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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, and more specifically to electronic timepieces in which the time standard is piezo-electric crystal oscillator other relatively high frequency time standard, the electrical output from which is used to derive signals which are employed to drive an electro-mechanical converter (usually an electric motor) driving the time indicating means of the timepiece. The invention is primarily concerned with the correction of the indication given by the seconds indicator and seeks to provide a timepiece wherein easy and certain correction of the seconds indication may be effected. This operation has been undesirably troublesome to effect in known crystal timepieces.

The accuracy of modern electronic timepieces is very high—the error rate per month is commonly less than ± 5 seconds and it is seldom seriously wrong. Its very accuracy, however, makes the user want to be able to correct a seconds hand error of several seconds which may have accumulated after a rather long period of use. It is by no means easy to make satisfactory provision for this. In a conventional electronic timepiece such a small error, if it is such as to make the watch slow, has to be corrected by stopping the timepiece, advancing the minute hand and setting it going again. This process is a nuisance to carry out. Also conventional electronic timepieces arranged to be corrected in this way are undesirably complicated. The present invention seeks to avoid these defects and provide improved electronic timepieces the seconds indications of which can be easily and certainly adjusted by simple means which can be made very small and of low power con-

sumption so as to be highly suitable for wrist watches.

According to this invention an electronic timepiece comprises a time standard, an integrated electronic circuit driven by said time standard, an electro-mechanical converter driven by said electronic circuit and a quick feed correcting switch for the seconds indicator of the timepiece said switch also constituting a pre-set switch for a frequency dividing counter circuit incorporated in said electronic circuit, said electronic circuit consisting of complementary field effect transistors and said electro-mechanical converter operating at a frequency of the order of several cycles per second. By the expression "quick feed correcting switch" as employed herein is meant a switch the operation of which quickly advances the indicator. The combined quick feed and pre-set switch provided by this invention may be a simple make and break switch. Quick advance of the seconds indicator may be obtained by means of a source of oscillatory energy the said combined switch being arranged to control the supply of oscillatory energy to said converter and also to preset said counter circuit.

The source of oscillatory energy may be a multi-vibrator the operation of which is controlled by the switch.

The converter may be a pulse motor having a driving coil with its ends connected between output terminals of the counter through circuit connections including inverters and one of which includes also a NOR gate having one input terminal connected to the source of oscillatory energy and the other input terminal fed from an output terminal of the counter.

The invention is illustrated in and further explained in connection with the accompanying drawings in which:—

Figure 1 is a diagrammatic representation of one embodiment of the invention; and

Figure 2 is an explanatory graphical figure.

Referring to Figure 1, K represents a high frequency crystal which forms part of a highly

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stable oscillator circuit including an inverter I_1 . Output from the oscillator circuit is fed to a counter and a pulse shaper within the block C. Block C has two output terminals OUT_1 and OUT_2 , what is herein termed a "pre-set" terminal PR. The shaped and frequency divided output at terminal OUT_2 is fed to one input of a NOR gate NR_1 which is followed by an inverter I_4 . The output at terminal OUT_1 is fed to an inverter I_2 followed by a further inverter I_3 . The output terminals of the inverters I_3 and I_4 are connected to the opposite ends of the driving coil L of an electric motor the rotor of which is represented at RT.

The second input to the gate NR_1 is provided from the output side of an inverter I_5 input to which is through a capacitor C from a second NOR gate NR_2 . When a switch SW is closed, positive potential is applied to the first input lead of this gate and the third output terminal PR of the block C is connected to this input lead. The output of inverter I_5 is referenced OUT_3 . The first input lead of gate NR_2 is connected to earth through a resistor as shown; positive potential is applied through a resistor R to the input side of inverter I_5 ; and a capacitor is connected across the switch SW.

Figure 2 represents, to a time abscissa axis, wave forms appearing at various points in Figure 1 and is drawn for the case—a practically convenient case—in which the oscillator frequency is 16384 kHz and the counter

in clock C is a 15 stage binary counter.

In normal operation of the timepiece pulsed current i which reverses every second flows through the coil L as shown in the left hand portion of the wave form i in Figure 2 and magnetic poles N and S are produced in alternation on the stator SS of the motor. The rotor RT of the motor is polarized into six poles as indicated in Figure 1 by the letters N, S thereon, and rotates through 60° every second. It drives through gearing a wheel 4 on which a seconds hand is fixed.

Quick adjustment of the seconds hand will now be described. The NOR gate NR_2 , inverter I_5 , capacitor C and resistor R constitute a monostable multi-vibrator the time constant of which is determined by the values of C & R. To one input lead of the gate NR_2 —the upper one as it appears in Figure 1—is applied a trigger pulse which is applied also to the reset terminal PR of the counter in the block C so that this counter is re-set every time the multi-vibrator is triggered. The above mentioned trigger pulse is produced when the switch SW is operated. When it is closed, the monostable multi-vibrator is triggered and a pulse is produced at OUT_3 as indicated at X in Figure 2. When it is opened a pulse is produced at OUT_1 as indicated at Y. When the switch is kept ON the

dividing counter is preset by the voltage at terminal PR. On opening switch SW this situation ceases and a pulse is produced at OUT_1 .

