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(54) ELECTRONIC TIMEPIECE

(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.

It is known to provide a timepiece with a stepping motor driven by a signal derived from a crystal vibrator, e.g. a quartz crystal vibrator, so that a seconds hand is indexed at one-second intervals. The stepping motor includes a pair of stator poles and a rotor, the stator poles being alternately magnetised to cause rotation of the rotor which is permanently magnetised.

Usually, this type of timepiece is provided with a setting circuit and a setting lever. The setting circuit has two functions: firstly, when a setting switch is closed, the setting circuit prevents current flowing to a driving coil; and secondly, at the instant when the setting switch is opened, an initial driving pulse is applied to the coil. The setting lever also has two functions: firstly, the setting lever determines the position of the rotor relative to the stator poles in order that the rotor is in a predetermined position ready for the initial driving pulse; and secondly, the setting lever prevents rotation of the rotor so as to allow the time indication to be altered without affecting the position of the rotor.

Generally, this type of timepiece is highly accurate and even in a compact watch the rate of the watch can easily be adjusted to be about ± 0.2 seconds per day. However, this error will accumulate over a period of time and so on an adjustment of the time indication will eventually be necessary.

According to the present invention there is provided an electronic timepiece comprising: a crystal oscillator for producing a standard time signal; a divider circuit for producing from the standard time signal a driving signal having a frequency of 1 Hz;

a stepping motor having a rotor and a stator and connected to be driven by said driving signal; a seconds hand connected to be driven by the stepping motor; switch means which, in one position thereof, prevents the driving signal from driving the stepping motor; and a manually adjustable member movement of which from a first position to a second position stops the seconds hand in a position where it indicates an even-number second, movement of the adjustable member from the second position to the first position causing the second hand to advance after an interval of one second.

The switch means may be a setting switch, there being provided a setting lever, replaceable by the adjustable member, the arrangement being such that when the adjustable member is in said second position, the setting switch prevents a driving signal from driving the stepping motor and the setting lever engages a part of the stepping motor, movement of the adjustable member from the second position to the first position initially causing the setting switch to allow the driving signal to drive the stepping motor and to advance the seconds hand after an interval of one second and subsequently causing the setting lever to disengage the part of the stepping motor within said interval of one second.

The setting lever may have a plurality of positions one of which is defined by one switch contact of the setting switch which switch contact forms a stop.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:

Figure 1 is a schematic plan view of part of a conventional timepiece;

Figures 2 and 3 are sections of the timepiece of Figure 1;

Figure 4 is a schematic plan view of part of an electronic timepiece according to the present invention;

Figure 5 is a section of the timepiece of Figure 4; and

Figure 6 shows the waveform of a driving

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signal for a conventional timepiece or for an electronic timepiece according to the present invention.

Referring first to Figure 1 to 3, a conventional timepiece known in Japan, for example a watch, will be described. A seconds hand (not shown) of the timepiece is mounted on a shaft for rotation with a fourth wheel 13 which engages with a rotor pinion 14. When a stem 1 is moved axially outwardly the position of a setting lever 4 moves from 4a to 4b and the position of a substantially triangular setting cam 8 moves from a position 8a to a position 8b. A setting circuit 100 has one terminal electrically connected to a resilient setting switch member 5 via a base plate of the timepiece and its other terminal electrically connected to a pin 6 which is electrically insulated from the base plate and all other parts of the timepiece by an insulating bush 7. Whenever the setting circuit 100 is turned ON. As soon as the setting circuit is turned OFF again an initial driving pulse of a pulsiform driving signal is produced by a dividing circuit 101 and energises a coil 102. The dividing circuit 101 derives the driving signal from the output of a crystal oscillator 103. This causes stator poles 10, 11 to be magnetised. A rotor 9 has six permanent magnetic poles. The setting cam 8 and the rotor 9 are fixed at predetermined angular positions relative to each other. The relative positions are such that when the setting cam 8 is at position 8b the seconds hand indicates an odd-number second, and when it is at position 8a it indicates an even-number second.

