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Radnik et al.

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[54] **ELECTRO-MECHANICAL DRIVE MECHANISM FOR WATCHES AND RELATED DEVICES**

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[52] **U.S. Cl.** ....**58/23 D,** 58/116, 74/126, 310/27

[51] **Int. Cl.** **G04c 3/00,** G04b 15/14, G02k 33/02

[58] **Field of Search** ....58/23, 48, 116; 74/126, 141.5; 235/92 C, 92 H; 310/15, 27, 29, 30

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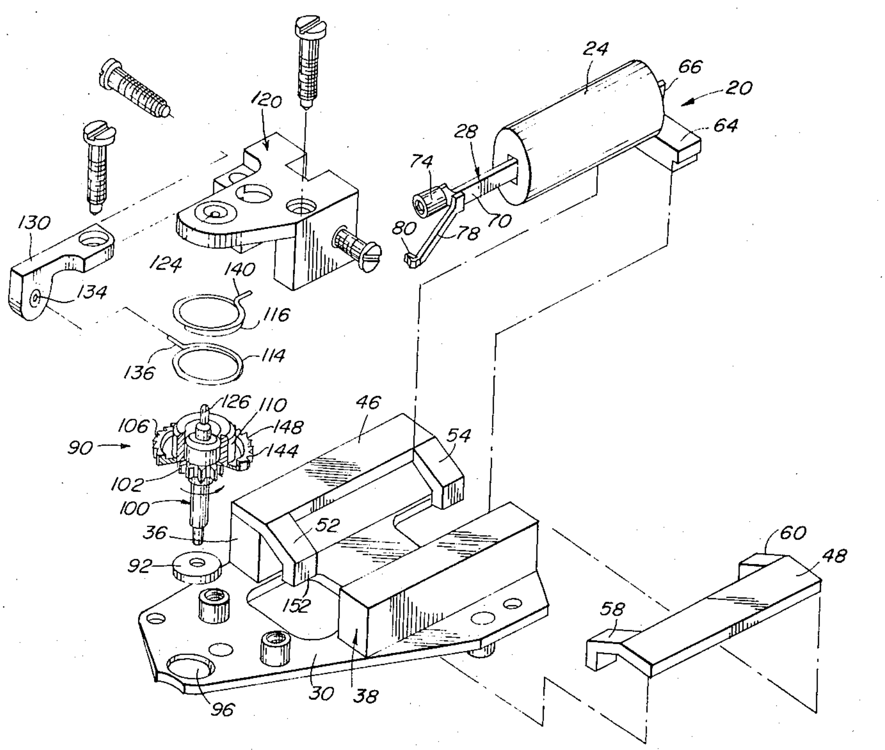
[57] **ABSTRACT**

In an electro-mechanical transducer for driving an escapement wheel of a timing device such as an electronic watch or the like, a miniature drive system comprising a clutch mechanism coupled to the shaft of the escapement wheel through an electro-magnetically actuated control arm mechanically to drive the escapement wheel stepwise, thereby to effect time-spaced incremental angular advancement of the escapement wheel.

