

June 20, 1961

W. PARISOE
ELECTROMAGNETIC DEVICE

2,989,668

Filed May 29, 1959

2 Sheets-Sheet 1

Fig. 1.

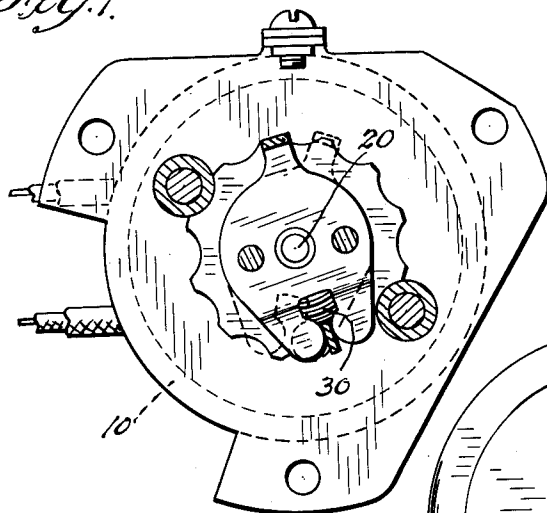


Fig. 3.

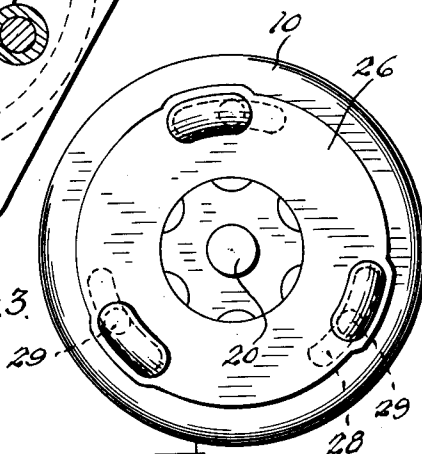
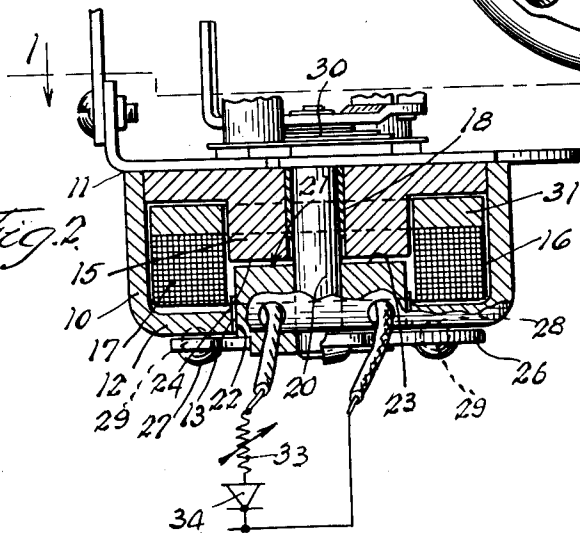


Fig. 2.



INVENTOR.
Wilbert Parisoe
BY
Robert L. Kahn.
Att.

