PATENT SPECIFICATION

825,233

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COMPLETE SPECIFICATION

Improvements in or relating to Electric Time-Pieces

We, BULOVA WATCH COMPANY INC., of 75—20, Astoria Boulevard, Flushing 70, New York, United States of America, a Corporation organized under the laws of the State of New York, 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 a watch or clock having a timepiece mechanism which is actuated by a pawl and ratchet wheel drive wherein the pawl is connected to an electrically driven vibrator, preferably of the tuning-fork type. The pawl is attached to the vibrator, and in the case of a tuning-fork type vibrator to one of its tines, at a point thereon that lies on a line which passes through the point of engagement between the pawl and the ratchet wheel and which is normal to a line passing through the said point of engagement and through the axis of oscillation about which the vibrator, or its tine, vibrates.

Inasmuch as the pawl reciprocates with a stroke the length of which is dependent upon the amplitude of oscillation of the vibrator, and inasmuch as this stroke length, in a direction substantially tangent to the ratchet wheel at the point of engagement between the pawl and the ratchet wheel, should, in order to cause the ratchet wheel to be rotated at a rate directly proportional to the extremely constant frequency at which the vibrator oscillates, be at least as great as the pitch of each ratchet wheel tooth but less than twice the pitch, the electrical means which oscillate the vibrator are so constructed and arranged that the vibrator is oscillated at such amplitude that the stroke length of the pawl will be within these limits. As a result, each reciprocation of the pawl will cause the ratchet wheel to be rotated throughout an angular distance which corresponds to the pitch of one ratchet tooth.

[*Price 3s. 6d.*]

It has been found, however, that even when the stroke length of the pawl is maintained within the proper limits, the ratchet wheel will, under the influence of its inertia, tend to continue rotating in the direction in which it is driven by the pawl. If this were permitted to occur, successive reciprocations of the pawl would not necessarily find the same in engagement with successive ratchet teeth, thereby adversely affecting the accuracy of the timepiece.

Also, it is possible for the pawl not only positively to engage, during its forward stroke, the particular ratchet tooth with which it is in engagement, but also during its back stroke to frictionally engage the same tooth and thus cause, or at least tend to cause, the ratchet wheel to rotate in a direction opposite to that in which it is normally driven by the pawl. If this were permitted to occur, the pawl might not, upon completing its back stroke, come into engagement with the next ratchet tooth. Instead, the pawl might remain in engagement with the same tooth so that each reciprocation of the pawl would not necessarily result in the proper angular advancement of the ratchet wheel, thereby again adversely affecting the accuracy of the timepiece.

In order to overcome this disadvantage, suitable braking means may be provided for preventing forward rotation of the ratchet wheel under the influence of its inertia after the pawl has completed its forward stroke as well as for preventing backward rotation of the ratchet wheel during the back stroke of the pawl.

Exemplatory embodiments of the present invention are diagrammatically illustrated in the accompanying drawing, in which:—

Fig. 1 is a schematic representation of a pawl and ratchet wheel arrangement according to the present invention;

Fig. 2 is a fragmentary perspective view of a pawl adapted to be used in a pawl and ratchet wheel arrangement according to the

present invention;

Fig. 3 is a fragmentary perspective view of a braking device adapted to be used in a pawl and ratchet wheel arrangement according to the present invention; and

Fig. 4 is a fragmentary view of another braking device adapted to be used in a pawl and ratchet wheel arrangement according to the present invention.

Referring now to the drawing, and to Fig. 1 thereof in particular, there is shown a tuning-fork type vibrator 1 having a base portion 2 and a pair of tines 3*a* and 3*b*, the vibrator being soldered, welded or otherwise fixedly secured to a member 2*a* which, in turn, is suitably fixed to the base plate of the timepiece, as for example, by a pair of screws 2*b*, in such a manner that the tines are freely oscillatable about their respective axes of oscillation $3a^1$ and $3b^1$.

A pawl 4 which has a natural frequency considerably greater than, and preferably at least twice as great as, the natural frequency of the vibrator is attached to the tine 3*b* at an attachment point *a*, the other end of the pawl, which may be in the form of a leaf spring, being in engagement with a ratchet wheel 5 at an engagement point *b*. The ratchet wheel 5 is preferably so positioned that its axis of rotation is normal to the plane of oscillation of the vibrator.

Each of the tines carries at its free end a magnetic drum 6 which is composed of a cup-shaped member 6*a* and a bar magnet 6*b* made of a very strong magnetic material such as Alnico. Each of the drums is thus formed with an inner annular chamber 6*c*.

A pair of tubular carriers 7 project into the two chambers 6*c*, respectively, each of these carriers being at one of its ends either directly or indirectly secured to the base plate. One of the carriers carries a coil 8 and the other carries a coil 9 which has approximately five to six times as many turns as coil 8, the arrangement of the parts being such that each carrier 7 encompasses the respective bar 6*b* with clearance and that each cup-shaped member 6*a* encompasses the respective coil with clearance, so that the magnetic drums are freely movable relative to the stationary carriers and coils. Oscillation of the tines 3*a* and 3*b* is therefore not impeded, and each of the coils together with its magnetic drums forms an electromechanical transducer.

