Oct. 4, 1960 C. H. BERILL 2,954,701

ELECTRO MAGNETIC ACTUATOR

Filed Nov. 27, 1957

Fig. 1

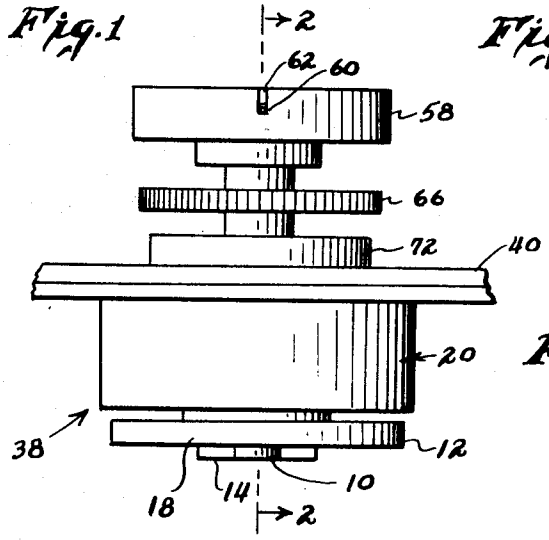


Fig. 4

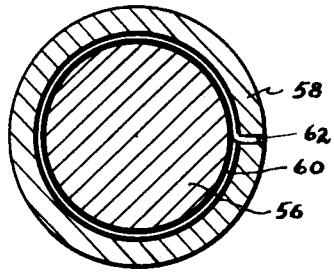


Fig. 5

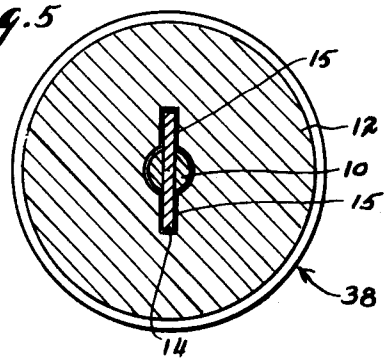


Fig. 2

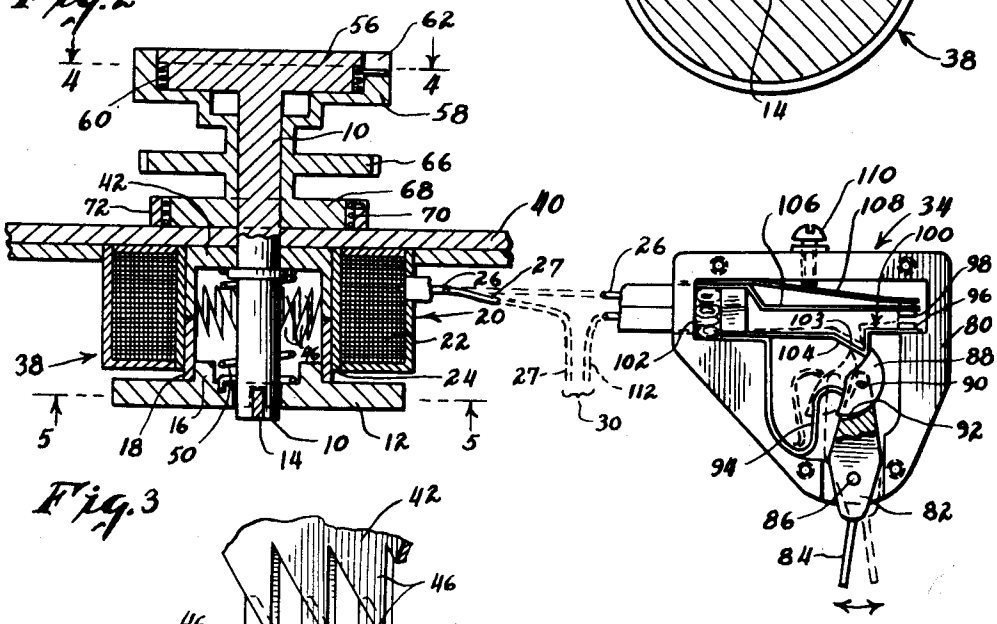


Fig. 3

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ELECTRO MAGNETIC ACTUATOR

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7 Claims. (Cl. 74—126)

This invention relates to electro-magnetic actuators and more especially to actuators for producing motion in a series of steps in response to repeated impulses.

