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(54) PIEZO-ELECTRIC GENERATING DEVICE

(71) We, KABUSHIKI KAISHA DAINI SEIKOSHA, a Japanese Company of 6-31-1, Kameido, Koto-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 piezoelectric generating devices.

In general, in a portable electronic device, such as an electronic timepiece, a silver cell, or mercury cell, for example, serves as a power source. The cells have, however, to be replaced at regular intervals which is not only inconvenient, but also costly.

According to the present invention there is provided an electrical generating device comprising: an oscillatable weight mounted so as to oscillate when the electrical generating device is moved bodily; a rotation converting mechanism for converting oscillating motion of the weight into unidirectional rotation; an escape wheel; energy storing means for storing energy transmitted to the escape wheel from the rotation converting mechanism; a control device connected to be driven by the rotation converting mechanism to allow the energy stored in the energy storing means to cause the escape wheel to rotate intermittently; and piezoelectric means arranged to be struck by either a part of the escape wheel or a part of the control device as a result of the intermittent rotation of the escape wheel.

An energy storing means may comprise at least one spring.

Preferably the control device includes a cam and an escapement device, the cam being arranged so that rotation thereof causes the escapement device to move and thereby to cause the escape wheel to rotate intermittently.

In one embodiment the piezoelectric means are mounted on the escapement device to be struck by teeth of the escape wheel upon intermittent rotation thereof.

In another embodiment the piezoelectric

means are mounted to be struck by the escapement device as the latter oscillates.

The escapement device may be a pallet.

The device may include a supporting case having at least a pair of output terminals connected electrically to the piezoelectric means.

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

Figure 1 is a schematic perspective view of a conventional electrical generating device;

Figure 2 is a plan view of one embodiment of an electrical generating device according to the present invention;

Figure 3 is a plan view of part of the generating device of figure 2 to explain the operation thereof;

Figure 4 is a plan view of part of another embodiment of an electrical generating device according to the present;

Figure 5 is a side view of an electrical generating device according to the present invention for use in an electronic timepiece;

Figure 6 is a plan view of the electrical generating device shown in figure 5;

Figure 7 is an electrical diagram of the electrical generating device shown in figure 3; and

Figure 8 is a sectional view of an electronic watch incorporating the electrical generating device of figure 5.

A conventional electrical generating device is shown in figure 1 and comprises an oscillatable weight 1 that oscillates as the generating device is moved bodily. A converting mechanism 2, including a 2-arm pawl lever 3 connected to weight 1, a transmission wheel 4 and a ratchet wheel 5 converts the oscillating motion of the weight 1 into rotation of the ratchet wheel 5. A piezoelectric element 7 is repeatedly struck by a hammer 6 as the ratchet wheel 5 rotates. An electromotive force is thus derived from the piezoelectric element 7.

The hammer 6 is resilient and may be made of, for example, spring steel, and is

arranged so that the free ends of the hammer 6 engages with the ratchet wheel 5.

Each time a tooth of the ratchet wheel 5 passes the free end of the hammer 6, the latter is caused to bend or flex and upon release it strikes the piezoelectric element 7 with a force dependent upon the energy stored in the hammer 6 as a result of its elasticity. The hammer 6 does not, however, store energy to any appreciable extent because it is only bent by the ratchet wheel 5 by a small amount.

In general the electromotive force produced by a piezoelectric element is dependent upon the magnitude of the force applied thereto, the electromotive force increasing if the applied force increases.

To charge a secondary cell an electromotive force above a predetermined level is required and it is difficult to cause a piezoelectric element to generate an electromotive force above this predetermined level. The conventional generating device cannot, therefore, be used to charge a secondary cell. Moreover, the ratchet wheel 5 of the conventional generating device has poor endurance because of the frictional forces occurring at the teeth thereof.

