A stepping motor for timepieces comprising a movable coil means which is intermittently activated by electrical drive means to move between two extreme positions and an escapement member engaging the coil means to transmit the step-by-step movement to an escapement wheel. The coil means and escapement member are poised so that radial accelerations that may affect the rotation of the coil means are eliminated by the compensating movement of the escapement member. The resultant low moment of inertia for the coil results in low power consumption and a highly efficient motor.

8 Claims, 4 Drawing Figures
STEPPING MOTOR FOR TIMEPIECES

BACKGROUND OF THE INVENTION

The present invention relates to timepieces and particularly to a drive means for such timepieces such as a stepping motor. The present motor includes a pivotal electrodynamically movable drive member that meshes at least indirectly by means of an escapement member with an escapement wheel and progressively drives the wheel ahead step by step. Such indexing motors are mostly installed in quartz or tuning fork controlled timekeeping devices in which, as a means of energy economy, no provision is made for a directly battery driven escapement wheel.

In a typical arrangement, the drive member is an elongated discoid coil that is swingable between two extreme positions in the magnetic field of an eight-pole permanent magnet arrangement by pulsating electrical excitations. The escapement member that meshes with the escapement wheel is securely in communication with the coil and is constantly drawn into one of the extreme positions by a spiral that conducts current to the coil.

This known arrangement can as a whole be balanced out and made substantially inert to translatory accelerations, but it has the negative feature that rotary accelerations about a given constructive value, as often occur by swinging the arm bearing the watch, can effect an unwanted moving ahead of the escapement wheel. This can add up to significant errors in timekeeping, particularly where the wearer of a wrist watch is a very active person or person who walks very much.

SUMMARY OF THE INVENTION

In contrast thereto, the present invention aims at the creation of an electrically actuating indexing motor of the above referred to type, which, with only a mirror investment for additional material, is compensated against rotary acceleration to a high degree and thereby ensures a greater accuracy of the timekeeping device.

According to the instant invention, this object is attained in that the drive member and the escapement member are separate components pivotal on parallel axes and have mechanical transmissional member by means of which the drive member and the escapement member are positively connected and movable in opposite directions, and with regard to either one of the pivotal axes have, at least periodically, practically identical moments of inertia. Moment of inertia is defined herein for each of the members as the product obtained by multiplying the mass moment of inertia of rotation of the member by the total angle through which the same member rotates about its pivotal axis.

This arrangement has the advantage that rotary impulses transmitted to the driving member by unavoidable imbalances and ever-present frictional forces are counteracted by a substantially equally great rotary impulse, whereby the disturbing influence of the former is neutralized. With regard to the specified production accuracies, it is of advantage that tolerances proper no longer need be regarded but, rather, only their deviations.

In one embodiment of the invention, the drive member has a lever with a pin at one end that engages, with play, a slot in the escapement member. If, in this case, the drive member and the escapement member are pivotal between two extreme positions, the drive member and the escapement member have the advantage of having identical moments of inertia in the two extreme positions. In fact, it is even permissible if the two moments of inertia between the extreme positions differ to a minor degree for at least for reasons of energy economy, care will be exercised that the drive member and so also the escapement member will be situated in one of the extreme positions the greater part of a time interval.

According to another embodiment of the invention, the drive member has a lever with teeth at one end that mesh with matching teeth on the escapement member. With regard to production technique, this embodiment is more difficult to realize but it has the advantage that the two moments of inertia, in relation to one of the pivotal axes, are always of identical size.

In an indexing motor assembly comprising a further embodiment of the invention, a safeguard against unintentional movement of the escape wheel — where the drive member is a pivotal elongated discoid coil before or between a flat permanent magnet arrangement within two extreme positions — can be provided in that the coil and/or the escapement member has a soft iron section of such form that it is more strongly attracted by the permanent magnet arrangement at the extreme positions than between said extreme positions.

The operation of such an arrangement requires electrical pulses of alternating polarity. This has the further advantages that an occasional unintentional movement ahead of the escape wheel within one interval of time has no influence upon the accuracy of the device since the next pulse would move the escape wheel into the respective positions anyhow.

However, the indexing motor can also be operated by impulses of identical polarity. To this end the soft iron member, in a different embodiment of the invention, is disposed in such an unsymmetrical manner that it is more strongly attracted to the one extreme position than to the other.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the present invention may be more clearly seen when viewed in conjunction with the accompanying drawings wherein:

FIG. 1 is a plan view of an embodiment of the indexing motor according to this invention.

