United States Patent [19]

Hetzel

[11] **3,754,476**

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[54] **MOTION TRANSFORMER**

[75] Inventor: **Max Hetzel,** Bienne, Switzerland

[73] Assignee: **Omega Louis Brandt Et Freres, S.A.,** Biene, Switzerland

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.**...................... **74/128,** 74/575, 58/23 D, 310/80

[51] **Int. Cl.**.. **F16h 27/02**

[58] **Field of Search**...................... 74/128, 126, 575; 310/80; 58/23 D; 101/250, 252

[56] **References Cited**

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Primary Examiner—Charles J. Myhre
Assistant Examiner—Wesley S. Raltiff, Jr.
Attorney—Dean S. Edmonds, James W. Laist et al.

[57] **ABSTRACT**

In a motion transformer for converting oscillatory to rotary motion, comprising a ratchet wheel mounted for both oscillatory and rotary motion, a pair of stops limiting the amplitude os such oscillatory motion, and a ratchet pawl coacting with the ratchet wheel and a restraining member preventing retrograde rotation thereof to convert oscillatory motion of the ratchet wheel to unidirectional rotary motion, the ratchet pawl comprises a resilient pawl arm fixedly mounted adjacent one end and carrying at the other end a pawl jewel in the form of a wafer having a convexly curved edge which abuts the ratchet wheel teeth.