Figure 2 illustrates one embodiment of an electrical generating device according to the present invention. An oscillatable weight 8, mounted in bearings 9, oscillates as the generating device moves bodily in the similar manner to the oscillatable weight in a self-winding watch. A rotation converting mechanism converts the oscillation of the weight 8 into uni-directional rotation. The rotation converting mechanism consists of an eccentric pin 11 disposed on the weight 8, a two-arm pawl lever 12 actuated upon oscillation of the weight 8 and fixed with the eccentric pin 11, a transmission wheel 13 driven in one direction by the lever 12 and an intermediate wheel 14 in mesh with the wheel 13.

The intermediate wheel 14 drives a mechanism 15 which consists of an axle 17 to which is fixed a pinion 16 engaging with the intermediate wheel 14, an escape wheel 18 having escape wheel teeth 19 and springs 20 serving as energy storing members, connected between the axle 17 and the escape wheel 18. The mechanism 15 rotates incrementally under the control of a control device 21.

The control device 21 consists of a cam 22 having a pinion 22' engaging with the intermediate wheel 14 and a pallet 23 which moves freely about an axle 24 in the manner of a pallet staff to serve as a control member. The pallet 23 is moved freely by the cam 22 and the teeth 19 of the escape wheel 18. The pallet 23 carries pawls 25, 26 engageable with the teeth 19 of the mechanism 15, the pawl 25 being shorter in length than the pawl 26.

Piezoelectric elements 27, 28 made, for example, of PZT (Titanic Acid Lead Zirconate) or barium titanate are disposed on the free ends of the pawls 25, 26. Electrical lead wires 29, 30, 31, 32 respectively, extend the piezoelectric elements 27, 28.

The operation of the above electrical generating device will now be described in connection with figures 2 and 3. When the generating device is moved bodily, the weight 8, moves in the clockwise direction or the counterclockwise direction as shown by the arrow A in figure 2. The rotation of the weight 8 makes the lever 12 move via the eccentric pin 11. The free ends of the lever 12 thus drive the transmission 12, 13 in the direction shown by the arrow C. The mechanism 15 is driven through the intermediate wheel 14 by the transmission wheel 13. The escape wheel 18 does not, however, rotate because one of the teeth 19 of the mechanism 15 is engaged by the pawl 26 of the pallet 23. Accordingly, the springs 20 store the energy generated by rotation of the weight 1.

Rotation of the escape wheel 18 is controlled intermittently by the control device 21. The cam 22 of the control device 21 is driven in the direction shown by the arrow E, by the intermediate wheel 14. In the condition where one of the teeth 19 of the mechanism 15 engages with the pawl 26 of the pallet 23, the latter is moved in the direction of the arrow F via the cam 22 which is driven in the direction of the arrow E by the rotation of the intermediate wheel 14. When the pawl 26 becomes disengaged on the tooth 19 of the escape wheel 15 as the result of the movement of the pallet 23, the escape wheel member 18 is rotated by the energy stored in the springs 20, as they return to their original position. Accordingly, the escape wheel member 18 rotates in the direction of arrow D and the pallet 23 moves to the position shown in figure 3, the succeeding tooth 19 of the mechanism 15 striking strongly against the piezoelectric element 27. Thus the piezoelectric element 27 generates a relatively high electromotive force.

When the tapered end of the piezoelectric element 27 is struck by the succeeding tooth 19 of the mechanism 15, the pallet 23 is moved freely in the direction of the arrow F, so that it returns to the position shown in figure 2. As a result the succeeding tooth 19 is rotated further by the energy stored in the springs 20 whereby to strike the piezoelectric element 28. A relatively high electromotive force is thus generated effectively from the piezoelectric elements 27, 28.

Figure 4 is a fragmentary plan view of another embodiment of an electrical generating device according to the present invention. Like parts in figure 2 and 4 have been designated by the same reference numerals.

The main difference between the embodiment illustrated in figure 2 and the embodiment illustrated in figure 4 is that in the latter, a piezoelectric element 34 is struck by the pallet 23, whereas in the former the piezoelectric elements 27, 28 are struck by the teeth 19 of the escape wheel 18.

