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Diersbock

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[45] **Oct. 23, 1973**

[54] QUARTZ CONTROLLED CHRONOMETER

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

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[21] Appl. No.: **127,724**

[52] **U.S. Cl.** ..... **58/23 D,** 310/36, 318/130

[51] **Int. Cl.** **G04c 3/00**

[58] **Field of Search** 310/36–39; 318/130; 58/23, 26

[56] **References Cited**

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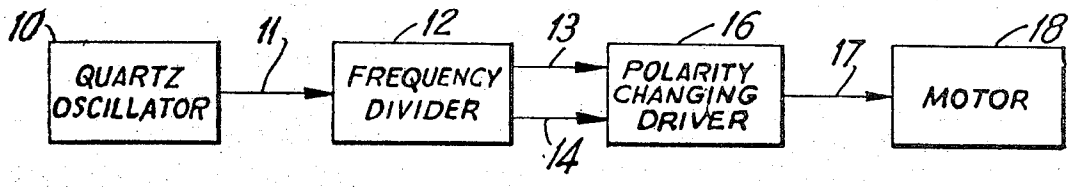
Primary Examiner—Richard B. Wilkinson
Assistant Examiner—Lawrence R. Franklin
Attorney—Richard A. Joel

[57] **ABSTRACT**

A quartz controlled timekeeping device such as a chronometer or watch comprises a high frequency quartz oscillator which is coupled to a divider which reduces the quartz frequency to the required output frequency.

The divider output is connected to a polarity changing driver which energizes a polarized motor. The driver changes the polarity of the driving current after every driving impulse and drives the rotor coil of the motor between alternate positions thereby driving the index system directly with quartz accuracy. A magnetic blocking system effectively blocks the indexing system when the motor is not operating but releases with a driving current impulse.

