

- [54] **ELECTROMECHANICAL TRANSDUCER FOR WATCHES**
[75] Inventor: **Walter Schlicht**, Freiburg, Germany
[73] Assignee: **International Telephone and Telegraph Corporation**, Nutley, N.J.
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[58] Field of Search **58/23 D, 288; 310/36, 38**

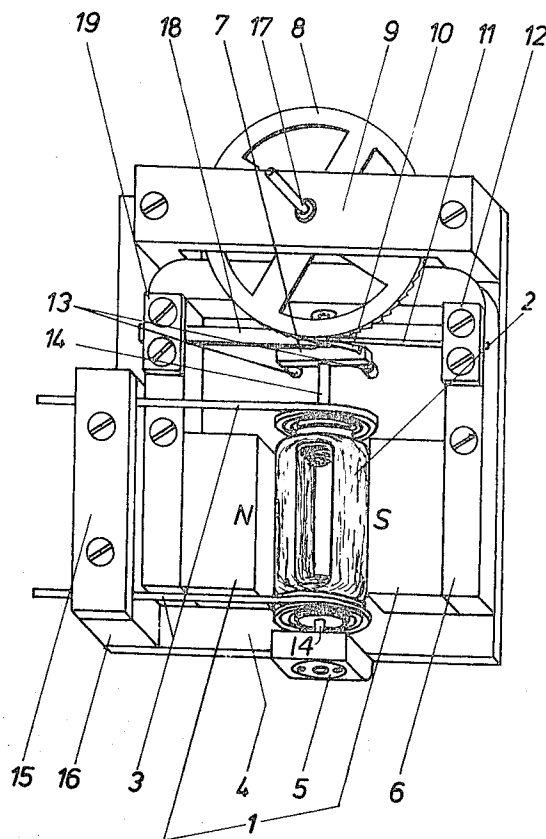
- [56] **References Cited**
UNITED STATES PATENTS
3,484,804 12/1969 Hermann et al. 58/23 R
3,604,201 9/1971 Dome..... 58/23 R
3,641,761 2/1972 Reese 58/28 B
3,676,993 7/1972 Bergey et al. 58/28 B