24 Claims, 8 Drawing Figures



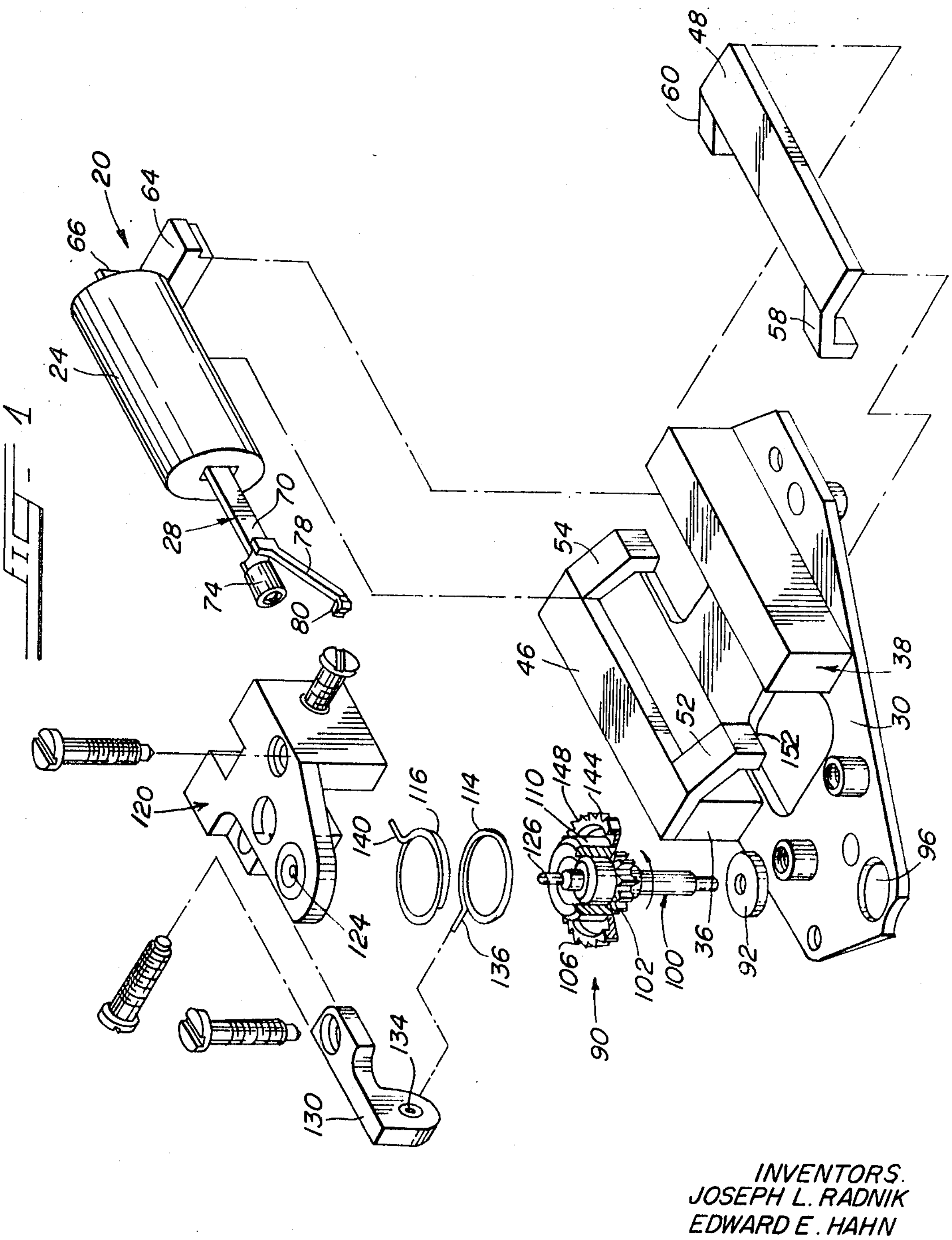


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FIG. 2

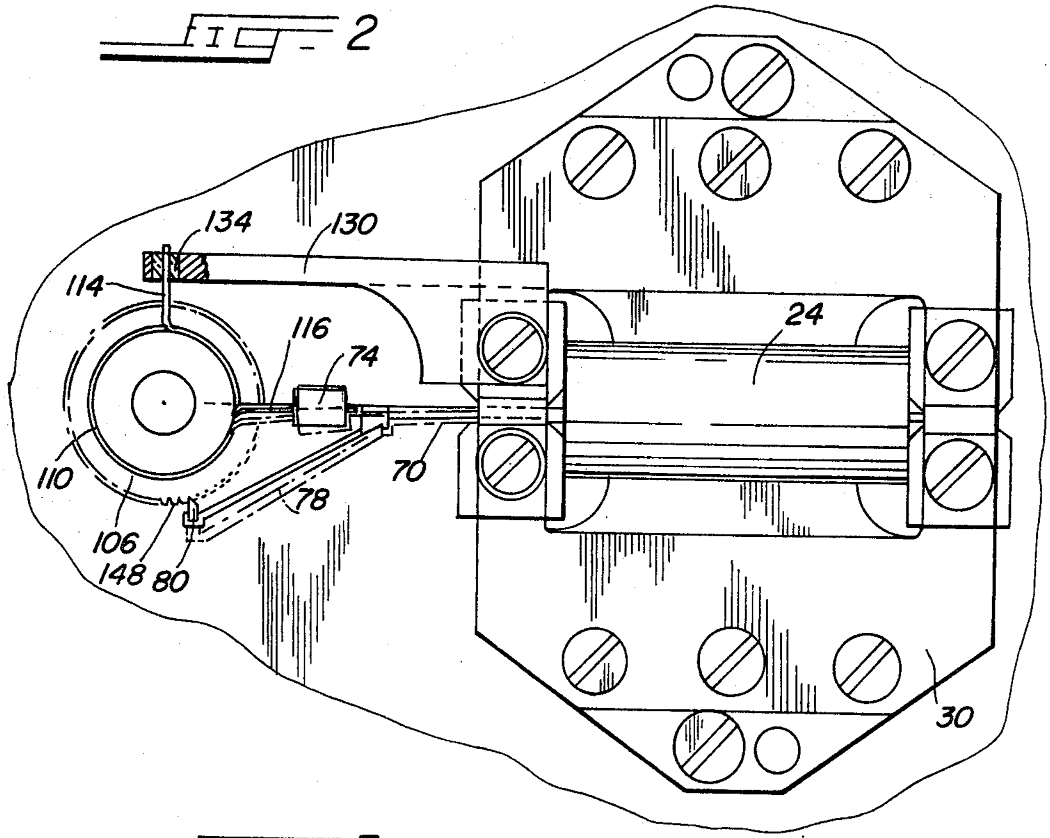

FIG. 3

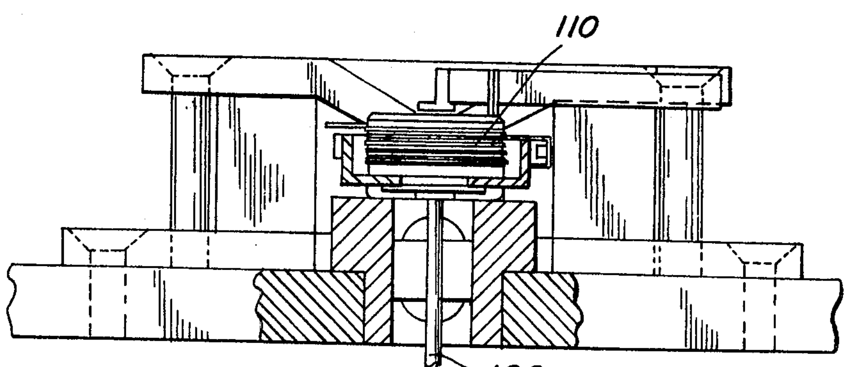

FIG. 4

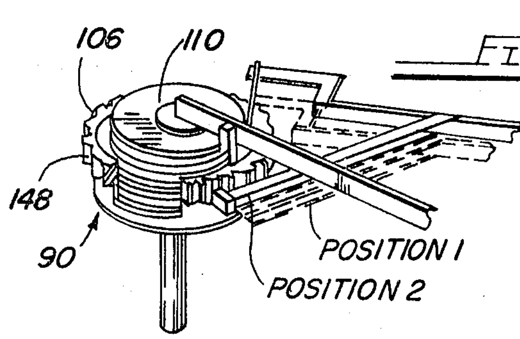

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FIG. 5

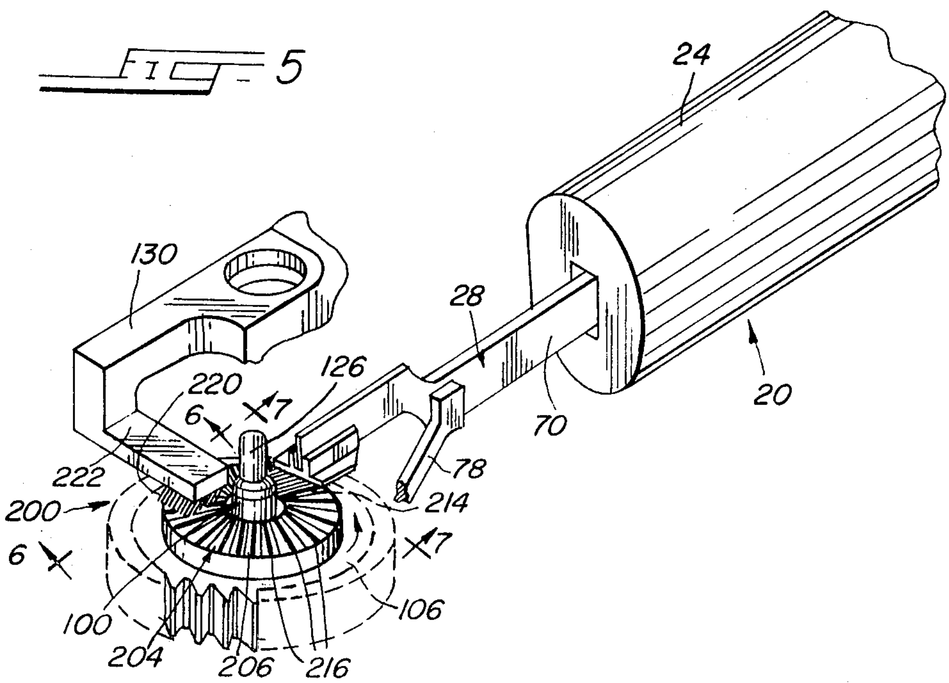


FIG. 7

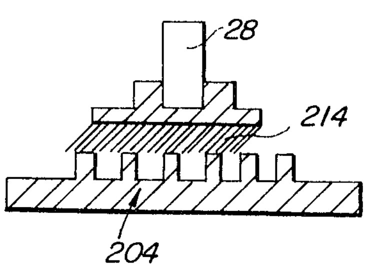


FIG. 6

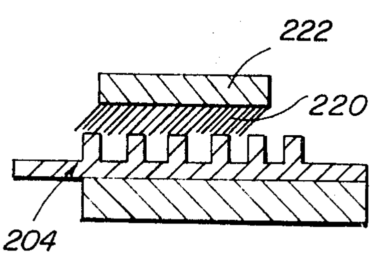
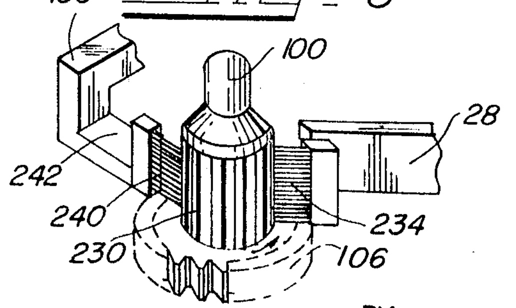


FIG. 8



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ELECTRO-MECHANICAL DRIVE MECHANISM FOR WATCHES AND RELATED DEVICES

This invention relates generally to improvements in drive systems of the type finding utility in precision timing devices such as electronic watches and chronometers. More particularly, the invention is directed to a miniature electromechanical actuator system effective to produce stepped, precise, incremental angular rotation of an output shaft at very low input power levels and with very low duty cycle operation.

In its preferred embodiment the invention includes a non-resonant electro-magnetic energy converter and a miniature clutch drive subassembly, the converter and the clutch and drive components cooperating to produce translational mechanical motion upon energization by low-amplitude, small duration current pulses supplied by a low voltage miniature battery and a transistor switch controlled through a precision oscillator. The translational motion is converted into rotational motion through the expedient of a "toothless ratchet" clutch sub-system. Precision angular stepping is achieved through the use of a pallet stone index wheel arrangement.