4 Claims, 14 Drawing Figures



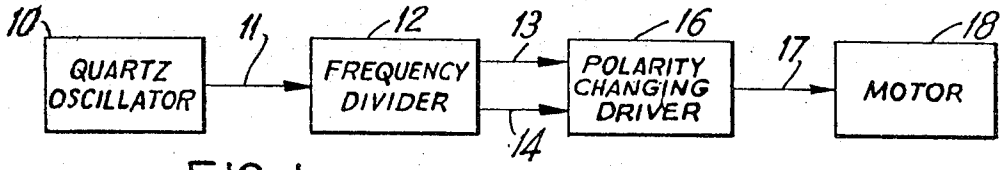


FIG. 1

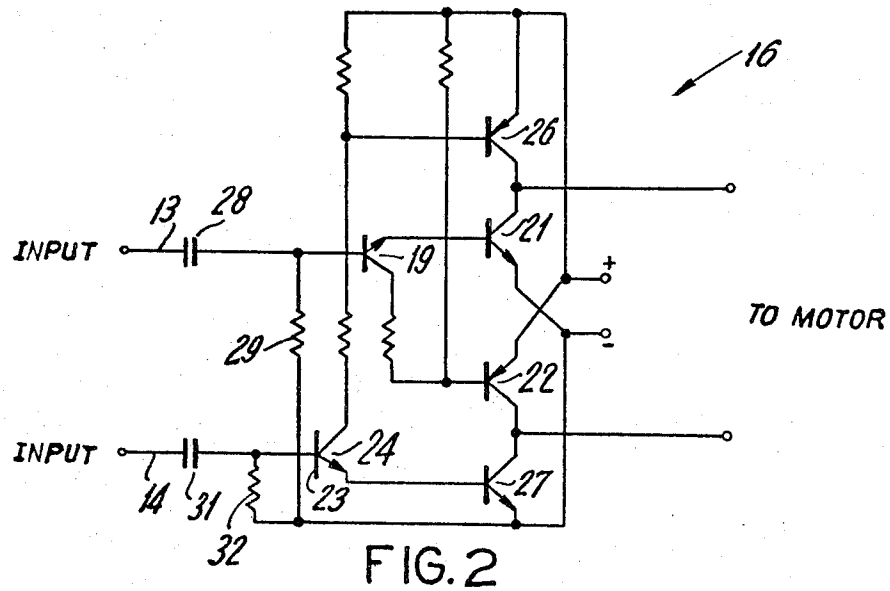


FIG. 2

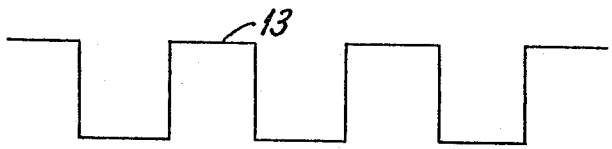


FIG. 3a

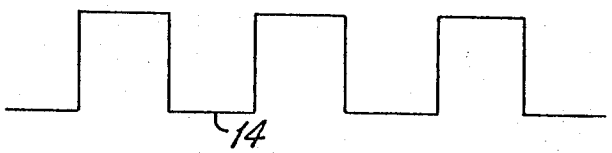


FIG. 3b

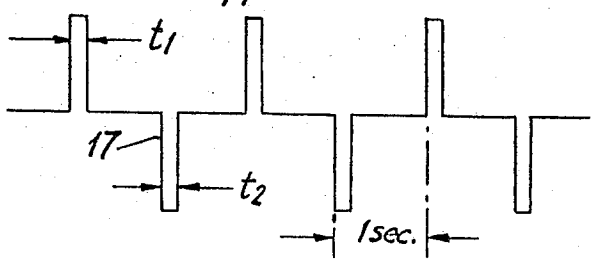


FIG. 3c

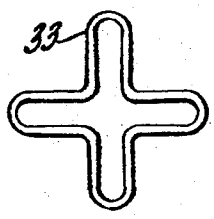


FIG.4a

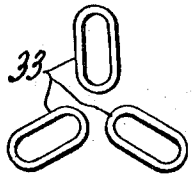


FIG.4b

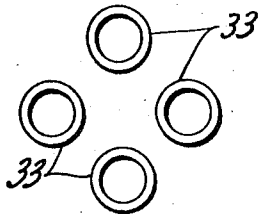


FIG.4c

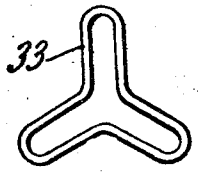


FIG.4d

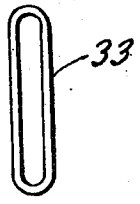


FIG.4e

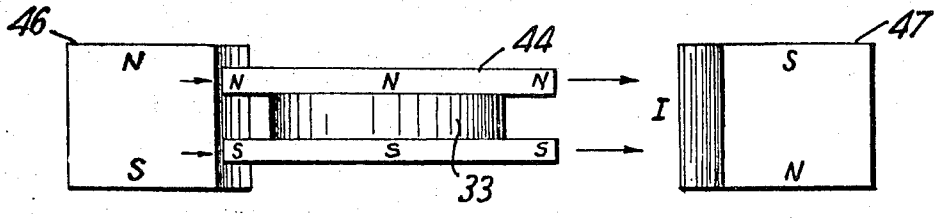


FIG.5a

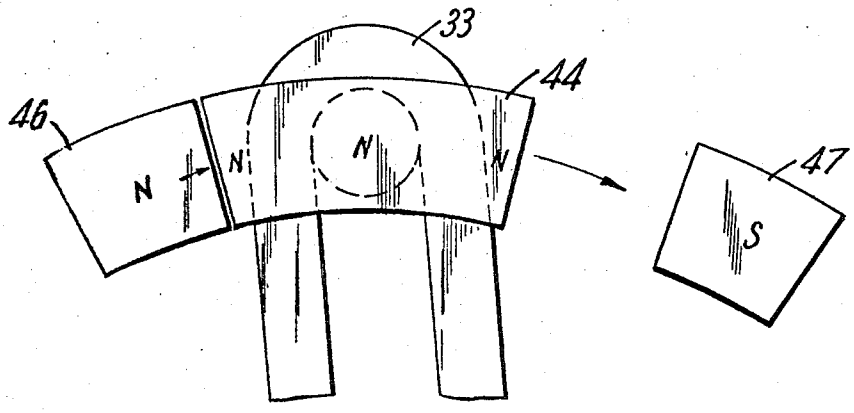


FIG.5b

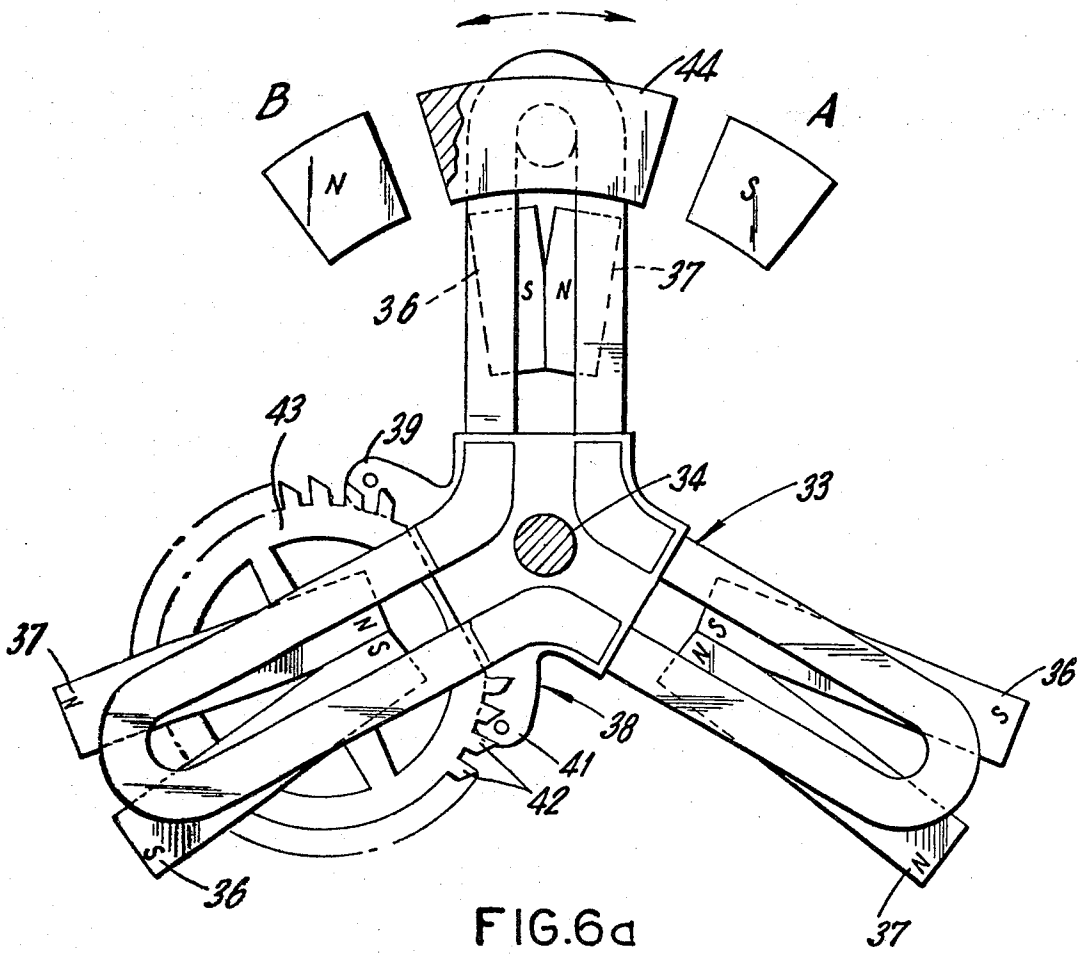

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FIG.6a

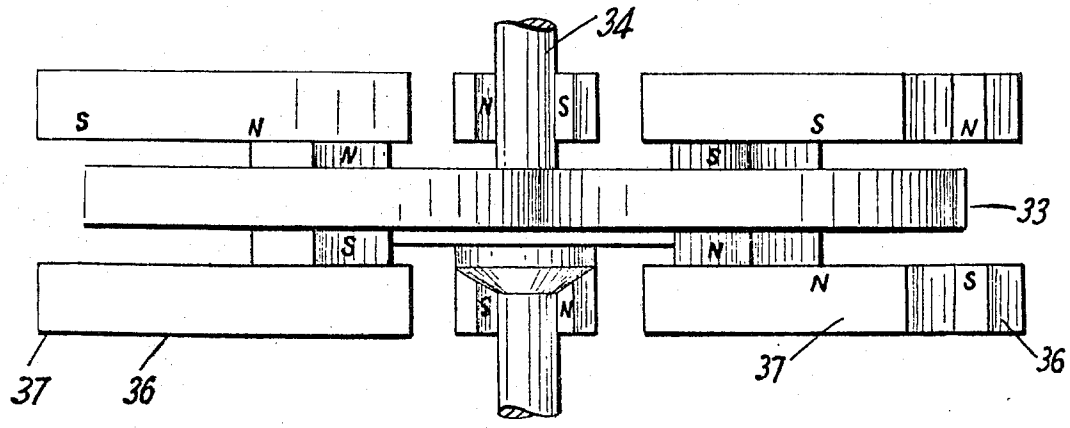
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FIG.6b

QUARTZ CONTROLLED CHRONOMETER

BACKGROUND OF THE INVENTION

The present invention relates to timekeeping devices and more particularly to a quartz controlled chronometer.

The present quartz controlled chronometers mainly comprise indicating systems driven by mechanical oscillators which are synchronized by the frequency of a quartz controlled oscillator. One of the problems encountered by synchronization systems of this type is that the low frequency mechanical oscillator tends to fall out of synchronization when the wrist movement affects the amplitude. On the other hand, quartz controlled chronometers which include indicating systems for directly indicating the divided