PATENT SPECIFICATION

799,824

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COMPLETE SPECIFICATION

Improvements in or relating to a Clock or Watch Mechanism

We, BULOVA WATCH COMPANY, INC., a company organised and existing under the laws of the State of New York, United States of America, of Bulova Park, Flushing, 70, New York, 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:—

This invention relates to a clock or watch mechanism which incorporates pawl and ratchet mechanisms for converting a vibratory motion into a rotary motion. The invention has particular applications to such a clock or watch mechanism intended for assembly in electronic devices for driving a clock or watch movement, such as are disclosed in the complete specification of Patent No. 761,609.

In the electronic device for driving a clock or watch movement described in the complete specification referred to above a mechanical vibrator is associated with a resonant circuit comprising a transistor and the driving of the clock or watch movement is obtained either by derivating electrical impulses from the resonant circuit to feed a synchronous motor or by converting the mechanical vibrations of the vibrator into a rotary motion.

Many satisfactory solutions have hitherto been proposed in most of the engineering branches for the conversion of a vibratory motion into a rotary motion. Particular difficulties arise, however, for a mechanism of the kind above indicated intended for driving a watch or clock movement, owing to the high vibration frequencies of the mechanical vibrator and the requirement of a uniform rotary motion independent of the amplitude of the vibrations of the mechanical vibrator.

The main object of this invention is therefore to provide a pawl and ratchet mechanism which is adapted to be used in association with an electronic device for driving a clock or watch movement.

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Another object of this invention is to provide a pawl and ratchet mechanism wherein the ratchet wheel forms a part of the clock or watch movement.

Still another object of the invention is to provide a pawl and ratchet mechanism wherein the ratchet wheel is subjected to the action of a braking device, so that the angular velocity of the ratchet wheel is uniform and independent of the vibration amplitude of the mechanical vibrator.

For a better understanding of this invention reference may be had to the following description taken in connection with the accompanying drawing which diagrammatically shows, by way of example, some embodiments of the invention.

In the drawing:—

Fig. 1 is an elevational view of a pawl and ratchet mechanism embodying the present invention;

Fig. 2 is an elevational view of another pawl and ratchet mechanism according to the invention;

Fig. 3 is a fragmentary sectional view of the mechanism of Fig. 2;

Fig. 4 is an elevational view of a pawl and ratchet mechanism illustrating a modification of the invention;

Fig. 5 is a fragmentary sectional view of the mechanism of Fig. 4;

Fig. 6 is a fragmentary elevational view of a modification of the mechanism of Fig. 4;

Figs. 7A, 7B and 7C show different types of gears which may be used for the ratchet wheel, and

Figs. 8A and 8B show different forms of the pawl which may be used in the mechanism according to the invention.

Referring to the drawing, and more particularly to Fig. 1, there is shown a pawl and ratchet mechanism comprising a ratchet wheel 1 fixedly mounted on an arbor 2 and forming a part of a clock or watch movement, not shown. A mechanical vibrator 3, diagrammatically illustrated, is caused to vibrate in reciprocat-

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ing motion along the directions indicated by the arrows 4 and 4^1, respectively. A pawl 5, consisting of a resilient strip, is fixed at one end thereof to the mechanical vibrator 3 and therefore pawl 5 is subjected to the vibrations of the mechanical vibrator 3. The free end of the pawl 5 engages the teeth 6 of the ratchet wheel. It follows that when the pawl 5 moves in the forward direction, indicated in Fig. 1 by the arrow 4^1, the free end of the pawl exerts a pressure on the tooth 6 of the wheel 1, thereby causing this wheel to rotate in the direction of the arrow 7. When the pawl 5 moves in the opposite direction, i.e. in the direction of the arrow 4, its free end slides on the side of the tooth 6, and because of the friction between the pawl and the tooth side, the ratchet wheel 1 could be caused to rotate in the opposite direction if suitable means were not provided to prevent this reverse motion. In the embodiment illustrated in Fig. 1 this means consists of a leaf spring 8, one end of which is anchored to a member 9 of the watch or clock frame by any suitable means, for instance by the screw 10, and the other end of which rests on the cylindrical surface of the arbor 2 of the ratchet wheel 1, exerting a light pressure thereon. From Fig. 1 it appears that the leaf spring 8 is mounted in a plane perpendicular to the plane of the ratchet wheel 1, so that the pressure exerted by the free end of leaf spring 8 on the arbor 2 is directed perpendicularly to the longitudinal axis thereof.

Since the described pawl and ratchet mechanism is intended for driving a clock or watch movement, its various elements must satisfy some precise requirements, in order that the mechanism may function satisfactorily.

