

[54] **ENERGY CONSERVING
INTERMITTENT MOTION DEVICE AND
METHOD**

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[58] Field of Search **74/84, 1.5, 2; 226/134, 156.8**

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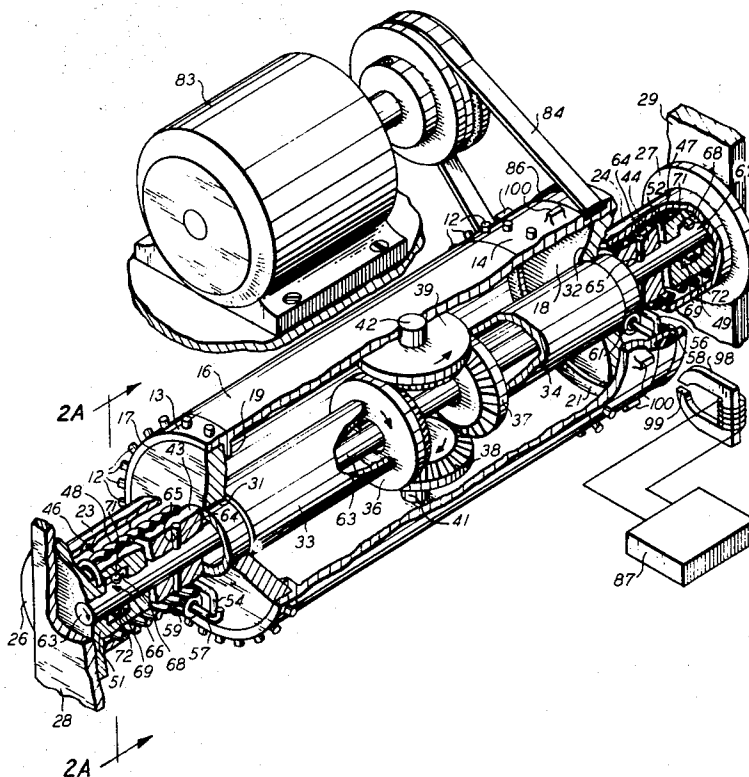
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Attorney—J. L. Landis and R. P. Miller

[57] **ABSTRACT**

In an energy conserving intermittent motion device, energy is alternately stored and released by twisting and untwisting a torsion rod to intermittently rotate a driven member, e.g., a feed platen. The torsion rod is twisted and untwisted by selectively restraining and releasing opposite ends thereof through pairs of clutch devices. Frictional losses in the system are compensated for by a servo-controlled variable torque motor which is controlled so as to supply just enough torque to compensate for the frictional losses.