5 Claims, 5 Drawing Figures

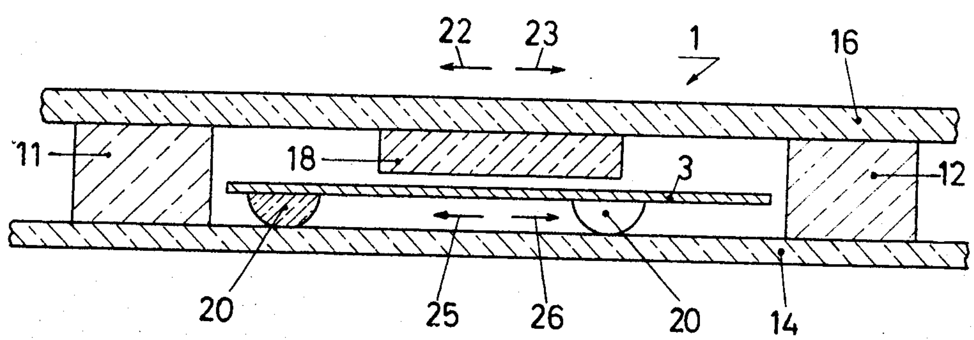


FIG.1

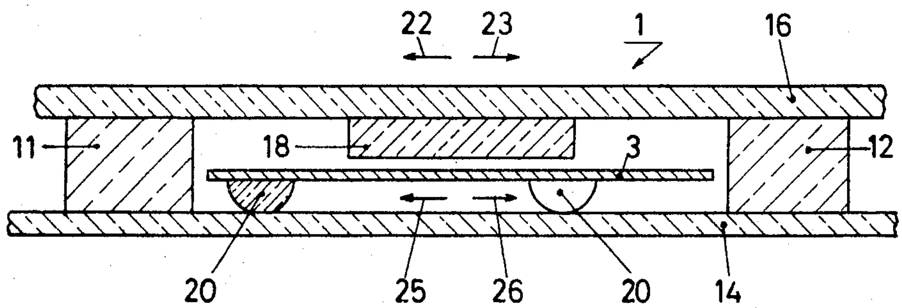


FIG.2

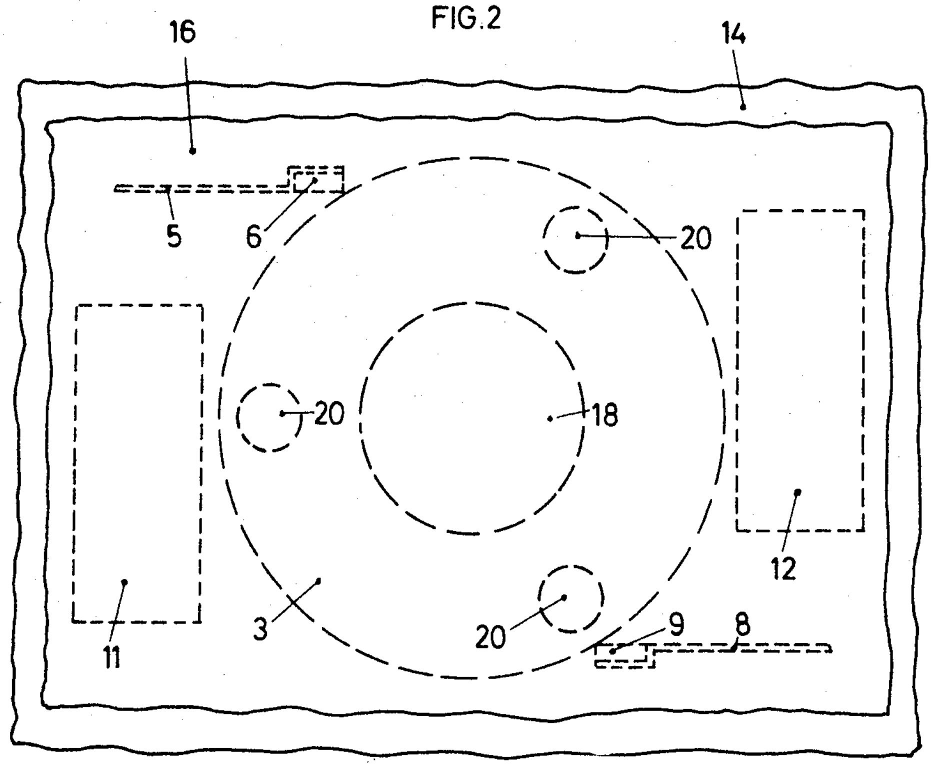


FIG. 3

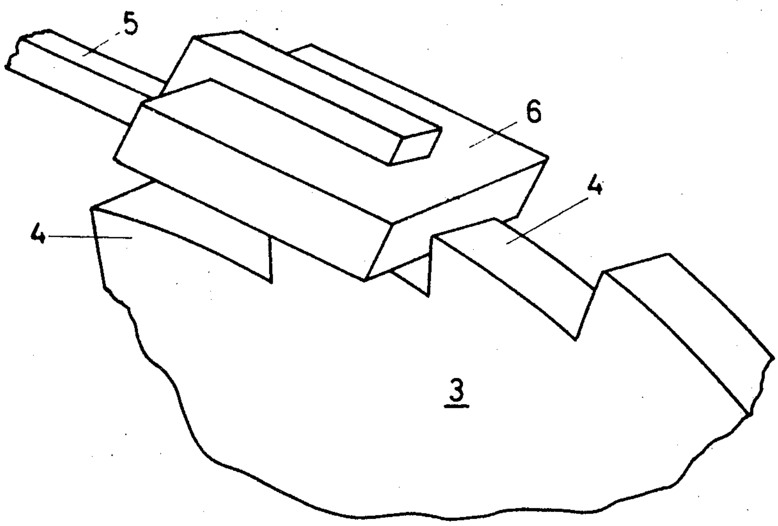


FIG. 4

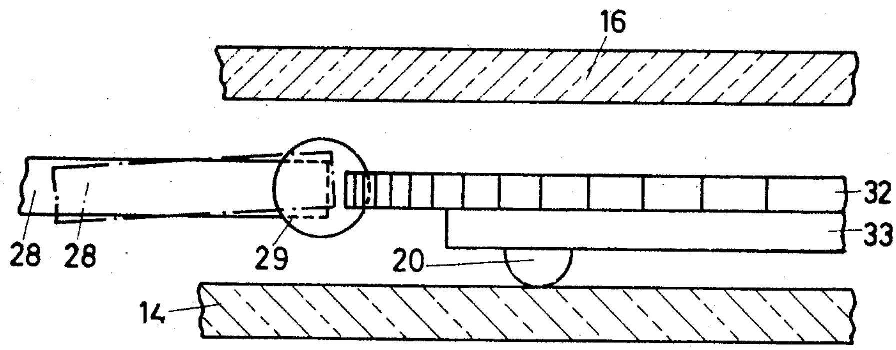
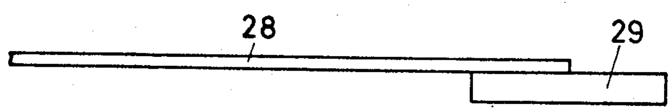


FIG. 5



MOTION TRANSFORMER

RELATED APPLICATION

This application describes an improvement on the motion transformer mechanism disclosed in U.S. application Ser. No. 88,715, 715, now U.S. Pat. No. 3,633,464.