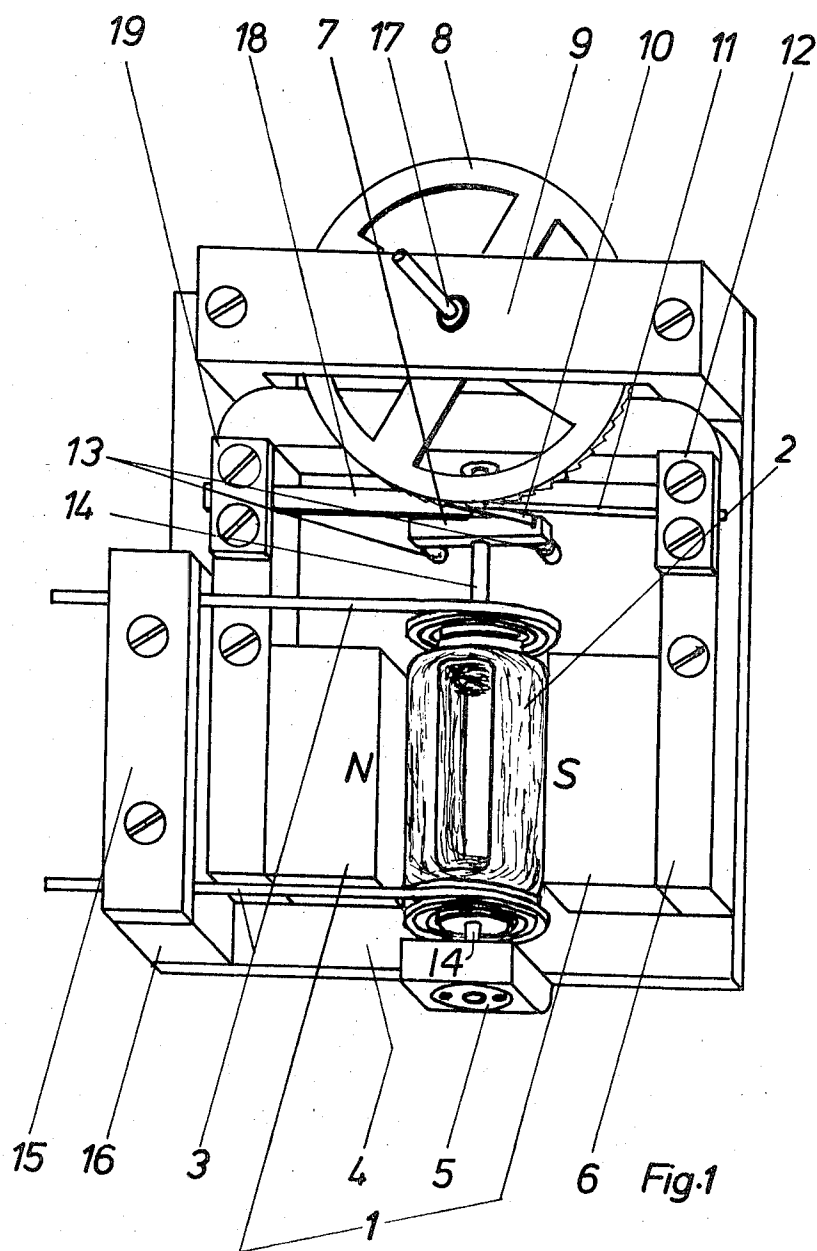
Primary Examiner—Edith Simmons Jackmon
Attorney, Agent, or Firm—John T. O'Halloran;
Menotti J. Lombardi, Jr.

[57] **ABSTRACT**

A stepping mechanism used in a watch includes an elongated air core moving coil which is rotatably mounted between magnetic poles with the longitudinal axis parallel to the pole faces. Current pulses through fixed coil springs at the ends rotate the moving coil in one direction with the springs causing return to the steady state position. The moving coil rotates a pawl carrier on an axial shaft which causes a pawl to engage a tooth of a ratchet on a crown gear. A second spring loaded fixed pawl engages another tooth to prevent movement in the reverse direction. Limit pins provide an angular rotation to engage one tooth at a time. The crown gear axis is perpendicular and aligned with the moving coil axis.

