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PAWL AND RATCHET MECHANISM DRIVEN BY VIBRATORY MEANS

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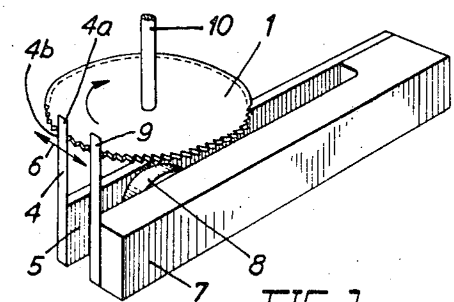

FIG. 1

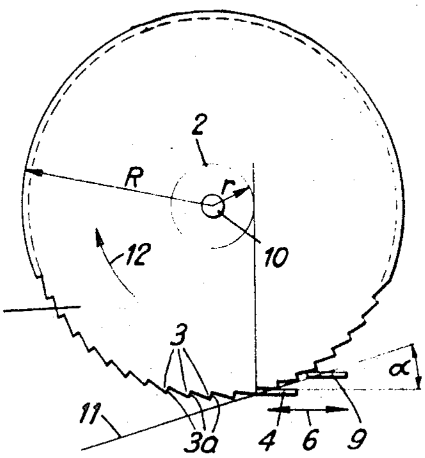

FIG. 2

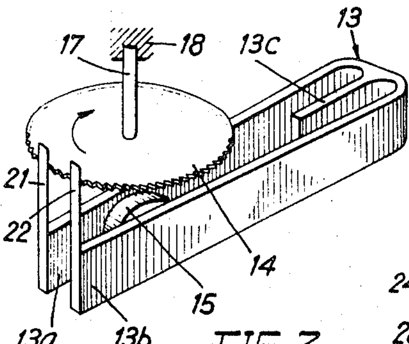

FIG. 3

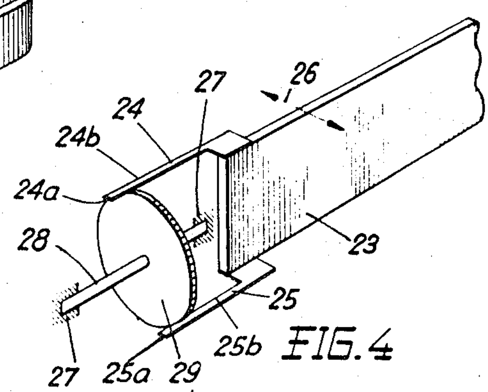

FIG. 4

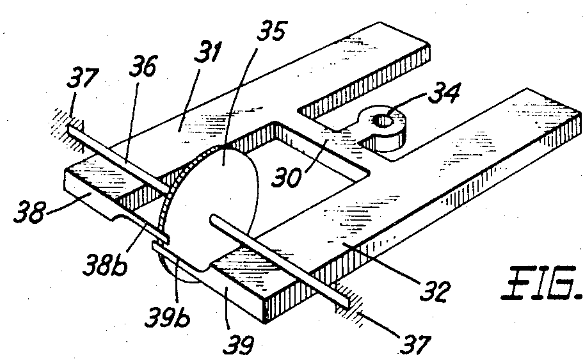

FIG. 5

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PAWL AND RATCHET MECHANISM DRIVEN BY VIBRATORY MEANS

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ABSTRACT OF THE DISCLOSURE

A pawl and ratchet mechanism, for operation by one or more vibratory members, is disclosed as including a ratchet wheel, preferably having sawteeth, and operated by one or more pawls. The feature of the disclosure is that the longitudinal center lines of the pawls extend substantially perpendicular to the diametric plane of the ratchet wheel, or parallel to the axis of the ratchet wheel. Each pawl comprises a relatively elongated rectangular blade rigidly attached to a vibratory member, and is so arranged that one of its narrow longitudinal edges faces in the direction of thrust, the blade being so designed that it is rigid in the direction of thrust but elastic in a direction at right angles to the plane of the thrust. Thus, the free end of the blade, which acts on the ratchet wheel, can perform elastic excursions from the position of rest, but with these excursions being only at right angles to the plane of the blade and not within or parallel to the plane of the blade.

Background of the invention

This invention is directed to pawl and ratchet mechanisms operable by vibratory means and, more particularly, to an improved, simplified, and completely reliable mechanism of this type which is substantially free from interference by external disturbances or vibrations.