For advancing a typewriter ribbon, or similar operations, it is advisable to advance the ribbon after each key movement, and to have this intermittent movement of the ribbon continue in the same direction until the end of the ribbon approaches and it becomes necessary to reverse the direction of the ribbon feed. The ribbon reversal is most conveniently done by reciprocating mechanism that makes one stroke for each impulse.

Such reciprocating actuators of the prior art have presented difficulties. One has been lack of endurance. In the kind of service required for a typewriter, where the actuator may be operated more than a hundred times in one minutes over long periods, day in and day out, the moving parts wear and develop excessive play, which eventually prevents the completion of the stroke of the actuator and destroys its usefulness. Another disadvantage has been inappropriate force curves, according to which the magnetic pull was too weak at the beginning of the stroke and too violent at the end.

It is an object of this invention to provide an improved electro-magnetic actuator having such large bearing surfaces that it operates indefinitely without noticeable wear. Another object is to provide an improved actuator of the character indicated and in which the magnetic pull curve is more uniform and the operated mechanism can be operated with less force and without excessive shock or vibration toward the end of its stroke.

The invention includes apparatus for rotating a shaft with intermittent step-by-step movement, and with simple and inexpensive mechanism for transmitting the reciprocating movement to a rotary shaft and for preventing retrograde movement.

Other objects, features and advantages of the invention will appear or be pointed out as the description proceeds.

In the drawing, forming a part hereof, in which like reference characters indicate corresponding parts in all the views;

Figure 1 is an elevation of a magnetic actuator made in accordance with this invention;

Figure 2 is a sectional view through the actuator shown in Figure 1, the section being taken on the line 2—2 of Figure 1 and the actuator is shown connected with a switch for supplying impulses intermittently;

Figure 3 is a greatly enlarged, fragmentary, perspective view of the sloping abutments of the actuator shown in Figures 1 and 2; and

Figures 4 and 5 are sectional views taken on the lines 4—4 and 5—5, respectively, of Figure 2.

The actuator shown in Figures 1 and 2 includes a shaft 10 which extends through an armature 12 at the lower end of the actuator. The armature 12 is movable axially along the length of the shaft 10; but there is a fin 14 secured to the lower end of the shaft 10 and extending into grooves 15 (Figure 5) in the armature 12. This fin prevents rotary movement of the armature 12 with respect

to the shaft 10 and causes the armature and shaft to rotate as a unit.

The armature 12 has a hub 16 (Figure 2), and there is a sleeve 18 surrounding the hub 16 and extending upwardly beyond the end of the hub 16. This sleeve 18 fits tightly over the hub 16 with a press fit so that the sleeve 18 and armature 12 form a unitary structure.

The sleeve 18 is axially movable in a casing 20 within which the sleeve 18 fits with a running clearance. This casing 20 encloses a chamber within which windings 22 are enclosed.

The casing 20 is of composite construction with its inner surface formed by a sleeve 24 made of brass, plastic or other non-magnetic material. This sleeve 24 provides the bearing surface in which the sleeve 18 slides. The rest of the casing 20 is preferably made of iron or other magnetic material and there are openings in the side of the casing for the emergence of the ends of the windings 22. These ends provide conductor 26 and 27 which lead to a power source 30. A switch 34 is connected between the windings 22 and one side of the power source 30.

The casing 20 and its winding 22 form a magnet, designated by the reference character 38, for attracting the armature 12 each time that an electric impulse is supplied to the winding 22 from the switch 34.

The upper end of the casing 20 is attached to a fixed support 40; and there is a magnetic core consisting of a shell 42 which is attached to the fixed support 40 and located within the sleeve 24 immediately above the upper end of the sleeve 18 which reciprocates with the armature 12. The confronting edges of the sleeve 18 and the shell 42 have teeth or abutments 46 which engage one another, as shown in Figure 3. The teeth or abutments 46 are of substantial width and located side-by-side around the entire circumference of the sleeve 18 and shell 42 so as to obtain a large area of wearing surfaces and resulting long service. In the construction illustrated, each of the teeth 46 is straight on one side and has a slope or cam surface 48 on its other side. A collar 49, fixed on the shaft 10 confronts a face of the shell 42 and serves as a thrust bearing to prevent upward movement of the shaft 10.