9 Claims, 6 Drawing Figures





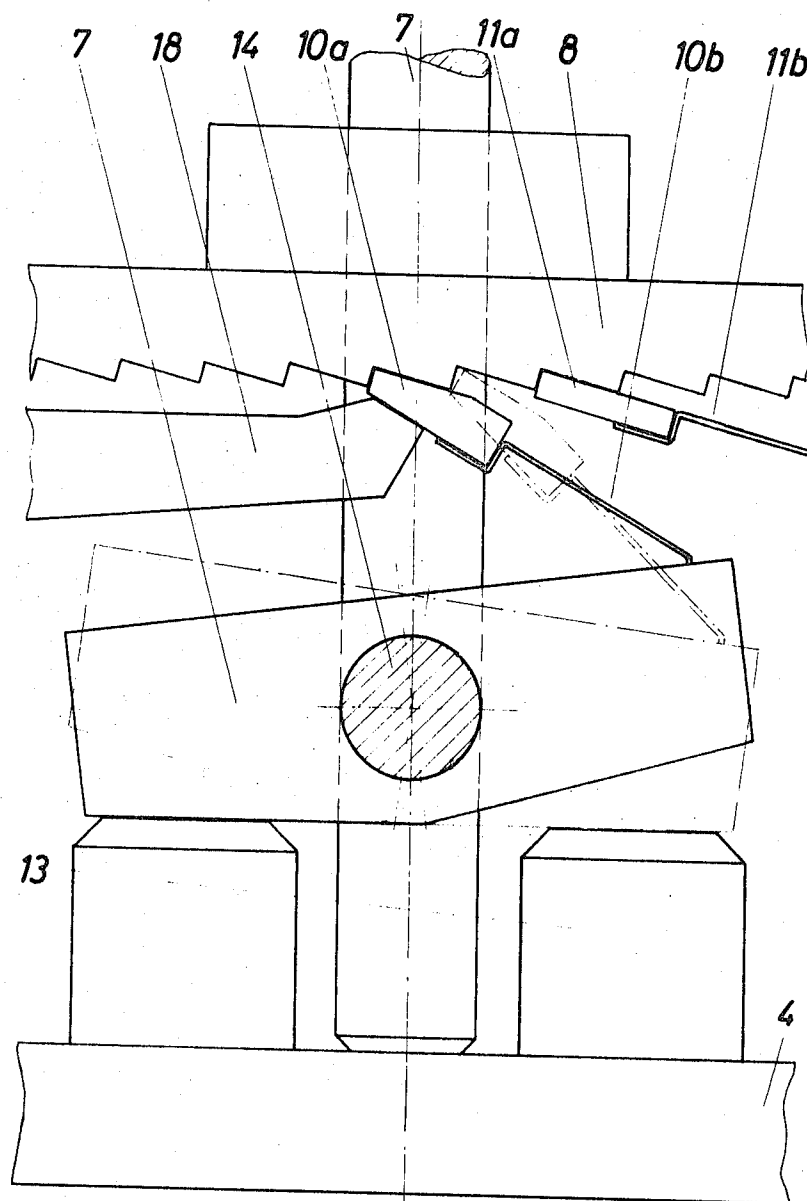
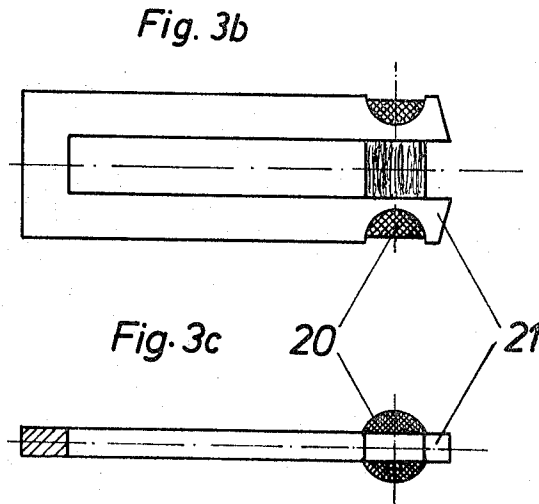
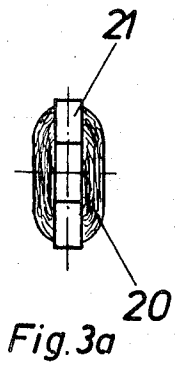
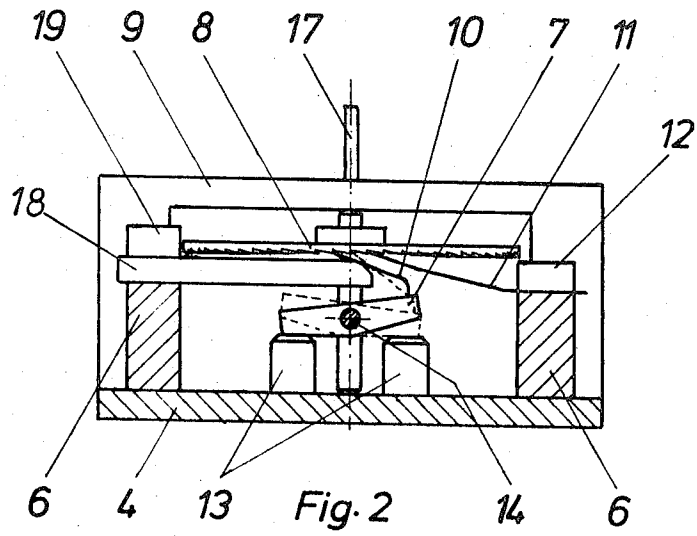


Fig. 2a



ELECTROMECHANICAL TRANSDUCER FOR WATCHES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention concerns a novel stepping mechanism for watches and particularly to a more reliable efficient electromechanical transducer which uses an air core coil mounted on springs to drive a pawl and ratchet mechanism.