The small dimensions of electric wrist watches or pocket watches render it essential that the efficiency of conversion of battery-derived electrical energy to rotative mechanical force for driving the escapement wheel be maintained at an extremely high level. For the most part, the electro-mechanical converters of the prior art have undesirable, inherently low conversion efficiencies due either to the arrangement of magnetic circuitry or to frictional impediments. It is the aim of the present invention to obviate the shortcomings of prior art devices and to provide a simple yet highly effective, low-friction electro-mechanical system for driving the escapement wheel of a timepiece or similar device.

In accordance with one embodiment of the present invention there is provided in an electrical watch mechanism utilizing a standard frequency transmitter stabilized by means of a resonant element and an electronic frequency reducer, an improved electro-mechanical transducer or electro-mechanical converter in which frictional losses are minimized and power demands are extremely low.

It is an important feature of the present invention that the electro-mechanical converter includes electro-magnetic means for dictating the movement of a control arm, the latter acting upon and driving a clutching assembly whereby electrical and electro-magnetic energy are effective to produce rotative motion of an escapement wheel.

It is another important feature of the electro-mechanical converter that there is established a unique intercooperation between permanent magnetic means and electro-magnetic means to impart pivotal movement to a control arm which drives an escapement wheel.

According to one preferred embodiment of the invention, a novel spring clutch and drive assembly utilized includes a pair of coaxial, wound spring elements embracing a drive shaft of an escapement wheel, the spring elements serving both as escapement wheel holding and advancing means.

