

PATENT SPECIFICATION

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(54) SOLID STATE WATCH MODULE

(71) We, TIMEX CORPORATION, a Corporation organized under the laws of the State of Delaware, United States of America, of Waterbury 20, Connecticut, United States of America, do hereby declare the invention, for which we 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:—

This invention relates generally to horological devices and, more particularly, to solid state electronic wristwatches.

Electronic wristwatches are known which have printed circuit substrates with integrated circuit components mounted thereon. It is also known to provide digital circuitry for reducing the frequency of a quartz crystal time reference and to use it to actuate an electro-optical display.

In order to provide for economical construction of electronic wristwatches, and repair or replacement of component parts, it is desirable that the electro-optical display component and the component containing electrical circuitry be separate members, and yet that all of the components can be easily assembled in a shock-resistant module for incorporating in a wristwatch case with a battery and having means to make external tests and adjustments without undue difficulty. It is also desirable to provide for economies of manufacture of the substrate containing the electronic circuitry using single layer "thick film" printing.

Accordingly, one object of the present invention is to provide an improved shock-resistant module of separable components for an electronic solid state wristwatch.

Another object of the invention is to provide an improved construction for a substrate carrying electrical components and integrated circuitry and for connecting the substrate to an electro-optical display for indicating the time in a wristwatch.

According to the invention, there is provided a solid state watch module

comprising electro-optical display means having electrically energizable characters visible on a viewing surface and also having a first plurality of electrical contact terminals connected to said characters, a substrate having printed circuit leads on at least one side thereof connected to a second plurality of electrical contact terminals, said substrate having an integrated circuit mounted thereon also connected to said printed circuit leads and adapted to provide driving signals to said display characters to give a time indication, an intermediate connector member having first means locating the display means on one side thereof and second means locating the substrate on the other side thereof and including electrically conductive members making contact between respective ones of said first and second plurality of contact terminals, and spring clip means adapted to hold said display means, connector member and substrate together in compression and to maintain said electrically conductive members in contact with the first and second terminals.

Briefly stated, a preferred embodiment of the invention comprises a watch assembly with an electro-optical display for indicating the time and employing integrated digital circuitry using binary dividers to reduce the frequency of a quartz crystal time reference. The electro-optical display has electrical contact terminals on an under surface, a substrate has an integrated circuit mounted thereon connected via printed circuit leads to electrical terminals on the substrate, an intermediate connector positions the display and substrate with respect to one another and provides electrical connections between the contact terminals on the display and on the substrate, and a spring clip holds the members together in a module. The module may also include a backing member holding the substrate and having openings for making external tests and adjustments on the substrate components.

The above and other features and ad-

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vantages of the invention will be more clearly understood by reference to the following description of a preferred embodiment illustrated in the accompanying drawings of which:—

Figure 1 is an elevation, partly in cross-section illustrating the assembled watch module;

Figure 2 is a plan view of an electro-optical display;

Figure 3 is a block diagram illustrating functions performed in a suitable integrated circuit;

Figures 4 and 5 are plan views of the front and rear sides of a printed circuit substrate;

Figure 6 is a partial circuit for the oscillator components on the substrate outside the integrated circuit;

Figure 7 is a circuit diagram of a display driver power supply, and

Figures 8 and 9 are front and rear plan views of the assembled module.

Referring to Figure 1 of the drawings, an electro-optical display 1 is positioned with respect to a substrate sub-assembly 2 by means of an intermediate connector member 3. The substrate sub-assembly 2 is mounted on a ceramic substrate 4 held in place by a backing member 5 and a spring clip 6.

Electro-optical display 1 may be any of the various types suggested in the prior art such as liquid crystal, electrophoretic, light emitting diode, or electrochromic, having the common characteristic that time-indicating characters are made visible on the viewing surface by providing suitable coded electrical signals to the display. The type of display shown in the preferred embodiment is a liquid crystal display of the "field effect" type which is commercially available and comprises a sandwich construction of a transparent polarizing layer 7, a glass layer 8, another glass layer 9 sealed thereto, another transparent polarizing layer 10, and a reflecting layer 11. A chamber between the glass layers 8, 9 contains liquid crystal material 12 suitable for display use in the twisted-nematic field-effect mode. A common transparent electrode layer 13 and separately energizable transparent electrodes 14 complete the display 1. Its operation is well known in the art.