One terminal of the coil 8 is connected to the base B of a transistor which is preferably of the germanium junction-type, and the other terminal of the coil 8 is connected to one terminal of a parallel circuit incorporating a resistor 10 and a capacitor 11. The other terminal of this parallel circuit is connected to the negative teminal 12 of a battery or other voltage source, the positive terminal 13 of which is connected to the transistor emitter E. One terminal of the coil 9 is connected to the transistor collector C and the other terminal of the coil 9 is connected to the negative terminal 12.

The above circuit is a self-regulating one in that it will cause the tines to oscillate not only at their natural frequency, but also at a substantially constant amplitude. In practice, the amplitude of oscillation of the tines will be maintained between such maximum and minimum amplitudes that the length of the stroke of reciprocation of the pawl, in the direction T (indicated by the line *c* which is tangent to the ratchet wheel at the engagement point *b*) will be at least as great as the pitch P of each ratchet tooth but not more than 2P, so that the vibrator will cause the ratchet wheel to be rotated at a rotational speed directly proportional to the frequency of oscillation of the vibrator.

According to the present invention, the above-mentioned attachment point *a* is so selected that it lies in a line *d* which passes through the engagement point *b* and which is normal to a second line *e* that passes through the engagement point *b* and through the axis of oscillation $3b^1$. Thus, the pawl is reciprocated along a path, represented by the line *d*, which is substantially tangent to a circle *f* having its center at the axis of oscillation $3b^1$ and passing through the engagement point *b* so that the entire driving force of the vibrator, rather than merely a component thereof, is transmitted to the ratchet wheel. In this way, the vibrator is operated at maximum efficiency so that the power consumption is extremely small, thus enabling even a very small battery to supply the timepiece with the required energy for a very long period of time.

It has been found that in order to insure proper positive engagement between the pawl 4 and the ratchet wheel 5, the path along which the pawl reciprocates should be inclined to the line tangent to the ratchet wheel at the point of engagement between the pawl and the ratchet wheel. The vibrator 1 and ratchet wheel 5 are therefore shown as being so arranged relative to each other that the line *d* which is the path along which the pawl 4 reciprocates, forms an angle *g* with the line *c* which is tangent to the ratchet wheel at the engagement point *b*. This angle *g* may be of the order of approximately 30°.

In the embodiment shown in Fig. 2, the pawl is in the form of a leaf spring 20 which carries at one end a substantially block-shaped engaging element 21 which is made of any suitable material and may be a precious or semi-precious jewel. The other end of the leaf spring 20 is soldered or otherwise attached to a mounting pin 22 which is inserted into a relative shallow bore 23 which does not extend more than about one quarter of the way through the tine 3*b*.

As set forth above, suitable braking means are provided for preventing forward rotation of the ratchet wheel under the influence of its inertia after the pawl has completed its forward stroke as well as for preventing backward rotation of the ratchet wheel during the back stroke of the pawl.

Fig. 3 is illustrative of one embodiment of such braking means. The same include a leaf spring 30 which carries, preferably at its free end, an engaging element 31 that frictionally engages the axle 32 which rotates together with the ratchet wheel 5. The engaging element is preferably convexly curved about an axis transverse to the axis about which the axle 32 rotates so that the engaging element 31 is in point contact frictional engagement with the axle 32.

In the embodiment shown in Fig. 4 the braking means are constituted by a stationary pawl which is preferably in the form of a leaf spring 40 the free end of which frictionally engages the teeth of the ratchet wheel 5, the driving pawl and the tine carrying the same being indicated at 4 and 3*b*, respectively. The leaf spring 40 thus acts not only as a friction brake but also as a pawl for positively preventing backward rotation of the ratchet wheel 5.

WHAT WE CLAIM IS:—

1. A watch or clock having a timepiece mechanism which is actuated by a pawl and ratchet wheel drive wherein the pawl is connected to an electrically driven vibrator, preferably of the tuning-fork type, characterized by the fact that the pawl is attached to the vibrator at a point thereon that lies on a line which passes through the point of engagement between the pawl and the ratchet wheel and which is normal to a line passing through the said point of engagement and through the axis of oscillation about which the vibrator oscillates.

2. A watch or clock according to Claim 1 wherein the pawl, in the case of tuning-fork type vibrator, is attached to one of the tines of the vibrator at a point thereon that lies on a line which passes through the point of engagement between the pawl and the ratchet wheel and which is normal to a line passing through the said point of engagement and through the axis of oscillation about which the said one tine oscillates.

3. A watch or clock according to either of the preceding claims wherein the ratchet wheel and the vibrator are so arranged relative to each other that the pawl is reciprocated along a path which forms an angle of the order of approximately 30° with a line tangent to the said ratchet wheel at the said point of engagement between the pawl and the ratchet wheel.

4. A watch or clock according to one or more of the preceding claims wherein the axis about which the ratchet wheel is rotatable is normal to the plane of oscillation of the vibrator.

5. A watch or clock according to one or more of the preceding claims wherein the natural frequency of the pawl is considerably greater than, and preferably at least twice as great as, the natural frequency of the vibrator.