When it is desired to adjust the second hand the switch SW is closed, an output voltage OUT_3 is at once produced by the multi-vibrator and a current in the same direction as that from the terminal OUT_2 flows through the motor driving coil L. The counter is reset at the same time. If, now, the switch SW is opened, an output voltage is at once produced at OUT_1 and reverse current flows through the coil L. Thus if the switch SW is successively opened and closed the rotor of the motor will be advanced through 120° (corresponding to 2 seconds) each time the switch is operated. When the required adjustment is obtained the switch SW is left open.

As regards pulse width, this is not at all critical: the requirement is merely that the motor receives pulses wide enough for driving it satisfactorily—for example, to quote a practical figure, about $1/64$ th second wide. The pulse width produced in OUT_1 and OUT_2 is the same, being determined by the clock pulse. While the pulse width in OUT_3 is not exactly the same, being determined by the time constant set by the values of R & C (Figure 1), these values should be chosen to give at least approximately the same pulse width (assumed to be $1/64$ th second) and if this is done trouble-free driving of the motor will be obtained. A condenser is connected across the switch to prevent overlap of the outputs at OUT_1 and OUT_3 . The additional components (over and above those normally provided in a crystal watch) necessary for providing for second hand adjustment are few.

Briefly to recapitulate the operation of time correction it will be seen that, when the switch SW is moved ON and OFF once, pulses a and b (as shown in the bottom line of Figure 2) are produced and the motor is moved forward two steps, i.e. by two seconds. Since (assuming a pulse width of $1/64$ th second) the combined width of pulses a and b is $1/32$ nd second, the second hand can be rapidly advanced. The rapidity of operation of the switch SW can be increased up to 32 times a second (on the foregoing assumption of pulse width) and the seconds hand still advanced rapidly. However, if (as is not thought likely) the switch SW is operated more rapidly than this, the pulses a and b come together and normal advance of the seconds hand is not obtained. This is why an electro-mechanical converter operating at a frequency of the order of cycles per second is selected.

As will now be seen, the advantage of quick and easy correcting advancement of the seconds hand is obtained while the use of the switch SW both for "quick feed" and re-setting of the frequency dividing counter re-

sults in greater simplicity and compactness. Furthermore the use of field effect transistor circuitry is of considerable advantage from the viewpoint of low power consumption while the monolithic integrated circuit construction enables great compactness, making the invention highly suitable for embodiment in wrist watches, to be easily attained.

WHAT WE CLAIM IS:—

10 1. An electronic timepiece comprising a time standard, an integrated electronic circuit driven by said time standard, an electro-mechanical converter driven by said electronic circuit, and a quick feed correcting switch
15 for the seconds indicator of the timepiece, said switch also constituting a preset switch for a frequency dividing counter circuit incorporated in said electronic circuit, said electronic circuit consisting of complementary
20 field effect transistors and said electro-mechanical converter operating at a frequency of the order of several cycles per second.

25 2. A timepiece as claimed in claim 1 wherein said switch is a simple make and break switch.

3. A timepiece as claimed in claim 1 or 2 wherein the said switch is arranged to control a supply of oscillatory energy to said converter as well as to preset said counter circuit.

4. A timepiece as claimed in claim 3 wherein the source of oscillatory energy is a multi-vibrator the operation of which is controlled by the switch.

5. A timepiece as claimed in any of the preceding claims wherein the converter is a pulse motor having a driving coil with its ends connected between output terminals of the counter through circuit connections including inverters and one of which includes also a NOR gate having one input terminal connected to the source of oscillatory energy and the other input terminal fed from an output terminal of the counter.

6. Electronic timepieces substantially as herein described with reference to the accompanying drawings.

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WHAT WE CLAIM IS:—

1. An electronic timepiece comprising a time standard, an integrated electronic circuit driven by said time standard, an electro-mechanical converter driven by said electronic circuit, and a quick feed correcting switch for the seconds indicator of the timepiece, said switch also constituting a preset switch for a frequency dividing counter circuit incorporated in said electronic circuit, said electronic circuit consisting of complementary field effect transistors and said electro-mechanical converter operating at a frequency of the order of several cycles per second.
2. A timepiece as claimed in claim 1 wherein said switch is a simple make and break switch.

3. A timepiece as claimed in claim 1 or 2 wherein the said switch is arranged to control a supply of oscillatory energy to said converter as well as to preset said counter circuit.

4. A timepiece as claimed in claim 3 wherein the source of oscillatory energy is a multivibrator the operation of which is controlled by the switch.

5. A timepiece as claimed in any of the preceding claims wherein the converter is a pulse motor having a driving coil with its ends connected between output terminals of the counter through circuit connections including inverters and one of which includes also a NOR gate having one input terminal connected to the source of oscillatory energy and the other input terminal fed from an output terminal of the counter.

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