In a second preferred embodiment of the invention a fiber clutch assembly serves as a coupling means by which a control arm advances an escapement wheel.

An important feature of the driving mechanism of the present invention is that there are invoked intermittent, time-spaced stepping pulses rather than a harmonic drive.

It is still another important feature of the present invention that the power requirement is 5 microwatts or less and that the duration of the control-arm-actuating pulse is exceedingly short.

Yet another feature of the invention is that frictional losses are minimized through the use of a flexural pivot in place of conventional bearings.

Other and further features and advantages of the invention will become apparent from a reading of the following specification taken in conjunction with the drawing in which:

FIG. 1 is an exploded perspective view of an electro-mechanical drive mechanism in accordance with one preferred embodiment of the present invention, and showing the interrelationship of its component parts;

FIG. 2 is an enlarged plan view of the spring clutch drive of the invention;

FIG. 3 is an elevational view showing the escapement wheel support and drive structure;

FIG. 4 is a fragmentary perspective view showing, schematically, the indexing pawl cooperating with the control arm of the clutching and drive mechanism, in two different positions;

FIG. 5 is a perspective view showing a second embodiment of a drive and clutch assembly in accordance with the invention;

FIGS. 6 and 7 are cross sectional views taken respectively on the lines 6—6 and 7—7 of FIG. 5 and showing the fiber-carrying drive arm, the cooperating clutch plate, and the fiber filament check means for preventing counter rotation of the driven clutch plate; and

FIG. 8 is a perspective view showing an alternative fiber clutch drive assembly, in accordance with the invention.

The present invention provides an improved system of conversion of electrical and electro-magnetic energy to rotative energy. As indicated above, and as described in detail below, the electro-magnetic energy converter produces translational mechanical motion when energized by low-amplitude, small duration current pulses supplied by a low voltage miniature battery and a transistor switch which is in turn controlled by a precision oscillator. The battery is conventional, and the precision oscillator does not broadly, as such, constitute an inventive feature of the invention. Accordingly, no detailed description is provided herein. The translational mechanical motion is converted into rotational motion by means of a "-toothless ratchet", clutch sub-system, and precision angular steps are ensured through the use of a pallet stone index wheel arrangement.

The miniature energy converter is a non-resonant, polarized electro-magnetic device which transforms low voltage electrical power into mechanical power at extremely low input power levels and low duty cycle rates. In the illustrative examples of invention described below, the intended use of the energy converter is as a power unit for miniature precision timing devices such as electronic watches and chronometers. The device itself is extremely versatile and is capable of operating and driving many mechanical systems including ratchet wheels, indexing mechanisms, and other drive systems to provide precision, incremental mechanical motion.

For purposes of illustration, the operation of the various components of the invention will be described herein with specific reference to a watch mechanism. Since the components of the watch mechanism other than the electro-magnetic drive assembly and the electro-mechanical transducer do not constitute part of the subject invention, no detailed description of these is provided herein.

Referring more particularly to the drawing, there is shown, in FIGS. 1 through 4 for the purposes of illustrative disclosure, one preferred embodiment of the electro-mechanical drive mechanism of the invention, incorporating the teachings thereof. As shown in FIG. 1, the physical components of the electro-magnetic drive and the electro-mechanical transducer include a solenoid assembly **20** comprising a solenoid coil **24** and an armature or control arm **28** extending axially into the coil **24** and projecting outwardly from one end thereof. The solenoid coil **24** is carried on a platen or plate **30** and is cradled between a pair of opposed permanent magnets **36** and **38** extending generally parallel to the axis of the coil **24**. Substantially co-extensive with the permanent magnets **36** and **38** and superimposed thereon is a pair of generally U-shaped pole pieces **46** and **48**, the respective poles or arms **52** and **54** and **58** and **60** extending toward the solenoid coil **24** and generally normal to the longitudinally extending axis thereof. A bar **64** of non-magnetic material is attached to plate **30** and supports the rear end **66** of the coil armature **28**.

Referring further to FIG. 1, which illustrates one preferred form of the clutch assembly, the forwardly projecting portion **70** of the coil armature **28** carries at its end a jeweled receptacle **74**. Also secured to the armature **28** and extending generally forwardly thereof is a ratchet arm **78** terminating in a jeweled probe or pallet stone **80**.

An escapement wheel assembly **90** is mounted on and rotatably supported by the magnet-carrying plate **30**. The escapement wheel assembly includes a plate jewel **92** secured in an opening **96** formed in the plate **30**. Rotatably engaged in the plate jewel **92** and extending upwardly therefrom is a drive shaft, output shaft or pinion staff **100**, and carried by the staff are a coaxial pinion **102**, a toothed ratchet wheel or escapement wheel **106**, and a "ratchet" drum **110**. In one form of the invention illustrated, a clutch assembly includes a pair of wound, coaxial springs **114** and **116** encircling and embracing the shaft-mounted drum **110**. One spring (spring **114**) serves as a locking spring, and the other (spring **116**) functions as a "toothless ratchet" mechanism. A bridge plate **120** surmounts the ratchet and pinion staff assembly **90**, the bridge having formed therein a jeweled bushing **124** in which the upper end **126** of the pinion staff **100** is rotatably received.

Secured to the bridge plate **120** and extending outwardly therefrom is a locking spring support arm **130** provided with a jeweled opening, socket or receptacle **134** into which an end **136** of the locking spring **114** is received. An end **140** of the other spring **116** is received in the jeweled receptacle **74** carried by the coil armature **28**. At the same time, the jeweled probe or pallet stone **80** extending from the coil armature **28** projects into and seats in an interdental space **144** between teeth or cogs **148** of the ratchet wheel **106**.