June 20, 1961

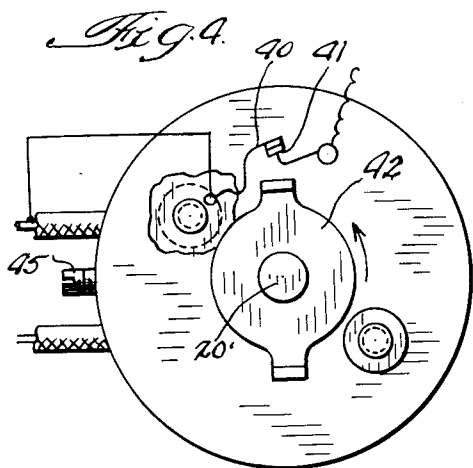
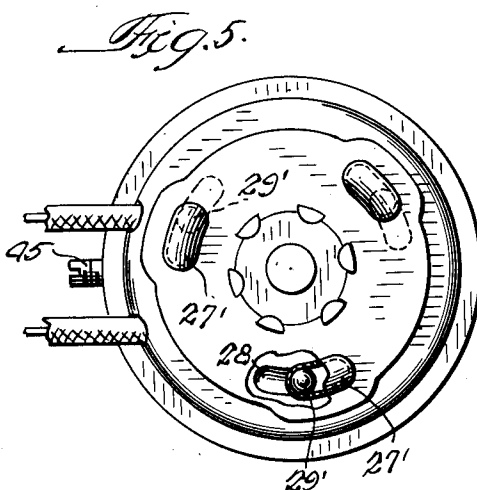
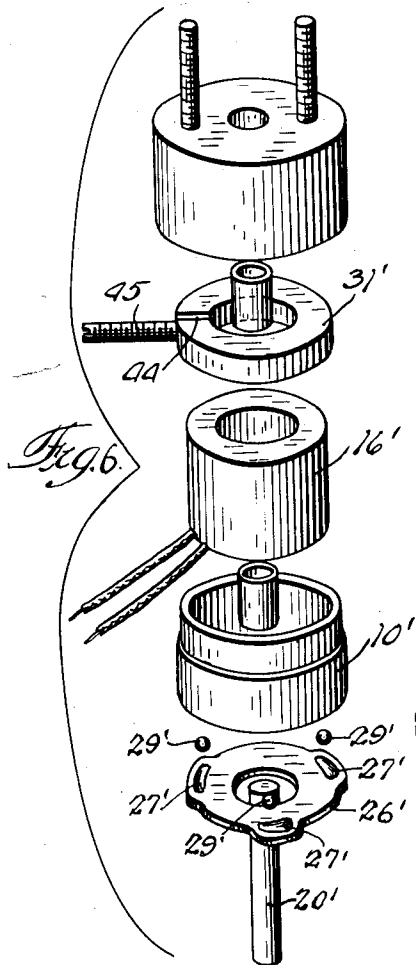
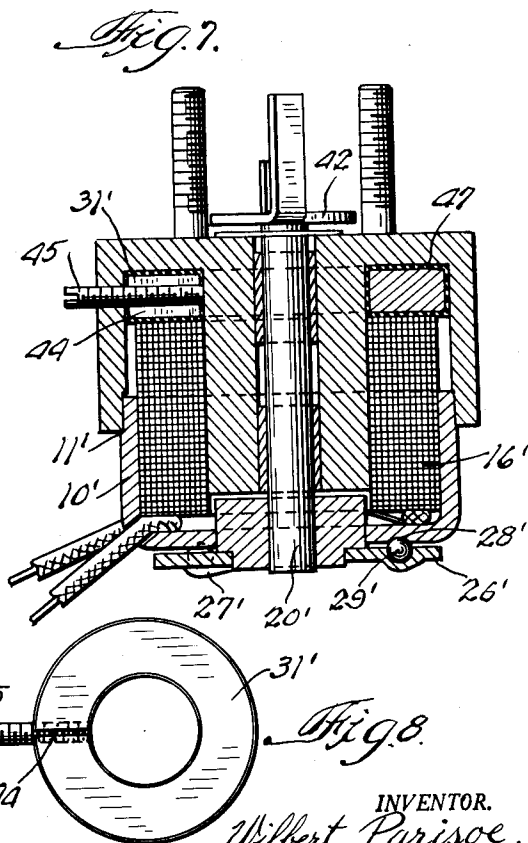
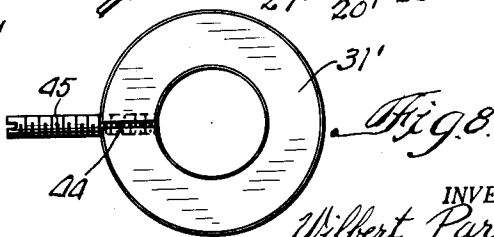
W. PARISOE

2,989,668

ELECTROMAGNETIC DEVICE

Filed May 29, 1959

2 Sheets-Sheet 2



INVENTOR.
Wilbert Parisoe.
BY
Robert L. Kahn.
Att'y.

1

2,989,668

ELECTROMAGNETIC DEVICE

Wilbert Parisoe, Highland Park, Ill., assignor to Oak Manufacturing Co., a corporation of Delaware
Filed May 29, 1959, Ser. No. 816,818
6 Claims. (Cl. 317-176)

This invention relates to an electromagnetic device having a movable armature operated by a winding and particularly to a solenoid for controlling the duration of an operating cycle.

The solenoid to which this invention is applicable is more fully disclosed in United States Patent No. 2,430,940, issued November 18, 1947 to Leland. Such a solenoid is useful for operating rotary switches and an application of this solenoid to rotary switches is disclosed in United States Patent No. 2,812,453, issued on November 5, 1957 to Mastney.

