

PATENT SPECIFICATION

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(54) IMPROVEMENTS IN OR RELATING TO ELECTRONIC TIMEPIECES

(71) We, KABUSHIKI KAISHA SUWA SEIKOSHA, a Japanese company, of 3—4, 4-chome, Ginza, Chuo-ku, Tokyo, Japan, 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 to electronic timepieces, hereinafter referred to as watches, and has for its object to provide improved electronic watches of relatively low cost and great compactness so that they can be made as wristwatches, which shall be such that they can be driven quickly when required for such purposes as time setting and time correction.

According to this invention an electronic timepiece comprises a relatively high frequency time standard oscillator, a frequency divider chain including re-settable frequency divider stages, driven by relatively high frequency output from said oscillator and arranged to produce pulses at a pre-determined frequency which is low in relation to said relatively high frequency, a motor driving circuit fed with said pulses, a pulse operated motor, time indicating means driven by said motor through a reduction ratio drive and make and break switch means manually operable at will, for producing re-setting action in said divider chain, said switch means being so connected and arranged that, upon operation thereof away from its normal condition of conductivity, a reset pulse is applied to said divider and an advancing pulse is applied substantially immediately and without delay to the motor, whereby, by rapid and repeated operation of the switch means, the time indication given by the watch can be rapidly changed.

The time standard oscillator preferably includes a quartz vibrator having a frequency of the order of thousands or tens of thousands of Hz and the relatively low frequency used for driving the motor is of the order of Hz.

The motor driver circuit may be composed

of bipolar transistors and there may be provided an integrated circuit including binary frequency dividers and waveform shaping circuits composed of complementary field effect transistors, said integrated circuit constituting a re-settable logic circuit, and make and break switch means arranged to re-set said logic circuit and to produce, substantially immediately and undelayed upon the opening thereof, a motor driving signal whereby, by rapid and repeated operation of the switch means, the time indication given by the watch can be rapidly changed.

The invention is illustrated in the accompanying drawings in which:—

Figure 1 is a block diagram of one form of watch in accordance with the present invention;

Figure 2 is a diagram of one of the divider and pulse forming stages in Figure 1. It is of integrated circuit construction and is composed of complementary MOS transistors;

Figure 3 is a diagram of a time delay circuit used in Figure 1. It is of integrated circuit construction and is composed of complementary MOS transistors;

Figure 4 is an explanatory graphical figure showing certain voltage waveforms occurring in the operation of the MOS-IC pulse circuits in Figure 1;

Figure 5 is a simplified schematic general arrangement view of a wristwatch in accordance with the invention; and

Figure 6 is another graphical figure which is employed in explaining the operation of a wristwatch in accordance with this invention.

As already stated the invention provides a watch which can, when required for such purposes as time correction, be made to run considerably more quickly, i.e. to change the indicated time considerably more quickly than occurs when the watch is running normally. As will be clear later, in the preferred embodiment of the invention means are provided whereby, when required, the indication given by the second hand of the watch may be caused to advance by one second in consider-

ably less than one second at a time and this may be repeated rapidly as often as required.

Figure 1 is a block circuit diagram divided by broken lines into portions B₁, B₂ and B₃ and showing one form of watch in accordance with this invention. In portion B₁ is a time standard oscillator including a quartz vibrator X having a frequency of the order of thousands of Hz or tens of thousands of Hz. The output from this oscillator is amplified and inverted by successive inverters I₁ and I₂, connected as shown to the input terminals of the first stage F₁ of a multistage divider and pulse former adjuster within the portion B₂. As will be seen the inputs to the two input terminals of F₁ are in phase opposition as conventionally indicated by the legends ϕ

and $\bar{\phi}$. The devices within the portion B₂ are composed of complementary field effect transistors (COS MOS). Circuits utilising such devices are of very low electric power consumption and are thus very suitable for a wristwatch where the practically permissible power consumption is limited. The divider stages F₁, F₂ . . . F_n are of the ripple binary counter divider type. The divider stages F₁ to F_n are resettable by resetting pulses applied at PR. The output from F₁ is indicated by

the references Q₁ and $\bar{Q}_1$ at the appropriate terminals and that from the last divider stage

F_n is similarly represented by Q_n and $\bar{Q}_n$. The output signal from the last stage F_n is a two-second period signal and is utilised to drive a transducer which drives the mechanically indicating means of the watch through gears (not shown in Figure 1) providing appropriate gear ratios.