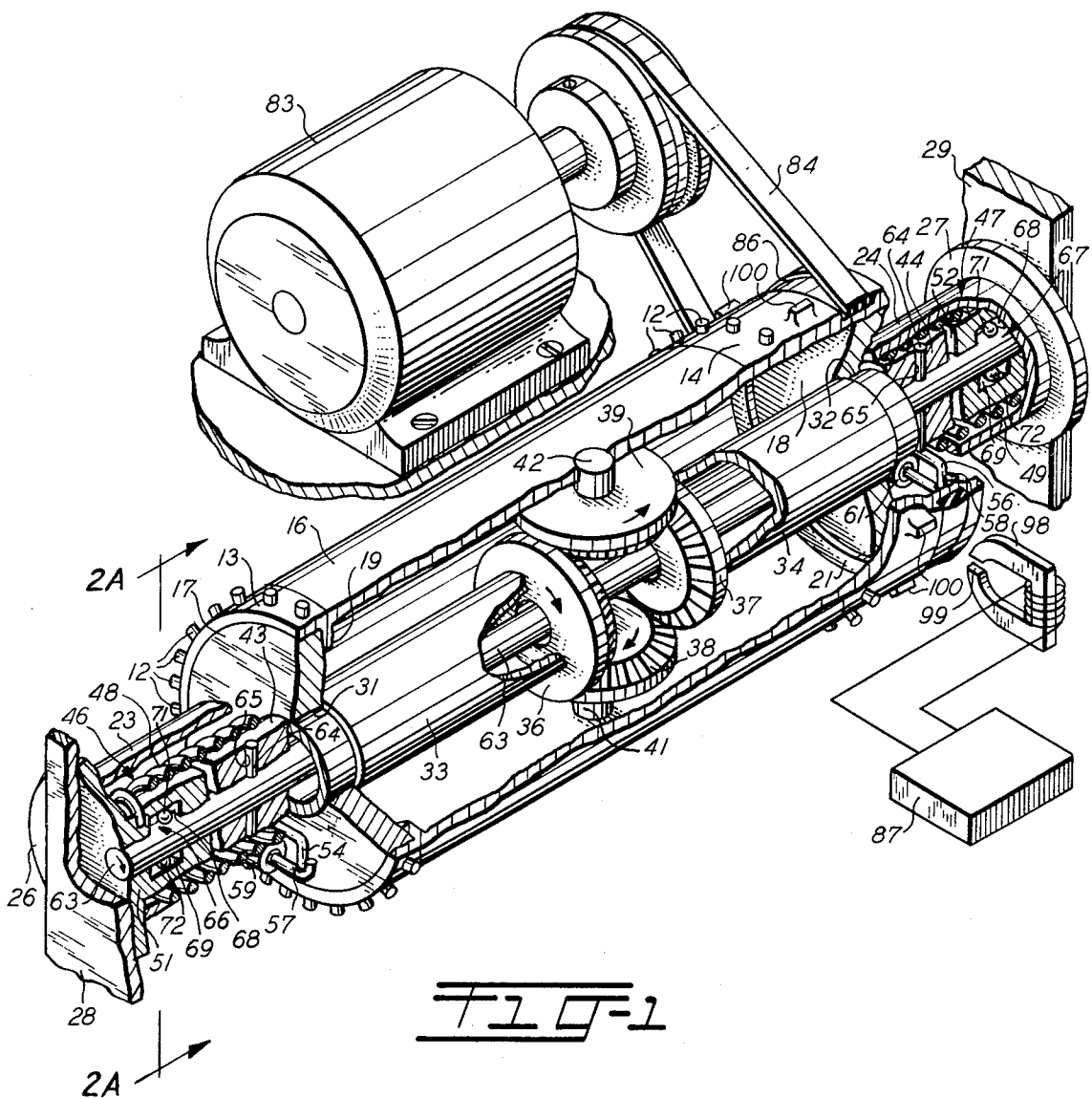
14 Claims, 16 Drawing Figures



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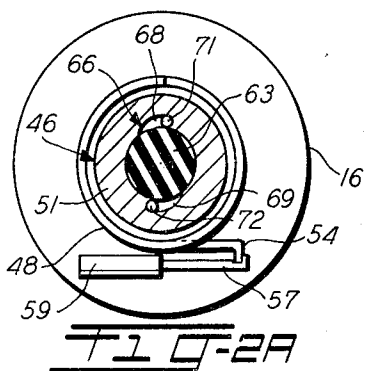
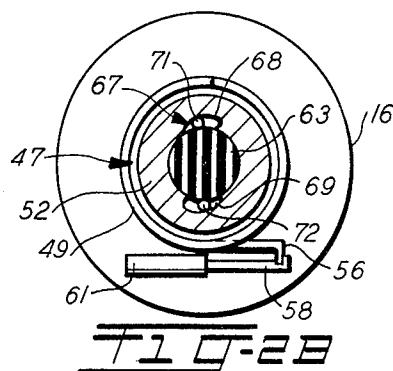
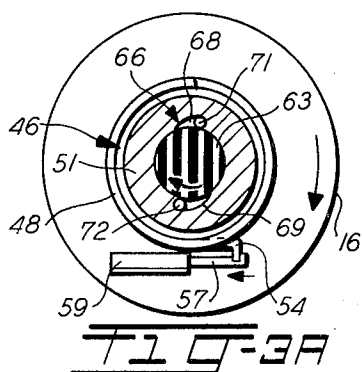
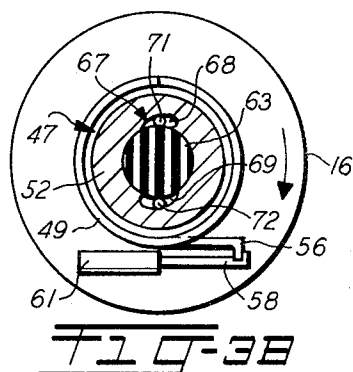
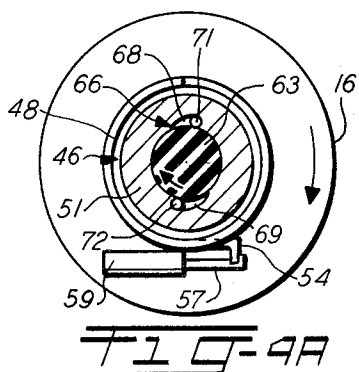
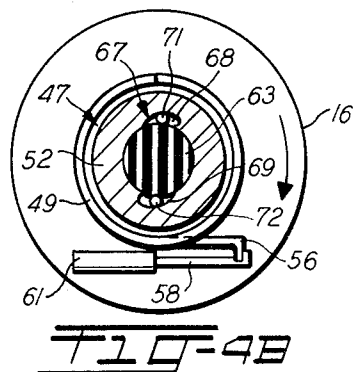
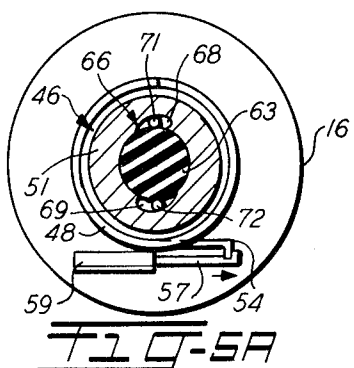
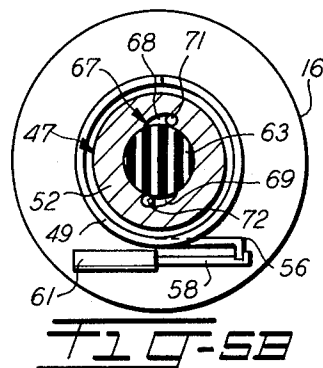
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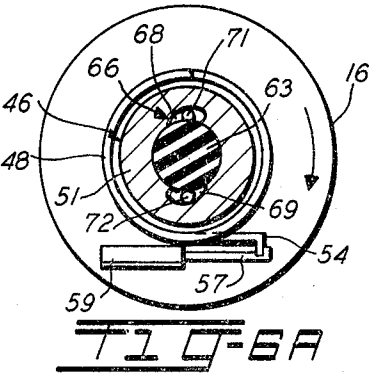
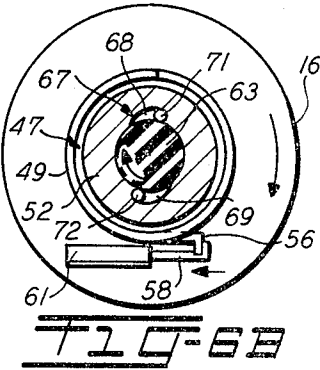
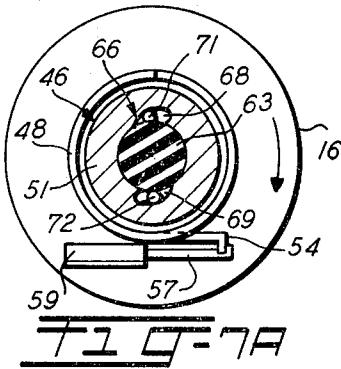
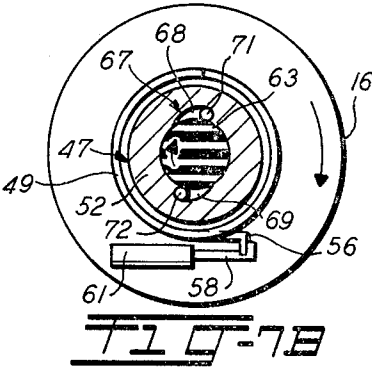
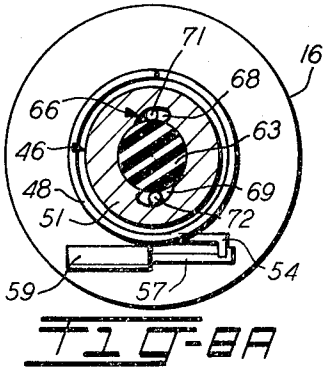
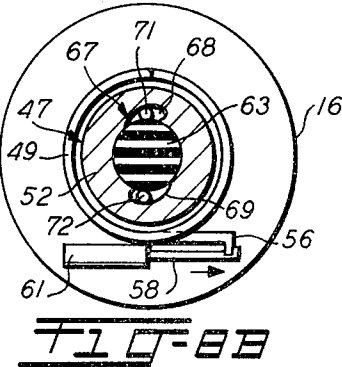
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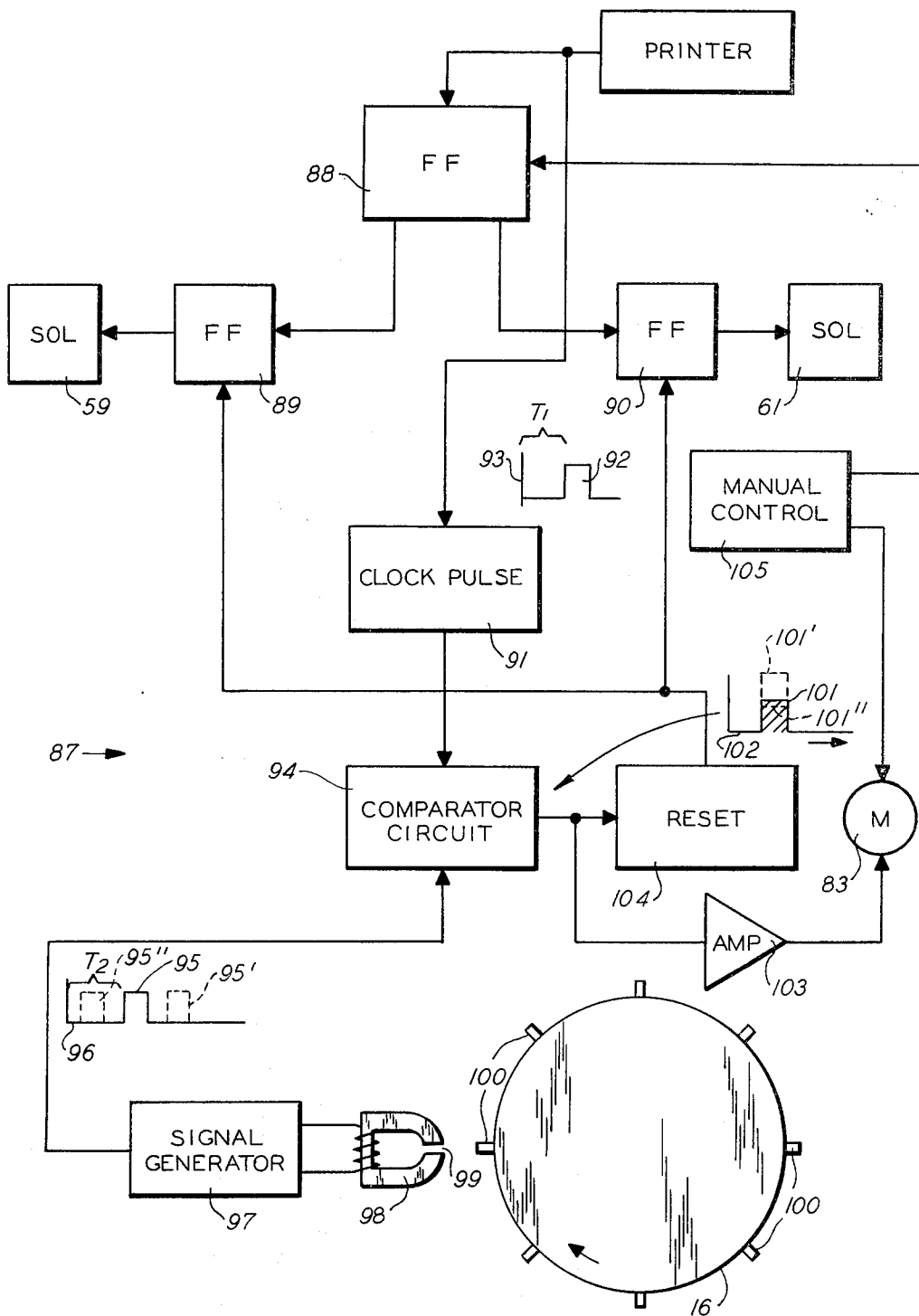