A spring 50 is compressed between the upper end of the shell 42 and a recess in the armature hub 16. This spring 50 is connected at its opposite ends with the shell 42 and the armature 12, and the spring is wound to a slight extent so as to impart a limited rotary bias to the armature 12. This bias is in a direction to hold the cam faces 48 of the teeth 46 on the sleeve 18 in contact with the cam faces of the upper teeth 46 of the shell 42. The grooves 15 in the armature 12 do not extend for the full height of the armature; and the upper ends of these grooves 15 rest on the fin 14 to limit the downward movement of the armature 12. The teeth 46 are long enough so that they do not come out of mesh with one another when the armature 12 is down against the fin 14.

From the description thus far, it will be apparent that the spring 50 normally holds the armature 12 in its lowered position, as shown in Figure 2, and with the armature rotated so as to hold the sliping faces of the lower teeth 46 in contact with the sloping faces of the upper teeth 46. Whenever the magnet 38 is energized, the armature 12 is pulled upward, and the lower teeth 46 slide further into mesh with the fixed upper teeth 46, thus imparting angular movement to the armature about the longitudinal axis of the shaft 10. As the armature 12 moves upwardly and angularly, its angular rotation is imparted to the shaft 10 without moving the shaft 10 axially because of the sliding connection provided by the fin 14 in the grooves 15. These grooves 15 are of a sufficient height so that they do not clear the top of the fin 14 when the armature 12

reaches the top of its stroke where it contacts with the bottom face of the casing 20.

When the supply of electricity to the magnet 38 is shut off, the armature 12 is pulled down again by the spring 50 and is rotated as it moves downwardly to restore it to its original position, the sloping faces of the teeth remaining in contact, as previously explained.

At the upper end of the shaft 10 there is a flange 56. This flange 56 rotates in a housing 58. There is a wire 60 wrapped in a helix and rotated between the flange 56 and the housing 58. This wire 60 is in contact with the flange 56 but is not connected thereto. The other end of the wire 60 extends into a recess 62 in the wall of the housing 58.

The wire 60 is wrapped in such a direction that the rotation of the flange 56, in the direction in which it turns when the shaft 10 is rotated by upward movement of the armature 12, causes the wire 60 to wrap tightly on the flange 56. This effect, which is produced by friction of the flange on the wire, causes the wire 60 to turn as a unit with the flange 56 and to turn the housing 58 because of the connection of the wire to the housing.

A gear 66 is secured to the housing 58 and rotates as a unit with the housing. This gear 66 is used to transmit successive angular movements of the housing 58 to typewriter ribbon spools or any other parts which are to be operated intermittently by the actuator of this invention.

When the flange 56 moves in the opposite direction, that is, in the direction in which it is moved as the armature 12 is pushed downwardly and moved angularly by the spring 50, the wire 60 tends to unwind from the flange 56, thus releasing the grip of the helix of wire on the flange 56. This release of the grip of the wire on the flange leaves the flange free to turn without rotating the housing 58.

In order to prevent the housing 58 from turning rearwardly as the result of some friction drag between the wire 60 and the flange 56, and in order to insure a more prompt release of the grip of the wire 60 on the flange 56 during downward movement of the armature 12, another flange 68 is provided at the lower end of the housing 58. This flange 68 is surrounded by a wire helix 70 located between the flange 68 and a ring 72 rigidly secured to the support 40. The wire 70 connects with the ring 72 in the same way as the wire 60 connects with the housing 58; but the wire helix 70 is wound in a direction to grip the flange 68 when that flange turns in the opposite direction to that which causes the wire 60 to grip the upper flange 56.