Figure 2 is a diagram showing one divider stage in detail. Input signals of mutually opposite polarities are applied at the input terminals ϕ and $\bar{\phi}$, and output signals appear

at the various divider stage outputs. I₃ is a polarity inverter. When the watch is to be

driven quickly a preset signal PR makes the signal at this inverter come to the higher of its two possible levels and the divider stages to which preset signals are applied are preset.

Figure 3 is a detail circuit diagram of a time delay circuit D included in the portion B₂ of Figure 1 and shown to the right of the divider stage F_n. In Figure 3 V_{DD} is a source voltage—generally from 1.35 to 1.5 volts for a wristwatch—and GND represents earth, i.e.

zero volts. The output terminals Q_n, $\bar{Q}_n$ of the last divider stage F_n and the output terminals

Q_D, $\bar{Q}_D$ of the time delay circuit D are connected to NOR and NAND gates as shown in Figure 1 and output signals required

for motor driving are obtained at terminals O₁, O₂, O₃, and O₄ together with those of the reset pulse PR (appearing at the terminals marked PR in Figure 1) and those at terminals Q₁, $\bar{Q}_1$.

Figure 4 shows in conventional fashion the relative phases of these signals. As will now be clear from Figure 2, the circuit is designed to be preset, and as soon as a preset switch SW (Figure 1) is opened, the output signals O₁ and O₄ are produced.

Within the portion B₃ of Figure 1 is a motor driver circuit composed of bipolar transistors and a monostable multivibrator producing pulse signals for quick operation. Normally the preset switch SW is open and, in this condition of the switch, the output signals O₁, O₄ and O₂, O₃ are alternately produced in pairs and motor driving transistors T₁, T₄ and T₂, T₃ are alternately rendered conductive so that current impulses are caused to flow alternately in opposite directions in the motor which is represented by driving coil L.

Figure 5 is a general schematic view showing the layout of a wristwatch in accordance with this invention. The electronic circuitry—time standard quartz oscillator, frequency dividing stages and so on—are housed in the housing IC; BB represents a battery; Y is the motor rotor; and 3# represents a gear train, 4# being the one second gear; and L is the motor driver coil. The rotor has six magnetic poles and rotates through about 60 degrees in response to each one second drive period.

For quick operation of the watch the preset switch SW is closed. When this happens the circuitry in portion B₂ of Figure 1 stops operating in its normal way and a monostable multivibrator within portion B₃ of Figure 2 is triggered. This monostable is composed of the transistors T₇ and T₈, the condensers C₁ and C₂, and the resistances R₂, R₃, R₄, R₅ connected as shown in manner known per se. The output signals from this monostable multivibrator make the motor driving transistors T₅ and T₆ conductive and a current pulse flows in the direction from (b) to (a)—see Figure 1—in the motor driver coil L at the moment of presetting. The second hand may be arranged to stop at an old second position when this happens and, of course, the motor is also arranged to stop at the corresponding position.

When the preset switch SW is re-opened the electronic circuitry within portion B₂ comes into normal operation and almost at once the motor driving transistors T₁ and T₄ become conductive. A current pulse now flows in the direction from (a) to (b) in the motor driver coil L. On the previous assumption that closing switch SW causes the second hand to stop in an odd second position the almost immediate effect of re-opening it is to cause

the said hand to step forward to an even second position. Consequently by rapid repeated operation of the switch SW it is possible to drive the second hand forward quickly. This action is illustrated graphically in Figure 6.

In Figure 6, PR is the voltage on the preset line, Ip is a group of current pulses through the motor coil L and MM represents the collector electrode voltage of the transistor T, of the monostable multivibrator. If the resettable divider stages in the portion B₂ were merely reset as in a conventional watch circuit of a watch of the nature herein in question, a motor driver pulse would be produced not at the moment when the reset switch was operated, but at a second after that. Accordingly quick operation of the watch is not obtainable with the conventional circuit as it is with the use of this invention which enables quick operation to be obtained, the second hand being advanced as rapidly as the setting switch can be operated. The additional elements required to achieve this result are few, small and inexpensive. Thus the time indication given by a watch in accordance with this invention can be rapidly altered for such purposes as time-setting and time-correction.