The solenoid assembly **20** which functions as a part of the miniature energy converter of the invention is a non-resonant, polarized, electro-magnetic device which transforms low voltage electric power to mechanical power at extremely low input power levels and low duty cycle rates. As illustrated and described, the energy converter consists of the combination of soft iron pole pieces, a soft iron armature, permanent magnets, and a coil.

In order to minimize frictional losses, the converter incorporates a flexural pivot in the form of a cantilever armature **28**. A unique and very important feature of the converter is that during its unenergized state, the armature **28** is sealed or stopped adjacent one pole or pole face **52** of the working gap **152**. This condition is achieved through the use of the permanent magnets **36** and **38** and mechanical unbalance. A low-amplitude, short-duration current pulse of the appropriate polarity produces an electro-magnetic force which overcomes the permanent magnet seal force, causing armature shifting and releasing the stored energy of the deflected cantilever. At the same time, the established electro-magnetic force also acts directly on the armature to urge it from its rest position. At the cessation of the current pulse, the armature returns to its "-stand-by", seal, or rest position under the influence of the permanent magnet forces. The armature **28** remains "distorted" and stressed in this position until the next current pulse.

The current pulses themselves may be derived from a 1.5 volt miniature battery through a transistor switch controlled by a precision oscillator (not shown). The battery, transistor switch and the precision oscillator form no part of the instant invention and, accordingly, no detailed description is provided, many appropriate and useful circuits being known in the prior art.

The dynamics of the armature are preferably selected to provide a mechanical response time which permits extremely low duty cycle operation of the converter. Current pulses of about 0.8 to 2.0 millisecond duration are adequate to operate ratchet wheels, indexing mechanisms, and other rotational drive systems. On a 1 stroke per second basis, the converter is capable of operating with an average power input of 5 microwatts or less from a miniature battery. The low power demand and consumption are particularly valuable in ensuring extended battery life.

Upon energization of the solenoid coil **24** of the energy converter, the resulting physical displacement or shifting of the armature **28** within the coil **24** is converted into rotational motion through the "toothless ratchet" spring clutch **116** (FIG. **2**). Precision angular steps are ensured by indexing achieved through the ratchet wheel **106** and the cooperating amrature-carried jeweled probe or pallet stone **80** acting thereupon. The exact mode of operation and the intercooperation of the various mechanical components are further amplified in the following description.

The power stroke of the energy converter, at pulsing of the electro-magnet, causes a shift of the armature **28** between the poles **52** and **58** of the pole pieces **46** and **48**. Since the armature is mechanically coupled to the upper spring (ratchet spring) **116**, the effect of armature shifting is to wind or unwind that spring. During the power stroke, the spring **116** is unwound, rotating freely on the ratchet drum **110**. At the same time, the output shaft or pinion staff **100** of the escapement wheel assembly is prevented from rotating by the frictional gripping or locking action of the lower clutch spring **114**. At termination of the applied driving pulse, the armature **28** returns to its quiescent position under the influence of the permanent magnets **36** and **38**. The return path executed by the armature **28** produces rotation of the clutch spring **116** in a direction to tighten the spring **116** which then grips and causes the ratchet drum **110** and the output shaft **100** secured thereto to rotate. During this particular time interval, the lower spring or locking spring **114** is "unwound" and exerts minimal locking torque to obviate interference with the rotation of the encircled ratchet drum **110**. It will be appreciated that under this mode of operation, the load upon the energy converter during the power stroke is of extremely low inertia and friction since the upper spring **116** has low mass and low friction in the unwound condition. Frictional losses are further minimized through the use of the flexural pivot of the armature **28** in place of conventional bearings. All of the above factors contribute to low duty cycle, fast response, and minimal damping of the mechanical system. An extremely simple structure having low input power requirements is achieved.

As illustrated and described above, the electro-mechanical converter of the invention provides controlled intermittent stepping rotational movement of the output shaft or drive shaft **100** of the escapement wheel assembly **90** through an impulse stepping system rather than through a harmonic drive. In the preferred embodiment of the invention illustrated, the output arm or armature **28** shifts at a frequency of 1 cycle per second and the output shaft **100** is driven 6° each shifting cycle, or 1 rotation per minute. Accordingly, the output shaft **100** may serve as the shaft for a second hand of a watch mechanism.

The manner in which the escapement wheel is driven will be apparent from the foregoing description and it will be understood that as the armature arm **28** moves from position **2** to position **1** as illustrated in FIG. **4**, the drive spring **116** tends to open and slide around the shaft-carried ratchet drum **110**. The fixed spring **114** tends to be tightened, ensuring that the drum and output shaft cannot rotate during this period of armature motion. At the same time, the escapement wheel keying jewel or pallet stone **80** moves out of contact with the face of cog or tooth **148** of the escapement wheel **106**. As the armature **28** returns from position **1** to position **2**, the drive spring **116** tends to wind, gripping the ratchet drum **110** and advancing the drum and escapement wheel **106** an incremental step. Concurrently, the pallet stone **80** moves into engagement with a face of the next cog **148** of the escapement wheel **106**. That is, the clearances provided are such that the rotational shift of the drum **110** effects an advancement of one tooth position before the pallet stone **80** reengages the escapement wheel **106**. This indexing procedure ensures a precise, controlled rotational shift for each shifting cycle of the driving armature **28**, and limits further rotation of the wheel **106**. In the particular embodiment of the invention illustrated, each step is 6°. In case of under travel of the escapement wheel, the pallet stone **80** ensures a completion of the step. The mechanism is simple, highly shock resistant, unusually reliable, has relatively few moving parts, and provides highly accurate control of the rotational motion and assurance of uniform precise incremental steps. It will be appreciated that, if desired, the physical arrangement of elements may be such that advancement of the escapement wheel occurs as the armature **28** moves from position 1 to position 2, that is, during shift from the rest position to the displaced position.