Mechanisms of the type to which the present invention is directed are used in precision technology. Ratchet and pawl drives of this type include some which comprise one driving pawl and one detent or holding pawl, sometimes referred to as a "click." Some mechanisms of this type include two diving pawls working in opposed cycles.

All these known devices have in common a ratchet wheel which is a sawtoothed ratchet wheel, and have, in common, the characteristic that the driving pawl which, as it moves to and fro, imparts rotary motion to the ratchet wheel, as well as a fixed "click" or detent, if one is used, are so positioned, with their flat face or faces in contact with the ratchet wheel, that their longitudinal center line or center lines lie in the diametric plane of the ratchet wheel.

Devices of this type are used, for example, in audio frequency stepping movements or mechanisms. In such applications, it is necessary to take account of forces of inertia, response frequencies and impressed freqeuncies arising from shocks and reverberation. Trouble of this kind may occur, for instance, if the pawl should slip sidewise off the teeth of the ratchet wheel, or may occur as a result of buckling of the pawl in the thrust direction and vibration in the plane of the buckle, irrespective of whether the pawl is in the form of a blade gripped at one end or otherwise.

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Summary of the invention

In accordance with the invention, a pawl and ratchet mechanism is provided and comprising a ratchet wheel driven by a vibratory member to which is rigidly attached a relatively elongated rectangular blade acting as a pawl. The blade is so fitted to the vibratory member that one of its narrow longer edges faces in the direction of thrust, and the blade is so designed that it is rigid in the direction of thrust but elastic in a direction perpendicular to the plane of the thrust. Thus, the free end of the blade, which acts on the ratchet wheel, can perform elastic excursions from the line of rest, but with these elastic excursions being only in a direction at right angles to the plane of the blade and not in or parallel to that plane.

Preferably, the thrust plane of each pawl extends at an angle of from 6° to 40° relative to the tangential plane at the point of attack on the ratchet wheel. The natural frequency of the pawl may be at least as high as the natural frequency of the vibratory member to which it is rigidly attached. The period of attack of the pawl on the ratchet should preferably not exceed, in duration, one quarter cycle of the vibratory member.

The vibratory member may be provided with two stepping pawls which act on the ratchet wheel at diametrically opposite points. Alternatively, two vibratory members may be provided each carrying a single stepping pawl, with the two vibratory members being so interconnected that they vibrate toward and away from each other. The two vibratory members may be positioned symmetrically relative to the diametric plane of the ratchet wheel, and may be fixed to the ends of a torsion vibrator forming a yoke between the two vibratory members at substantially their mid-lengths.

An object of the present invention is to provide an improved ratchet and pawl mechanism operable by vibratory means.

Another object of the invention is to provide such a mechanism in which it is substantially impossible for the pawl to slip out of engagement with the teeth of the ratchet wheel.

A further object of the invention is to provide such a mechanism obviating buckling of a pawl in the direction of thrust and obviating vibration of the pawl in the plane of the buckle.

Still another object of the invention is to provide such a mechanism including a ratchet wheel driven by a vibratory member having attached thereto a relatively elongated rectangular blade acting as a pawl, with the blade extending perpendicular to the diametric plane of the ratchet wheel and substantially parallel to the axis thereof.

A further object of the invention is to provide such a mechanism in which one elongated narrow edge of the blade faces in the direction of thrust, and in which the blade is so designed that it is rigid in the direction of thrust but elastic in the direction perpendicular to the thrust plane.

Yet, another object of the invention is to provide such a mechanism in which the blade acting on the ratchet wheel can perform elastic excursions from the line of rest but substantially only at right angles to the plane of the pawl and not within or parallel to such plane.

A further object of the invention is to provide such a mechanism in which the thrust plane of each pawl forms a predetermined angle with respect to the tangential plane at the point of attack of the pawl on the ratchet wheel.

Still another object of the invention is to provide such a mechanism in which the natural frequency of the pawl may be at least as high as the natural frequency of the vibratory member to which it is attached.

Brief description of the drawings

For an understanding of the principles of the invention, reference is made to the following description of typical embodiments thereof as illustrated in the accompanying drawings.