The embodiment above described and illustrated has the substantial advantages of being small and compact, light, relatively inexpensive and simple, reliable, of low power consumption, well adapted for production by mass production methods, suitable for wrist-watches and other watches of small size, and reliable.

WHAT WE CLAIM IS:—

1. An electronic timepiece comprising a relatively high frequency time standard oscillator, a frequency divider chain including resettable frequency divider stages, driven by relatively high frequency output from said oscillator and arranged to produce pulses at a pre-determined frequency which is low in relation to said high frequency, a motor driving circuit fed with said pulses, a pulse operated motor, time indicating means driven by said motor through a reduction ratio drive and make and break switch means manually operable at will, for producing re-settable action in said divider chain, said switch means being so connected and arranged that, upon

operation thereof away from its normal condition of conductivity, a reset pulse is applied to said divider and an advancing pulse is applied substantially immediately and without delay to the motor, whereby, by rapid and repeated operation of the switch means, the time indication given by the watch can be rapidly changed.

2. A timepiece as claimed in claim 1 wherein the time standard oscillator includes a quartz vibrator having a frequency of the order of thousands or tens of thousands of Hz and the relatively low frequency used for driving the motor is of the order of Hz.

3. A timepiece as claimed in claim 1 or 2 wherein the motor driver circuit is composed of bipolar transistors; there is provided an integrated circuit including binary frequency dividers and waveform shaping circuits composed of complementary field effect transistors, said integrated circuit constituting a re-settable logic circuit; and the manually operable switch means comprise make and break switch means arranged to re-set said logic circuit and to produce, substantially immediately and undelayed upon the opening thereof, a motor driving pulse whereby, by rapid and repeated operation of the switch means, the time indication given by the watch can be rapidly changed.

4. A timepiece as claimed in any of claims 1 to 3 wherein the motor driver circuit includes a main circuit driven by output signals from an integrated circuit frequency dividing and pulse forming chain and a sub-circuit including a monostable multivibrator, said main circuit being effectively in parallel with said sub-circuit and said monostable multivibrator and wherein said switch means is arranged, when moved to a predetermined one of two possible positions to reset said integrated circuit chain and trigger said monostable multivibrator to cause a drive pulse to be fed to the motor.

5. Electronic timepieces substantially as herein described and illustrated in the accompanying drawings.

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The embodiment above described and illustrated has the substantial advantages of being small and compact, light, relatively inexpensive and simple, reliable, of low power consumption, well adapted for production by mass production methods, suitable for wrist-watches and other watches of small size, and reliable.

WHAT WE CLAIM IS:—

1. An electronic timepiece comprising a relatively high frequency time standard oscillator, a frequency divider chain including resettable frequency divider stages, driven by relatively high frequency output from said oscillator and arranged to produce pulses at a pre-determined frequency which is low in relation to said high frequency, a motor driving circuit fed with said pulses, a pulse operated motor, time indicating means driven by said motor through a reduction ratio drive and make and break switch means manually operable at will, for producing re-settable action in said divider chain, said switch means being so connected and arranged that, upon

operation thereof away from its normal condition of conductivity, a reset pulse is applied to said divider and an advancing pulse is applied substantially immediately and without delay to the motor, whereby, by rapid and repeated operation of the switch means, the time indication given by the watch can be rapidly changed.

2. A timepiece as claimed in claim 1 wherein the time standard oscillator includes a quartz vibrator having a frequency of the order of thousands or tens of thousands of Hz and the relatively low frequency used for driving the motor is of the order of Hz.

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4. A timepiece as claimed in any of claims 1 to 3 wherein the motor driver circuit includes a main circuit driven by output signals from an integrated circuit frequency dividing and pulse forming chain and a sub-circuit including a monostable multivibrator, said main circuit being effectively in parallel with said sub-circuit and said monostable multivibrator and wherein said switch means is arranged, when moved to a predetermined one of two possible positions to reset said integrated circuit chain and trigger said monostable multivibrator to cause a drive pulse to be fed to the motor.

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