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(54) ELECTRONIC TIMEPIECE

(71) We, KABUSHIKI KAISHA DAINI SEIKOSHA, a Japanese Company of 31-1, 6-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, for example, electronic wristwatches.

According to the present invention there is provided an electronic timepiece comprising: drive means; hands for indicating a time indication; and a gear train connected to drive the trains from the drive means, the gear train being arranged so that the amount of play therein during adjustment of the hands in a clockwise direction is substantially the same as the amount of play therein during adjustment of the hands in a counterclockwise direction.

In the preferred embodiment, the drive means includes a driving circuit for producing during an initial period after adjustment of the hands has been effected, a plurality of supplementary driving pulses to take up the play in the gear train, the driving circuit producing at the end of said initial period a pulsiform driving signal to drive the hands through the gear train at the correct rate.

The drive means may include a motor connected to be driven by the driving circuit and coupled to drive the gear train.

The timepiece may include quartz crystal means for producing a time standard signal which is fed to the driving circuit.

Preferably the gear train has a plurality of meshing gear wheels, an adjustment gear, for rotating the gear wheels of the gear train to effect adjustment of the hands, being in mesh with the gear wheel in the middle, or substantially in the middle of the gear train.

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

Figure 1 shows schematically a gear train of a conventional electronic timepiece;

Figure 2 is a view similar to Figure 1 of the gear train after hands of the conventional electronic timepiece have been adjusted;

Figure 3 shows schematically a gear train of one embodiment of an electronic timepiece according to the present invention;

Figure 4 is a view similar to Figure 3 of the gear train after hands of the electronic timepiece have been adjusted in the clockwise direction;

Figure 5 is a view similar to Figure 3 of the gear train after hands of the electronic timepiece have been adjusted in the counterclockwise direction;

Figure 6 illustrates graphically a driving signal applied to the electronic timepiece of Figure 3; and

Figure 7 is a circuit diagram of a driving circuit of the electronic timepiece of Figure 3.

A conventional electronic timepiece as shown in Figure 1 comprises a rotor pinion 1 driven by a motor (not shown) and a gear train consisting of a fourth gear wheel 2, a fourth gear wheel pinion 3, a third gear wheel 4, a third gear wheel pinion 5 and a center gear wheel 6 on which a minutes hand 12 is mounted.

When hands (only the minutes hand is shown in Figure 11) of the conventional electronic timepiece is set, the rotor pinion 1 is used to drive the gear train. When the hands are rotated in the counterclockwise direction, the pinion 1 and the gear wheels, 2, 4, 6 are in the relative positions shown in Figure 1 when the pinion 1 has stopped. When the hands are rotated in the clockwise direction, the pinion 1 and the gear wheels 2, 4, 6 are in the relative positions shown in Figure 2. It will be seen that there is back lash or play in the gear train. When the electronic timepiece is restarted after a counterclockwise hand-setting adjustment has been performed, the pinion 1 starts to rotate after 1-second in the case where the seconds hand is indexed in 1-second steps. However, after a clockwise hand-setting adjustment has been performed, the gear train is as shown in Figure 2, the center gear wheel 6 and the minutes hand 12 not moving until the play between

each of the gear wheels 2, 4 6 has been completely taken up even though the pinion 1 is rotating. This affects the timekeeping of a conventional electronic timepiece with two hands, and is apparent as a time delay. With a conventional electronic timepiece having a centre seconds hand, there is divergence between the minutes and seconds hands this is disadvantageous since, conventionally, the hands of a conventional timepiece are usually set in the clockwise direction.

One embodiment of an electronic timepiece according to the present invention is illustrated in Figures 3 to 5. The electronic timepiece may be a quartz crystal controlled timepiece having two hands and a quartz crystal element for producing a standard time signal. Like parts in Figures 1 and 3 have been designated by the same reference numerals and will not be described further.

A friction pinion 7 is frictionally fitted to the axis of the centre gear wheel 6. The electronic timepiece has a minutes pinion 8, a minutes gear wheel 9 which is formed of the body with the minutes pinion 8, a cannon pinion 10 on which the minutes hand 12 is mounted, an hours gear wheel 11 on which there is mounted an hours hand 13, a setting wheel 14 which engages with the friction pinion 7 and a clutch wheel 15 which engages with the setting wheel 14 during a hand-setting adjustment.

Figure 3 shows the electronic timepiece in the normal running condition. Any play in the transmission from the rotor pinion 1 to the cannon pinion 10 is completely taken up. When the hands are rotated in the clockwise direction, during a hand-setting adjustment, any play in the gear train is between the rotor pinion 1 and the gear wheels 2, 4, 6 as is shown in Figure 4. When the hands are rotated in the counterclockwise direction during a hand-setting adjustment operation, any play in the gear train is between the friction pinion 7, gear wheels 9, 11 and the cannon pinion 10 as shown in Figure 5. Thus because the setting wheel 14 engages with the middle gear wheel, namely the centre gear wheel 6, of the gear train, the amount of play during adjustment of the hands in the clockwise direction is substantially the same as the amount of play during adjustment of the hands in the counterclockwise direction.