FIG-9

ENERGY CONSERVING INTERMITTENT MOTION DEVICE AND METHOD

BACKGROUND OF THE INVENTION

This invention relates to an energy-conserving intermittent motion device and method, and more particularly to improved energy-conserving intermittent motion systems in which stored energy is released from an elastic member to accelerate a mechanism and then recovered in the elastic member to decelerate and stop the mechanism.

PRIOR ART AND TECHNICAL CONSIDERATIONS

In many high speed paper transport mechanisms it is desirable to obtain short step times, however, in order to obtain short step times prior art mechanisms usually required the expenditure of significant amounts of energy to not only initiate the stepping motion but also to stop the motion. The application of this initiating energy is obtained by the use of relatively powerful actuators which increase the inertias imparted to component parts such as platens, belts and the like. The resulting rapid acceleration and deceleration or abrupt stops of these components results in wear, noise and vibration; all of which are undesirable mechanical characteristics.

Generally, the prior art mechanisms do not smoothly accelerate and decelerate the movable components of the system with harmonic motion, but rather they abruptly initiate motion and then abruptly interrupt motion without recovering in a useful way the kinetic energy initially released.

SUMMARY OF THE INVENTION

An object of this invention is to provide a new and improved mechanism and method for conserving energy in an intermittent motion device.

Another object is to provide improved torsion bar drive systems, of the general type disclosed in R. W. Nordin U.S. Pat. 3,316,769.

