

March 14, 1944.

H. T. SPARROW

2,344,178

ELECTROMAGNETIC DEVICE

Filed Nov. 6, 1941

2 Sheets-Sheet 1

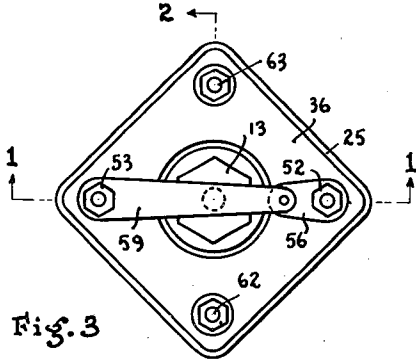


Fig. 3

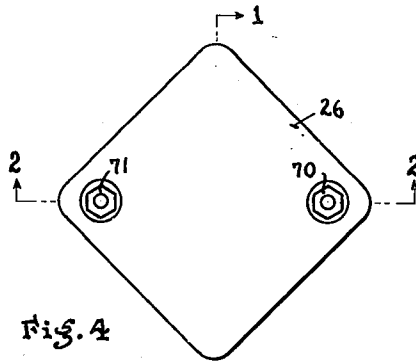


Fig. 4

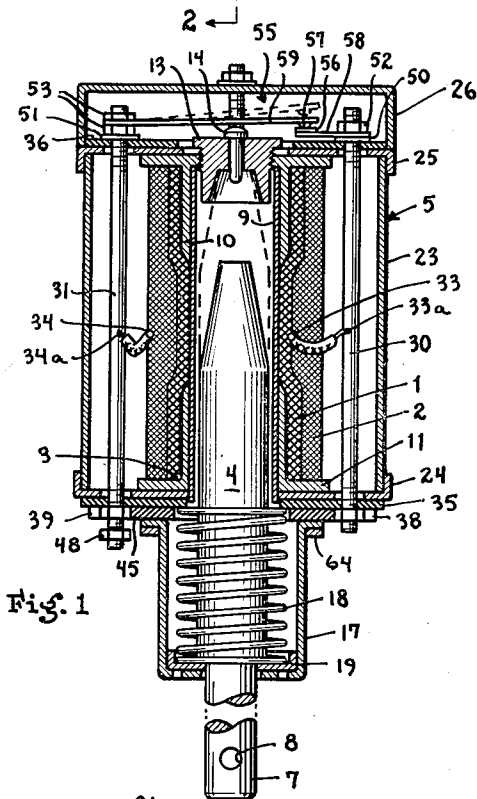


Fig. 1

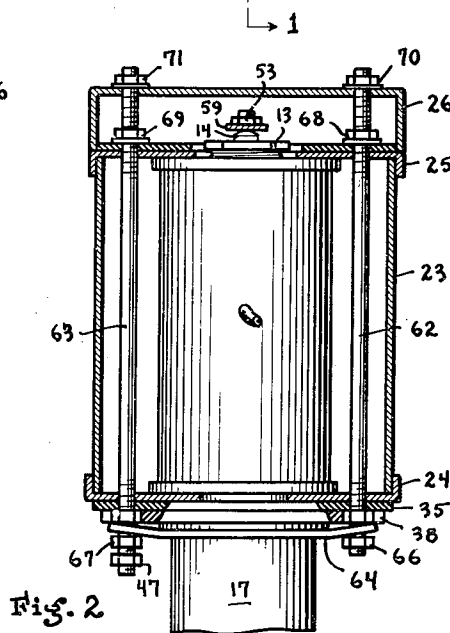


Fig. 2

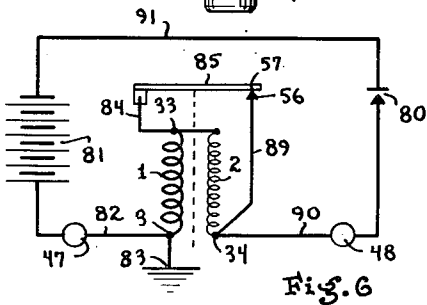


Fig. 6

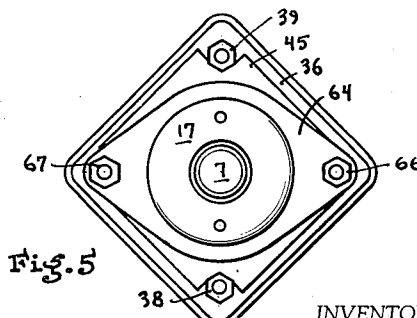


Fig. 5

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2 Sheets-Sheet 2

Fig. 8

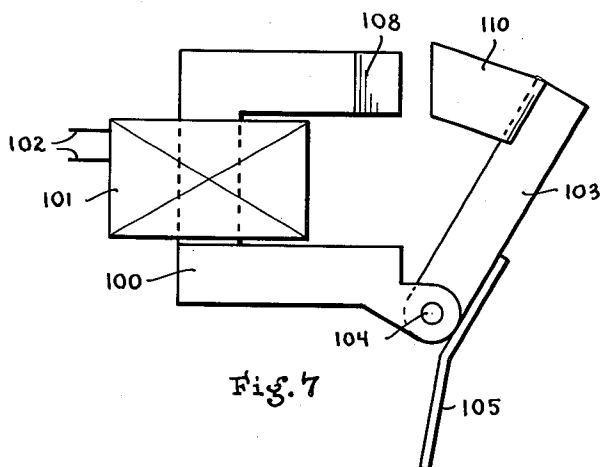
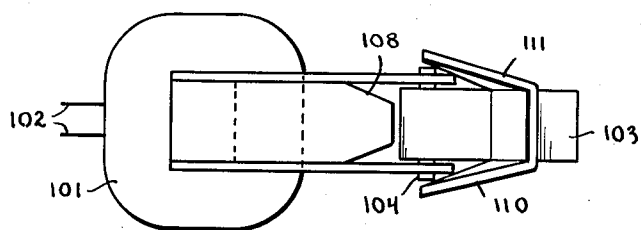