SUBJECT OF THE INVENTION

This invention relates to motion transformers, especially for use in timepieces such as wrist watches, for converting oscillatory or reciprocating motion to rotary motion. The invention pertains particularly to motion transformers comprising a ratchet wheel mounted in an enclosure so that it can oscillate back-and-forth through a limited path of travel and also rotate substantially about its center axis, and further comprising stops to limit the amplitude of the back-and-forth oscillatory motion, and a pawl coacting with the ratchet wheel and a restraining member preventing retrograde rotation thereof to cause the ratchet wheel to rotate unidirectionally at a velocity determined by the frequency of the oscillations. The restraining member may be a second pawl or it may be a brake preventing retrograde motion of the ratchet wheel. The rotating ratchet wheel is coupled magnetically to the drive gear in a watch or other timepiece gear train.

The invention provides, in such a motion transformer, an improved ratchet pawl comprising a resilient pawl arm fixedly mounted adjacent one end and carrying adjacent its other end a pawl jewel in the form of a wafer having a convexly curved edge which abuts the ratchet wheel teeth. The convexly curved edge of the pawl jewel is advantageously substantially circularly curved; and in fact a pawl jewel in the form of a substantially cylindrical disc is in general preferred. The pawl jewel is mounted on the resilient arm with the axis of its curved edge disposed approximately perpendicular to the axis of rotation of the ratchet wheel. The pawl arm is preferably a substantially straight resilient member to which the pawl jewel is adhesively bonded with its curved edge projecting beyond the end of such arm.

The ratchet pawl design of the invention greatly facilitates assembly of motion transformers of the character described by diminishing the adverse effects of imprecise alignment of the ratchet pawl with the ratchet wheel. It has been found that due to the small dimensions of the parts, it is extremely difficult to arrange the pawls, in particular the pawl jewels, in the proper position relative to the teeth of the ratchet wheel, that is, in such a way as to have the pawl jewels bear squarely against the radial flanks of the ratchet teeth. Special care must be taken in the case of square or rectangular pawl jewels that their front edges are exactly parallel to the flanks of the teeth they engage; that is, such edges of the pawl jewels must be parallel to the axis of rotation of the ratchet wheel. Even a slight mounting error can result in a point-like contact between the pawl jewel and the edge of the teeth of the ratchet wheel. This in its turn may result in having asymmetric forces act on the ratchet wheel so that additional frictional forces will develop during the motion of the ratchet wheel.

DESCRIPTION OF THE DRAWINGS

In the Drawings:

FIG. 1 is a sectional view of a motion transformer in which the invention is embodied;

FIG. 2 is a top plan view of the motion transformer of FIG. 1;

FIG. 3 is a greatly enlarged perspective view of a ratchet wheel and pawl, in which the pawl comprises a rectangular pawl jewel as heretofore proposed;

FIG. 4 is an enlarged fragmentary sectional view of a motion transformer generally similar to FIG. 1 but of modified construction and showing the ratchet wheel in edge view; and

FIG. 5 is a side view of a preferred form of ratchet pawl according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

The motion transformer 1 shown in FIGS. 1 and 2 constitutes a unitary assembly mounted in an enclosure formed of base plate 14 and cover plate 16 joined by side members (not shown) and hermetically sealed after assembly and adjustment. A light lubricating oil of low viscosity, say one centistoke, may fill the enclosure. The assembly may be constructed and adjusted prior to sealing the cover plate in place. In use the assembly is mounted on a vibratory member (e.g., a tuning fork) which is caused to vibrate at a predetermined frequency by a battery-energized electronic circuit, as is well understood in the electric timepiece art. The mounting of the motion transformer of FIG. 1 on such vibratory member is such as to cause the assembly to oscillate back-and-forth in the direction indicated by the arrows 22 and 23.