In this last-named patent, means are provided for preventing overshoot of the load due to the fact that the solenoid armature is operating at maximum speed near the end of its stroke. As is more fully disclosed in the first-mentioned patent to Leland, the solenoid has an armature which is adapted to turn inwardly toward the solenoid structure during energization.

The operating winding is a simple coil having a suitable ferro-magnetic structure including as a part thereof a movable armature. In the specific embodiment of the invention, the armature is rotatable through a predetermined fixed angle and is also translatable along its axis during rotation. The means for controlling the armature movement is fully disclosed in the prior patents and will also be described herein.

In connection with the operation of such a solenoid, it has been found that the speed of movement of the armature during energization of the winding is influenced by the potential applied to the winding for energizing the same. Inasmuch as the solenoid is generally provided with automatic switching means for opening the energizing circuit after the armature has moved through its prescribed range, and since the armature is restored to its initial starting position automatically by suitable means, it has been found that the overall operating time of a solenoid is subject to wide fluctuations depending upon the magnitude of the applied potential.

Such solenoids are energized by direct current and in certain applications it is important that the duration of an entire operating cycle for the solenoid be substantially constant in spite of variations in applied potential. Inasmuch as the time taken by the armature in moving during energization of the windings is cut down substantially with increase in potential, it follows therefore that it is necessary to delay the return stroke of the armature to maintain the overall period generally constant.

The mechanism with which the rotary solenoid is generally associated, examples of which are disclosed in the patents previously identified, makes it impractical to control the speed of return of the armature by operating on such mechanism. This invention provides simple means for controlling the speed of return stroke of the armature of a solenoid. In the specific example disclosed, the duration of the armature return is automatically increased as the speed of armature movement during energization increases in response to increased applied potential. In short the invention makes possible a controlled delay action on armature movement.

The invention generally contemplates the provision of a short circuited winding closely coupled to the energizing winding of the solenoid, the shorted winding being disposed in a portion of the solenoid so that the stroke of the armature is affected. In order to provide an adjustable control over the return stroke, one form of the in-

2

vention contemplates the provision of a resistor disposed across the operating winding during the return stroke. By controlling the value of the resistor, the return characteristics of the armature may be accurately controlled. In another form of the invention, means are provided for directly varying the ohmic resistance of a shorting ring.

It has been found that the overall duration of an operating cycle for a solenoid embodying the improvements suggested above is maintained within close limits over substantial variations of operating potential for the solenoid. It is understood that any time during which the armature is maintained in energized position is not included in operating time. It is clear that an armature may be retained in energized position indefinitely providing the energizing winding does not overheat. It has also been found that a flexible simple control for the speed of operation of an armature for any type of electromagnetic device can be provided by means of the present invention.

In order that the invention may be fully understood, it will now be disclosed in detail in connection with the drawings wherein FIGURE 1 is a sectional view taken on the line 1-1 of FIGURE 2 showing the new solenoid.

FIGURE 2 is a section through a portion of the solenoid to illustrate the windings and certain of the mechanical structure, this figure also showing in diagrammatic form the circuit connections for the winding.

FIGURE 3 is a bottom view of the device illustrated in FIGURE 2.

FIGURE 4 is a top view of the solenoid embodying the present invention, this view showing in diagrammatic form the switch for opening the energizing circuit at the end of an operating stroke.

FIGURE 5 is a bottom view.

FIGURE 6 is an exploded view of a modification.

FIGURE 7 is a sectional elevation along lines 7-7 of FIGURE 5 showing the modification.

FIGURE 8 is a detail of the short circuiting ring of the modification.

Referring first to FIGURES 1 to 3 inclusive, the solenoid to which this invention may be applied has ferro-magnetic housing 10 having top edge 11 and inwardly directed flange portion 12 at the bottom thereof. Flange portion 12 terminates in annular cylindrical surface 13. Cooperating with housing 10 is annular member 15 which in section is generally angle-shaped. Housing 10 and annular member 15 cooperate to provide a generally toroidal region 16 within which is disposed winding 17 for energizing the solenoid. It is understood that housing 10 and member 15 are both of suitable ferro-magnetic material, such as soft iron, and that members 10 and 15 are fitted together snugly to reduce reluctance.

Annular member 15 has bore 18 which is generally co-axial with toroidal region 16. Within bore 18 is non-magnetic stub shaft 20 which is movable both longitudinally and rotationally. Rigidly secured to stub shaft 20 is armature 21. Armature 21 has generally cylindrical surface 22 spaced from cylindrical surface 13 by a small clearance to permit armature movement. Armature 21 has end face 23 which is spaced from end face 24 of annular member 15 by an air gap whose magnitude will vary with armature movement.

