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(54) SYNCHRONIZED QUARTZ CRYSTAL WATCH

(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 which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a synchronized watch and more particularly to a watch synchronized by a quartz crystal oscillator.

The use of a quartz oscillator of highly stable frequency in conjunction with a frequency divider to control the frequency of a slave oscillator has long been known, see for example United States Patent No. 3,110,853. However, an application of this desirable means of control to an electric watch has posed problems. It is an object of the present invention to provide a new and improved arrangement utilizing a high frequency time base to control the accuracy of a watch.

According to the invention there is provided a synchronized watch comprising a low frequency oscillator for driving the watch, said oscillator being regulated to run normally fast, a high frequency time base, means for dividing down the output of the high frequency time base to provide lower frequency timing pulses, first means for totalling the number of oscillations of the low frequency oscillator and second means for totalling the number of timing pulses from the dividing means, and means for halting the low frequency oscillator when the first totalling means has counted a predetermined number of pulses and for releasing the low frequency oscillator when the second totalling means has counted the same predetermined number of pulses thereby synchronizing the watch in accordance with the output from the high frequency time base.

Also according to the invention there is provided a synchronized watch comprising a low frequency oscillator for driving the watch, said oscillator being regulated to run normally fast and thus to produce a deviation from the

required frequency, a high frequency time base, a divider for reducing the output from the time base to provide highly accurate low frequency timing pulses at the said required frequency, means which compares the respective frequencies of the low frequency oscillator pulses and the timing pulses, and means to deactivate the low frequency oscillator for a fixed time period and to permit the said oscillator to be re-activated at the end of said period.

The watch may suitably comprise a low frequency oscillator such as a balance wheel which supplies pulses to a first counter. When the counter has totalled a number of pulses corresponding to a fixed time interval, a flip-flop is triggered, activating a solenoid to stop the balance wheel which is normally regulated to run fast. A quartz crystal oscillator supplies a divided down output to a second counter which resets the flip-flop when the counter has totalled the number of pulses corresponding to the fixed time interval. The solenoid is deactivated and the watch starts immediately thereby eliminating any accumulated errors.

In an alternative embodiment, pulses from the balance wheel and the divided down quartz oscillator pulses are fed to a flip-flop which produces a square wave output of increasing width due to the frequency difference between the inputs. The output voltage is integrated by an RC network and a Schmitt trigger circuit is activated when the capacitor reaches the circuit's critical level. A solenoid is then activated for a fixed short interval of time determined by a monostable multivibrator to stop the balance wheel. After elapse of the time interval, the balance wheel assumes oscillating.

The watch is thus normally regulated to run fast and is synchronized at intervals to eliminate accumulated error. Means are provided for stopping the balance wheel for a fixed period of time and releasing the balance wheel for oscillation as determined by the quartz synchronizing frequency.

The present invention will now be further

described with reference by way of example to the accompanying drawings wherein:—

Figure 1 is a schematic diagram of a first embodiment of the invention;

5 Figure 2 is a schematic diagram of a second embodiment of the invention; and

Figure 3 illustrates the wave forms at point A on the output of the flip-flop in Figure 2.

10 The invention as embodied in Figures 1 and 2 is a quartz crystal synchronized watch having a balance wheel 10 or 20 respectively which is synchronized by a quartz crystal frequency standard 11 or 22. Since the details of such a watch, apart from the present invention, are conventional, they will not be discussed in detail herein. It is well known, for example, that the balance wheel is coupled to a drive train of the watch and causes movement of the watch hands. A synchronization of the watch in the interest of accuracy may, therefore, be achieved by regulating the movement of the balance wheel.

25 With reference to Figure 1 of the drawings, the watch therein represented includes the balance wheel 10 having a spring finger 12 mounted on the periphery and extending outwardly therefrom. The balance wheel 10 normally oscillates at a low frequency which is fed to a first counter 13. In a typical case, the balance wheel 10 will oscillate at a frequency of $(3+\epsilon)$ Hz, where " ϵ " represents the fractional deviation of the balance wheel 10 from the required precise frequency of 3.000 Hz. The counter 13 is designed to count up to N pulses which corresponds theoretically to a fixed time interval. The relationship between the number of pulses N and the deviation ϵ is such that

$$N > \frac{1}{\epsilon}$$

40 The counter 13 is connected to a flip-flop 14, the output of which is normally low but goes high when counter 13 reaches N pulses. This activates a solenoid 16 which forces a movable member 17 forward into engagement with spring finger 12 to stop the balance wheel 10. Normally, the balance wheel 10 would be halted at or near its maximum excursion.

45 The high frequency output from the quartz crystal oscillator time base 11 is fed through a divider 18 to a second counter 19. The quartz crystal oscillator frequency may be initially in the 60 KHz range and be divided down to 3.000 Hz by divider 18. When counter 19 reaches N pulses, the solenoid 16 is released and the watch starts immediately. Both counters 13 and 19 are reset when solenoid 16 is deactivated. The watch is designed to normally run fast so that any accumulated timing errors are erased when the balance wheel 10 is stopped. The stopping is momentary so that no problem arises when viewing

the watch. It is to be further noted that the counters 13 and 19 may be combined in a single up-down counter.