The motion transformer mechanism comprises a ratchet wheel 3 provided with ratchet teeth (not shown). The ratchet wheel is not secured in place by a fixed pivot or shaft, but instead is free to oscillate within the enclosure through a limited path of back-and-forth travel in the directions indicated by the arrows 25, 26, and also to rotate substantially about its center. Oscillation of the entire motion transformer assembly by the vibratory member on which it is mounted causes the ratchet wheel, because of its inertia, to oscillate correspondingly within and relative to the enclosure. A first resilient pawl arm 5 terminates at one end in a pawl jewel 6 which engages the ratchet wheel teeth and is fastened at its other end to the enclosure base plate. Similarly, a restraining member in the form of a second resilient pawl arm 8 is provided at one end with a pawl jewel 9 which engages the ratchet wheel teeth and is attached at its other end to the enclosure base plate. The pawl jewels 6 and 9 engage the ratchet wheel at substantially opposite ends of a wheel diameter that is approximately normal to the direction of oscillation.

The pawl arms 5 and 8 are shown in FIG. 2 as being formed with offset seats to receive the pawl jewels 6 and 9, as has been customary heretofore in the mounting of rectangular pawl jewels. However, in accordance with the invention, the pawl jewels 6 and 9 are preferably cylindrical discs and the provision of the offset seats to receive them is unnecessary.

A pair of stop members 11 and 12 secured fixedly to the enclosure base plate limit the maximum path of travel of the ratchet wheel in its back-and-forth oscillation. As the ratchet wheel oscillates the pawls compel rotation of the ratchet wheel (in a clockwise direction in the apparatus as viewed in FIG. 2), as is described in detail in the above-mentioned U.S. application Ser. No. 88,715, now U.S. Pat. No. 3,633,464.

The ratchet wheel 3 is made of magnetic material of high coercivity, such as platinum-cobalt alloy, and is permanently magnetized. Thereby it is magnetically attracted to and coupled with a fixedly pivoted magnetic wheel (not shown) which may be the drive gear of a timepiece gear train and which is mounted externally of the enclosure in parallel relation with and directly below the base plate **14.** Not only does the magnetic coupling of the ratchet wheel to the external fixed pivot wheel provide for driving the latter by rotation of the former, but it also causes the ratchet wheel to be attracted toward the base plate **14** and away from the cover plate **16.** Although the cover plate **16** normally is not touched by the freely moving ratchet wheel **3,** it is provided with axial deflection limiting means in the form of a disc **18** which preferably, like the base plate **14** and the cover plate **16,** is made of a hard non-magnetic material such as jewel stone, e.g., ruby, and which, since it is ground to a lamina, is transparent.

The ratchet wheel **3** is provided with three supports **20** which may be glued or cemented to the wheel **3.** These supports **20,** having the shape of spherical segments or hemispheres, likewise are made of jewel stone, in particular ruby, or alternatively, of hard metal, e.g., tungsten carbide. Three supports **20** of this type are provided, thus ensuring a reliable and neat mounting of the ratchet wheel **3** on the base **14.**

FIG. **1** also shows by way of the arrows **22** and **23** the directions in which the vibrator imparts back-and-forth oscillation to the entire motion transformer **1.** Arrows **25** and **26** show the direction of the oscillatory movement of the ratchet wheel **3** relative to its enclosure, a movement which depends on the inertia of the ratchet wheel **3** and which is controlled by the pawls **5** and **8** with jewels **6** and **9,** and by the stop members **11** and **12,** in such a way that the ratchet wheel is made to rotate in one direction (clockwise, as viewed in FIG. **2**).