quartz frequency, for example one cycle per second or one half cycle per second without synchronization have other disadvantages. These later systems generally have a relatively high power consumption and a blocking arrangement of low efficiency when the motor is not operating.

The following patents represent some of the prior art pertinent to the field of the present invention: U.S. Pat. Nos. 2,546,371; 3,163,808; 3,212,252 and 3,435,311. Other patents may, of course, exist and be relevant to the present invention. Briefly, U.S. Pat. No. 3,212,252 to A. Nakai shows the use of a quartz oscillator with a divider while U.S. Pat. No. 2,546,371 to E. Peterson shows the generation of pulses of alternately opposite polarities and Matsuzawa U.S. Pat. No. 3,435,311 discloses an oscillator drive energized by pulses of opposite polarity. In U.S. Pat. No. 3,163,808, a polarized motor includes a pair of coils mounted thereon and a flip-flop for polarizing the armature in opposite directions.

SUMMARY OF THE INVENTION

The present invention relates to a highly accurate timekeeping device including a high frequency time base such as a quartz oscillator which is coupled to a frequency divider which reduces the quartz frequency to one or one half hertz. The divider output is connected to a polarity changing driver which energizes a polarized motor. A system is thus provided which indicates directly the divided quartz frequency with quartz accuracy. Furthermore, the use of driving pulses of changing polarity results in low power consumption.

The driving circuit is a new arrangement for small timepieces which changes the polarity of the driving current after each driving impulse. The motor which is activated by the driving current comprises one or more symmetrically mounted rotor coils mounted on the index lever staff. The rotor coil is driven back and forth by the alternating pulses while the lever drives an index wheel. A magnetic blocking system is also provided to block the indexing system when the motor is not driving. The polarized motor has the added advantage of being self-correcting since, if the timepiece receives a hard shock, the rotor may be tossed to its opposite rest position due to torsional acceleration and advance the index wheel ahead of its pulse. The pulse following will not advance the index wheel again since the polarity of the driving current for that pulse and the polarity of the magnet in that rest position are attractive. Synchronization between pulse and mechanical switching up to one step out of phase is thereby assured.

Accordingly, it is an object of this invention to provide a new and improved timepiece.

Another object of this invention is to provide a new and improved quartz controlled timepiece having a low power consumption and indicating means being directly driven by the divided quartz frequency.

A further object of this invention is to provide a quartz controlled timepiece which is self correcting and includes a unique magnetic blocking system in combination with a polarized motor.