65 In the embodiment of Figure 2, which represents a quartz watch construction similar to that of Figure 1, pulses from the balance wheel 20 are fed to a flip-flop 21. The normal pulse rate from the low frequency balance wheel oscillator 20 is $(3+\epsilon)$ Hz, where " ϵ " represents the fractional deviation from the precise frequency due to the fact that the watch is regulated to run fast. 70

75 The quartz crystal oscillator 22 supplies high frequency pulses to a divider 23 where they are divided down to a precise output frequency of 3.000 Hz. The quartz oscillator pulses are also fed to the flip-flop 21 and the output therefrom is shown in Figure 3. It is to be noted that the width of the square wave pulses 24 increase from W_1 to W_2 due to the frequency difference between the balance wheel 20 and crystal oscillator 22. 80

85 The output voltage from flip-flop 21 is integrated by the combination of a resistor 26 and a capacitor 27. When the capacitor voltage reaches the critical level of the Schmitt trigger portion of a circuit 28, solenoid 29 is activated for a short fixed time interval T determined by the monostable multivibrator portion of circuit 28. Stop member 31 is driven into engagement with the spring finger 32 to halt the oscillation after the elapse of time T. While the value of T is not critical, it must be less than 1/6 second. 90 95

During a 24 hour period, the solenoid 29 must be activated to compensate for the number of seconds the watch is regulated to run in the fast direction. The power consumption of the watch is within acceptable limits under these conditions since no continuous correction is used. For example, if the watch runs 2 minutes per day fast and the power consumption of the solenoid is 2 milliamperes at 1.5 volts, the current drain will be 24 milliamperes hours/year. 100 105

The time delay between turn off and turn on is so small as to be imperceptible to the user. The intermittent correction is, therefore, most advantageously employed. 110

The invention as described above can also be used with conventional switch-contact watch designs or electronic watches wherein the driving amplifier is switched on and off. It is to be understood that the above-described arrangements are merely illustrative examples of the invention. Numerous other arrangements within the scope of the appended claims may be readily devised by those skilled in the art. 115

WHAT WE CLAIM IS:—

120 1. A synchronized watch comprising a low frequency oscillator for driving the watch, said oscillator being regulated to run normally fast, a high frequency time base, means for dividing down the output of the high fre- 125



described with reference by way of example to the accompanying drawings wherein:—

Figure 1 is a schematic diagram of a first embodiment of the invention;

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quency time base to provide lower frequency timing pulses, first means for totalling the number of oscillations of the low frequency oscillator and second means for totalling the number of timing pulses from the dividing means, and means for halting the low frequency oscillator when the first totalling means has counted a predetermined number of pulses and for releasing the low frequency oscillator when the second totalling means has counted the same predetermined number of pulses thereby synchronizing the watch in accordance with the output from the high frequency time base.

15 2. A synchronized watch in accordance with Claim 1 wherein the low frequency oscillator comprises a balance wheel and the high frequency oscillator comprises a quartz crystal oscillator.

20 3. A synchronized watch in accordance with Claim 2 wherein the means for halting the low frequency oscillator comprises a flip-flop which receives input signals from the outputs of the first and second totalling means, a solenoid activated and deactivated by the flip-flop, and means responsive to the solenoid to contact the balance wheel to stop said wheel.

25 4. A synchronized watch in accordance with Claim 2 wherein the means for halting the balance wheel comprises switching means responsive to the first and second totalling means and solenoid means operated by the switching means to contact a spring finger mounted on the balance wheel.

30 5. A synchronized watch in accordance with any one of the preceding claims wherein the first and second totalling means comprise an up-down counter.

40 6. A synchronized watch in accordance with Claim 1 or Claim 2 wherein the first and second totalling means comprises a first counter coupled to the low frequency oscillator and a second counter coupled to the dividing means.

45 7. A synchronized watch in accordance with Claim 6 wherein the means to halt and release the low frequency oscillator comprises solenoid means, connected to a flip-flop, to halt said oscillator when the first counter has counted a predetermined number of pulses which raises the output of the flip-flop, and to release said oscillator when the second counter has counted the same predetermined number of pulses.

8. A synchronized watch comprising a low frequency oscillator for driving the watch, said oscillator being regulated to run normally fast and thus to produce a deviation from the required frequency, a high frequency time base, a divider for reducing the output from the time base to provide highly accurate low frequency timing pulses at the said required frequency, means which compares the respective frequencies of the low frequency oscillator pulses and the timing pulses, and means to deactivate the low frequency oscillator for a fixed time period and to permit the said oscillator to be reactivated at the end of said period.

9. A synchronized watch in accordance with Claim 8 wherein the low frequency oscillator comprises a balance wheel and the high frequency time base comprises a quartz crystal oscillator.

10. A synchronized watch in accordance with Claim 8 or Claim 9 wherein the means which compares the respective frequencies of the pulses comprises a flip-flop coupled to the low frequency oscillator and to the frequency divider, and the means for deactivating and permitting reactivation of the low frequency oscillator comprises an integrator connected to the output of the flip-flop, a trigger circuit activated when the integrator output reaches a predetermined voltage level, and means for stopping the watch for a predetermined interval of time when the trigger circuit is activated.

11. A synchronized watch in accordance with Claim 10 wherein the means for stopping the watch for the said interval comprises a monostable multivibrator coupled to the trigger circuit, and solenoid means responsive thereto to engage and stop the low frequency oscillator for a fixed time period determined by the multivibrator.

12. A synchronized watch substantially as hereinbefore described with reference to Figure 1 or Figures 2 and 3 of the accompanying drawings.

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