

PATENT SPECIFICATION (11)

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(54) CONTROLLING THE AMPLITUDE OF A BALANCE WHEEL OSCILLATOR

(71) We, TIMEX CORPORATION, a Corporation organized under the laws of the State of Delaware, United States of America, of Waterbury 20, Connecticut, United States of America, 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:—

The present invention relates to battery powered timepieces having balance wheel oscillators and more particularly to a means for controlling the amplitude of said oscillators.

A conventional design for battery-powered timepieces involves a contact switch which is periodically closed by a coil-carrying balance wheel during its oscillations. The switch completes a circuit through the coil to provide a driving pulse in connection with a stationary magnet system positioned opposite the coil.

Through shocks or accelerations, balance wheel amplitudes vary considerably. If a low nominal amplitude (low driving force) is used and the shock reduces the amplitude, considerable time is needed to bring the amplitude to its nominal value. If a high nominal amplitude (high driving force) is used and the shock increases the amplitude, the balance wheel could overbank. In both cases, timekeeping will be adversely affected.

Accordingly, it is an object of this invention to provide means for controlling the amplitude of balance wheel oscillators used in timepieces.

A more specific object of this invention is to provide a new and improved means for controlling the amplitude of an oscillatory balance wheel including semi-conductor means mounted in parallel with the driving coil and polarized in a direction opposite to the driving current. According to the invention there is provided a battery powered timepiece including a driving coil mounted on an oscillatory balance wheel to interact with magnet means, a switch closed by the balance wheel during the oscillations thereof to supply power to the coil from the battery,

and semi-conductor means mounted on the balance wheel in parallel with the coil to dampen the amplitude of the balance wheel oscillations by permitting the flow of reverse current across the coil when the voltage induced in the coil reaches a predetermined level caused by an increase in the amplitude.

By connecting the semi-conductor means in parallel with a driving coil, a high driving force can be used because the semi-conductor determines the nominal amplitude. This results in a faster return of low amplitudes to the nominal value and in damping high amplitudes above the nominal value thereby preventing to a great extent overbanking and errors of time keeping caused by shocks or voltage variations. Any desired amplitude voltage characteristic (amplitude control) can be established by selecting the right break-through voltage of the semi-conductor means in order to dampen the high amplitudes, and by establishing the necessary driving power requirement to increase the low amplitudes rapidly.

The mechanical contact system used in the present invention does not require a sensing coil, and the semi-conductor means, such as diodes, are connected across the driving coil. The diodes are polarized in a direction opposite to the driving current flow and allow the flow of reversed current when the induced voltage reaches a certain voltage level created by high amplitudes. The driving current flow is not controlled and the diode functions as a damping device at high amplitudes. The system also prevents contact burning to a considerable degree.

The invention will now be further described by way of example with reference to the accompanying drawings wherein:—

Figure 1 is a circuit diagram for a typical timepiece embodying the present invention; Figures 2a, 2b and 2c depict various alternative forms of the semi-conductor means to be used in the circuit of Figure 1;

Figure 3 shows a voltage-time diagram for a typical three magnet balance wheel motor system without amplitude control, the coil

being mounted to the oscillating balance wheel;

Figure 4 shows the same voltage-time diagram but at low amplitudes;

5 Figure 5 shows the voltage-time diagram of the aforementioned oscillator with amplitude control;

Figure 6 shows the amplitude voltage diagram of the balance wheel oscillator both with and without amplitude control; and

10 Figure 7 shows an exemplary balance wheel with semi-conductor means mounted thereon in accordance with the present invention.

15 Referring to Figures 1 and 7, the timepiece has the circuit as shown in Figure 1 wherein a moving coil 11 is mounted on an oscillatory balance wheel 12 opposite a stationary magnet or, preferably an array of three magnets of alternately opposite polarity (not shown). The interaction of the driving coil 11 and the magnet(s) is conventional and well known in the art; thus, driving pulses are induced in the coil 11 during the movement of the balance wheel 12 past the magnet(s) provided a switch 13 is closed. The switch 13 comprises a contact arm mounted opposite the balance wheel 12 to intermittently be engaged by a contact 14 on the balance wheel 12 during the movement of the balance wheel and connect the battery cell 15 into the circuit. A suitable contact spring assembly is shown in our pending Application No. 34068/71 (Specification No. 1,316,392).

35 Semi-conductor means is mounted on the balance wheel 12 in parallel with the coil 11. In the embodiment of Figures 1 and 7 the semi-conductor means is a diode 16 polarized in a direction opposite to that of the driving current and functions as a damping device at high amplitudes. The diode 16 permits the flow of reverse current when the voltage induced in the coil 11 reaches a predetermined voltage level created by high amplitudes.