First of all, it is necessary that the ratchet wheel 1 be caused to rotate an angle corresponding to a single tooth pitch for each impulse imparted by the pawl. From Fig. 1 it may easily be seen that this requirement is fulfilled when the total displacement of the pawl 5 is greater than one but less than twice the tooth pitch. In other words, if A is the vibration amplitude of the vibrator 3 and p is the tooth pitch of the wheel 1, the maximum displacement of the pawl 5 is 2A and the above condition is expressed by the relationship:—

$$p<2A<2p.$$

On the other hand, the braking device associated with the ratchet wheel 1 must not only prevent the reverse motion of the latter but also prevent that, if for casual circumstances, such as a shock, the amplitudes of the vibrations of the pawl 5 are greater than the normal value, the ratchet wheel 1 rotates an angle corresponding to two or three teeth or more. Accordingly, it is necessary that the braking force acting on the ratchet wheel be not greater than a predetermined value in order to prevent an excessive power consumption from the mechanical vibrator 3, on the one hand, and on the other hand be not less than another predetermined value in order that the braking force be sufficient to prevent the wheel to rotate, by virtue of its momentum, for each impulse imparted by the pawl, an angle corresponding to more than one tooth pitch.

The maximum and minimum of this braking force may be easily calculated.

Assuming, for the sake of simplicity, that the vibration amplitude A of the pawl is equal to the tooth pitch p of the ratchet wheel 1, i.e. assuming that $A=p$, the displacement x of the pawl in terms of the time t is, at each moment:—

$$x=p\sin\omega t, \qquad (1)$$

where $\omega=2\pi f$, and f is the vibration frequency of vibrator 3. The acceleration is then:—

$$x^{11}=-p\,\omega^2\sin\omega t, \qquad (2)$$

the maximum value of which is:—

$$x^{11}_{max}=-p\,\omega^2. \qquad (3)$$

Let θ be the moment of inertia of the ratchet wheel 1 about its center, and r the distance of this center to the working point of the force k exerted by the pawl 5 on the tooth, the force k may be expressed by the relationship:—

$$k=\frac{\theta}{r^2}\,.\,p\,\omega^2. \qquad (4)$$

The power N requested by the braking device and supplied by the vibrator 3 is given by the relationship:—

$$N=a\,.\frac{\theta}{r^2}\,p^2 f^3, \qquad (5)$$

where a is a constant depending upon the system of measures used.

It appears from equation (5) that in order to reduce to a minimum the power N it is necessary that the moment of inertia θ and the tooth pitch p of the ratchet wheel be as small as possible, especially when the frequency of the vibrator 3 is relatively high, as is the case for the pawl and ratchet mechanisms of the kind described.

The pawl 5 must also satisfy precise requirements. First of all its stiffness must be sufficient in order that its natural frequency f_0 be higher than the vibration frequency f of the mechanical vibrator 3. In the embodiment illustrated in Fig. 1, the pawl 5 consists of a thin leaf of rectangular section. If b is the thickness and l the length of this leaf, the natural frequency f_0 is:—

$$f_0=c\,.\frac{b}{l} \qquad (6)$$

where c is a constant depending on the elasticity of the material forming the leaf spring and the system of measures employed. The dimensions b and l may be therefore so chosen that $f_0>f$.

On the other hand, the pawl 5 must be flexible enough so as to exert on the ratchet wheel a force, the moment of which, multiplied by the friction coefficient, is lower than the moment of the braking force exerted by the braking device on the wheel. Should this condition not be satisfied, the ratchet wheel 1 could be caused to rotate in the opposite direction upon the moving of the pawl in the backward direction, as stated above.

Figs. 2 and 3 illustrate another embodiment of the invention, wherein the braking spring 8 acts on the end face of the arbor 2 instead of on the cylindrical surface thereof. In this case the force exerted by the spring 8 is directed along the longitudinal axis of the arbor, and the spring 8 is mounted in a plane parallel to the face of the ratchet wheel 1.

In the embodiments of the invention described above the braking device acts on the arbor 2 of the ratchet wheel 1. The braking action may be obtained also by acting directly on a surface of the ratchet wheel.

Referring to Figs. 4 and 5, there is shown a pawl and ratchet mechanism embodying this form of the invention. The braking device consists of a sleeve 11 fixedly mounted at one end thereof on the frame 9 of the clock or watch movement. Sleeve 11 is so designed and mounted that the free end thereof is in the vicinity of the face of the ratchet wheel 1. Within the sleeve 11 is slidably mounted a plug 13 of suitable material, which plug is urged by a coil spring 12 against the surface of the wheel 1. Plug 13 may be formed with any suitable material provided that the coefficient of friction of the plug on the surface of the wheel satisfy the requirements stated above.