To adjust the time indication of the timepiece, if the stem is moved axially outwardly when the seconds hand indicates nearly 59 seconds, an operating lever 2, having a dowel engaged in a cut-away portion 1a of the stem, pivots about a pin 3 fixed to the base plate, so that the operating lever moves from a position 2a to a position 2b. This movement of the operating lever urges the setting lever 4 to pivot about a pin 15 against the force of a setting lever spring 12. Thus, the setting lever 4 is urged towards the position 4b against the action of the setting lever spring which biases the setting lever towards the position 4a. Before the setting lever 4 engaged with a rotor pinion 33 on which the member 5 comes into electrical contact with the pin 6 so that the setting circuit 100 is turned ON. Subsequently, the setting lever 4 achieves the position 4b to engage with the setting cam 8.

As mentioned above, when the seconds hand indicates 59 seconds (or any given odd-number second), the setting cam 8 is at position 8b so that the rotor 9 is positioned as shown in Figure 1 and maintained in this position by the setting lever 4. Therefore, the seconds hand is fixed indicating 59 seconds

(or any given odd-number second). When the minutes and hours hands (not shown) are adjusted, the frictional torque between a centre wheel and a cannon pinion is transmitted to the rotor pinion 14 through the centre wheel, a third wheel and the fourth wheel 13. However, the rotor pinion 14 and the fourth wheel 13 do not rotate because the setting lever 4 engages the setting cam 8. Thus the minutes and hours hands can be adjusted while the seconds hand remains fixed.

After adjustment, if necessary, of the minutes and hours hands, the stem 1 is moved axially inwardly at a predetermined time (e.g. determined by a time signal). When the stem is moved axially inwardly, the operating lever 2 is moved to the position 2a and the setting lever is moved to the position 4a under the action of the setting lever spring 12. Thus the setting lever is disengaged from the setting cam 8 and subsequently the setting switch member 5 becomes electrically disconnected from the pin 6. At this moment the setting circuit 100 is turned OFF and an initial driving pulse is provided by the divider circuit 101 to the coil 102, whereby the stator poles 10, 11 are magnetised as shown in Figure 1. This causes the rotor 9 to rotate in a clockwise direction by one step equivalent to 1 second. This movement of the stem axially inwardly supplies the initial driving pulse substantially immediately to the coil, thus the rotor 9 rotates by one step virtually instantaneously after the stem 1 has been so moved. Therefore, the seconds hand indicates zero seconds (or any even-number second) and is in line with the correct time. Thereafter, the seconds hand continues to keep step with the correct time.

Due to errors in the dimensions of the various parts of such a conventional timepiece, the operation may be the reverse of that intended. That is to say, as the stem 1 is moved axially inwardly, the setting switch member 5 may become electrically disconnected from the pin 6, and the setting circuit 100 may be turned OFF, before the setting lever 4 is disengaged from the setting cam 8. Thus, the initial driving pulse will not rotate the rotor 9 since it is still prevented from rotating by the setting lever 4. The width of the initial driving pulse is 50 milliseconds as shown in Figure 6, so if the setting cam 8 is engaged with the setting lever 4 for more than 50 milliseconds after the setting circuit is turned OFF, then the initial driving pulse will have disappeared before the rotor 9 is free to rotate. A second driving pulse is produced after a time interval of 1 second from the start of the initial driving pulse. As the second driving pulse is of opposite polarity to the initial driving pulse (so the current flowing to the coil 102 is in the opposite direction), the stator poles are of

opposite polarity to those shown in Figure 1. Thus, the second driving pulse causes no rotation of the rotor as it will remain attracted by the stator poles. When the third driving pulse (of the same polarity as the initial driving pulse) is produced, the stator poles are magnetised as shown in Figure 1 and so the rotor now rotates in a clockwise direction for the first time. However, the timepiece has lost 2 seconds relative to the correct time.