In figure 4, the piezoelectric element 34 is secured on one side of the pallet 23 in a position to be struck by the pallet 23 as it moves. An abutment (not shown) is disposed on the other side of the pallet. The piezoelectric element 34 is connected to electrical feed wires 35, 36. The mechanism 15 and the pallet 23 of the electrical generating device of figure 4 operate in the same manner as in the electrical generating device of figure 2, the mechanism 15 being rotated by the energy stored in the springs 20. The pallet 23 is moved freely and strongly in the direction of arrow F when one of the teeth of the escape wheel 18 strikes the free end of the pawl 25. The pallet 23 thus strongly strikes the piezoelectric element 34 and as a result the latter generates a relatively high electromotive force.

In this embodiment, the piezoelectric element 34 is disposed on one side of the pallet 23. However, piezoelectric elements may be disposed on both sides of the pallet 23.

In the above embodiments of the present invention, the kinetic energy stored in the mechanism 15 is considerable because the springs 20 store the rotational energy of the weight 8. The weight 8 is rotated by the user by every movement of his wrist in the case where the generating device is assembled in an electronic wristwatch. The relationship between the escape wheel 15 and the pallet 23 is thus similar to the escape mechanism of a mechanical wristwatch.

Referring now to figures 5 and 6 there is illustrated an electrical generating device according to the present invention for use in an electronic timepiece. A supporting case 41 consists of a lower plate 42 which is circular and an upper plate 43. The lower plate 42 has a plurality of recesses 44 for fixing the supporting case 41 and has output terminals 45, 46 which extend through an electrically insulating member 47. The electrical generating device is supported by jewels 48 as shown in figure 6 from the supporting case 41.

In figure 7 there is shown an electrical circuit diagram of the generating device shown in figure 2 connected to the output terminals 145, 146 as shown in figure 5. A rectifier 131 is connected to the wires 29, 30, 31, 32 and the output wires 133, 134 are connected to the output terminals 145, 146 respectively. Output electrical lead wires,

133, 134 are also connected to leads 135, 136 of a secondary cell 137.

Figure 8 is a side view of an electronic watch 15 incorporating the electrical driving device G of figure 5, 6, and 7. The generating device G is fixed in the interior of the electronic watch by means of screws 51 passing through the recesses 44 in the casing 41. Terminals 52, 53 are connected to the output terminals 145, 146 respectively and to a timekeeping circuit 54 which serves as a load.

In a modification the springs 20 may be replaced by other energy storing devices, for example, springs made of piano wire, plate springs, rubber springs and synthetic resin springs. These materials have the advantage of reducing or preventing aging of the mechanism 15 and so it may be used for a relatively long period without deterioration. The configuration and structure of the weight 8 and the rotation conversion mechanism may be changed from that shown in the drawings.

The battery life and electric power supply is improved considerably if the generating device is used to charge either a silver oxide cell of high capacity or a silver peroxide cell.

WHAT WE CLAIM IS:—

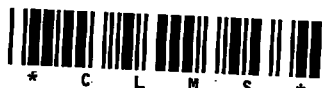
1. An electrical generating device comprising: an oscillatable weight mounted so as to oscillate when the electrical generating device is moved bodily; a rotation converting mechanism for converting oscillating motion of the weight into uni-directional rotation; an escape wheel; energy storing means for storing energy transmitted to the escape wheel from the rotation converting mechanism; a control device connected to be driven by the rotation converting mechanism to allow the energy stored in the energy storing means to cause the escape wheel to rotate intermittently; and piezoelectric means arranged to be struck by either a part of the escape wheel or a part of the control device as a result of the intermittent rotation of the escape wheel.

2. A device as claimed in claim 1 in which the energy storing means comprises at least one spring.

3. A device as claimed in claim 2 in which the control device includes a cam and an escapement device, the cam being arranged so that rotation thereof causes the escapement device to move and thereby to cause the escape wheel to rotate intermittently.

4. A device as claimed in claim 3 in which the piezoelectric means are mounted on the escapement device to be struck by teeth of the escape wheel upon intermittent rotation thereof.