Fig. 6 shows a modification of the construction of Figs. 4 and 5. In this case the braking device consists of a leaf spring 14, the free end of which has a form of a fork and exerts a light pressure on an annular braking member 15, the inner diameter 2^1 of which is greater than the diameter of the arbor 2, so that the annular member 15 may be freely mounted on arbor 2. The annular braking member 15 is urged by the leaf spring 14 against the face of the ratchet wheel (not shown) to exert the desired braking action.

In the above described embodiments of the invention the ratchet wheel 1 is provided with a saw tooth gearing, as shown in Fig. 7A. It will be noted, however, that the pawl and ratchet mechanism according to this invention permits to use a tooth gearing of any type for the ratchet wheel 1. For instance the ratchet wheel may be provided either with **V**-shaped teeth with equal sides (Fig. 7B) or sinusoidal gearing (Fig. 7C), the latter being particularly advantageous when the tooth pitch p is very small, since the sinusoidal gearing results in a less expensive manufacture of the ratchet wheel.

From the foregoing description it will be seen that the pawl 5 acts on the teeth 6 of the ratchet wheel by pressure. Alternatively, the pawl 5 may operate by pulling action. Referring to Fig. 8A, there is shown a pawl 5, the free end of which is bent to form a hook 5^1 which engages the teeth 6 of the ratchet wheel 1. When the pawl 5 moves in the direction of the arrow 4, the hook 5^1 pulls the tooth 6 thus causing the ratchet wheel 1 to rotate. In the reverse displacement of the pawl 5, i.e. in the direction of the arrow 4^1, the hook 5^1 slips on the tooth surface to engage the side of the adjacent tooth 6.

Since the pawl and ratchet mechanism according to this invention is intended for driving a clock or watch movement, the wear of the various elements thereof has to be taken into consideration. The element of the mechanism which is especially subjected to wear is the pawl 5 because of the high frequency of its vibrations.

In order to reduce the wear of this element, the pawl 5 may be formed with a very hard material, such as hardened steel, glass, sintered hard metal, or a gem stone, such as ruby or sapphire.

However, the pawl 5 will preferably be formed with a steel strip provided at the free end with a gem stone. Such a pawl arrangement is shown in Fig. 8B, wherein the pawl 5 of hardened steel is provided at its free end with a gem stone 16 engaging the teeth of the ratchet wheel 1. In another embodiment of the invention (not shown) the gem stone 16 is mounted to form an acute angle with respect to the pawl portion 5^1, so that the pawl has a hooked free end such as that illustrated in Fig. 8A. While the invention has been described and illustrated with reference to specific embodiments thereof, it will be understood that other embodiments may be resorted to without departing from the invention. Accordingly, the forms of the invention set out above should be considered as illustrative and not as limiting the scope of the following claims.

WHAT WE CLAIM IS:—

1. A clock or watch mechanism including a mechanical vibrator of which the vibratory motion is converted into rotary motion for driving the movement by pawl and ratchet mechanism, comprising a ratchet wheel, a pawl operatively associated with said ratchet wheel, and a braking device, one end of said pawl being fixed to said mechanical vibrator so that the pawl is subjected to forward and backward displacements according to the vibrations of said vibrator, the other end of the pawl engaging the teeth of said ratchet wheel so as to cause the same to rotate in one direction, the braking device acting on said ratchet wheel to limit the angular displacement thereof in said one direction to an angle corresponding to a single tooth pitch and prevent said ratchet wheel from rotating in the opposite direction, said pawl being so constructed that its natural frequency is higher than the vibration frequency of the mechanical vibrator and the moment of the force exerted by said pawl on said ratchet wheel upon its

backward displacement multiplied by the friction coefficient is lower than the moment of the braking force exerted by said braking device on said ratchet wheel.

2. A clock or watch mechanism according to Claim 1, in which said braking device consists of a leaf spring, one end of which is fixed to the frame of the clock or watch movement and the other end of which bears on the staff of said ratchet wheel so as to exert a braking force thereon.

3. A clock or watch mechanism according to Claim 2, in which said leaf spring lies in a plane perpendicular to the face of said ratchet wheel, the free end of said leaf spring bearing on the cylindrical surface of the staff of said ratchet wheel so as to exert on said staff a pressure perpendicular to the longitudinal axis thereof.