FIG. 2 is a section along the line 2 — 2 in FIG. 1.

FIG. 3 is a perspective view of the permanent magnet arrangement of the indexing motor shown in FIG. 1, and

FIG. 4 is a section of a plan view of a further embodiment of the indexing motor in accordance with this invention.

DETAILED DESCRIPTION OF THE INVENTION

FIGS. 1, 2 and 3 represent a first embodiment of an indexing motor pursuant to this invention. Accordingly, a driving member contains an elongated discoid coil which is wound in such a way that it generates a magnetic field when excited, which in FIG. 1 stands perpendicular to the plane of the drawing. Coil 10 contacts with a permanent magnet arrangement 12 composed of four magnets 14, 16, 18 and 20. The perma-
nent magnets are positioned on carrier plates 22 and 24 to which they are secured, for example, by bonding.

Coil 10 is not wound on any body and is pivotally mounted on a staff 28 between two extreme positions inside of two frame plates 30 and 32 by centrally arranged securing member 26. Coil 10 on the one hand can be electrically excited by pulses fed over a terminal 34, a spiral 36 and a conductor 38. The circuit path further includes a terminal 40, a spiral 42 and a conductor 44. Spiral 36 is secured to staff 28 by insulating members 46 and spiral 42 by clamping member 48. Conductor 44 is also secured to said staff 28.

In operation, coil 10, when excited by a current in a counterclockwise direction, assumes the position shown in FIG. 1. If, however, coil 10 is excited clockwise by a current, its magnetic field reverses and it swings into the other extreme position not shown in FIG. 1.

The indexing motor of the instant invention furthermore contains an escape wheel 50 that is engaged by the escapement pins 52 and 54 which move the escape wheel progressively ahead step-by-step. The escape wheel 50 may serve as a seconds wheel which actuates the remaining hands of the watch through a drive arrangement (not shown).

The escapement pins 52 and 54 are not in direct mechanical communication with coil 10, but are disposed on an escapement member 56 mounted within two frame plates 60 and 62 on a staff and pivotal in the opposite direction of coil 10. It is advantageous to have the axes of the two staffs disposed parallel to each other.

As transmitting means between coil 10 and escapement member 56 there is disposed, in the first illustrated embodiment, a lever 64 secured to coil 10 and/or its securing member 26 and a slot 66 disposed approximately centrally in the escapement member 56 and pointing in the direction of the staff 58 of said member 56. A pin 68 is mounted at the end of lever 64. The transmitting means comprised of lever 64 and slot 66, in coaction with pin 68, effect the constant oppositely oriented pivotal movement of coil 10 and escapement member 56.

As shown in FIG. 4, the transmitting means may also be comprises of a lever 70 in communication with coil 10 as well as teeth 72 in or on the escapement member 56 which latter component meshes with teeth 74 at one end of lever 70. In this case, too, the transmitting means comprised of lever 70 and teeth 72 constantly ensures that, in coaction with teeth 74, the coil 10 and the escapement member 56 are pivotally moved in contrary directions.

The actual moments of inertia of coil 10 and escapement member 56, i.e., the moments of inertia of these components including those of all components in communication with the same, are selected so that they are identical with reference to one of the axes of the staffs 28 or 58. In a reference of moments of inertia from one axis to a joint reference axis the transmission ratio is taken into account, in this case it is determined by the position of pin 68 with regard to the staffs 28 and 58 and/or the pair of gear sections formed by teeth 72 and 74. It is possible depending on the space available and/or on the material comprising the escapement member 56, to compensate for the moment of inertia of coil 10 (including that of securing member 26 and lever 64) by a more or less voluminous escapement member 56. The angles about which coil 10 and escapement member 56 are pivoted likewise depend on the transmission ratio of the two pivoting masses, naturally in vise versa relation.

In the arrangement of FIG. 1, the transmission ratio between coil 10 and escapement member 56 changes during their pivotal movement by a minor amount. This variation may be neglected in practical operation. It is, however, of advantage to dimension the arrangement in such a way that the uniformity of the moments of inertia occurs in the specified sense precisely at the two extreme positions. Since coil 10 for energetic reasons is only impulsively excited and thus only moves in unison with the escapement member 56 for a fraction of an interval (for example, in 5 of 100 milliseconds) and is otherwise situated at one of the extreme end positions (e.g., for 95 milliseconds) this design can attain a practically adequate compensation of the two pivotally moving masses. Where necessary complete compensation can also be theoretically obtained by the arrangement as shown in FIG. 4, since the transmission ratio of a pair of gear sections does not change during their pivotal movement.