In accordance with a preferred embodiment of the invention, potential energy is initially stored in an elastic member such as a twisted torsion rod and then selectively released to rotate a driven member such as a paper transporting platen. The twisted torsion rod may be connected to the platen by a transmission device, such as an epicyclic gear train, and is initially held in the twisted position by pairs of clutches acting on each end of the rod. By releasing one clutch at one end while holding the clutch at the other end engaged, the torsion rod will untwist and rotate the platen in a harmonically accelerating mode. After the torsion rod has completely untwisted it will retwist due to momentum transferred from the rotating platen back through the epicyclic gear train to the torsion rod. While transferring momentum back to the torsion rod the platen will decelerate until it stops. Since there will be frictional losses, all of the energy initially imparted to the platen by the torsion rod cannot be returned, therefore an auxiliary energy source, e.g., an electric motor, is used to impart additional torque to the platen to compensate for these frictional losses. When the torsion rod stops retwisting, the clutches are again rendered effective to preclude untwisting in the opposite direction. When it is desired to again rotate the platen, one of the clutches on the opposite end of the torsion rod is released and the cycle repeats itself.

BRIEF DESCRIPTION OF THE DRAWINGS

A complete understanding of the invention may be had by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein:

FIG. 1 is a perspective view, partially broken away, illustrating an energy conserving intermittent motion device which includes a torsion rod arranged to drive a platen of a printer in accordance with the principles of the present invention;

FIG. 2A is a partially schematic sectional view looking from the left end of FIG. 1, taken generally along the line 2A-2A

of FIG. 1 and illustrating an initial condition where both ends of the twisted torsion rod are restrained from rotation thereby preventing the platen from rotating;

FIG. 2B is a schematic view similar to FIG. 2A, but showing portions of the right end of the apparatus as viewed from the left in FIG. 1;

FIGS. 3A and 3B are views similar to FIGS. 2A and 2B but with the left end of the torsion rod in FIG. 3A released for rotation while the right end in FIG. 3B remains restrained from rotation to allow the rod to untwist and thereby accelerate the platen;

FIGS. 4A and 4B show the left end of the torsion rod in FIG. 4A continuing to rotate but retwisting and absorbing momentum from the platen to decelerate the platen, while the right end of the rod in FIG. 4B remains restrained from rotation;

FIGS. 5A and 5B show both ends of the torsion rod again restrained as in FIGS. 2A and 2B while the rod is in a twisted state;

FIGS. 6A and 6B show the right end of the torsion rod in FIG. 6B released for rotation to again accelerate the platen as the rod untwists while the left end of the rod in FIG. 6A is restrained from rotation;

FIGS. 7A and 7B show the right end of the torsion rod in FIG. 7B continuing to rotate but retwisting to absorb momentum from the platen and thereby decelerate the platen while the left end of the rod in FIG. 7A is restrained from rotation;

FIGS. 8A and 8B show both ends of the torsion rod again restrained as in FIGS. 2A and 2B and FIGS. 5A and 5B so as to prevent the platen from rotating; and

FIG. 9 is a block diagram illustrating a control motor which supplies additional rotational energy to the intermittent motion device of FIG. 1 to compensate for energy losses incurred while operating the device.

DETAILED DESCRIPTION

In the illustrated embodiment of the invention disclosed in FIG. 1, there is shown an energy-conserving intermittent motion device for feeding paper (not shown) in a high-speed teleprinter, or page printing machine. Margin feed holes in opposite edges of the paper receive two sets of pins 12 on a pair of sprocket wheels 13 and 14 which are joined by a tubular member which for purposes of this illustration is a platen 16.

The platen 16 is mounted for rotation on a pair of disc bearings 17 and 18 positioned within the opposite ends of the platen. In order to locate and maintain the platen 16 on the bearings 17 and 18, a pair of circular flanges 19 and 21 are secured within the interior of the platen and abut the inner sides of the bearings. The bearings 17 and 18 are in turn rigidly secured to respective support sleeves 23 and 24 which are welded or otherwise attached to circular mounting plates 26 and 27 secured to side frame panels 28 and 29 of the printer.

The bearings 17 and 18 each have central bores that form additional bearing surfaces 31 and 32. Mounted for rotation within the bearing surface 31 is a first hollow spindle 33. The first spindle 33 is rigidly secured to a first input bevel gear 36 while a second spindle 34 is rigidly secured to a second input bevel gear 37 which is axially aligned with and spaced from the first bevel gear. The bevel gears 36 and 37 are in turn meshed with third and fourth bevel gears 38 and 39 which are output gears mounted for rotation on stud shafts 41 and 42. The shafts 41 and 42 are rigidly secured to the platen 16 and will rotate the platen 16 if the third and fourth bevel gears 38 and 39 are orbited about the longitudinal axis of the platen.

The spindles 33 and 34 are rigidly secured to first cylinders 43 and 44 which form rotatable portions of a pair of spring clutches, designated generally by the numerals 46 and 47 respectively. Wrapped around the first cylinders 43 and 44 are coil springs 48 and 49 which each have first ends anchored in bores formed in second cylinders 51 and 52 respectively. The second cylinders 51 and 52 are axially aligned with, but slightly spaced from, the first cylinders 43 and 44, and are

fixed to the mounting plates 26 and 27 to form fixed portions of the spring clutches 46 and 47.

In order to selectively prevent the first cylinders 43 and 44 from rotating with respect to the second cylinders 51 and 52 the coil spring 48 is initially tensioned so as to be tightly wrapped around both the first cylinder 43 and the second cylinder 51 of the left-hand spring clutch 46 while the coil spring 49 is initially tensioned so as to be tightly wrapped around the first cylinder 44 and second cylinder 52 of the right-hand clutch 47. This of course prevents the spindles 33 and 34, which are rigidly connected to the cylinders 43 and 44 from rotating thereby holding the first and second bevel gears 36 and 37 stationary. When the first and second bevel gears 36 and 37 are held stationary, the third and fourth bevel gears 38 and 39 are prevented from rotating and orbiting thereby holding the platen 16 stationary.