In order to control the movement of the armature and force the same to have a corkscrew motion, metal plate 26 is rigidly attached thereto. It is preferred to have metal plate 26 of ferro-magnetic material in order to improve the efficiency of operation. As will be apparent later, it makes no difference whether metal plate 26 is directly attached to armature 21 or to stub shaft 20.

As is more fully disclosed in the Leland patent referred to, the opposing surfaces of plates 26 and housing portion 12 are provided with a plurality of arcuate cam grooves

27 and 28, respectively, within which balls 29 may ride. A steel ball 29 is provided for each cooperating pair of cam grooves 27 and 28. The cam grooves are arcuate with respect to the axis of shaft 20 and the arc angle will depend upon the desired solenoid stroke.

The depth of cam grooves 27 and 28 varies so that as ball 29 moves along the two cam grooves, due to relative rotation of the armature and housing, the cam action will permit plate 26 to approach part 12 of the housing during energization. Upon de-energization of the winding, suitable means, such as spring 30, will rotate the armature in the reverse direction causing the plate 26 to move away from the flange part of the housing.

Insofar as the present invention is concerned, the structure so far described may be considered as conventional and other means for securing travel of an armature may be provided.

In accordance with the present invention, copper ring 31 is disposed within toroidal region 16 adjacent edge portion 11 of the housing. This copper ring has one turn or may be replaced by a winding whose ends are connected together to short circuit the same. The ring or winding, as the case may be, will be designed so that the movement of the armature on the return stroke will be delayed a desired amount. This will be controlled by the ring dimensions or coil turns. As is well understood, the close coupling between the ring and ferromagnetic circuit causes the ring to act as a shorted transformer winding.

Due to manufacturing tolerances, it is preferred to provide a vernier action in the form of a variable resistor and a rectifier although the latter may be omitted if desired. The variable resistor and rectifier may be connected in series with what may be termed the short-circuited secondary designated here as 31. However, if a short circuited ring is used, it is preferred to have the resistor and rectifier across operating winding 17. Accordingly, resistor 33 and rectifier 34 are connected across winding 17.

As has been indicated above, rectifier 34 may be omitted but if inserted the rectifier should be so poled as to permit passage of current through the resistor from the operating winding during the return stroke of the armature. This current will flow in opposite direction to the flow of current when the solenoid is energized from a suitable d.c. potential source. The resistor may be permanently connected across the operating winding or may be switched across the winding only during the return stroke by automatic switching means. Where automatic switching means are used, it will be unnecessary to provide a rectifier since the resistor will not be connected across the operating winding during energization.

The application of an abnormally high direct voltage to the operating winding will magnetize the ferromagnetic structure more intensely and result in a much faster movement of the armature. Due to the greater flux density in the iron resulting from the higher energizing current, the decay of the current in the operating winding which occurs after current is shut off may be delayed thus reducing the speed of return movement of the armature in response to its spring bias. It has been found that the total operating time of a solenoid can be constant within close limits in spite of substantial variations of operating time of the armature during energization as a result of differences in energizing potential.

Referring now to FIGURES 4 to 8 inclusive, a modification of the construction embodying the present invention is shown. As has been previously indicated, the short circuiting ring in the construction illustrated in FIGURES 1 to 3 inclusive may be considered as a transformer secondary which is closely coupled to the operating winding functioning as a transformer primary. In the form of the invention illustrated in FIGURES 1 to 3 inclusive, the loss due to the resistor across the energizing winding (the primary of the transformer during

the return stroke) is reflected in the secondary and results in a delay action. In the modification now to be described, the construction has been modified so that the resistance is physically in the short circuiting ring.

The modified construction illustrated in FIGURES 4 to 8 inclusive is generally similar to that illustrated in FIGURES 1 to 3 inclusive insofar as the rotary mechanism, energizing winding and other mechanical details.

As illustrated in FIGURE 4—and this applies equally well to the modification illustrated in FIGURES 1 to 3 inclusive—a switch comprising movable contact 40 cooperating with fixed contact 41 is provided. This switch is normally closed in the idle position of the armature. However, when the solenoid has been energized and the armature has been turned, plate 42, secured to the armature, is adapted to open the switch near the end of the armature stroke. The means for accomplishing this may consist of a suitably shaped portion of the contact arm operated by plate 42.