Glass layer 8 of the display projects to form a ledge 15 providing electrical contact terminals 23 on its underside. The display is located in connector member 3 by means of a recess 16 with a bottom ledge on which the display 1 rests.

Further details of the electro-optical display illustrated in Figure 1 may be seen by reference to Figure 2. Although any suitable characters for indicating the time

could be used, the display indicated is a seven segment digital display for indicating hours and minutes. Another suitable type of display might be a pseudo-analog display imitating conventional watch hands as suggested in United States Patent No. 3,540,209. Also cumulative type displays using dots or bar graphs to indicate selected intervals of time in progressive or cumulative fashion may be chosen. Displays of these latter two types are to be regarded for the purposes of this invention as displays which use "characters".

The display indicated in Figure 2 includes 7-segment characters 17, 18, 19, a single segment character 20 and a "colon" characters 21. The 7-segment characters, such as 17 are made up individually energizable segments such as 17a, 17b etc. Each segment such as 17b is connected by a lead 22 to a respective conductive layer 23 which extends to form an electrical contact terminal which is exposed on the underside of the glass ledge 15 (see Figure 1). A "common" contact terminal 24 is connected to the transparent conductive layer 13 on the other side of the liquid crystal material, so that a voltage gradient across the liquid crystal material can be established to energize the desired segment.

Referring now to Figure 3 of the drawings, the block diagram illustrates functions which are carried out in an integrated circuit "chip" depicted by the phantom line enclosure 25. An amplifier 26 co-operates with external circuit elements later to be described, via terminals 27, to provide a high frequency oscillator vibrating at 32,768 Hz, controlled by a piezoelectric quartz crystal.

A divider 28 comprising 15 "divide-by-two" stages reduces the frequency of the incoming impulses to one Hz. The signal is divided by 60 in a "seconds" counter 29 which includes a reset capability. The signal is divided again by 60 in a "minutes" counter 30 and divided again by 12 in a "hours" counter 31. The latter two counters 30, 31 provide binary coded decimal (BCD) outputs to a 7-segment decoder drive 32 for indicating minutes in the "ones" display position, an identical decoder driver 33 for indicating minutes in the "tens" display position, an identical decoder driver 34 for indicating hours in the "ones" display position, and a single segment decoder driver 35 for indicating hours in the "tens" display position. The corresponding display character for the latter is either "1" or blank in a twelve hour display, hence only one segment need be driven.

Another single segment decoder driver 36, which may be identical to the aforementioned driver 35, actuates the colon, which receives a 1 Hz input causing it to

flash at a 1Hz rate. The aforementioned drivers 32—36 are activated by a 32 Hz signal taken at a suitable interstage point on the divider 28.

5 Since the liquid crystal segments normally require a higher driving voltage than is provided by the small energy cell in the watch, an external circuit to be discussed in connection with Figure 7 of the drawing elevates the display driving voltage supplied to drivers 32—36. This external circuit is provided with high frequency impulses from a terminal 65 by a pulse generator 37.

10 The integrated circuit 25 also includes logic circuits for changing or updating the displayed time, this provision being indicated at 38. Logic block 38 provides capability to selectively advance the minutes or hours counters 30, 31 at a 1 Hz rate, and/or to reset the "seconds" counter 29 to zero by manipulation of external switches S—1, S—2. The watch may also be turned off by switch S—3.

15 The aforementioned functional blocks for the amplifiers, dividers, counters, drivers and other logic elements may be carried out by techniques well known to those skilled in the art using CMOS circuits to reduce power consumption.

20 Referring now to Figures 4 and 5 of the drawings which are the front and rear side views respectively of the substrate sub-assembly 2 shown in Figure 1 of the drawings, the substrate itself comprises a flat ceramic plate 4 with printed circuits applied to both sides employing single layer thick film printing using conventional techniques. The substrate also serves as the mounting for the various electronic components to be discussed as well as the integrated circuit 25 and carries the switch and power supply contacts, as well as electrical contact terminals.

25 Referring first to Figure 4, a printed circuit lead is seen at 41 extending between the integrated circuit chip 25 and a layer of conductive material forming an electrical contact terminal 42 on the upper surface of the substrate. Other printed circuit leads similar to 41 are provided for other contact terminals similar to 42, which extend generally in a row along the lower side. A similar row 43 of electrical contact terminals for the display is seen at the upper side. Terminals 42 are precisely aligned with respective terminals 23 on the display (Fig. 2).