When it is desired to advance the platen either the spindle 33 or the spindle 34 is released to rotate. This release is attained through the agency of clutch control detents 54 and 56, which project from second ends of the coil springs 48 and 49. (See also FIGS. 2A and B.) When the clutch detents are pulled leftward by actuators 57 and 58 the coil springs are slightly uncoiled. The actuators 57 and 58 are associated with armatures of electro-magnets 59 and 61 which when energized slide the actuators 57 and 58 to the left to release the clutches 46 and 47.

Both the first cylinders 43 and 44 and the second cylinders 51 and 52 have aligned longitudinal bores for receiving an elastic torsion bar or rod 63, which when twisted and then released provides the torque to rotate the platen 16. The torsion rod 63 is rigidly secured at opposed end sections to the first cylinders 43 and 44 of the spring clutches 46 and 47 by pins 64 which pass through the torsion rod and are seated within bores 65 in the first cylinders. With this arrangement, the spring clutches 46 and 47 constitute means for selectively clamping the end of the torsion rod to retain an axial twist placed in the rod, until rotation of the platen is desired.

The ends of the torsion rod 63 are selectively permitted to rotate, after release of one of the spring clutches 46 or 47, in only the clockwise direction (when looking from the left in FIG. 1 and as viewed in FIGS. 2A through 8B) by a pair of one-way clutches designated generally by the numerals 66 and 67. Each of the one-way clutches 66 and 67 consists of a pair of short arcuate slots 68 and 69 (see also FIGS. 2A and B) which are located in the cylinders 51 and 52 and contain a pair of balls 71 and 72 positioned adjacent to the torsion rod 63. The slots 68 and 69 taper counterclockwise toward the torsion rod 63 so that as an end of the rod 63 is rotating in a clockwise direction, the balls 71 and 72 will be urged into wider portions of the slots and will allow the torsion rod to rotate; but, if the end of the torsion rod 63 attempts to rotate in the counterclockwise direction, the balls 71 and 72 will be cammed into narrow portions of the slots and will press against the torsion rod to prevent it from rotating in the counterclockwise direction. By preventing alternate ends of the torsion rod 63 from rotating, the rod may be retained in a twisted condition.

Recalling that the second cylinder 51 is fixed to the side plate it will be appreciated that, when the coil spring 48 of the left-hand spring clutch 46 is tightened around the first and second cylinders 43 and 51, both the left end of the torsion rod 63 and the first bevel gear 36 are held stationary. If the spring 49 of the right-hand spring clutch 47 is slack, the cylinder 44 will be free to rotate in the clockwise direction (looking in from the left end) thereby allowing the bevel gear 37 and the right-hand end of the torsion rod 63 to rotate in the clockwise direction. When the left-hand spring clutch 46 is locked and the right-hand spring clutch 47 is released, the torsion rod 63 may then be longitudinally twisted a desired amount clockwise about its left end by rotating the platen 16 in the clockwise direction. After the torsion rod 63 has been twisted by rotating the platen 16 several degrees (for example 10° in a typical embodiment) or the equivalent of one half a line space of paper feed, the spring clutch 47 is engaged and

the torsion rod is held in the twisted position by the spring clutch 47 and the one-way ball clutch 67 which prevents counterclockwise rotation of the right end of the torsion rod. While in the twisted condition potential energy is stored in the torsion rod 63, generally as disclosed in the Nordin patent, and the bevel gear 37 is held stationary. This is the initial position illustrated in FIGS. 2A and B, where the right end (FIG. 2B) is shown in an exaggerated example twisted 45° clockwise from the left end (FIG. 2A).

If the left-hand spring clutch 46 is then released while the right-hand spring clutch 47 is engaged and the torsion rod 63 is twisted with the clockwise twist, the torsion rod will untwist about the right-hand end rotating the cylinder 43, spindle 33 and bevel gear 36 in a clockwise direction. This is the position illustrated by the arrows in FIG. 1. The bevel gear 36 will in turn rotate the bevel gears 38 and 39 as illustrated by the arrows, which will react against the stationary bevel gear 37 and orbit about the longitudinal axis of the platen 16. Since the gears 38 and 39 are connected to the platen 16 by the shafts 41 and 42, the platen angularly accelerates in the clockwise direction, with a very high initial acceleration generally as disclosed in the Nordin patent, as the gears orbit.

The platen 16 continues to accelerate, but at a progressively decreasing rate of acceleration, under the influence of the untwisting torsion rod 63 until the torsion rod is completely untwisted (FIGS. 3A and 3B). Thereafter, the platen continues to rotate due to its momentum and retwists the torsion rod in the reverse direction (with a counterclockwise twist as indicated in FIGS. 4A and 4B) about its right-hand end which is clamped by the engaged spring clutch 47. In the retwisting process, the platen decelerates as described in the Nordin patent, and after the torsion rod 63 has absorbed all of the momentum transferred back to it, the torsion rod will stop retwisting and attempt to untwist. However, the one-way clutch 66 will prevent the torsion rod 63 from untwisting since the balls 71 and 72 will be cammed against the torsion rod 63 by the slots 68 and 69 when the left end of the torsion rod attempts to rotate in the counterclockwise direction. Thus, the retwist of the torsion rod is preserved for use in a subsequent advancing step.

Since there are frictional forces present in this system, as in any system, the torsion rod 63 will not retwist to the extent that it was originally twisted and therefore will tend to store less potential energy than it initially had. In order to compensate for these frictional losses a servo-controlled variable torque motor 83 is provided to apply additional torque to the platen 16 through a belt 84 which is positioned in a groove 86 formed in the right end section of the platen 16. The motor 83 is controlled by an energy compensating circuit which is designated generally by the numeral 87 composed of generally conventional components.

Referring now to FIG. 9 where the servo motor control circuit 87 is shown in detail, a line feed signal is locally generated or received by the printer when it is desired to rotate the platen 16 to advance the paper associated therewith. The line feed signal is applied to a flip-flop circuit 88 which alternately channels the signal through one of a pair of bistable multivibrators or flip-flops 89 and 90 to either the left-hand solenoid 59 or the right-hand solenoid 61 to alternately release either the left-hand spring clutch 46 or the right-hand spring clutch 47 allowing the twisted torsion rod 63 to untwist and rotate the platen 16. The line feed signal is also received by a clock pulse generator 91 which after a predetermined time interval T_1 generates a clock pulse 92 as shown schematically in the time-pulse diagram 93.