In the modified construction, there is provided copper ring 31' which differs from ring 31. Ring 31' is split at 44 to open the ring. The split is here shown as complete to provide an electrical discontinuity in the ring. However, if desired, the split may extend from the outside of the ring inwardly part way. Ring 31' has a tapped recess provided at the split to accommodate screw 45. Ring 31' is preferably of copper or other low resistance material and screw 45 is also of copper or other low resistance material. The ring is so machined and cut that screw 45 will engage the threads very tightly to make good electrical contact. By controlling the depth of penetration of screw 45 into the ring, the electrical resistance of the ring as a short circuiting member can be accurately controlled. If desired, screw 45 may be of higher resistance material, such as brass, or the ring may be of brass and the screw may be of copper.

In order to permit screw 45 to be adjusted externally, the housing may be provided with an aperture through which the screw may project or into which a screw driver may be inserted for reaching the head of screw 45.

Instead of having a simple machine screw as illustrated, it is possible to have a tapered pin operate in a tapered slot in the ring. Thus, a tapered pin will have a sort of cam effect and will open the ring as the pin goes in to bridge an increasing amount of metal.

In the modification illustrated here, it is desirable to provide electrical insulation 47 around the short circuiting ring, or at least around the part where split 44 occurs. This is to prevent the metal of the housing from short circuiting the split in the ring.

While the invention has been illustrated in connection with a rotary solenoid, it is understood that it may be applied to other electromagnetic devices where a short circuiting winding is used. Thus, there are many instances where a copper slug or ring is used to provide a delay action. By opening the ring and providing an adjustable metal insert for controlling the electrical resistance of the short circuiting ring, the effects of the ring may be accurately controlled.

This is a continuation-in-part of my application, Serial No. 777,304, filed December 1, 1958, and now abandoned.

What is claimed is:

1. An electromagnetic device having an operating winding and ferro-magnetic core structure, including an armature movable in response to magnetic flux in said core and armature, said operating winding being adapted to be energized by direct current for obtaining armature movement, a split short circuiting copper ring closely coupled to said winding, said split ring comprising a normally open single turn winding which is adapted to function as a secondary of a transformer whose primary is the operating winding, a copper member shaped to fit into the split of the ring and means for controlling the insertion of the member into the split portion to

5

control the amount of copper bridging the split whereby the ohmic resistance of the split ring can be accurately controlled and thereby control the delay characteristics of the device.

2. The construction according to claim 1 wherein said means for controlling the insertion of the member comprises cooperating threads upon the member and in the split portion of the ring, said copper member constituting a copper bolt which can be threaded into the split to any desired depth.

3. A rotary solenoid having a substantially constant operating period over wide variations of energizing current, said solenoid comprising a generally toroidal ferro-magnetic structure, said ferro-magnetic structure having a shaft disposed at the axis of the toroid and having attached thereto as an armature a portion of the ferro-magnetic structure, said armature being movable around and along the toroid axis, means for limiting the movement of said armature and shaft to a partial turn with longitudinal travel of the armature along toroid axis to impart a corkscrew movement thereto, said armature being separated from the remainder of the ferro-magnetic structure by an air gap whose magnitude is increased to a maximum value when said armature is at one end of its travel, means for biasing said armature to said one end of its travel from which upon solenoid energization said armature moves toward the other end of its travel range, an energizing winding within an annular chamber of the toroidal ferro-magnetic structure,

6

a split copper ring within said toroidal chamber, a copper member shaped to fit into the split portion of the ring and means for controlling the insertion of the copper member into the split portion of the ring to control the amount of copper bridging the split whereby the ohmic resistance of the split ring can be accurately controlled and thereby control the delay characteristics of the solenoid.

4. The construction according to claim 3 wherein said means for controlling the insertion of the member comprises cooperating threads upon the member and in the split portion of the ring, said copper member constituting a copper bolt which can be threaded into the split to any desired depth.

5. The construction according to claim 4 wherein said copper ring is located in said toroidal region remote from said movable armature.

6. The construction according to claim 5 wherein said toroidal ferro-magnetic structure is apertured of provide access to said copper bolt from the exterior of said solenoid.

References Cited in the file of this patent

UNITED STATES PATENTS

1,240,471	Miller	Sept. 18, 1917
1,792,512	Siegmund	Feb. 17, 1931
2,473,598	Leland	June 21, 1949