2. Description of the Prior Art

As a result of the development of monolithically integrated binary frequency dividers for crystal-controlled watches, it is now possible for the watch manufacturer to depart from the balance-wheel principle and to use simple stepping mechanisms for driving the hands of clocks and watches. Since the accuracy of such clocks and watches is exclusively dependent upon the stability of the crystal resonator frequency, such stepping mechanisms merely have to convert the low-frequency output pulses of the frequency dividers into a mechanical movement.

As a rule, these stepping mechanisms operate on the electrodynamic principle wherein a moving coil arranged within a permanent magnetic field on reset springs is angularly deflected against the spring action as soon as a current is permitted to flow in the coil, with the coil returning to normal upon disconnection of the current.

In a known previous arrangement, the moving coil is wound on a core and is excited into mechanical resonance for stepping along a toothed ratchet wheel by pawl mechanisms.

In this conventional arrangement the core-wound moving coil has a length which is substantially greater than the diameter of the coil, thus achieving a small moment of inertia. Owing to the fact, however, that the mechanical resonant frequency of the moving coil system must be tuned to the reduced frequency of the output pulses of the frequency divider, the dimensions of the known type of moving coil must be held very accurately, and are therefore particularly critical. The resonance principle also makes it necessary for the moving coil to be deflected by at least 180°. In addition, this requires a moving coil oscillating frequency in the order of some 10 Hertz, so that a mechanical gear reduction is necessary between the ratchet wheel and the crown gear.

Although this arrangement is supposed to be relatively insensitive to external shock and impact, it is possible that strong arm movements will affect the drive of the ratchet wheel to cause irregular stepping operation. In addition, very narrow tolerances must be adhered to for both the moving coil and the spiral springs, since inaccuracies in the weight and the dimensions of the coil and springs have a great influence upon the resonant frequency of the moving coil. Finally, substantial energy is required to effect the continuous step-by-step acceleration of the ratchet wheel.

SUMMARY OF THE INVENTION

It is therefore the object of the present invention to avoid the disadvantages of the prior arrangements, and to provide a novel electromechanical transducer for watches which does not require specific tolerances for the moving coil and which is insensitive to shock and

spin movements and in which irregularities due to sudden acceleration of the ratchet wheel are negligible. According to the present invention, this is accomplished by a moving coil having an air-core without an iron core. At one end of the coil axis, there is a driving pawl which engages one of the teeth of the crown gear having a known type of surface toothing. The shaft of the gear vertically intersects the coil axis from which the pawl extends. A magnetic yoke supports another stationary pawl engaging another one of the teeth of the crown gear. The pawls and teeth of the crown gear are designed so that the gear is stepped by one tooth during each resetting of the moving coil. The device is used in quartz watches for stepping the crown gear by rotation of the moving coil which is traversed by a current pulse. The coil oscillates on reset springs within the airgap of a permanent magnet which includes the magnetic yoke. The moving coil has a diameter which is relatively small compared to its length.

An example of a particular embodiment of the present invention will now be explained in greater detail with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a perspective view of an electromechanical transducer according to the present invention,

FIG. 2 shows a side view in partial cross-section of the electromechanical transducer of FIG. 1,

FIG. 2a shows an enlarged view of a portion of the device of FIG. 2, and

FIGS. 3a, b and c show top, front and side views of a tool for use in manufacturing the coil of the electromechanical transducer.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows the novel electromechanical transducer of the present invention with all of the elements mounted on a base plate 4 which may be either of insulating material or metal. On the base plate are two magnet poles 1 which, together with the magnetic yoke 6, constitute a permanent magnet system for producing a radial magnetic field within the airgap as formed by the magnet poles N, S.