Other objects and advantages of the present invention will be more clearly seen when viewed in conjunction with the accompanying drawings wherein:

FIG. 1 is a block diagram of the circuit of the present invention;

FIG. 2 is a circuit diagram of the polarity changing driver of FIG. 1;

FIGS. 3*a*, 3*b*, and 3*c* show the relationship between the driver input and output pulses;

FIGS. 4*a*, 4*b*, 4*c*, 4*d* and 4*e* show various coil configurations which may be used in the rotor of the timepiece motor;

FIGS. 5*a*, and 5*b* illustrate the blocking system of the present invention;

FIGS. 6*a*, and 6*b* show schematically the motor and the operation thereof.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIG. 1 of the drawings, the timepiece of the present invention comprises a quartz oscillator **10** which supplies a high frequency output **11** to the divider **12.** The divider **12** reduces the quartz frequency to one or one half hertz on outputs **13** and **14.** As shown in FIGS. 3*a–c*, the driver **16** changes the polarity of the driving current **17** to the motor **18** after each impulse **13** and **14.** The motor **18** is directly driven by the divided quartz frequency thereby providing highly accurate timekeeping without the disadvantages present in quartz synchronized systems. One important drawback, which is avoided, is the tendency of the mechanical vibrator to fall out of synchronization when wrist movement affects the amplitude.

The quartz oscillator **10** comprises a conventional quartz crystal which is activated to oscillate at its resonant frequency. The quartz frequency, which is then fed to the divider **12** as oscillator output **11,** generally ranges from approximately 8,000 Hz to 5,000,000 Hz depending upon crystal selection. The divider **12** is a conventional multi-stage frequency divider which reduces the quartz output to 1 Hz or one-half Hz on divider outputs **13** and **14.**

The driver **16** comprises a current polarity changing unit which functions as shown in FIG. 3c. The polarity of the driving current **17** is changed by the driver **16** after each pulse **13** and **14** thereby making it possible to energize a polarized electric motor **18.** Referring to FIG. **2,** the driver **16** operates in the following manner. A rising potential on input **13** saturates transistors **19, 21** and **22.** At the same time ground potential on input **14** to the base **23** cuts off transistors **24, 26,** and **27** driving the current flow in one direction. After the time interval t_1 capacitor **28** is discharged by resistor **29** and transistors **19, 21** and **22** are driven to cut off. The circuit is then in a neutral position.

At this point, rising potential on input **14** saturates transistors **24, 26** and **27** driving current flow in the opposite direction. After the time interval t_2, capacitor **31**

is discharged by resistor 32 and transistors 24, 26 and 27 are driven to cut off. The circuit now is in the neutral position once again. The length of the driving impulses 17 can be adjusted with resistors 29 or 32 or capacitors 28 and 31. It is to be noted, however, that $t_1 = t_2$ = length of the driving impulse.

The motor 18 which is shown in FIGS. 6*a* and 6*b* includes a rotor 33 which may comprise a single coil or a plurality of symmetrically mounted individual coils. Various suitable coil arrangements are illustrated in FIGS. 4*a* – 4*e* with the embodiment of FIG. 4*d* selected for further discussion as the rotor 33 in FIGS. 6*a* and 6*b*.

The center portion of the coil system or rotor 33 is mounted on the index lever staff 34. The coil rotor continuously switches back and forth between two stationary systems of permanent magnets 36 and 37. An alternative approach (not shown) would be to use a single magnet system with a shunt. The staff 34 also includes an index lever 38 mounted thereto with arms 39 and 41 for engaging the teeth 42 of an index wheel 43. As the rotor 33 switches back and forth in accordance with the drive pulses 17, the lever 38 drives the wheel 43 which is coupled to the indicating means in a conventional manner. Preferably the wheel 43 includes 30 or 60 circumferentially arranged teeth to be compatible with one or one half hertz driver output frequency.

The motor 18 is driven by the driving impulses 17 of opposite polarity such that the first impulse turns the rotor 33 from position A to position B. One second later a second impulse turns the rotor coil 33 back from position B to position A. The motor 18 functions continuously in this manner with quartz accuracy since the driving pulses come directly from the quartz oscillator via the divider 12 and driving unit 16.