5. A device as claimed in claim 3 in which the piezoelectric means are mounted



The main difference between the embodiment illustrated in figure 2 and the embodiment illustrated in figure 4 is that in the latter, a piezoelectric element 34 is struck by the pallet 23, whereas in the former the piezoelectric elements 27, 28 are struck by the teeth 19 of the escape wheel 18.

In figure 4, the piezoelectric element 34 is secured on one side of the pallet 23 in a position to be struck by the pallet 23 as it moves. An abutment (not shown) is disposed on the other side of the pallet. The piezoelectric element 34 is connected to electrical feed wires 35, 36. The mechanism 15 and the pallet 23 of the electrical generating device of figure 4 operate in the same manner as in the electrical generating device of figure 2, the mechanism 15 being rotated by the energy stored in the springs 20. The pallet 23 is moved freely and strongly in the direction of arrow F when one of the teeth of the escape wheel 18 strikes the free end of the pawl 25. The pallet 23 thus strongly strikes the piezoelectric element 34 and as a result the latter generates a relatively high electromotive force.

In this embodiment, the piezoelectric element 34 is disposed on one side of the pallet 23. However, piezoelectric elements may be disposed on both sides of the pallet 23.

In the above embodiments of the present invention, the kinetic energy stored in the mechanism 15 is considerable because the springs 20 store the rotational energy of the weight 8. The weight 8 is rotated by the user by every movement of his wrist in the case where the generating device is assembled in an electronic wristwatch. The relationship between the escape wheel 15 and the pallet 23 is thus similar to the escape mechanism of a mechanical wristwatch.

Referring now to figures 5 and 6 there is illustrated an electrical generating device according to the present invention for use in an electronic timepiece. A supporting case 41 consists of a lower plate 42 which is circular and an upper plate 43. The lower plate 42 has a plurality of recesses 44 for fixing the supporting case 41 and has output terminals 45, 46 which extend through an electrically insulating member 47. The electrical generating device is supported by jewels 48 as shown in figure 6 from the supporting case 41.

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In a modification the springs 20 may be replaced by other energy storing devices, for example, springs made of piano wire, plate springs, rubber springs and synthetic resin springs. These materials have the advantage of reducing or preventing aging of the mechanism 15 and so it may be used for a relatively long period without deterioration. The configuration and structure of the weight 8 and the rotation conversion mechanism may be changed from that shown in the drawings.

The battery life and electric power supply is improved considerably if the generating device is used to charge either a silver oxide cell of high capacity or a silver peroxide cell.

WHAT WE CLAIM IS:—

1. An electrical generating device comprising: an oscillatable weight mounted so as to oscillate when the electrical generating device is moved bodily; a rotation converting mechanism for converting oscillating motion of the weight into uni-directional rotation; an escape wheel; energy storing means for storing energy transmitted to the escape wheel from the rotation converting mechanism; a control device connected to be driven by the rotation converting mechanism to allow the energy stored in the energy storing means to cause the escape wheel to rotate intermittently; and piezoelectric means arranged to be struck by either a part of the escape wheel or a part of the control device as a result of the intermittent rotation of the escape wheel.

2. A device as claimed in claim 1 in which the energy storing means comprises at least one spring.

3. A device as claimed in claim 2 in which the control device includes a cam and an escapement device, the cam being arranged so that rotation thereof causes the escapement device to move and thereby to cause the escape wheel to rotate intermittently.

4. A device as claimed in claim 3 in which the piezoelectric means are mounted on the escapement device to be struck by teeth of the escape wheel upon intermittent rotation thereof.

5. A device as claimed in claim 3 in which the piezoelectric means are mounted

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- 4 to be struck by the escapement device as the latter moves.
- 5 6. A device as claimed in any of claims 3 to 5 in which the escapement device is a pallet.
7. A device as claimed in any preceding claim including a supporting case having at least a pair of output terminals connected electrically to the piezoelectric means.
- 10 8. An electrical generating device substantially as herein described with reference to and as shown in Figures 2 to 8 of the accompanying drawings.
9. An electronic timepiece, for example a wristwatch, including a device as claimed 15 in any preceding claim.

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