4. A clock or watch mechanism according to Claim 2, in which said leaf spring lies on a plane parallel to the face of said ratchet wheel, the free end of said leaf spring bearing on the end face of the staff of said ratchet wheel so as to exert on said staff a pressure directed along the longitudinal axis thereof.

5. A clock or watch mechanism according to Claim 1, in which said braking device consists of a sleeve anchored at one end thereof to the frame of the clock or watch movement and extending toward one face of said ratchet wheel, a plug of suitable material being slidably mounted within said sleeve and being subjected to the action of spring means to bear against said face of the ratchet wheel.

6. A clock or watch mechanism according to Claim 1, in which said braking consists of an annular member freely mounted on the staff of said ratchet wheel, said annular member being urged by spring means against the face of said ratchet wheel.

7. A clock or watch mechanism according to any of the preceding Claims 1 to 6, in which said pawl consists of a resilient strip which acts by pressure on the teeth of said ratchet wheel.

8. A clock or watch mechanism according to any of the preceding Claims 1 to 6, in which the free end of the pawl is bent to form a hook engaging the teeth of said ratchet wheel so as to exert thereon a pulling action.

9. A clock or watch mechanism according to Claim 7, in which the built up end of said pawl consists of a gem stone, such as a ruby or a sapphire.

10. A clock or watch mechanism according to Claim 8, in which the hook of said pawl consists of a built up piece of hard material.

11. A clock or watch mechanism according to Claim 10, in which the hook of the pawl consists of a gem stone, such as a ruby or a sapphire.

12. A clock or watch mechanism, substantially as hereinbefore described with reference to the accompanying drawings.

13. A time-piece including a mechanism as claimed in any one of the preceding claims.

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799,824 COMPLETE SPECIFICATION
I SHEET

This drawing is a reproduction of the Original on a reduced scale.

Fig.1

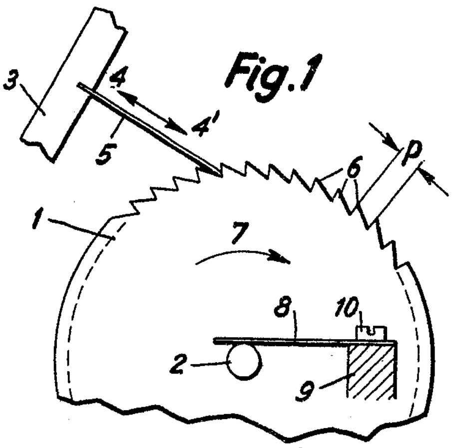

Fig.8A

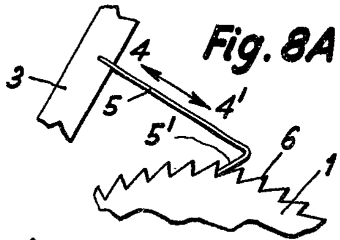

Fig.8B

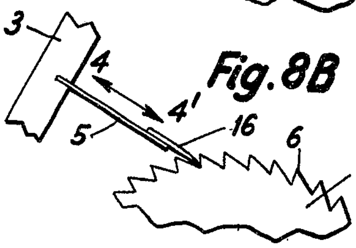

Fig.2

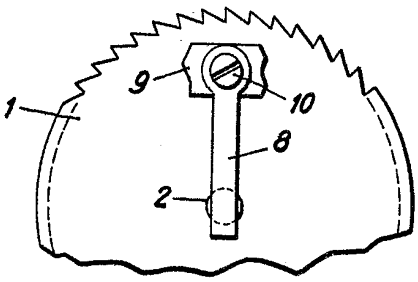

Fig.3

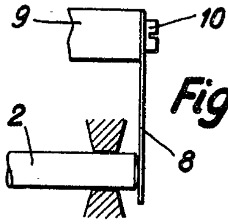

Fig.4

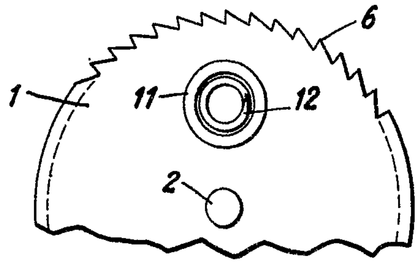

Fig.5

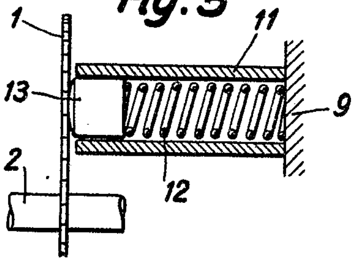

Fig.7A

Fig.7B

Fig.7C

Fig.6