A second embodiment of the clutch assembly, fabricated in accordance with the concept of the instant invention and finding utility as a drive shaft advancing mechanism, is illustrated in FIGS. 5–7. As shown, the clutch assembly 200 differs from the dual spring embodiment of FIG. 2, previously described, principally in the form of mechanical elements through which the drive shaft 100 and the escapement wheel 106 carried thereby are advanced.

A clutch plate 204, mounted on the drive shaft 100 for rotation therewith, is provided on a principal surface 206 thereof extending generally normally of the drive shaft 100, with a plurality of elements establishing surface irregularities and constituting abutment means for cooperative interengagement with extremities of fiber-like projections 214 carried on the projecting end portion of the armature or control arm 28 of the solenoid assembly 20. In the particular form of the clutch plate illustrated, the surface of the plate 204 is formed with an array of raised, radial spokes or ribs 216 whose side wall facets constitute abutment faces through which the contacting end of the fibers 214 impel the clutch plate 204 annularly about the drive shaft 100 as the armature 28 is energized to execute shifting steps.

The fiber-like elements 214 are oriented to form an angle of about 20° to about 45° with the plate 204. The angle is not critical, but is to ensure that, during the return movement or reset of the armature 28, the fibers 214 will wipe smoothly across the surface of the clutch plate with minimum friction. Any tendency of the clutch plate to rotate in a "reverse" direction is further obviated through the use of positive check means consisting of a fixed array of fiber elements 220 carried on a bar 222 secured to the support arm 130. As indicated in FIG. 5, the fibers 220 are oriented to contact the surface of the clutch plate at an angle to permit the plate to advance under the applied stepping force of the armature, but to check and to preclude reverse rotation of the plate 204.

While the exemplary clutch plate is shown with ribs, it is contemplated that any other suitable surface treatment may be utilized, including a wire mesh or latticed surface, or an etched surface. The fibers may be natural or synthetic filaments or may be metal wires. It will be readily apparent to those skilled in the art to which the present invention pertains that, alternatively (FIG. 8) an appropriately surfaced drum or cylinder 230 encircling and coaxial with the drive shaft 100 may be used to fulfill the function of the clutch plate 204. In the arrangement shown the driving fibers or drum advancing fibers 234 are oriented to abut the drum at an angle and at a disposition to effect annular advancement thereof. A second set of fiber elements 240, carried on a bar 242 secured to the support arm 130 prevents counter rotation of the drum 230.

It will be appreciated that for each of the drive systems of FIG. 5 and 8 there may be a simple "reversal" of parts with the fibers affixed to the disc 204 (or to the drum 230) and the irregular abutment surface being carried by the control arm 28. A similar abutment surface, appropriately angled or oriented, would be carried by the support arm 130.

Although the invention has been described with reference to a timepiece, it will be appreciated that the structures disclosed are capable of numerous related and non-related applications including other precision timing mechanisms and indexing devices.

While preferred embodiments of the novel electro-mechanical drive mechanism of the invention have been illustrated and described, it is understood that the same is capable of modification and that such modifications may be made without departure from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. An electro-mechanical transducer actuable through an electrical current applied thereto to convert electrical energy to rotative motion, and comprising:

an escapement wheel rotatively supported on a drive shaft,

a control arm, and means supporting said control arm for shifting movement in a plane substantially normal to a rotational axis of the drive shaft of said escapement wheel,

clutch means intercoupling said control arm with said escapement wheel for driving said escapement wheel through said control arm,

magnetic means including electro-magnetic means operationally coupled to said control arm,

said magnetic means being responsive to electrical energy applied thereto to provide electro-magnetic pulses at time-spaced intervals,

said pulses acting upon said control arm to effect displacement thereof,

said displacement of said control arm being effective to actuate said clutch mechanism;

thereby to rotate said escapement wheel and to produce incremental angular advancement of said escapement wheel at corresponding said time-spaced intervals.

2. The structure as set forth in claim 1 wherein said clutch means comprises:

first and second wound spring means encircling and embracing said drive shaft,

said first and second spring means being axially spaced and coaxially mounted on said drive shaft for tensioned gripping engagement therewith,

means coupling said control arm to the first said spring means to constitute said spring means a drive spring for said drive shaft,

means securing said second spring means against rotation relative to said drive shaft,

said second spring means being a fixed spring and comprising shaft gripping means wound about said drive shaft in a direction to prevent rotation of said drive shaft during unwinding of said first spring means and to permit rotational advancement of said drive shaft during winding of said first spring means.

3. The structure as set forth in claim 2 wherein said first spring means is wound in a sense to slip relative to said drive shaft during unwinding and to grasp and rotate said drive shaft during winding, and

said second spring means is wound in a sense to grip and hold said drive shaft during unwinding of said first spring means and to slip relative to said drive shaft during winding of said first spring means.

4. The structure as set forth in claim 1 wherein said escapement wheel is formed with an encircling array of teeth about the periphery thereof, and wherein said control arm periodically to interject into interdental spaces between said teeth of said escapement wheel to abut and bear against said teeth to serve as means to regulate stepwise angular advancement of said escapement wheel and to provide exact, incremental rotative steps.

5. The structure as set forth in claim 1 wherein said magnetic means includes permanent magnet means operatively disposed to impress a magnetic force upon said control arm to hold said control arm at a rest position and to retain said control arm in said rest position in a mechanically stressed state, and

wherein a current pulse applied to said electro-magnetic means produces an electro-magnetic force effectively opposing said magnetic force of said permanent magnet means to overcome said magnetic force and to release said control arm,

said control arm being responsive to said electro-magnetic force and being operable to shift from and then to return to said rest position to effect an annular incremental rotative advancement of said escapement wheel.