6. A watch or clock according to one or more of the preceding claims wherein the pawl is in the form of a leaf spring attached at one end thereof to the vibrator and carrying at its other end an engaging element which engages the teeth of the ratchet wheel, the engaging element preferably being in the form of a block which is made of any suitable material such as a precious or semi-precious jewel.

7. A watch or clock according to one or more of the preceding claims wherein suitable braking means are provided for preventing forward rotation of the ratchet wheel under the influence of its inertia after the pawl has completed its forward stroke as well as for preventing backward rotation of the ratchet wheel during the back stroke of the pawl.

8. A watch or clock according to one or more of the preceding claims wherein the braking means are in the form of a leaf spring carrying, preferably at its free end, an engaging element which frictionally engages the axle which rotates together with the ratchet wheel, the said engaging element preferably being convexly curved about an axis transverse to the axis about which the axle rotates so that the said engaging element is in point contact frictional engagement with the axle.

9. A watch or clock according to one or more of the preceding claims wherein the braking means are in the form of a stationary pawl which is preferably in the form of a leaf spring the free end of which frictionally engages the teeth of the ratchet wheel.

10. A watch or clock substantially as hereinbefore described with reference to the accompanying drawings.

For the Applicants,
HASELTINE, LAKE & CO.

Reference has been directed in pursuance of Section 9, subsection (1) of the Patents Act, 1949, to Patent No. 761,609.

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825,233
1 SHEET

COMPLETE SPECIFICATION

FIG. 2.

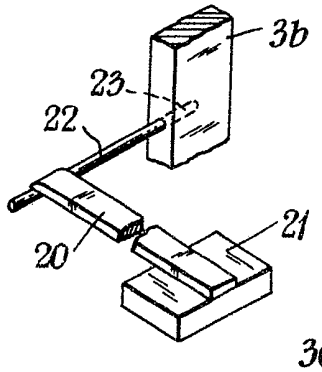


FIG. 1.

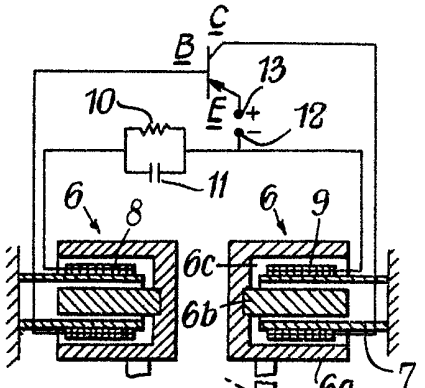
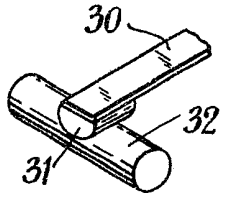


FIG. 3.



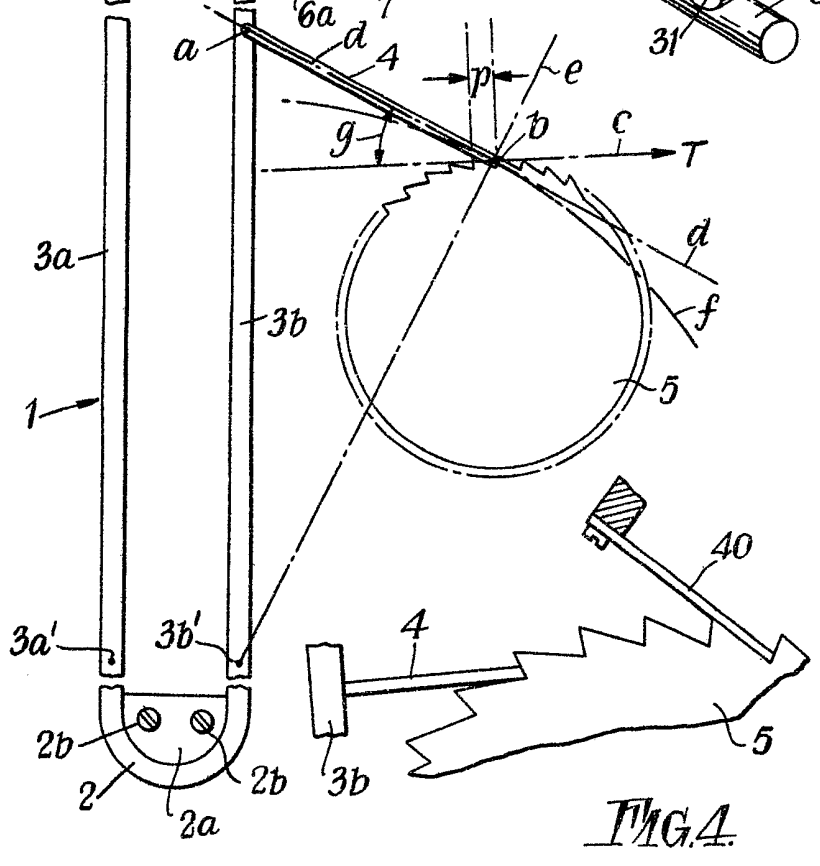


FIG. 4.