As described in detail in the above-mentioned application Ser. No. 88,715, the entire motion transformer **1** is, for example, connected to a tuning fork, which imparts to it a translatory motion alternately in the direction of the arrows **22** and **23.** The ratchet wheel **3,** due to its inertia, will lag behind when the enclosure moves in the direction of the arrow **22,** with the result that it will move relative to the enclosure in the direction of the arrow **26** until its corresponding tooth or teeth run up against the stop **12.** Meanwhile the enclosure has started to moved in the direction of the arrow **23,** so that the ratchet wheel **3** due to its inertia now moves relative to the enclosure in the direction of the arrow **25,** until the stop **11** acts to brake its motion. This to-and-fro oscillation of the ratchet wheel **3** in its enclosure occurs at the frequency with which the tuning fork or other vibrator oscillates. During this to-and-fro motion of the ratchet wheel **3** the pawl jewels **6** and **9** on the resilient pawl arms **5** and **8** engage the teeth of the ratchet wheel **3,** whereby during movement of the ratchet wheel **3** in one direction it is pivoted on one of the pawl jewels as fixed point, and during movement in the other direction the corresponding edge of the other pawl jewel serves as the fixed point for the pivoting of the ratchet wheel **3,** so that the ratchet wheel **3** is caused to execute a unidirectional rotary motion; that is, the back-and-forth oscillatory motion of the motion transformer assembly is converted by the action of the ratchet and pawls wheel into rotary motion of the ratchet wheel.

It is quite obvious that this rotary motion must take place with as little frictional and other losses as possible. Accordingly, the contact surface between ratchet wheel and base plate, provided by the supports **20,** is designed as small as possible, approaching point contacts. Because the weights here involved are so small, this can be done without difficulty, for even with nearly point contacts the contact pressures will remain exceeding small.

FIG. **3** shows on a greatly enlarged scale a part of a ratchet wheel **3** with teeth **4,** with a rectangular pawl jewel **6** on the pawl arm **5** in its proper engagement position. Such positioning requires mounting both the pawl arm and the pawl jewel with extreme precision, which in the case of square-shaped pawl jewels of this type having, e.g., a thickness of 0.06mm. (0.0024 inch), a width of 0.16 mm (0.0063 inch) and a length of 0.22 mm. (0.0087 inch) is extremely difficult to achieve. Normally the front edge face of a rectangular pawl jewel **6** does not abut in a linear manner against the radial flank of the tooth **4** as shown in FIG. **3.** Instead one corner only of this tooth flank is in contact with such front edge surface, since the pawl jewel **6** or pawl arm **5** or both normally will be inadvertently mounted in a slightly askew position because of the difficulty of accurately aligning such small parts.

FIG. **4** is a fragmentary cross section of a motion transformer similar to that according to FIG. **1,** comprising base plate **14,** cover plate **16** and ratchet wheel **32.** In this embodiment the ratchet wheel may be made of non-magnetic beryllium bronze, to which a permanently magnetized wheel or disc **33** is adhesively bonded. Supports **20,** preferably of jewel stone such as ruby, are cemented to the magnet wheel **33,** whereby the ratchet wheel **32** with the magnet wheel **33** rides easily on the base plate **14.** Normally three such supports **20** are provided, on which, during operation, the ratchet wheel **32** with the attached magnet wheel **33** both oscillates to-and-fro and rotates relative to the base plate.

A resilient pawl arm **28** is provided with a pawl jewel **29,** which in accordance with the invention is disc-shaped, and serves to transform oscillatory motion to rotary motion of the ratchet wheel **32** in the manner described above. As can be seen in FIG. **4,** no matter in what position the pawl arm **28** is attached to the pawl jewel **29,** the pawl jewel will bear in a proper fashion against the ratchet teeth, even when, as indicated by the dash-dotted lines in FIG. **4,** the pawl arm **28** is connected to the disc-shaped pawl jewel **29** in a pronounced eccentric manner. The mounting of the pawl jewel in this design is therefore considerably less sensitive to proper positioning than in the case of rectangular pawl jewels. Hence the functioning of the ratchet parts, particularly the engagement of the pawl jewel **29** with the teeth **4** of the ratchet wheel **3,** is optimized.