30 The precise circuit arrangement of terminals or printed circuit leads leading to the integrated circuit chip 25 is not material to the present invention, so no attempt will be made to describe the circuit in detail.

35 Other printed circuit leads, such as 44, lead from the integrated circuit 25 to con-

ductive inserts such as 45, which are exposed on both sides of the substrate (see Fig. 5) to form "test points" for making external tests of the circuit components.

Other printed circuit leads, such as 46, lead to switch elements (see Fig. 3).

Other printed circuit leads are connected to external components mounted on the substrate, such as lead 47 connected to a "chip" capacitor 48 bonded to the substrate.

70 The upper surface of substrate 4 provides the mounting area for integrated circuit 25 within an insulating plastics dam 49, which is fastened to the substrate via heat deformable projections 50 protruding to the opposite side of the substrate. Integrated circuit chip 25 is wire-bonded to the printed circuit leads, and the cavity inside the dam which also contains discrete components 62, 66 and 67, is then filled with an encapsulant to protect the circuit and other components.

80 Referring to Figure 5, showing the other side of the substrate, printed circuit leads such as 51 provide connections between the power supply and components such as coil 52. A variable resistor 53 is applied by thick film printing techniques and a wiper arm 54 adjusts the resistance to trim the oscillator frequency (see Fig. 6). The substrate also serves as mounting platform for the quartz crystal 55, negative battery terminal 56, and the positive battery terminal 57 with an extending grounding tab 58. Tab 58 is adapted to ground the positive terminal of the energy cell to the metallic watch bezel.

85 Figures 6 and 7 show circuit diagrams for some of the external components mounted on the substrate which are necessary to the operation of the watch. Figure 6 shows the external oscillator tank circuit as described in more detail and claimed in co-pending Application No. 47169/73, Serial No. 1,429,257. The circuit includes quartz crystal 55, one terminal of which is connected to ground via the series combination of capacitor 60 and trimming resistor 53 while the other terminal is connected to ground via capacitor 61. This tank circuit, when connected via terminals 27 to the oscillator amplifier in the integrated circuit (see Fig. 3) causes oscillations at the natural frequency of the quartz crystal 55.

90 Referring to Figure 7, a circuit is shown for increasing the voltage at a terminal 63 above battery voltage applied at a terminal 64 when pulses are applied at a terminal 65.

95 A PNP transistor 66 has its base connected to terminal 65 via resistor 62. Terminal 64 is grounded and connected via the emitter-collector path to inductor coil 52. Terminal 63 is connected via a diode 67 to one side of the coil and via capacitor 68 to the other side of the coil. Intermitent

pulses applied at 65 from the pulse generator 37 of the integrated circuit (see Fig. 3) cause transistor 66 to conduct intermittently so that the energy stored in coil 52 will cause a high voltage to be maintained across capacitor 68. This is a well known circuit often termed a "fly-back" power supply. The voltage at terminal 63 is utilized as a power supply by the drivers 32—36 in the integrated circuit.

Reference to the substrate sub-assembly of Figures 4 and 5 will illustrate the location of most of the components in the circuit drawings of Figures 6 and 7, where the same reference numerals have been employed where possible.

Referring back now to Figure 1, the manner of electrically connecting the substrate sub-assembly 2 and the display 1 will be described. The substrate 4 is located in a recess 70 on the underside of connector member 3 inside a skirt 3a, so that the electrical contact terminals 42 on the upper side of the substrate are precisely aligned with the respective electrical contact terminals 23 on the underside of the display ledge 15. For each pair of terminals, a tiny electrically conductive rubber lead 71 passing through a hole in the connector member 3 makes contact between a pair of associated terminals 23, 42. The conductive rubber lead 71 is compressible and is a commercially known material available from Chomerics, Inc.

The backing member 5 of insulating plastics also extends into recess 70 of connector member 3 against the ceramic substrate 4. Backing member 5 is provided with inclined notches 72 to receive the ends 73 of the spring clip 6. The spring clip also includes a peripheral projecting ridge 74 extending around the display viewing surface and pressing against the top of the display surface. When the resilient arms of spring clip 6 are snapped around the assembly so that the ends are nested in recesses 72, the entire assembly is compressed together in a module and the conductive rubber leads 71 are compressed making positive contact between terminals 23, 42.

Figures 8 and 9 illustrate further details of the module assembly. The ends of the conductive rubber rods 71 are seen through the transparent display 1. The spring clip 6 is seen to include a window 6a framing the display with four resilient arms 6b passing around notches in the connector member 3.