The moving coil 2 is arranged with its longitudinal axis in the airgap between the magnet poles N, S, so that the axis will extend parallel in relation to the plane surface of the base plate 4. The lower end is mounted on a shaft 14 supported in a journal bearing 5 which, depending upon the required mechanical quality of the transducer, may be provided with a jewel. A second journal bearing for the upper end of coil 2 and shaft 14 is arranged in the upper transverse portion of magnetic yoke 6.

The moving coil 2 is connected to a pair of spiral springs, one at each of the upper and lower ends, through which the current pulse required for deflecting the coil is applied. The inner ends of the spiral springs 3 are secured at opposite ends of the shaft 14 and the outer ends are mounted on a holder 16 made of insulating material and fixed to the base plate 4 by means of a clamp 15 which also is of an insulating material.

Mounted on the base plate above the transverse portion of the magnetic yoke 6 is a bearing bridge 9 for the crown gear 8 which has a shaft 17 extending vertically in relation to the base plate. The crown gear is provided

with teeth around the outer surface in a known configuration. The shaft 17 of the crown gear 8 is arranged to vertically intersect a line extending from one end of coil axis 14.

A pawl carrier 7 is mounted centrally on the end of the coil axis shaft 14 extending toward crown gear 8. The pawl 10 is secured at one end of carrier 7. Mounted on base plate 4 below the two ends of the carrier are two limiting stop pins 13 which restrict rotary movement of the moving coil 14 to about 20° as the pawl carrier 7 meets the stop pins. Another ratchet pawl 11 is mounted on the right side of magnetic yoke 6 and secured by a clamping member 12.

Both the pawl 10 and the teeth of the crown gear 8 are so designed that the crown gear is stepped by a single tooth during each resetting of the moving coil. For this purpose a pawl stop 18 is provided, with the pawl 10 engaging the end surface thereof. The pawl stop 18 is mounted on the left side of magnetic yoke 6 and secured by clamping member 19.

The moving coil 2 which is wound without a core, is retained in the indicated normal position by the spiral springs 3. The dashed line in FIG. 2 shows the position of the pawl carrier 7 in the condition after the moving coil has been deflected by a current pulse. Due to the deflection of the moving coil, the pawl carrier 7 is deflected until meeting the limiting stop pin shown on the right side in FIG. 2, so that the pawl 10 will engage the successive tooth of the crown gear 8 lying next to the original tooth. Upon termination of the current flow in the moving coil 2, the latter is returned to the normal position by the action of the spiral springs, so that pawl 10 engages a tooth and steps crown gear 8 in the clockwise direction. At the same time the ratchet pawl 11 engages a new tooth.

From the energy standpoint, this action is equivalent to the opposite embodiment which steps the gear during the initial deflection of the coil. However, due to the stepping movement being effected while the moving coil is returning to normal, the coil is deflected by a short current pulse, and thus sufficient time remains for the stepping action during the comparatively long interval between two successive current pulses. To achieve reliable operation, the duration of the current pulse can be adjusted so that the pawl carrier 7 reaches the limiting stop pins 13 prior to the termination of the current pulse.

FIG. 2a, on an enlarged scale, shows a further embodiment of the invention. The pawls 10, 11 which may be in the form of springs 10b, 11b, carry jewels 10a, 11a. The jewel 10a of pawl 10 has a wedge-shape at its end which is in engagement with a tooth of the crown gear 8 and is mounted on spring 10b so that the edges of the jewel 10a will fit against both the front and the rear faces of a tooth of the crown gear 8. The front face of the tooth is the primary one that meets the pawl during the stepping operation.