That the mounting of the pawl jewel **29** on the pawl **28** may be much simplified can be clearly seen in FIGS. **4** and **5.** The resilient pawl arm **28** may with advantage be designed in the form of a substantially straight member and need not, as shown in FIG. **3,** be provided with an offset seat to receive and locate the pawl jewel. It is very difficult to produce with precision a satisfactory offset seat for a rectangular pawl jewel on the pawl arm. In particular, the parallelism of the seat surface relative to the arm cannot reliably be maintained in quantity production, due to the small dimensions involved, with the result that inaccuracies in the angle of engagement of pawl jewel, pawl arm and ratchet teeth may easily occur. And it is not practical to omit the offset seat on the pawl arm when using rectangular or square-shaped pawl jewels, for otherwise positioning of the contact edge of the jewel perpendicularly to the direction of the spring is vertically impossible.

The described design is applicable in all motion transformers subject to reciprocating movement having a pawl-operated ratchet wheel. It not only makes construction of such motion transformers less expensive, but it also permits a practically foolproof mounting of pawls and ensures smooth and accurate running of the ratchet wheel.

The drawings and the foregoing description particularly show the use of cylindrical disc pawl jewels in apparatus according to the invention. However, the pawl jewel need not be fully or accurately cylindrical (circular in plan view). It is only necessary that the pawl jewel be convexly curved along the edge which engages the radial flank of the ratchet teeth. A curvature which departs from that of a true circle, such as an oval curvature, or a shape which departs from that of a true cylinder, such as a conical shape, may successfully serve as the curvature or shape of the pawl jewel. And only the portion of the pawl jewel which engages the ratchet teeth need be so curved or shaped. For example, the pawl jewel may be semi-cylindrical (semi-circular) provided the curved edge surface is presented to the ratchet teeth.

As is apparent from FIGS. 4 and 5, the pawl jewel is preferably mounted so that the curved surface engaging the ratchet teeth projects substantially beyond the end of the resilient ratchet arm. It is also apparent that the mounting of the pawl jewel is such that in the pawl and ratchet wheel assembly the axis through the center of curvature of the pawl jewel is approximately perpendicular to the axis of rotation of the ratchet wheel.

I claim:

1. A motion transformer for converting oscillatory motion to rotary motion comprising a ratchet wheel mounted both for oscillatory back-and-forth motion substantially on a diameter thereof and for rotary motion substantially about its center, a pair of stops fixedly mounted for limiting the amplitude of the oscillatory motion of the ratchet wheel, and a ratchet pawl coacting with said ratchet wheel and a restraining member preventing retrograde rotation thereof to convert oscillatory motion of said ratchet wheel to unidirectional rotary motion, said ratchet pawl comprising a resilient pawl arm fixedly mounted adjacent one end and carrying adjacent the other end a pawl jewel engaging the teeth of the ratchet wheel, characterized in that the pawl jewel is in the form of a wafer having a substantially circularly curved edge against which the ratchet wheel teeth abut, said pawl jewel being mounted with the axis of said curved edge disposed approximately perpendicularly to the axis of rotation of the ratchet wheel.

2. A motion transformer according to claim **1**, wherein the pawl jewel is a disc of substantially cylindrical form.

3. A motion transformer according to claim **1**, wherein the pawl arm is a substantially straight resilient member to which the pawl jewel is adhesively bonded with the curved edge of said jewel projecting beyond the end of said arm.

4. A motion transformer for converting oscillatory to rotary motion comprising a ratchet wheel mounted both for oscillatory back-and-forth motion substantially on a diameter thereof and for rotary motion substantially about its center, a pair of stops fixedly mounted for limiting the amplitude of said oscillatory motion, and a pair of pawls engaging the teeth of said ratchet wheel substantially at the ends of a wheel diameter approximately normal to the direction of said oscillatory motion, characterized in that each of said pawls comprises a resilient arm fixedly mounted at one end and carrying at the other end a pawl jewel in the form of a wafer having a convexly curved edge which abuts the ratchet wheel teeth, the axis of curvature of said curved jewel edge being disposed approximately perpendicularly to the axis of rotation of the ratchet wheel.

5. A motion transformer according to claim **4** wherein each pawl jewel is a substantially cylindrical disc.

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