The clock pulse 92 is compared in a comparator circuit 94 to a sensed pulse 95 which is shown schematically in the time pulse diagram 96. The sensed pulse 95 is generated by a signal generator 97 which is connected to a magnetic pickup head 98 having a gap 99 that senses the position of individual iron slugs 100 which are embedded in the periphery of the platen 16.

The slugs 100 are separated from one another by a distance which corresponds to a single line feed spacing on the paper

which is being printed upon. While the paper is being printed upon, the platen 16 is positioned so that the gap 99 of the pickup head 98 is located midway between a pair of the slugs 100. When the paper is advanced a single line feed spacing the gap 99 is positioned midway between a pair of the slugs 100.

When either of the spring clutches 46 or 47 is released, the platen 16 rotates carrying one of the slugs 100 past the gap 99 in the magnetic pickup head 98 disturbing the magnetic field in pickup head and generating the sensed pulse 95. A time interval T_2 between the initiation of rotation of the platen 16 and the generation of the pulse 95 is compared in the comparator circuit 94 to the predetermined time interval T_1 of the clock pulse 92 to generate an output energy pulse 101 which is shown in the diagram 102. The energy pulse 101 is transmitted to the motor 83 through an amplifier 103 and supplies enough energy to the motor while the platen 16 decelerates, to compensate for frictional losses in the system.

The magnitude of the output pulse 101 is determined by the time relation of the clock pulse 92 with respect to the sensed pulse 95. If the pulses 92 and 95 occur at the same time, making T_2 equal to T_1 , the comparator circuit controls the generation of a pulse having a predetermined amount of energy 101 which energy pulse is applied to the motor 83 so as to supplement the energy released by the torsion rod 63 to rotate the platen 16 just enough to provide a single line feed. However, if a sensed pulse 95' occurs later than the clock pulse 92 making T_2 greater than T_1 indicating that the platen 16 has not rotated either fast enough or far enough for the predetermined amount of energy to fully compensate for frictional losses, an amount of energy 101' which is correspondingly greater than the predetermined amount of energy 101 is applied to the motor 83. On the other hand if a sensed pulse 95'' occurs before the clock pulse 92, making T_2 less than T_1 and indicating that the platen 16 is rotating too fast or has rotated too far, an amount of energy 101'' which is correspondingly less than the predetermined amount of energy 101 is applied to the motor 83 causing the motor to generate less torque. Thus, the magnitude of the pulse of energy 101 applied to the motor 83 is inversely proportional to the speed of rotation of the platen 16, so that the motor 83 delivers to the platen 16 just enough energy to compensate for frictional losses in the system and the platen will always rotate the desired amount which is usually a single line space.

In order to insure that the platen 16 stops after it has rotated the desired number of degrees, a reset circuit 104 monitors the output pulse 101 from the comparator circuit 94 and detects the trailing extremity of the output pulse. Upon sensing the trailing extremity of the output pulse 101, the reset circuit 104 impresses a reset signal on both of the bistable multivibrators 89 and 90 associated with the solenoids 59 and 61. The multivibrator 89 or 90 which was set by the flip-flop 88 to energize its associated solenoid 59 or 61 is then reset to deenergize its associated solenoid so that the spring clutch 46 or 47 connected thereto will return to its engaged state and prevent further twisting of the torsion rod 63. When it is desired to again rotate the platen 16 the other one of the spring clutches 46 or 47 is released and the cycle is repeated.

A manual control device 105 is provided to energize the motor 83 and a selected one of the solenoids 59 or 61 through flip-flop 88 so as to permit rotating the platen 16 to pretwist the torsion rod 63 in either direction, or to adjust or change the amount of twist at any time, as well as permitting adjustment of the position of the platen.

SEQUENTIAL OPERATION

Referring now to FIGS. 2A through 8B, the series of sequential steps of one complete cycle of operation of the motion transferring mechanism is illustrated with each pair of related views (A and B) depicting various operating conditions of the spring clutches 46 and 47, the one-way clutches 66 and 67, the solenoids 59 and 61 and the motion of the torsion rod 63.

FIGS. 2A and 2B illustrate the initial condition where the left-hand end of the torsion rod 63 is held stationary by the spring clutch 46 (FIG. 2A) while the right-hand end of the torsion rod has been pretwisted clockwise about its longitudinal axis to store potential energy and is held stationary by the spring clutch 47 (FIG. 2B).

A platen feed stepping operation is initiated by energizing the solenoid 59 to retract the armature 57, thereby loosening the coil spring 48 and disengaging the spring clutch 46 to allow the left-hand end of the torsion rod 63 to rotate in the clockwise direction (FIG. 3A). Since the right-hand end of the torsion rod 63 is restrained from rotation by the spring clutch 47, as shown in FIG. 3B, the torsion rod untwists in the clockwise direction about its stationary right-hand end as its left-hand end rotates. As the torsion rod 63 untwists, it rotates the cylinder 43 (FIG. 1) by means of the pin 64 to drive the spindle 33 which in turn rotates the first bevel gear 36 in a clockwise direction. Rotation of the bevel gear 36 rotates the third and fourth bevel gears 38 and 39 respectively, as shown in FIG. 1. The rotating third and fourth bevel gears 38 and 39 walk upon the now stationary second bevel gear 37. As the third and fourth bevel gears 38 and 39 rotate and walk on the stationary bevel gear 37 they necessarily orbit around the longitudinal axis of the platen 16 and harmonically accelerate the platen to rotate in a clockwise direction.

Referring now to FIGS. 4A and 4B, the right-hand portion of the torsion rod 63 is still prevented from rotating by the spring clutch 47 while the left-hand portion is now retwisting or rewinding due to the transfer of inertia from the rotating platen 16, the bevel gears 36, 38 and 39 and the spindle 33 back to the torsion rod. In other words, the momentum of the rotating parts returns to the torsion rod 63 the major portion of the kinetic energy expended by the torsion rod while it was untwisting thereby retwisting the torsion rod in the reverse direction to store potential energy therein. As this energy transfer takes place, the platen 16 is harmonically decelerated until it stops rotating.