In the drawings:

FIG. 1 is a perspective view of one form of ratchet and pawl mechanism, driven by a vibratory member, and embodying the invention;

FIG. 2 is a plan view of the ratchet wheel and the two pawls shown in FIG. 1;

FIG. 3 is a perspective view, similar to FIG. 1, showing a mechanism embodying the invention and including two vibratory tongues;

FIG. 4 is a perspective view showing a mechanism embodying the invention and comprising a single vibratory member carrying two stepping pawls; and

FIG. 5 is a perspective view of a further embodiment of the invention in which two vibratory members, each carrying a stepping pawl, are secured on a torsion vibrator.

Description of the preferred embodiments

Referring first to FIGS. 1 and 2, FIG. 1 is a simplified perspective view of one embodiment of the invention, including a ratchet wheel **1** the shape of whose teeth can be seen particularly clearly in FIG. 2. The teeth **3** are right-angled sawteeth and are particularly suitable for the purposes of the invention when the circle **2**, to which the planes of the thrust faces **3***a* of the individual teeth **3** are commonly tangent, has a diameter equal to about one-fifth of the ratchet wheel diameter 2R. The radius r of circle **2** may be slightly larger or smaller, of course, but it should equal not less than 0.1R and not exceed 0.6R.

The reciprocating or oscillating stepping pawl **4** is rigidly attached to the free end of a vibratory member **5**, and the plane of vibration of pawl **4** does not coincide with the diametric plane of ratchet wheel **1** but is in spaced parallel relation with the diametric plane of ratchet wheel **1**. Vibratory member **5** is attached to an electromechanical transducer **8**, which may be in the form of a bracket, so that it may be vibrated by the electromechanical transducer.

As can be seen from FIGS. 1 and 2, blade **4**, acting as the stepping pawl, is not only fitted to vibratory member **5** with one of its narrow longitudinal edges **4***b* facing in the direction of thrust **6**, but is also so designed that it is rigid in the direction of thrust but elastic in a direction perpendicular to the thrust plane. Thus, its free end **4***a*, which acts on ratchet wheel **1**, can vibrate naturally only at right angles to the plane of the blade and not within or parallel to that plane. The plane of blade **4** forms an angle of from 6° to 40° with the tangential plane **11** at the point of attack of pawl **4** on ratchet wheel **1**. Blade **4** has a natural frequency at least as high as the natural frequency of vibrator member **5** to which it is rigidly attached, thereby insuring that the period of attack of the teeth of ratchet wheel **1** does not exceed the duration of one-quarter of a cycle of vibratory member **5**. The appropriate natural frequency can be obtained by selection of a blade of suitable length and thickness.

Another pawl **9**, corresponding to pawl **4**, is rigidly attached to bracket **7**, its mode of attachment and its elastic properties being precisely the same as those of pawl **4**.

When vibratory member **5** vibrates, pawl **4**, which is rigidly attached thereto, turns ratchet wheel **1** fixed to spindle **10** in the direction of the arrow **12**, while blade **9**, acting as a "click" or detent, prevents reverse movement of wheel **1**. As compared to existing ratchet mechanisms incorporating a blade-type pawl having its longitudinal center line substantially in the direction of thrust, the invention mechanism has several very outstanding advantages. Thus, all longitudinal stress in the pawl is eliminated and hence, and more especially, there can be no "buckle" vibrations. Also, its rigidity in the approximately tangential direction in relation to the wheel is independent of the forces transmitted, and can be adapted to particular stability requirements. The resilience of the pawl lies substantially in a direction approximately radial to the ratchet wheel, so that reliable engagement at audio frequency is possible because, in the invention mechanism, the elasticity can be determined at will and irrespective of the rigidity of the drive. This resilience in the radial direction also determines behavior of the blade or pawl when shocks occur. Such external disturbances can, in no event, interrupt the drive due to the pawl shipping off the teeth, and excursions of the pawl due to shocks have no effect.

The gap between the edges of attack of the two pawls, when they are at rest, must approximate $(n+\frac{1}{2})$ times the tooth pitch, if no disturbance is to arise even when the amplitude of the vibratory member undergoes wide fluctuations. In this expression, n is any whole number.

The embodiment of FIG. 3 differs from that of FIGS. 1 and 2 mainly in that it includes two vibratory members, **13***a* and **13***b*, rather than one vibratory member. The vibratory members **13***a* and **13***b* are the prongs of a tuning fork indicated generally at **13**, and including a mounting or fixing portion **13***c*. An electromechanical converter **15** serves to maintain the vibration of the tuning fork **13**. The prongs of the tuning fork vibrate in the plane of the fork, and a spindle **17** is mounted in two bearings **18**, only one of which is visible in the drawing, so that it extends perpendicular to the plane of the tuning fork. Spindle **17** carries ratchet wheel **14** which may be of precisely the same kind as that shown in FIGS. 1 and 2.