In the normal position of the coil, the end of jewel 10a of pawl 10 also contacts a correspondingly shaped end surface of the pawl stop 18, while the top surface area of the jewel contacts the rear surface of the respective tooth of the crown gear 8. Both the top and bottom surfaces of jewel 10a together form an angle of preferably 15° to 18° while the surfaces of both the front and the rear face of the teeth are preferably vertical with respect to each other.

This embodiment of jewel 10a reliably prevents the crown gear from being stepped in excess of one circular tooth pitch, since the rear face of the tooth which is in engagement with the jewel, upon further rotation or any external acceleration, would have to press the jewel vertically in the downward direction. Such movement, however, is prevented by the jewel meeting the end surface of the pawl stop 18. Turning of the crown gear 8 in the opposite direction is also prevented by the ratchet pawl 11, so that the crown gear 8 will remain firmly oriented in its position after each stepping operation. Preventing the crown gear from being further rotated can also be realized without the aid of a jewel. For this purpose, the pawl stop 18 would have to be extended so that in the normal position of the moving coil 2 the spring of the pawl, will meet the end surface of the stop.

Since the present electromechanical transducer does not employ mechanical resonance as used in the prior art, the moving coil can be made much more simple, with the dimensions being uncritical as regards the stepping reliability. The present device can therefore use a coreless or air core coil. Such a coil can be made easily as shown in FIGS. 3a, b and c.

For this purpose, a U-shaped coil winding tool 21 is used which is made from a flexible material with the ends having the capability of being pressed together. Each end of the U-shaped tool 21 is provided with a recess 20 into which the coil is wound. Upon application of the necessary number of turns, the individual coil windings are secured in position with respect to one another either by spraying with, or immersion into, a lacquer. Upon hardening of the lacquer, the ends of the U-shaped tool are pressed together to permit the coil to be removed.

Since the present transducer can be operated with relatively short current pulses, the moving coil may be wound with substantially less resistance than a coil used in the mechanical resonance type arrangement. This permits normal sized wire to be used. The current flowing in the coil is then momentarily larger than in the conventional arrangement. However, since current flows only for a fraction of a second, the entire energy consumption of this arrangement is about one quarter less than in the conventional arrangement. This saving of energy can be utilized to operate frequency-divider stages to further reduce the usual frequency of some ten Hertz to a frequency of one Hertz.

What is claimed is:

1. An electromechanical stepping device comprising a magnetic yoke having a pair of opposite facing poles, a movable air core coil rotatably supported between said poles on a shaft having a longitudinal axis between and parallel to the opposite faces of said poles, a pair of reset springs secured at opposite ends of said shaft and connected to said coil to apply current thereto, both said springs being rotatable with said coil and shaft and returning said coil to a reset position, a toothed gear mounted on a central axis, said gear axis being aligned with and perpendicular to said coil shaft axis, and a first pawl mounted at one end of said shaft to rotatably engage separate successive teeth of said gear upon each return movement of said coil after application of a current pulse to rotate said coil, said gear being stepped by one tooth during each return movement of said coil.

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2. The device of claim 1 including a pawl carrier rotatably mounted at one end of said shaft securing said first pawl thereon, and a pair of limit stop pins mounted under each end of said carrier to limit rotatable movement of said carrier.

3. The device of claim 2 including a second pawl secured at one side of said yoke to successively engage another one of said teeth of said gear each time said first pawl engages a tooth.

4. The device of claim 3 including a pawl stop secured at the other side of said yoke to limit movement of said first pawl.

5. The device of claim 4 wherein said first and second

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pawls are mounted at the ends of springs.

6. The device of claim 5 including a pair of jewels secured respectively at the end of each pawl engaging said teeth.

5 7. The device of claim 6 wherein the edges of said jewel at the end of said first pawl engage both the front and rear face of a tooth of said gear.

8. The device of claim 7 wherein another edge of said jewel engages a surface of said pawl stop.

10 9. The device of claim 7 wherein the front and rear faces of the teeth of said gear form an angle of 90°.

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