From this description of the flanges 56 and 68, and their associated wires 60 and 70, respectively, it will be apparent that the construction provides two automatic clutches, the upper one of which engages to rotate the housing 58 with the flange 56 during upward movement of the armature, and the other of which engages to prevent rotation of the housing 58 during the return movement of the armature 12 to the lower end of its stroke. Thus, the housing 58 and its connected gear 66 rotate with a step-by-step movement, that is, through limited angular movements always in the same direction in response to electric impulses supplied to the magnet 38.

The switch 34 is constructed to supply an impulse of current each time that its actuating element is rocked back and forth through a predetermined stroke. This switch has a housing 80 enclosing a chamber from which a lever 82 projects through an opening in a wall of the housing. This lever 82 has an extension 84 in position to be operated by a bar of the typewriter or other apparatus with which the invention is to be used. If necessary, a spring can return the lever 82 to its original position.

The lever 82 and its extension 84 form the actuating element of the switch 34. The lever 82 rocks on a pin 86 secured to the housing 80. A latch 88 is located between the two sides of a forked upper end of the lever 82; and this latch 88 connected to the lever 82 by a pin 90. The lower part of the latch 88 contacts with a surface 92 of the lever 82 to limit movement of the latch in a counter-clockwise direction around the pin 90; and a leaf spring 94 urges the latch into contact with the surface 92. The fixed end of the spring 94 is secured to an inside wall of the housing 80.

In the upper part of the housing 80 there are two electric contacts 96 and 98. The lower contact 96 is carried by an arm 100 made of spring metal and fixed at one end to an insulating block 102 secured to the wall of the housing 80. There is a depressed reaction 103 of the arm 100 over the upper end of the lever 82, and one side of this depressed section is sloped to provide a cam face 104.

When the lever 82 swings counter-clockwise, the latch 88 catches on the straight side of the depressed section 101 and rocks clockwise on the pin 90 as the pin moves toward the left with the rocking of the lever 82. This rocking movement of the latch lowers the upper end of the latch until it passes under the depressed section 101. The spring 94 then moves the latch, with respect to the lever 82, back to its original condition in contact with the surface 92 of the lever 82.

When the lever 82 again swings clockwise, the latch 88 cannot turn on the pin 90, because the bottom of the latch is already in contact with the surface 92 that stops further rotation of the latch, and the movement of the latch 88 toward the right with the lever 82 causes the latch to travel along the cam face 104 and displace the spring arm 100 and contact 96 upwardly. This brings the contact 96 up against the contact 98 to close the circuit of the switch 34. Further movement of the latch toward the right brings it beyond the end of the cam face 104 and the switch arm 100 moves downwardly with a snap action.

The upper contact 98 is carried by an arm 106 which is preferably made of spring material having a bias that tends to move the contact 98 further away from the contact 96. This bias is opposed, however, by a leaf spring 108 that bears against the top of the arm 106 above the contact 98. The pressure of this spring 108 against the arm 106, and the resulting spacing of the upper contact 98 from the lower contact 96, is adjustable by a screw 110 threading through the top wall of the housing 80. The screw 110 has sufficient friction in the threads to hold it in any adjusted position.

The left hand ends of the arm 106 and the spring 108 are secured to the insulation block 102, the arm 106 is connected with the conductor 26 leading to the magnet 38, and the arm 100 is connected with another conductor 112 leading to the power source 30.

From this description of the switch 34 it will be apparent that movement of the lever 82 counterclockwise does not close the switch, but return movement of the lever 80 clockwise lifts the lower contact 96 up against the contact 98 to close the switch 34 to supply an impulse of current to the magnet 38.

The preferred embodiment of the invention has been illustrated and described, but changes and modifications can be made and some features can be used in different combinations without departing from the invention as defined in the claims.