Each fork prong **13***a* and **13***b* has rigidly attached to its free end a stepping pawl **21** or **22**, respectively, both stepping pawls being of precisely the same description as the pawl **4** of FIGS. 1 and 2, so that further description is unnecessary. The spacing of the two thrust edges, when the two tuning fork prongs are at rest, is again $(n+\frac{1}{2})$ times the tooth pitch. When the turning fork vibrates, the two fork prongs **13***a* and **13***b* swing toward and away from each other, so that each of the pawls **21** and **22**, acts in turn as a stepping pawl, while the other is moving back in relation to the direction of rotation of ratchet wheel **14**. All of the advantages mentioned above are possessed also by the embodiment of the invention shown in FIG. 3.

FIG. 4 illustrates a further embodiment of the invention incorporating a single vibratory member which may be, for example, an elastic vibrating tongue. This vibratory member **23**, which can be set vibrating by suitable means which have not been illustrated, carries, on its free end, two pawls in the shape of blades **24** and **25**. The respective longer narrow edges **24***a* and **25***a* of the two pawls face in the direction of thrust **26** indicated by the double headed arrow, one edge facing in each direction. A spindle **28** extends parallel to the planes of the two blades, and is carried in bearings **27**, and a ratchet wheel **29** is fixed to spindle **28**. As in the embodiments previously described, blades **27** and **25** are so designed and fitted that they are rigid in the direction of thrust, but elastic in a direction at right angles to the thrust plane. Thus, the blade ends **24***a* and **25***a*, which act on ratchet wheel **29**, can carry out natural vibrations only at right angles to the planes of the blades, and not within these planes.

In the arrangement of FIG. 4, the stepping pawls act on ratchet wheel **29** at diametrically opposite points. The arrangement is extremely reliable in operation. As in the embodiments previously described, the spacing of the two thrust edges should be $(n+\frac{1}{2})$, or some value not too greatly different from $(n+\frac{1}{2})$, times the tooth pitch.

Another embodiment of the invention is shown in FIG. 5. In this later embodiment, a pair of vibratory members **31** and **32** are situated at the ends of a torsion vibrator **30** so as to form with the latter a letter H, the whole assembly being provided with an eyelet **34** for attachment to a base. Between vibratory members **31** and **32** there is disposed a ratchet wheel **35** which is fixed to a spindle **36** mounted to extend parallel to torsion vibrator **30** in bearings **37**.

One end of vibratory member **31** has rigidly attached thereto a relatively elongated substantially rectangular blade **38** acting as a pawl, and the corresponding end of the vibratory member **32** has rigidly attached thereto a relatively elongated substantially rectangular blade **39** acting as a pawl. Pawls **38** and **39** engage ratchet wheel **35** in the same manner as pawls **21** and **22** engage ratchet wheel **14** of FIG. 3. As in the other embodiments, the narrow longitudinal edges **38*b*** and **39*b*** of the pawls lie in the direction of thrust, and the pawls are so designed that they are rigid in the direction of thrust but are elastic in a direction at right angles to the thrust plane. The same conditions as previously mentioned, with respect to the desirable natural frequency of the pawls and the spacing between the thrust edges, apply also to the embodiment of FIG. 5.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. A ratchet and pawl mechanism driven by vibratory means, comprising, in combination, a rotatable ratchet wheel having sawtooth form teeth around its periphery; at least one vibratory member; and at least one relatively elongated substantially rectangular blade rigidly secured to each vibratory member and acting as a pawl engaging said teeth to step said ratchet wheel upon vibration of the associated vibratory member; the thrust plane of each blade forming an angle of from 6° to 40° with the plane tangent relative to said ratchet wheel at the point of attack of the pawl on the teeth of the rachet wheel; each blade being mounted on its associated vibratory member so that one narrow longitudinal edge thereof faces in the thrust direction for engagement with said teeth with the longitudinal axis of the blade being perpendicular to the plane of movement of the vibratory member; each blade being rigid in its thrust direction but elastic in a direction normal to the plane of its thrust, whereby its free end, engageable with the teeth of said ratchet wheel, performs elastic excursions only at right angles to the plane of the blade and not within or parallel to that plane.