When the motor 18 is at rest after a driving impulse 17, the entire indexing system is blocked by an iron or ferrite core 44 which is positioned at one or several ends of the coil as shown more particularly in FIGS. 5*a* and 5*b*. The iron core 44 positioned in the coil 33 becomes an electromagnet when a driving pulse 17 is received. The polarity of this electromagnet is determined by the current direction of the pulse 17.

The iron core 44 cooperates with two permanent magnets 46 and 47. With the core 44 initially held by magnet 46, a driving impulse 17, with the current I in the indicated direction, changes the core 44 into an electromagnet with the same polarity as the permanent holding magnet 46. A repelling force is thereby created between the electromagnet 44 and the magnet 46 causing separation thereof. Unlike spring blocking or present magnetic blocking systems, little power is required to overcome the blocking. The system functions similarly but in the other direction with magnet 47 as a pulse 17 of opposite polarity is received.

In instances where a severe shock is received, the rotor could be thrown out of position, for example, from position A to position B. The watch would, in effect, be gaining one second but through polarization of the driving current, the rotor 33 misses the next driving impulse and is correct once again. The motor 18 is therefore, self-correcting.

The invention as described above has many advantages such as providing a direct indication of the divided quartz frequency with quartz accuracy in a low cost design. A low power consumption results from using driving impulses of changing polarity and very little power is needed for blocking or releasing of the indicating system. No hairsprings are necessary for electrical motor connections but however, if used, they serve to store potential energy and further reduce power consumption. Furthermore no mechanical click, blocking or return springs are required. The subject timepiece also readily provides a jump second indication.

It is understood that the above-described arrangements are merely illustrative examples of the application of the principles of the invention. Numerous other arrangements may be readily devised by those skilled in the art which will embody the principles of the invention and fall within the spirit and scope thereof.

I claim:

1. A timepiece having time indicating means comprising:
- a quartz crystal oscillator having a high frequency output,
- a frequency divider for reducing the output of the quartz oscillator to a low frequency,
- a polarity changing driver connected to the divider for changing the polarity of the driving current after each driving impulse, the polarity changing driver comprising a first input line and a second input line, a first plurality of transistors coupled to the first input line such that rising potential on said first input line saturates said first plurality of transistors, a second plurality of transistors coupled to said second input line such that ground potential on the second input line cuts off said second plurality of transistors while the first plurality of transistors are saturated, and means coupled to each input line for producing a predetermined output pulse upon receipt of an input from the divider, and wherein,
- the means for producing a predetermined out-put pulse comprises a resistor-capacitor network connected across the first and second input lines, and,
- each plurality of transistors comprises a first transistor having its base connected to a particular input line and second and third transistors, the base of the second transistor being connected to the collector of the first transistor and the base of the third transistor being connected to the emitter of the first transistor.

2. A timepiece having time indicating means comprising:
- a quartz crystal oscillator having a high frequency output,
- a frequency divider for reducing the output of the quartz oscillator to a low frequency,
- a polarity changing driver connected to the divider for changing the polarity of the driving current after each driving impulse and,
- a polarized oscillatory motor energized by the driver output such that out-of-phase driving pulses fail to drive the motor and said motor is thereby self-correcting, the motor including an index lever staff, a rotor coil mounted thereon and a pair of stationary magnet systems between which the rotor coil is oscillated by the polarized driving pulses when the pulses are in phase, and,
- indexing means directly coupled to the motor and driven thereby to operate time indicating means.

3. A timepiece in accordance with claim 2 wherein:

the motor further includes an oscillatory coil and a blocking system for maintaining the indexing means in position when the motor is not driving, said system comprising a magnetizable core mounted in a predetermined position within the coil and a pair of spaced apart magnets located at the limits of oscillation and cooperating therewith

to hold the indexing means after each driving impulse.

4. A timepiece in accordance with claim 2 wherein: the rotor coil comprises a plurality of coils symmetrically mounted about the staff.

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