The operation of setting the conventional timepiece has been described above in the case where the seconds hand is stopped indicating 59 second (or any odd-number second). If, on the other hand, the seconds hand is stopped indicating 0 second (or an even-number second), that is to say, if the setting cam is at 8a when the seconds hand is stopped, the poles of the rotor are disposed oppositely to those shown in Figure 1, the setting cam 8 is rotated by one step by the end portion 4a of the setting lever 4 when the stem is moved axially outwardly. Thus the seconds hand indicates 1 second (or an odd-number second). Thus, the starting of the timepiece is the same as that described above.

Referring now to Figures 4 and 5, there is schematically illustrated a timepiece, e.g. a watch, according to the present invention. The timepiece comprises a stem 21, a stator having poles 22, 23 and screwed to a base plate of the timepiece, a setting lever 24 and a pin 25 fixed to the base plate and about which the setting lever pivots. A pin 26 is connected to one terminal of a setting circuit 200 and is electrically insulated from the base plate by an insulating bush 27. A pin 28 is fixed to the setting lever 24 and is engageable with the stem 21. A setting lever spring 29 is arranged to urge the setting lever 24 in a clockwise direction. A substantially triangular setting cam 30, in operation, is indexed every second and rotates in a clockwise direction. A rotor 31 is fixed to the setting cam and has a plurality (six shown) of permanent magnetic poles positioned as shown in Figure 4 when the setting cam is at position 30b. A seconds hand (not shown) is mounted on a shaft of a fourth wheel 32 engaged with a rotor pinion 33 on which the setting cam and the rotor are fixed. The seconds hand is so mounted on the fourth wheel that it indicates 0 second (or any other even-number second) when the setting cam is at position 30b. The other terminal of the setting circuit is electrically connected to the base plate and the setting lever 24 via the stator.

To effect a time adjustment, for example when the seconds hand indicates about 0 second, so that the setting cam is at position 30b and the poles of the rotor are positioned as shown in the drawing, the stem 21 is

moved axially outwardly so that it is disengaged from the pin 28 with the result that the setting lever 24 moves from position 24a to position 24b under the action of the setting lever spring 29. This causes an end of the setting lever to come into electrical contact with the pin 26 which, in turn, causes the setting circuit 200 to be turned ON. The setting lever 24 is, therefore, maintained in the position 24b so that the seconds hand stops indicating 0 second. Thus, it will be appreciated that the setting lever 24 and the pin 26 constitute a setting switch which, when closed, turns the setting circuit ON and which when open, turns the setting circuit OFF.

When the stem 21 is moved axially outwardly and before the setting circuit 200 is turned ON, that is, before a pulsiform driving signal from a divider circuit 201 has ceased, the setting lever begins to engage with the setting cam. When the setting lever is at position 24b, the minutes and hours hands (not shown) may be adjusted. In this case, as in the case of the conventional timepiece, the setting lever prevents rotation of a third wheel (not shown), the fourth wheel 32 and the rotor due to frictional torque acting on a centre wheel (not shown) by virtue of the fact that the setting cam is engaged by the setting lever. After adjusting the minutes and hours hands, if the stem is moved axially inwardly at a predetermined time (i.e. determined by a time signal), the stem engages with the pin 28, the setting lever rotates in a counterclockwise direction about the pin 25 and becomes electrically disconnected from the pin 26. Thus the setting circuit 200 is turned OFF and the divider circuit 201 produces an initial driving pulse of the driving signal to a coil 202 so that the stator poles are magnetised as shown in Figure 4. The divider circuit 201 derives the driving signal which has a frequency of 1Hz from the output of a crystal oscillator 203. The rotor remains attracted to the stator poles and does not rotate even though the setting lever is out of engagement with the setting cam. After a time interval of 1 second, a second driving pulse of opposite polarity to the initial driving pulse is produced. This second driving pulse magnetises the stator poles oppositely to that shown in Figure 4 so that the rotor is indexed by one step in a clockwise direction. Therefore, after a time interval of one second after the stem has been moved axially inwardly the seconds hand has moved by one second and indicates one second (in the case where it was stopped at 0 second) and is in step with the correct time.