What is claimed is:

1. An electro-magnetic actuator comprising a shaft rotatable about its longitudinal axis, bearing means in which the shaft turns, an armature near one end of the shaft and movable axially of the shaft, a connection between the armature and the shaft and through which rotation of the armature is transmitted to the shaft, the armature being movable through a stroke lengthwise of the shaft, an electro-magnet enclosing a hollow space and having a pole face across which the armature extends in position to be attracted toward the pole face, means for causing the armature to move through a reverse stroke in a direction away from the pole face, movable abutment surfaces carried by the armature and located within

the space enclosed by the magnet, fixed abutment surfaces confronting the movable abutment surfaces and also located within the space enclosed by the magnet, said abutment surfaces extending at an angle to the direction of movement of the armature so that motion of the movable abutment surfaces along the fixed abutment surfaces imparts rotary movement to the armature and through said connection to the shaft, a clutch having a driven member rotated by the shaft, and means preventing reverse movement of said driven member.

2. The electro-magnetic actuator described in claim 1 and in which the abutment elements are teeth having sloping surfaces on at least the sides of the movable and fixed surfaces that confront one another, the teeth being longer than the stroke of the armature and always in mesh with one another for all positions of the armature.

3. The electro-magnetic actuator described in claim 2 and in which there are spring means urging the rotatable abutment element to move angularly about the axis of the stroke of the armature, the force of the spring means being in a direction to hold the sloping faces of the teeth in continuous contact with one another.

4. The electro-magnetic actuator described in claim 1 and in which the electro-magnet has an annular winding, and the movable abutment surfaces carried by the armature extend upwardly into the center opening through the annular winding, and there are a fixed support for the magnet, and a shell within the upper end of said center opening and on which the fixed abutment surfaces are formed.

5. An electro-magnetic actuator comprising an electric magnet having a pole face, an armature extending across the pole face and movable through a stroke with respect to the magnet, and toward and from the magnet, a rotary element from which the actuator transmits motion to other apparatus, and motion-transmitting connections between the armature and the rotary element including two sleeves which are surrounded by the magnet and which have end faces confronting one another and with cam surfaces on their confronting faces, one of the sleeves being movable about its longitudinal axis and with respect to the other sleeve, the cam surfaces being at an angle to the direction of the axial movement, one of the sleeves being rotatable about said longitudinal axis and the other sleeve being held against rotation, and means connecting the rotatable sleeve with the rotary element including a one-way clutch which transmits motion in one direction only.

6. An electro-magnetic actuator including an annular electric magnet for connection to a fixed support, an iron casing extending around the top, bottom and outside of the magnet, a non-magnetic sleeve which forms the inside wall of the electric magnet, a cup enclosed within the upper end of the sleeve and having a cylindrical portion extending downwardly along the inside surface of the sleeve with a bottom edge formed with long teeth, an armature comprising a ferrous metal disc located below

the end face of the electric magnet, a hub extending upwardly from the disc, a cylindrical sleeve secured around the outside of the hub and extending upwardly from the hub into the non-magnetic sleeve within the magnet and having teeth at its upper end which mesh with the teeth of the cup, a shaft extending through center openings in the cup and armature, a fin secured to the lower end of the shaft and extending loosely into grooves in the bottom face of the armature, the grooves having upper walls which rest on the fin to support the armature from the shaft, a housing at the upper end of the shaft, the housing being rotatable on the shaft, a thrust bearing at one end of the housing for contact with the fixed support, a flange at the upper end of the shaft having a bearing surface in contact with the housing for preventing donward movement of the shaft, a first one-way clutch means between the flange and the housing for turning the housing when the shaft moves in one direction, and a second one-way clutch means between the housing and the fixed support for preventing the housing from turning in the direction opposite to that in which it is rotated by the first one-way clutch means.

7. An electro-magnetic actuator comprising a core and an energizing winding around the core, downwardly extending teeth around the circumference of the core and intermediate the ends of the core, each of said teeth having a face on one side sloping in a tangential direction, said teeth being of substantial radial width and located adjacent to one another around the circumference of the core so as to provide a large total abutment area, a sleeve extending upwardly into the core and having an upper end face with teeth thereon complementary to the teeth on the core and meshing therewith and of substantial radial width to obtain a large total wearing area in contact with the abutment area provided by the teeth on the core, means urging the sleeve to move angularly to maintain its teeth in contact with the sloping faces of the core teeth, the sleeve being movable also axially toward and from the core to change the extent of mesh of said teeth and to impart relative rotation to the sleeve by cam action of the sloping faces of the core teeth.

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