame comprising a plurality of spaced terminal tags 2 and overlies the channel

formed between opposed sets thereof. Transmissive ceramic plate 1 may be secured to the upper surface of the conductive frame comprised of terminal tags 2 by any conventional means. Frame 2 provides a conductive support for transmissive ceramic plate 1. A surface area of transmissive ceramic plate 1 of predetermined proportions overlies the channel provided in conductive frame 2. Terminal tags 2 include an interior raised portion on which transmissive ceramic plate 1 is mounted and a recessed exteriorly extending portion to which electrode leads may be connected.

Overlying transmissive ceramic plate 1 in parallel and selectively spaced therefrom is a linear polarizing plate 3 which may be fabricated of any suitable material known to function in the manner described. Underlying transmissive ceramic plate 1 in parallel and selectively spaced therefrom is a light reflective plate 4 which may be fabricated of any conventional material known to function in the manner described.

The ceramic plate 1, conductive frame 2, linear polarizing plate 3, and light reflective plate 4 are all housed in a solid, transparent resin casing 5. Resin casing 5 may be of any conventional transparent resin which is non-reactive with the elements embedded therein. While the interior raised portion of conductive frame 2 is embedded in resin 5, the recessed exteriorly extending portion thereof is not encased therein.

These resin encased elements, as described, comprise the display cell for an electronic timepiece. In practice, when no voltage is applied to the display cell, light directed toward the display cell as generally shown by directional arrow 6, enters the upper portion of the display cell and is reflected on light reflective plate 4 and redirected outwardly in a direction opposite to that of its entry. When voltage is applied to the display cell, the incoming light is doubly refracted on transmissive ceramic plate 1. When the value of the double refraction is nearly $\lambda/4$, the incoming light is not redirected outwardly and a time display occurs.

Transmissive ceramic plate 1 may be fabricated by hot pressing an admixture of lanthanum oxide, lead titanate and lead zirconate. Such hot pressed ceramics are conventionally referred to in the art as "PLZT." In these transmissive ceramics, lead hafnate may be conveniently substituted therein for lead zirconate with the same satisfactory results. These transmissive ceramics are characterized by light transmission therethrough, and more importantly, they have a light-scattering or double refractive character which may be induced by an electric field and stress to illuminate a time display. The particular character of a PLZT is functionally dependent upon its composition. Particularly useful in the fabrication of a PLZT for time display purposes, is a composition wherein the ratio of zirconium to titanium is about 65 to 35. In one preferred PLZT composition of the type wherein the ratio of zirconium to titanium is 65 to 35, the composition includes from about 9 to about 10% lanthanum. PLZT compositions of this type are sensitive to double refraction under stress or electrically induced, and the double refractive character thereof terminates upon removal of the electric field or stress. In another preferred PLZT composition including zirconium and titanium in atomic proportions of about 65 to 35, and from about 7 to about 8% lanthanum, the double refractive character of the ceramic induced by stress or an electric field is retained and mem-

orized for a short period of time after removal of the field or stress.

The transmissive ceramic display cell as generally shown schematically in FIG. **1**, is highly reliable and mechanically simple to operate. Moreover, the transmissive ceramic plate is an insulator and only relatively small amounts of current flow therethrough; therefore, a minimum amount of power is required in the display. Thus, a transmissive ceramic provides the display cell with optimum display characteristics. An embodiment of an electrode arrangement which displays time and may be utilized in connection with the transmissive ceramic cell is best seen in FIG. **2**.

Referring now to FIG. **2**, the electrode arrangement shown therein is based on the "⊟ -shape" employed in a conventional numeral display. Discrete segments of the linear side walls of the arrangement are comb-shaped electrodes. Interior discrete electrode segments are connected and drawn to a common input **7**. Electrodes of the type generally disignated **8** and **9** are drawn to discrete comb-like segments for independently displaying a selected discrete segment.

In practice, an electrode arrangement of the type best seen in FIG. **2** is provided on either one or both surfaces of transmissive ceramic plate **1** and when energized, a time display occurs. Since it is impractical to employ a dynamic scattering method for disclosing the display, each discrete electrode segment must be connected to a respective transistor. As a consequence of this type of construction, the driving circuit therefor would ordinarily be large and complex, even if integrated circuits were employed. Furthermore, if as contemplated, the transmissive ceramic and driving circuit therefor were disposed on the base plate, the base plate would have to be provided with a very large surface area because of the interconnected wires thereon.

A second aspect of this invention provides an improved arrangement whereby time may be displayed on the transmissive ceramic by a compact miniaturized driving circuit. The driving circuit is mounted on the opposite surface of the base plate, for instance, a dial disc of an electronic watch on which the transmissive ceramic is concomitantly mounted. The mounted driving circuit is connected to the transmissive ceramic by means of a print wiring which extends into through holes provided in the base plate. This arrangement not only compacts the display and driving circuit therefor, it also provides a display with optimum reliability. An embodiment of a suitable arrangement is best seen in FIGS. **3** and **4**.

Referring now to FIGS. **3** and **4**, a dial disc **10** is provided on which a transmissive ceramic display cell **11**, of the type shown schematically in detail in FIG. **1**, is mounted. To a plurality of terminal tags **12** mounted on dial disc **10**, a concomitant plurality of print wires **13** are connected, for instance, by solder connections. Print wires **13** are introduced onto the opposite surface of dial disc **10** through a plurality of through holes provided in the dial disc. As best seen in FIG. **4**, the through holes **14** provide means through which print wires **13** may be connected with an integrated circuit decoder **15**. Also operatively connected on the reverse surface of dial disc **10** are an oscillating circuit **16** and a divider circuit **17**, as well as other conventional circuitry usually employed in electronic timepieces of the type disclosed.

In the arrangement of the type shown, both driving circuit and display are disposed on a single base plate and wiring contacts therefor may be miniaturized and the wiring itself may be minimized. The arrangement is easy to construct and assemble, and provides a display of optimum reliability.

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 constructions without departing from the spirit and scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings 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 display assembly for an electronic timepiece including a display cell comprising a transparent resin casing, a transmissive ceramic plate embedded in said casing, electrodes mounted on said transmissive ceramic plate for displaying a time setting, a conductive frame engaging said transmissive ceramic plate, said conductive frame having an inner portion embedded in said casing and an outer portion extending outside said casing, said conductive frame comprising respective parallel pluralities of discrete terminal tags, each terminal tag being conductively connected to an electrode, a linear polarizing plate embedded in said casing in overlying parallel relationship relative to said transmissive ceramic plate, and a light reflective plate embedded in said casing in underlying parallel relationship relative to said transmissive ceramic plate.

2. The display assembly as claimed in claim **1** including a dial disc supporting said display cell, said dial disc having an upper and a lower surface, and being provided with a plurality of through-holes, said display cell being mounted on said upper surface of said dial disc, a driving circuit for said electronic timepiece being mounted on said lower surface of said dial disc, and a plurality of print wires for connecting said driving circuit to said respective pluralities of terminal tags through said through-holes provided in said dial disc.

3. The display assembly as claimed in claim **1** wherein said inner portion of said conductive frame which is embedded in said casing is raised relative to said outer portion of said conductive frame which is free of said casing.

4. The display assembly as claimed in claim **1** wherein said transmissive ceramic plate consists essentially of an admixture of lanthanum oxide, lead titanate and lead zirconate.

5. The display assembly as claimed in claim **4** wherein the atomic ratio of zirconium to titanium in the admixture is about **65** to **35**.

6. The display assembly as claimed in claim **4** wherein the admixture includes from about **7** to **10%** of lanthanum.

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