45 Figures 2a to 2c show alternative arrangements of the semi-conductor means. In Figure 2a the semi-conductor means shown comprises a diode 17 and a zener diode 18 connected in series therewith, both diodes being polarized in a direction opposite to the driving current flow in coil 11. The driving current flow in coil 11 is not indicated in Figures 2a—2c but is assumed to be in the opposite direction to that indicated in Figure 1. In Figure 2b the semi-conductor means shown comprises series connected diodes 19 and 21. In Figure 2c the semi-conductor means shown comprises a transistor 22 having its base and collector connected to one end of coil 11 and its emitter connected to the other end of coil 11. The break-through values of the various semi-conductor devices would, of course, be selected to provide the desired damping effect.

Figure 3 shows a typical voltage-time diagram for a conventional three magnet balance wheel motor system without amplitude control. The induced voltage pulses P_1 range up to a value of 1.3 volts while the driving voltage pulse P_2 has a maximum voltage of 1.3 volts in the negative direction. At low amplitudes, the P_1 voltage is below 0.7 volts, the selected break-through voltage. Full driving power accelerates the balance wheel oscillator, and the amplitude increases rapidly. With the present invention, however, when the amplitude of the voltage P_1 reaches the break-through voltage level of the semi-conductor device 16 or 17—18 or 19—21 or 22, as the case may be, the device starts to conduct. This dampens the system in the high amplitude range as shown in Figure 5 where P_1 is limited to 0.7 volts.

Figure 6 shows the relationship between amplitude and voltage in typical instances both with and without the present invention. It is noted, that the curve bends over or is damped to the break-through voltage with amplitude control while it continues to increase linearly without amplitude control. Any desired amplitude-voltage characteristic may be established (amplitude control) by selecting a corresponding break-through voltage for the semi-conductor means and by providing the necessary driving power to increase the low amplitudes rapidly.

WHAT WE CLAIM IS:—

1. A battery powered timepiece including a driving coil mounted on an oscillatory balance wheel to interact with magnet means, a switch closed by the balance wheel during the oscillations thereof to supply power to the coil from the battery, and semi-conductor means mounted on the balance wheel in parallel with the coil to dampen the amplitude of the balance wheel oscillations by permitting the flow of reverse current across the coil when the voltage induced in the coil reaches a predetermined level caused by an increase in the amplitude.

2. A timepiece in accordance with Claim 1 wherein the semi-conductor means comprises at least one diode polarized in a direction opposite to the driving current flow.

3. A timepiece in accordance with Claim 1 wherein the semi-conductor means comprises a diode and a zener diode connected in series therewith, both diodes being polarized in a direction opposite to the driving current flow.

4. A timepiece in accordance with Claim 1 wherein the semi-conductor means comprises a transistor having its base and collector connected to one end of the coil and its emitter connected to the other end of the coil.

5. A timepiece in accordance with Claim 2 wherein the magnet means comprises a



being mounted to the oscillating balance wheel;

Figure 4 shows the same voltage-time diagram but at low amplitudes;

5 Figure 5 shows the voltage-time diagram of the aforementioned oscillator with amplitude control;

Figure 6 shows the amplitude voltage diagram of the balance wheel oscillator both with and without amplitude control; and

Figure 7 shows an exemplary balance wheel with semi-conductor means mounted thereon in accordance with the present invention.

15 Referring to Figures 1 and 7, the timepiece has the circuit as shown in Figure 1 wherein a moving coil 11 is mounted on an oscillatory balance wheel 12 opposite a stationary magnet or, preferably an array of three magnets of alternately opposite polarity (not shown). The interaction of the driving coil 11 and the magnet(s) is conventional and well known in the art; thus, driving pulses are induced in the coil 11 during the movement of the balance wheel 12 past the magnet(s) provided a switch 13 is closed. The switch 13 comprises a contact arm mounted opposite the balance wheel 12 to intermittently be engaged by a contact 14 on the balance wheel 12 during the movement of the balance wheel and connect the battery cell 15 into the circuit. A suitable contact spring assembly is shown in our pending Application No. 34068/71 (Specification No. 1,316,392).

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2. A timepiece in accordance with Claim 1 wherein the semi-conductor means comprises at least one diode polarized in a direction opposite to the driving current flow.

3. A timepiece in accordance with Claim 1 wherein the semi-conductor means comprises a diode and a zener diode connected in series therewith, both diodes being polarized in a direction opposite to the driving current flow.

4. A timepiece in accordance with Claim 1 wherein the semi-conductor means comprises a transistor having its base and collector connected to one end of the coil and its emitter connected to the other end of the coil.

5. A timepiece in accordance with Claim 2 wherein the magnet means comprises a



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3 three magnet arrangement wherein the magnets are mounted in a stationary array of alternating polarity opposite the balance wheel, and the switch comprises a switch arm
5 mounted opposite the balance wheel to be engaged by contact means on the balance wheel during the oscillations thereof, said diode dampening the amplitude to prevent overbanking and contact burning during
10 said engagement.

6. A battery powered timepiece substantially as hereinbefore described with reference to the accompanying drawings.

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