Ideally, the torsion rod 63 recovers and stores all the kinetic energy initially expended; however, due to frictional losses within the system, all of this energy cannot be restored to the torsion rod, therefore, the motor 83 supplies this additional energy through the belt 84 to the platen 16. The servocircuit motor control 87 insures that the motor 83 supplies only that amount of energy necessary to compensate for the frictional losses within the system.

After the torsion rod 63 has been reverse twisted and the platen 16 has stopped rotating, there is a tendency for the torsion rod to unwind in the counterclockwise direction. However, the balls 71 and 72 of the one-way clutch 66 are (1) urged by the torsion rod 63 into the narrow portion of the slots 68 and 69 and (2) cammed against the fixed cylinder 51 preventing the torsion rod from untwisting. At this time, the reset circuit 104 operates to deenergize the solenoid 59 to operate the left spring clutch 46 so as to reengage the left end of the rod 63. The condition shown in FIGS. 5A and 5B then exists where the platen 16 is held stationary while the torsion rod 63 is in a reverse twisted condition with potential energy stored therewithin. While the platen 16 is in this condition the paper being advanced can be printed upon or otherwise utilized.

Referring now to FIGS. 6A through 8B, a similar sequence of operation is repeated, only this time the left end of the rod 63 is prevented from rotation by the spring clutch 46 while the right-hand end of the torsion rod is released for rotation by the spring clutch 47. Since the torsion rod 63 is prevented from rotating in a counterclockwise direction it only rotates in a clockwise direction so that by alternately locking and releasing opposite ends of the rod it continually rotates the platen 16 in the clockwise direction.

In FIGS. 6A and 6B, the right-hand end of the rod 63 is shown rotating in a clockwise direction and driving the spindle 34 to rotate the second bevel gear 37. Since the first bevel gear 36 is prevented from rotating by the engagement of the

spring clutch 46, the second bevel gear 37 causes the third and fourth bevel gears 38 and 39 to orbit about the longitudinal axis of the platen 16 to rotate the platen 16 in a clockwise direction. Referring now to FIGS. 7A and 7B, the torsion rod 63 is shown retwisting in the same fashion as in FIG. 4A. The torsion rod 63 continues to retwist until it has absorbed all of the kinetic energy released by the momentum of the rotating parts and has received additional kinetic energy from the motor 83 to compensate for frictional losses. The condition illustrated in FIGS. 8A and 8B is similar to FIGS. 2A and 2B in which both ends of the torsion rod 63 are again prevented from rotating. The cycle illustrated in FIGS. 2A and 2B through FIGS. 8A and 8B then repeats itself to intermittently rotate the platen 16 in order to intermittently advance the sheet of paper.

With this arrangement, wherein the decelerating reverse twist of the torsion bar is augmented and preserved in each cycle for use in the next cycle, it will be apparent that extremely fast cycle times can be realized, typically a few milliseconds for platen line-feed of the type illustrated. Note that, in the Nordin patent, the temporary reverse twist is completely unwound and the torsion bar must be fully rewound in the first direction since only one end of the bar ever drives the load.

Another significant effect is that the unit automatically stops the platen or load at the desired spot at the end of each cycle, when the torsion bar has been fully retwisted and attempts to untwist in the opposite direction. Thus, external stops are eliminated and an extremely quiet device is realized, in addition to eliminating mechanical stop elements which wear, and associated control circuits.

While one specific embodiment of the invention has been described in detail above, it will be apparent that various modifications may be made from the specific details described without departing from the spirit and scope of the invention. In particular, while a specific clutch and epicyclic gear-drive arrangement is illustrated, various equivalent mechanisms could be substituted. An important feature of the invention resides in the use of some mechanical coupling mechanism to selectively connect first one end of the torsion bar to the load and then the other, to drive the load in the desired incremental steps while reverse twisting the torsion bar during each step as disclosed. One additional form of drive which can be used in place of the epicyclic gear train shown is a rotary-band differential (not shown), utilizing bevelled wheels in place of the gears 36-39, the wheels being coupled by pairs of tensioned metal bands to each other and the platen 16 so that rotation of either of two input wheels corresponding to the gears 36-37 causes revolution of a floating bevel member corresponding to one of the gears 38 or 39 to rotate the platen.

What is claimed is:

1. In a device for transmitting intermittent motion; a rotatable member,
an elastic agency for alternately storing and releasing energy when wound and unwound respectively about alternate ends thereof,
means for holding said elastic agency wound about said alternate ends,
means for selectively releasing said holding means,
means associated with said alternate ends of said elastic agency to restrict rotation of said ends to one direction,
means for transferring kinetic energy from said released elastic agency to said rotatable member to angularly accelerate said rotatable member and to transfer momentum from said rotatable member to said elastic agency to decelerate said rotatable member and rewind said elastic agency to store potential energy therein, and
means rendered effective while said rotatable member decelerates for imparting additional kinetic energy to said rotatable member in an amount that is substantially equal to the difference between the released kinetic energy and the kinetic energy remaining in said rotating rotatable member.

2. The mechanism of claim 1 wherein said means for imparting additional kinetic energy is a variable torque motor controlled by a circuit which supplies to the motor a pulse of energy the magnitude of which is inversely proportional to the speed of rotation of the rotatable member.

3. The device of claim 1 wherein said elastic agency is an elongated rod which when wound and unwound is twisted about the longitudinal axis thereof.

4. The device of claim 3 wherein said means for transferring kinetic energy includes:

first and second input means individually secured to said ends of said elastic rod, and

output means connected to said rotatable member and to said first and second input means, said output means being driven by said first input means and reacting against said second input means to rotate said rotatable member when one of said ends of said elastic rod is unwinding and being driven by said second input means and reacting against said first input means to rotate said rotatable member when the other of said ends of said elastic rod is unwinding.

5. The device of claim 4 wherein said first and second input means are input bevel gears and wherein said output means is at least one output bevel gear meshed with both of said input bevel gears.