The reliability of the indexing motor according to this invention in the face of unintentional movements of coil 10 is enhanced in the embodiments illustrated in FIGS. 1 and 2 by the two soft iron member 76 and 78. The member 76 and 78 are secured to coil 10 and/or lever 64 in such a way that they are attracted more strongly by the permanent magnet arrangement 12 at the extreme positions than in between said extreme positions. Since also escapement member 56, during its pivotal movement, comes close to permanent magnet arrangement 12, soft iron members 80 and 82 may also be provided on said escapement member, as indicated in FIG. 1 by a dot and dash line.

In order to index escapement wheel 50 progressively ahead by only one tooth at a time, coil 10 must be alternately excited by impulses of positive and negative polarity. It is, however, also possible to omit the soft iron members 78 and 82 and to excite coil 10 by the impulse of a single polarity pulse only.

To facilitate the introduction of coil 10 and the components combined therewith into the permanent magnet arrangement 12, the carrier plates 22 and 24 have a recess 84 which, for reasons of expediency, is disposed somewhat obliquely.

It is to be understood that the above-described arrangements are merely illustrative examples of the application. Numerous other arrangements may be readily devise by those skilled in the art which will embody the principles of the invention and fall within the spirit and scope thereof.

I claim:

1. In a stepping motor for electrically driven timepieces including an escapement wheel the combination which comprises:

a pivotally electrodynamically movable drive member comprising a coil pivotal between two extreme positions,

an escapement member pivotally mounted about an axis parallel to the axis of the drive member and engaging the escapement wheel to step the timepiece,

magnet means interacting with the coil so that the coil is more strongly attracted by the magnet means
at the extreme positions than between said positions, and, said drive member and said escapement member being positively coupled and movable in opposite directions and wherein said drive member and escapement member have at least periodically substantially the same moments of inertia to prevent timekeeping errors due to rotary accelerations of the timepiece.

2. A stepping motor in accordance with claim 1 wherein:
the drive member further includes a lever coupled to the coil, said lever engaging the escapement member to transmit motion thereto.

3. A stepping motor in accordance with claim 1 wherein:
the drive member includes a coil and a shaped lever coupled to each other and rotatable about the same axis, the lever including projecting means to engage the escapement member.

4. A stepping motor in accordance with claim 3 wherein:
the escapement member includes a slotted portion engaged by the lever projecting means to drive said member back and forth, and spaced projecting means to alternately engage the escapement wheel.

5. A stepping motor in accordance with claim 1 wherein:
at least one of said members includes a soft iron component disposed in an unsymmetrical arrangement so that the particular member is more strongly attracted in one extreme position than the other.

6. In a stepping motor for electrically driven timepieces including an escapement wheel the combination which comprises:
a pivotal electrodynamically movable drive member comprising an elongated discoid coil having a soft iron portion thereon for purposes of magnetic attraction,
an escapement member pivotably mounted about an axis parallel to the axis of the drive member and engaging the escapement wheel to step the timepiece, and
said drive member and said escapement member being positively coupled and movable in opposite directions and wherein said drive member and escapement member had at least periodically substantially the same moments of inertia to prevent timekeeping errors due to rotary accelerations of the timepiece.

7. In a stepping motor for electrically driven timepieces including an escapement wheel the combination which comprises:
a pivotal electrodynamically movable drive member,
an escapement member pivotably mounted about an axis parallel to the axis of the drive member and engaging the escapement wheel to step the timepiece, and
said drive member and said escapement member being positively coupled and movable in opposite directions and wherein said drive member and escapement member have at least periodically substantially the same moments of inertia to prevent timekeeping errors due to rotary accelerations of the timepiece.

8. In a stepping motor for electrically driven timepieces including an escapement wheel the combination which comprises:
a pivotal electrodynamically movable drive member including a coil and a shaped lever coupled to each other and rotatable about the same axis, the lever having a plurality of teeth at one end thereof, and
an escapement member pivotably mounted about an axis parallel to the axis of the drive member and engaging the escapement wheel to step the timepiece, said escapement member including a toothed portion engaged by the toothed portion of the lever, and
said drive member and said escapement member being positively coupled and movable in opposite directions and wherein said drive member and escapement member have at least periodically substantially the same moments of inertia to prevent timekeeping errors due to rotary accelerations of the timepiece.

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