Consequently, after hand-setting adjustment has been performed, the cannon pinion 10 starts to move after the rotor pinion 1 has rotated a number of times. However, this causes a limited delay in the time indicated by the hands so that a driving circuit is arranged to supply supplementary driving pulses as shown in Figure 6 to the motor driving the rotor pinion 1 at the time when the electronic timepiece is restarted after hand-setting adjustment.

During an initial time period T_1, a plurality of supplementary driving pulses are applied to the motor. The period T_1 is the motor driving period determined by the constitution of the gear train of the electronic timepiece and may, for instance, be one-second, two-second, five-second etc. In subsequent motor driving periods, T_2, T_3 only one pulse is applied to the motor. The number of supplementary driving pulses occurring in the period T_1 are sufficient to compensate for play in the gear train resulting from the hand-setting adjustment. Each of the teeth in gear train have a profile designed to reduce play to a minimum after a hand-setting adjustment has been performed.

It will be appreciated that play in the gear train generated by a hand-setting adjustment can be compensated instantaneously by applying a suitable number of supplementary driving pulses to the electronic timepiece so that the hands display the time indication correctly.

A driving circuit to produce the driving signal illustrated in Figure 6 is shown in Figure 7. The driving circuit comprises an oscillating circuit 20, a frequency dividing circuit 21, a control circuit 22 and a switch 23 to operate the control circuit.

The switch 23 is operated between ON and OFF states by a stem (not shown). The control circuit 22 consists of a RS flip-flop 24, a NOR gate 25, an inverter circuit 26, a NAND gate 27, inverter circuits 28, 29 and a rapid feed switch 30. The control circuit 22 is operated by an output signal from the dividing circuit 21 and the signal passing the switch 23 when in the ON state. The output signal from the control circuit 22 is fed back to the dividing circuit 21.

The switch 23 is in the OFF state when the electronic timepiece is in the normal running condition and is in the ON state during hand-setting adjustment so that a terminal *a* circuit is logic 0.

After seconds hand adjustment has been made, the switch 23 is in the OFF state whereby the terminal *a* is at logical 1. Accordingly, the dividing circuit 21 having a plurality of dividing stages, starts to count immediately it is reset, i.e. at time t_0.

An output signal at terminal *f* of the flip-flop 24 is maintained logic 1 and an output signal at the terminal *h* is maintained logic 1. Accordingly, an output pulse train including the supplementary driving pulses, controlled by the output signal at terminal *i*, is produced from the terminal *k*.

When the terminals *b*, *c*, *d* all become logic 1, the output signal at terminal *f* becomes logic 0 since the flip-flop 24 is reset when a terminal *e*, which receives an

output signal from the inverter 28, becomes logic 1.

In the driving circuit shown in Figure 7, a counter is used in the dividing circuit 21. However, it is possible to use other types of counters.

When the terminal *f* becomes logic 0 the terminal *h* becomes logic 0. Accordingly, a normal output pulse train is produced at terminal *k*. That is to say, output signals from the terminals *i*, *b*, *c*, *d*, *j* are fed to the terminal *k* via an AND gate. Assuming now that the output signal of the terminal *k* is logic 1 upon operation of the switch 30, a pulse train is produced from the terminal *k* in the same manner as the pulse train is produced from the terminal *k* when the switch 23 changes from the ON state to the OFF state.

The number of supplementary driving pulses generated during the period T_1 corresponds to the rotation of the rotor pinion 1 sufficient to compensate for the play in the gear train after the seconds hand adjustment has been made.

WHAT WE CLAIM IS:—

1. An electronic timepiece comprising: drive means; hands for indicating a time indication; and a gear train connected to drive the trains from the drive means, the gear train being arranged so that the amount of play therein during adjustment of the hands in a clockwise direction is substantially the same as the amount of play therein during adjustment of the hands in a counterclockwise direction.

2. A timepiece as claimed in Claim 1 in which the drive means includes a driving circuit for producing, during an initial period after adjustment of the hands has been effected, a plurality of supplementary driving pulses to take up the play in the gear train, the driving circuit producing at the end of said initial period a pulsiform driving signal to drive the hands through the gear train at the correct rate.

3. A timepiece as claimed in Claim 2 in which the drive means includes a motor connected to be driven by the driving circuit and connected to drive the gear train.

4. A time piece as claimed in Claims 2 or 3 including quartz crystal means for producing a time standard signal which is fed to the driving circuit.

5. A timepiece as claimed in any preceding claim in which the gear train has a plurality of meshing gear wheels, an adjustment gear, for rotating the gear wheels of the gear train to effect adjustment of the hands, being in mesh with the gear wheel in the middle, or substantially in the middle of the gear train.

6. An electronic timepiece, for example, a wristwatch, substantially as herein described with reference to and as shown in Figures 3 to 7 of the accompanying drawings.

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