6. The structure as set forth in claim 5 wherein said electro-magnetic force opposing said magnetic force of said permanent magnet means serves as well to urge said control arm from said rest position.

7. An electro-mechanical transducer comprising the combination with a rotatively supported escapement wheel of toothless ratchet means coupled to said escapement wheel and operable to advance said escapement wheel in incremental steps at controlled time-spaced intervals,

said toothless ratchet means comprising drive means rotatively shifting said escapement wheel,

cooperating clutch means restricting rotative shifting of said escapement wheel to only one annular direction, and

electro-mechanical means for actuating said drive means.

8. The structure as set forth in claim 7 and further comprising a control arm and electro-mechanical means to convert electrical energy to rotative motion,

said electro-mechanical means including electro-magnetic means operative periodically to shift said control arm from a quiescent rest position to an electro-magnetically established displaced position,

means operative to return said control arm to its quiescent rest position upon cut-off of electro-magnetic forces applied thereto, and

mechanical means coupling said control arm to said drive means to effect stepped incremental annular advancement of said escapement wheel at cessation of said electro-magnetic forces and during ensuing shifting of said control arm in returning from its electro-magnetically established displaced position to its quiescent rest position.

9. The structure as set forth in claim 7 and further comprising a control arm and electro-mechanical means to convert electrical energy to rotative motion,

said electro-mechanical means including electro-magnetic means operative periodically to shift said control arm from a quiescent rest position to an electro-magnetically established displaced position,

means operative to return said control arm to its quiescent rest position upon cut-off of electro-magnetic forces applied thereto, and

mechanical means coupling said control arm to said drive means to effect stepped incremental advancement of said escapement wheel at initiation of said electro-magnetic forces and during ensuing displacement of said control arm from its quiescent rest position to its electro-magnetically established displaced position.

10. In an electrical watch mechanism and the like including:

an electric power cell,

an electrical transmitter having a resonant element as a frequency stabilizer,

an electro-mechanical transducer to convert electrical energy to rotative motion, and

an electronic frequency divider interposed functionally between the transmitter and the electro-mechanical transducer;

the improvement wherein said electro-mechanical transducer comprises, in combination:

an escapement wheel rotationally supported on a drive shaft,

first and second spring means encircling and embracing said drive shaft,

said first and second spring means being axially spaced and coaxially mounted on said drive shaft for tensioned gripping engagement therewith,

a control arm and means supporting said control arm for angular movement in a plane substantially normal to a rotational axis of the drive shaft,

means coupling said control arm to said first spring means to constitute said first spring means a drive spring for said drive shaft,

magnetic means including electro-magnetic means responsive to electrical energy applied thereto to provide magnetic pulses at time-spaced intervals to effect angular displacement of said control arm,

means securing said second spring means against rotation relative to said drive shaft,

said second spring means being a fixed spring and comprising clutch means wound about said drive shaft in a direction to prevent rotation of said drive shaft during unwinding of said first spring means and to permit rotational advancement of said drive shaft during winding of said first spring means.

11. The structure as set forth in claim 1 wherein said clutch means comprises a fiber clutch assembly including:

a clutch element and means securing said clutch element to said escapement wheel for rotation therewith,

said clutch element having an irregular surface defining abutment means adapted to engage ends of cooperating fiber means presented thereagainst,

fiber means carried by said control arm at an outwardly extending end portion thereof and shiftable therewith,

said fiber means projecting in planes intersecting said abutment means and angled in a direction to effect rotation of said clutch element upon actuation of said control arm;

whereby displacement of said control arm presents projecting free ends of said fiber means into driving contact with said abutment means to effect rotative shifting of said clutch element and said escapement wheel about said drive shaft.

12. The structure as set forth in claim 1 wherein said clutch means comprises a fiber clutch assembly including:

a disc-like rotatable clutch plate coaxial with and secured to said drive shaft of said escapement wheel for rotation therewith,

a principal surface of said clutch plate extending generally normally of said drive shaft and carrying a plurality of elements defining facets extending generally upwardly from said clutch plate and constituting abutment means adapted to engage cooperating fiber means presented thereagainst,

fiber means carried by said control arm at an outwardly extending end portion thereof and shiftable therewith,

said fiber means projecting in planes intersecting said facets of said clutch plate, and angled forwardly with respect to a direction of rotation of said clutch plate;

whereby displacement of said control arm presents projecting free end portions of said fiber means into stressing abutment contact with said facets of said clutch plate to effect rotative shifting of said clutch plate and said escapement wheel about said drive shaft.

13. The structure as set forth in claim 12 wherein said fiber means presented to said clutch plate lie in planes defining angles in the range of about 20° to 45° with said principal surface of said clutch plate.

14. The structure as set forth in claim 12 and further comprising fixed fiber means and means supporting said fixed fiber means with free projecting ends thereof in contact with said clutch plate at facets thereof,

said fixed fiber means being angled in a direction to permit annular advance of said clutch plate and said escapement wheel secured thereto,

whereby said fixed fiber means allow sliding passage of said elements of said clutch plate defining said facets, and constitute check means limiting rotation of said clutch plate to one direction only.

15. The structure as set forth in claim 11 and further comprising fixed fiber means and means supporting said fixed fiber means with free projecting ends thereof in contact with said clutch element,

said fixed fiber means being angled in a direction to permit annular advance of said clutch element and said escapement wheel secured thereto,

whereby said fixed fiber means allow sliding passage of said clutch element in contact therewith and constitute check means limiting rotation of said clutch element to one direction only.