6. In a harmonic intermittent drive mechanism,

a first clutch device,

a second clutch device,

an elongated member twisted about its longitudinal axis and held by said first and second clutch devices,

means for alternately releasing said first and second clutch devices to allow said member to untwist and then retwist, a driven member,

means responsive to the untwisting of said member for driving the driven member,

means responsive to the momentum of the driven member for retwisting said elongated member, and

means controlled by the degree of retwisting of said elongated member for further retwisting said elongated member to an extent equal to the amount of original twist.

7. The mechanism of claim 6 wherein said first clutch device and said second clutch device each consist of both a one-way clutch to restrict rotation of the elongated member to one direction and a selectively operated clutch to selectively hold said elongated member.

8. In a mechanism for advancing a driven member,

a torsion rod,

a pair of clutch devices acting on opposite ends of the torsion rod for holding the rod twisted about its longitudinal axis in a first fashion,

means for selectively releasing one of the clutches to allow the rod to untwist,

means for transferring the untwisting motion of said rod to advance the driven member,

means rendered effective upon the untwisting of the rod and continued advance of the driven member under the influence of momentum for retwisting the rod in a fashion opposite to said first fashion, and

means controlled by the extent of advance of the driven member for further advancing the driven member to further retwist said bar in said second fashion until the amount of retwist is equal to the amount of twist in the first fashion and for rendering said released clutch effective to hold said rod in said retwisted second fashion.

9. In a mechanism for intermittently line feeding a strip of material,

a mounting frame,

a tubular platen mounted for rotation with respect to said mounting frame to line feed the strip of material,

a torsion rod extending longitudinally within said tubular platen,

a pair of clutch devices acting on opposite ends of said torsion rod for holding said torsion rod stationary with respect to said frame and initially twisted about its longitudinal axis in a first fashion,

means for selectively releasing one of the clutches to allow the rod to untwist by allowing one end of said rod to rotate,

first means for transferring rotation positioned within said tubular platen and connected both to said tubular platen and to said one end of said rod to (1) transfer rotation from said one end of said rod to said platen and to (2) retwist said rod in a second fashion opposite to said first fashion upon untwisting of said rod and continued rotation of said platen under the influence of momentum,

means for rendering said one of said clutches effective to hold said rod in said retwisted second fashion,

means for selectively releasing the other of said clutches to allow the rod to again untwist to rotate the other end of said rod,

second means for transferring rotation positioned within said tubular platen and connected both to said tubular platen and to said other end of said rod to (1) transfer rotation from said other end of said rod to said platen and to (2) retwist said rod in said first fashion upon the untwisting of said rod and continued rotation of said platen under the influence of momentum,

means for rendering said other of said clutches effective to hold said rod in said retwisted first fashion, and

means controlled by the extent of rotation of the platen to further retwist said torsion rod when said torsion rod is retwisting until the amount of retwist is equal to the amount of original twist existing in either the first or second fashions.

10. A mechanism for transmitting intermittent motion to a load, which comprises:

a torsion bar;

means for selectively clamping the ends of the bar to retain an axial twist in the bar;

means for unclamping only a first end of the bar to permit the bar to untwist about the clamped second end, thus rotating the first end of the bar;

means for mechanically coupling the first end of the bar to the load so that rotation of the first end of the bar drives the load in a desired direction and so that the momentum of the moving load continues for a time to rotate the first end of the bar after the bar has been untwisted to retwist the bar a given amount in the reverse direction, after which the clamping means is actuated to reclamp the first end of the bar to retain the reverse twist;

means for unclamping only the second end of the bar to permit the bar to untwist about the clamped first end, thus rotating the second end of the bar; and

means for mechanically coupling the second end of the bar to the load similarly to the first-end coupling means to drive the load, untwist the bar and retwist it again in the first direction after which the clamping means is actuated to reclamp the second end of the bar to retain the retwist.

11. The mechanism as recited in claim 10, further comprising

ing means for applying additional force to the system while the bar is coupled to the load to further rotate the unclamped end of the bar in the direction it is rotating so as to compensate for the work performed in driving the load and friction losses, to provide a predetermined amount of twist after each retwisting step.

12. A method of transmitting intermittent motion to a load, which comprises:

a. twisting a torsion bar about its axis in a first direction;

b. clamping both ends of the bar to retain the twist;

c. unclamping only a first end of the bar to permit the bar to untwist about the clamped second end, thus rotating the first end of the bar;

d. mechanically coupling the first end of the bar to the load so that rotation of the first end of the bar drives the load in a desired direction and so that the momentum of the moving load continues for a time to rotate the first end of the bar after the bar has been untwisted, to retwist the bar a given amount in the reverse direction;

e. reclamping the first end of the bar after it has been retwisted a desired amount to retain the reverse twist;

f. subsequently, unclamping only the second end of the bar to permit the bar to untwist about the clamped first end, thus rotating the second end of the bar;

g. mechanically coupling the second end of the bar to the load similarly to the coupling in step (d) to drive the load, untwist the bar and retwist it again in the first direction; and

h. reclamping the second end of the bar to retain the retwist.

13. The method as recited in claim 12, further comprising the steps of applying additional force to the system during steps (d) and (g) to further rotate the unclamped end of the bar in the direction it is rotating in steps (c) and (f), so as to compensate for the work performed in driving the load and for friction losses, to provide a predetermined amount of twist after each of steps (d) and (g).

14. In a device for transmitting intermittent motion,

a rotatable member,

an elastic member for alternately storing and releasing energy when wound and unwound respectively about opposite ends,

means selectively operable to individually prevent rotation of said opposite ends to allow said elastic member to be alternately wound and unwound about said ends,

means for transferring kinetic energy from said elastic member to said rotatable member to angularly accelerate said rotatable member when either of said ends is unwinding and to transfer momentum from said rotatable member to said elastic member to decelerate said rotatable member and rewind said elastic member to store potential energy therein, and

means rendered effective while said rotatable member decelerates for imparting additional kinetic energy to said rotatable member in an amount substantially equal to the difference between the released kinetic energy and the kinetic energy transferred by the momentum of said rotating member.

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