2. A ratchet and pawl mechanism driven by vibratory means, as claimed in claim **1**, wherein the natural frequency of each pawl is at least as high as the natural frequency of its associated vibratory member to which it is rigidly attached.

3. A ratchet and pawl mechanism driven by vibratory means, as claimed in claim **1**, in which each pawl comprises a stepping pawl whose period of attack on the teeth of said ratchet wheel has a duration not in excess of ¼ of a cycle of the associated vibratory member.

4. A ratchet and pawl mechanism driven by vibratory means, as claimed in claim **1**, in which each sawtooth has a thrust surface and a sloping surface extending at right angles to each other; the planes of the thrust surfaces of said teeth being commonly tangent to a circle concentric with said ratchet wheel and having a radius which is substantially not less than 0.1 the radius of said ratchet wheel and substantially not more than 0.6 the radius of said ratchet wheel.

5. A ratchet and pawl mechanism driven by vibratory means, as claimed in claim **1**, in which said mechanism includes a single vibratory member; and a second relatively elongated substantially rectangular blade fixed relative to said mechanism and acting as a detent pawl engaging the teeth of said ratchet wheel, said second pawl comprising a blade having one narrow longitudinal edge engageable with the thrust surfaces of said teeth and having characteristics of rigidity, elasticity and elastic excursion directions identical with those of said first-mentioned blade.

6. A ratchet and pawl mechanism driven by vibratory means, as claimed in claim **1**, including two vibratory members, each provided with a single stepping pawl, the vibratory members being interconnected in such a manner that they vibrate toward and away from each other.

7. A ratchet and pawl mechanism driven by vibratory means, comprising, in combination, a rotatable ratchet wheel having sawtooth form teeth around its periphery; two vibratory members; and two relatively elongated substantially rectangular blades, one of said blades being rigidly secured to one of said vibratory members while the other blade is rigidly secured to the other one of said vibratory members; said blades acting as pawls engaging said teeth to step said ratchet wheel upon vibration of the associated vibratory member; the two vibratory members being interconnected in such a manner that they vibrate toward and away from each other; each blade being mounted on its associated vibratory member so that one narrow longitudinal edge thereof faces in the thrust direction for engagement with said teeth with the longitudinal axis of the blade being perpendicular to the plane of movement of the vibratory member; each blade being rigid in its thrust direction but elastic in a direction normal to the plane of its thrust, whereby its free end, engageable with the teeth of said ratchet wheel, performs elastic excursions only at right angles to the plane of the blade and not within or parallel to that plane; said two vibratory members comprising the respective arms of a tuning fork; the axis of rotation of said ratchet wheel extending between said arms and perpendicular to the general plane of said tuning fork.

8. A ratchet and pawl mechanism driven by vibratory means, comprising, in combination, a rotatable ratchet wheel having sawtooth form teeth around its periphery; a single vibratory member; and a pair of relatively elongated substantially rectangular blades rigidly secured to said vibratory member and acting as stepping pawls acting on said ratchet wheel at diametrically opposite points thereof to step said ratchet wheel upon vibration of the vibratory member; each blade being mounted on the vibratory member so that one narrow longitudinal edge thereof faces in the thrust direction for engagement with said teeth with the longitudinal axis of the blade being perpendicular to the plane of movement of the vibratory member; each blade being rigid in its thrust direction but elastic in a direction normal to the plane of its thrust, whereby its free end, engageable with the teeth of said ratchet wheel, performs elastic excursions only at right angles to the plane of the blade and not within or parallel to that plane.

9. A ratchet and pawl mechanism driven by vibratory means, comprising, in combination, a rotatable ratchet wheel having sawtooth form teeth around its periphery; two vibratory members; each vibratory member having a relatively elongated substantially rectangular blade rigidly secured thereto, said blades acting as pawls engaging said teeth to step said ratchet wheel upon vibration of the associated vibratory member; said two vibratory members being part of a torsion vibrator and being positioned on either side of the diametric plane of said ratchet wheel; each blade being mounted on its associated vibratory member so that one narrow longitudinal edge thereof faces in the thrust direction for engagement with said teeth with the longitudinal axis of the blade being perpendicular to the plane of movement of the vibratory member; each blade being rigid in its thrust direction but elastic in a direction normal to the plane of its thrust, whereby its free end, engageable with the teeth of said ratchet wheel, performs elastic excursions only at right angles to the plane of the blade and not within or parallel to that plane.

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