16. The structure as set forth in claim 1 wherein said clutch means comprises a fiber clutch assembly including:

a drum-like rotatable cylinder encircling, secured to, and coaxial with and drive shaft to said escapement wheel for rotation therewith,

an enveloping surface of said cylinder being surfaced to define abutment means adapted to engage cooperating fiber means presented thereagainst,

fiber means carried by said control arm at an outwardly extending end portion thereof and shiftable therewith,

said fiber means projecting in planes intersecting said abutment means of said cylinder and angled in a direction to effect rotation of said cylinder upon actuation of said control arm;

whereby displacement of said control arm presents projecting free ends of said fiber means into driving contact with said abutment means to effect rotative shifting of said cylinder and said escapement wheel about said drive shaft.

17. The structure as set forth in claim **16** and further comprising fixed fiber means and means supporting said fixed fiber means with free projecting ends thereof in contact with said rotatable cylinder,

said fixed fiber means being angled in a direction to permit annular advance of said rotatable cylinder and said escapement wheel secured thereto,

whereby said fixed fiber means allow sliding passage of said rotatable cylinder in contact therewith and constitute check means limiting rotation of said rotatable cylinder to one direction only.

18. The structure as set forth in claim **1** wherein said clutch means comprises first and second cooperating clutch elements,

means coupling said first of said clutch elements to said drive shaft for rotation therewith,

means coupling said second of said clutch elements to said control arm for energization thereby,

said first and said second clutch elements being disposed to interengage upon actuation of said control arm;

whereby displacement of said control arms upon application of electro-magnetic pulses thereto effects incremental angular advancement of said drive shaft and of said escapement wheel supported thereon.

19. The structure as set forth in claim **1** wherein said clutch means comprises a fiber clutch assembly including:

cooperating first and second clutch elements for interengaging mechanically, rotatably to advance said drive shaft and said escapement wheel carried thereby in response to actuation of said control arm,

means securing said first of said clutch elements to said drive shaft for rotation therewith,

means securing said second of said clutch elements to said control arm for shifting movement therewith,

one of said clutch elements having an irregular surface defining abutment means for engaging ends of cooperating fiber means presented thereagainst,

the other of said clutch elements comprising fiber means projecting in planes intersecting said abutment means for stressing engagement therewith during actuation of said control arm to effect stepped advancement of said escapement wheel at said time spaced intervals.

20. In an electrical watch mechanism and the like including:

an electric power cell,

an electrical transmitter having a resonant element as a frequency stabilizer,

an electro-mechanical transducer to convert electrical energy to rotative motion,

an electronic frequency divider interposed functionally between the transmitter and the electro-mechanical transducer,

a drive shaft and an escapement wheel rotatively supported thereon,

a control arm, and means supporting said control arm for shifting movement in a plane substantially normal to a rotational axis of the drive shaft of said escapement wheel, and

clutch means intercoupling said control arm with said escapement wheel for driving said escapement wheel through said control arm;

the improvement wherein said clutch means comprises, in combination:

a disc-like rotatable clutch plate coaxial with and secured to said drive shaft of said escapement wheel for rotation therewith,

a principal surface of said clutch plate extending generally normally of said drive shaft and carrying a plurality of elements defining facets extending generally upwardly from said clutch plate and constituting abutment means adapted to engage cooperating fiber means presented thereagainst,

fiber means carried by said control arm and extending outwardly therefrom,

said fiber means projecting in planes intersecting said facets of said clutch plate;

whereby shifting displacement of said control arm presents projecting free end portions of said fiber means into stressing abutment contact with said facets of said clutch plate effects annular shifting of said clutch plate and said escapement wheel about said drive shaft.

21. In an electrical watch mechanism and the like including:

an electric power cell,

an electrical transmitter having a resonent element as a frequency stabilizer,

an electro-mechanical transducer to convert electrical energy to rotative motion,

an electronic frequency divider interposed functionally between the transmitter and the electro-mechanical transducer,

a drive shaft and an escapement wheel rotatively supported thereon,

a control arm, and means supporting said control arm for shifting movement in a plane substantially normal to a rotational axis of the drive shaft of said escapement wheel, and

clutch means intercoupling said control arm with said escapement wheel for driving said escapement wheel through said control arm;

the improvement wherein said clutch means comprises, in combination:

a drum-like rotatable clutch coaxial with and secured to said drive shaft of said escapement wheel for rotation therewith,

an outer, bounding, generally cylindrical surface of said clutch being faced to define irregularities consisting abutment means adapted to engage fiber means presented thereagainst,

fiber means carried by said control arm and extending outwardly therefrom,

said fiber means engaging in stressing and driving contact said abutment means of said clutch;

whereby shifting displacement of said control arm effects annular shifting of said clutch and said escapement wheel about said drive shaft.

22. The structure as set forth in claim **1** wherein said escapement wheel is formed with a plurality of radial teeth disposed in a plane perpendicular to an axis of rotation of said drive shaft, and further comprising:

an indexing pawl,

means securing said indexing pawl to said control arm for movement therewith,

whereby upon actuation of said control arm said indexing pawl shifts into and out of successive interdental spaces about said escapement wheel and into abutting contact with faces of said teeth to provide positive, precise, incremental stepping of said escapement wheel.

23. The structure as set forth in claim **1** wherein said magnetic means comprises a non-resonant, polarized assembly including, in combination, both permanent and electro-magnetic elements.

24. The structure as set forth in claim 18 wherein one of said clutch elements comprises abutment means disposed to engage fiber means presented thereagainst, and the other of said clutch elements comprises fiber means disposed to engage said abutment means in driving relation therewith.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,657,875 Dated April 25, 1972

Inventor(s) Joseph L. Radnik et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Claim 4, column 6, line 50, after "arm" insert -- includes pawl means operable --; claim 16, column 9, line 2, cancel "and" and substitute -- said --; same line 2, "to" should read -- of --; claim 20, column 10, line 23, before "effects" insert -- and --; claim 21, column 10, line 49, cancel "consisting" and substitute -- constituting --.

Signed and sealed this 6th day of February 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

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