Referring to the rear side of the assembly as shown in Figure 9, the backing member 5 includes an aperture 75 for the battery or energy cell, an aperture 76 for the protruding quartz crystal 55, an aperture 77 for providing external access to the wiper arm 54 of the trimming resistor, and holes 78 for

probes to selected test points such as 45 on the substrate.

The display/connector/substrate assembly/backing member components are assembled and fastened together using the single retaining clip 6 which provides a positive compression of all parts of the "sandwich". This compression ensures adequate interconnection of the display to the substrate via the conductive rubber terminals and also eliminates all play between members of the assembly, resulting in a shock-resistant module. The skirt 3a on the connector member partially enveloping the periphery of the substrate furthermore provides protective cushioning of the substrate.

The aforescribed module may be assembled in a watch case and removed and disassembled with ease to replace any individual components.

WHAT WE CLAIM IS:—

1. A solid state watch module comprising: electro-optical display means having electrically energizable characters visible on a viewing surface and also having a first plurality of electrical contact terminals connected to said characters, a substrate having printed circuit leads on at least one side thereof connected to a second plurality of electrical contact terminals, said substrate having an integrated circuit mounted thereon also connected to said printed circuit leads and adapted to provide driving signals to said display characters to give a time indication, an intermediate connector member having first means locating the display means on one side thereof and second means locating the substrate on the other side thereof and including electrically conductive members making contact between respective ones of said first and second plurality of contact terminals, and spring clip means adapted to hold said display means, connector member and substrate together in compression and to maintain said electrically conductive members in contact with the first and second terminals.

2. A watch module according to Claim 1, further including a backing member disposed on the other side of the substrate from said connector member, said spring clip means being provided with resilient arms arranged to compress the backing member against the display means via the substrate and connector member.

3. A watch module according to Claim 1, wherein said first means on the connector member comprises a first recess for receiving the display means and wherein said second means comprises a second recess for receiving the substrate, whereby the first and second contact terminals are aligned with respect to one another.

pulses applied at 65 from the pulse generator 37 of the integrated circuit (see Fig. 3) cause transistor 66 to conduct intermittently so that the energy stored in coil 52 will cause a high voltage to be maintained across capacitor 68. This is a well known circuit often termed a "fly-back" power supply. The voltage at terminal 63 is utilized as a power supply by the drivers 32—36 in the integrated circuit.

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probes to selected test points such as 45 on the substrate.

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2. A watch module according to Claim 1, further including a backing member disposed on the other side of the substrate from said connector member, said spring clip means being provided with resilient arms arranged to compress the backing member against the display means via the substrate and connector member.

3. A watch module according to Claim 1, wherein said first means on the connector member comprises a first recess for receiving the display means and wherein said second means comprises a second recess for receiving the substrate, whereby the first and second contact terminals are aligned with respect to one another.



4. A watch module according to Claim 3, wherein an insulating backing member with exposed notches is arranged to fit in said second recess against the substrate, said spring clip means having resilient arms engaging in said backing member notches. 30
5. A watch module according to Claim 2 or 4, wherein said substrate is provided with printed circuit leads on both sides thereof, said second plurality of contact terminals being connected to printed circuit leads on the display side of the substrate, and further including test point terminals on the other side of the substrate connected to selected printed circuit leads, said backing member having probe holes providing access to said test point terminals without disassembling the watch module. 35
6. A watch module according to any one of Claims 2 to 5, wherein said spring clip has a window framing the display means viewing surface and resilient arms adapted to snap around the module. 40
7. A watch module according to any one of the preceding claims, wherein said first plurality of contact terminals are spaced on an undersurface of said display means, and wherein said second plurality of contact terminals are similarly spaced on the display side of said substrate, and wherein said electrically conductive members comprise a plurality of compressible conductive leads passing through said connector member and connecting respective pairs of first and second contact terminals. 45
8. A watch module according to any one of the preceding claims including an insulating dam mounted on said substrate, said integrated circuit being disposed within said dam and surrounded by encapsulating material. 50
9. A watch module according to any one of the preceding claims wherein the side of the substrate opposite the display means includes a printed circuit resistor with a wiper arm providing a variable resistor accessible for adjusting the watch frequency without disassembling the module.
10. A solid state watch module substantially as hereinbefore described with reference to the accompanying drawings.

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