As will be appreciated from the above discussion, when the stem 21 is moved axially inwardly the setting switch is opened and subsequently the setting lever 24 disengages

the setting cam 30. For one second after the setting switch is opened the rotor 31 remains attracted by the stator poles and does not rotate. Therefore, there is a period of one second after the opening of the setting switch in which the setting lever must disengage the setting cam. If the disengagement occurs within this one second then the timepiece can operate normally in a trouble-free manner. Even if there are errors in the dimensions of the various parts of the timepiece, there is still a relatively long time in which the setting lever can disengage the setting cam without affecting operation of the timepiece.

In the conventional timepiece it is necessary that the setting switch is opened after the setting lever 4 is disengaged from the setting cam. It is for this reason difficult to mount the setting lever 4 and the setting switch member 5 as a unit on the base plate. With the timepiece shown in Figures 4 and 5 the setting switch is opened before the setting lever is disengaged from the setting cam so that it is possible to mount the setting switch and the setting lever as a unit on the base plate. Further, one switch contact of the setting switch can be used to define one of the two positions of the setting lever. It will be appreciated, therefore, that the timepiece according to the present invention and described above has fewer and smaller parts than the conventional timepiece.

Heretofore, when the time indication was adjusted the stem had to be moved when the seconds hand indicated about 59 seconds and the seconds hand had to be stopped indicating 59 seconds. This is not always particularly convenient to the user of the timepiece. It is more convenient to stop the timepiece with the seconds hand indicating 0 seconds and then start the timepiece in accordance with the standard time signal. Thus, the timepiece described above is more convenient to the user than the conventional timepiece.

In the embodiment described above with reference to Figures 4 and 5 when the stem is shifted axially inwards at a predetermined time, the rotor remains attracted to the stator poles by a first driving pulse and does not rotate even though the setting lever is out of engagement with the setting cam. Therefore, this first driving pulse, it will be appreciated, is not always required.

An electronic timepiece as shown in Figures 4 and 5 is also described and claimed

in our co-pending Application No. 9793/72 (Serial No. 1,383,525).

Attention is directed to the claims of our Patent No. 1,302,220.

WHAT WE CLAIM IS:—

1. An electronic timepiece comprising: a crystal oscillator for producing a standard time signal; a divider circuit for producing from the standard time signal a driving signal having a frequency of 1 Hz; a stepping motor having a rotor and a stator and connected to be driven by said driving signal; a seconds hand connected to be driven by the stepping motor; switch means which, in one position thereof, prevents the driving signal from driving the stepping motor; and a manually adjustable member movement of which from a first position to a second position stops the seconds hand in a position where it indicates an even-number second, movement of the adjustable member from the second position to the first position causing the seconds hand to advance after an interval of one second.

2. An electronic timepiece as claimed in which the switch means is a setting switch, there being provided a setting lever, displaceable by the adjustable member, the arrangement being such that when the adjustable member is in said second position, the setting switch movement a driving signal from driving the stepping motor and the setting lever engages a part of the stepping motor, movement of the adjustable member from the second position to the first position initially causing the setting switch to allow the driving signal to drive the stepping motor and to advance the seconds hand after an interval of one second and subsequently causing the setting lever to disengage the part of the stepping motor within said interval of one second.

3. An electronic timepiece as claimed in claim 2 in which the setting lever has a plurality of positions one of which is defined by one switch contact of the setting switch which switch contact forms a stop.

4. An electronic timepiece as claimed in claim 1 and substantially as herein described with reference to and as shown in Figures 4 and 5 of the accompanying drawings.

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