Fig. 7

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UNITED STATES PATENT OFFICE

2,344,178

ELECTROMAGNETIC DEVICE

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9 Claims. (Cl. 175—335)

This invention relates to improvements in electromagnetically operated devices and among other objects involves the provision of means for a more efficient application of the magnetic forces established therein with an accompanying improvement in the operating characteristics. One object of the invention is the provision of an improved solenoid device of the type disclosed in the patent to Bower et al. No. 1,978,737.

A particular object of the invention is to provide a solenoid device of improved operating efficiency and of an improved construction which provides for the efficient production thereof by reducing to a minimum the size and number of parts required, together with an improved and compact arrangement for the ready alignment, assembly and encasement of the elements of the device.

An additional object of the invention is the provision of novel and improved means for electromagnetic devices by which the elements of the devices may be properly aligned and readily assembled in casing means in which cover members are secured to the casing by means which form supports for the switching means, electrical connecting means for the coils within the casing and also terminal members for the devices.

A further object of my invention is the provision in relay and solenoid devices of means for the improvement of the operating characteristics, such as the pull-distance characteristics, with a resultant improvement in the operating efficiency of the devices.

The invention relates to the provision of supplemental electromagnetic means for relay devices which serve to complete an initial magnetic circuit between the core and armature members when the coil is initially energized and the armature is in the retracted position to substantially reduce the magnetic force otherwise required for the initial movement of the armature to its attracted position when the coil is energized. It is also the purpose of the invention to provide means for use in relay and solenoid devices by which the armature member is moved to an attracted position by a succession of sustained forces and whereby the tractive force may be maintained relatively constant throughout the entire stroke of the armature.

A further object of my invention is the provision of switching means operated by the electromagnetic devices and associated therewith for the control of circuits which provide the magnetic force necessary for initiating and sustaining the movement of the armature member from

a retracted position to an attracted position in cooperation with the core member and for thereafter reducing the magnetic force to a value necessary for retaining the armature in its attracted position.

Devices constructed in accordance with my invention have broad application and are especially adapted for use in the operation of locking devices, valve mechanisms and relay contacts that require a relatively long throw or stroke and also those requiring the application of a relatively constant force throughout the entire stroke of the armature. The devices are well adapted for use in various aircraft applications by reason of the relatively high efficiency of operation and corresponding reduction in weight of the core, coil and other elements together with the relatively small amount of power required for their operation.

Objects, advantages and features of the invention will be apparent from the description having reference to the drawings and forming a part of this application.

Figure 1 is a vertical section through the improved solenoid structure as viewed from the lines 1—1 of Figure 3;

Figure 2 is a vertical view of the device partly in section shown in Figure 1 as viewed along the line 2—2 of Figure 3;

Figure 3 is a top view of the device shown in Figure 1 having the switch cover removed therefrom;

Figure 4 is a top view of the device shown in Figure 2;

Figure 5 is a bottom view of the device shown in section in Figure 2;

Figure 6 is a schematic diagram of a circuit employed in connection with the operation of the solenoid;

Figure 7 is a vertical view of a relay device constructed in accordance with the invention, and

Figure 8 is a top view of the relay device shown in Figure 7.

Referring in detail to the drawings, in Figure 1, I have shown a solenoid device having coil means consisting of the coils 1 and 2, together with a plunger or armature member 4. The coil means and the upper portion of the armature member are housed in casing means generally denoted by the reference character 5.

A rod 7 is formed by that portion of the armature extending beyond the casing and has a hole drilled therein through which means, not shown, such as valves, switches and locking devices may

be secured for actuation by the armature. The armature is mounted for movement within an annular non-magnetic sleeve member 9. Annular magnetic sleeve members 10 and 11 positioned along the non-magnetic sleeve 9 serve together with the sleeve 9 to support the coil means with respect to the armature. A magnetic core and stop member or plug 13 having extended end portions is adjustably secured to the flange-like extension of the annular magnetic sleeve member 10 and this member has extended and tapered end portions for cooperation with the armature as described below. A switch actuating pin 14 is mounted for reciprocation therein to actuate a switching means 55 by action of the armature with respect to the stop member. Secured to the base portion of the casing 5 is a spring guide cup 17, in which is housed an armature biasing spring 18. This spring is secured at one end to the follower guide cup 19 which in turn is secured to the armature and the other end of the spring is mounted against the casing means 5. The casing means 5 consists of the side casing member 23 which is secured between the cup-shaped cover members 24 and 25. The switching means, described below, is mounted upon the cover member 25, and a top cover member 26 is provided for enclosing the switching means. A pair of bolt members 30 and 31 extend within the casing means and through the cover members 24 and 25. Insulating plates 35 and 36 are mounted upon the cover members 24 and 25, respectively. The bolt members 30 and 31 extend through the insulating members 35 and 36 and also through relatively large apertures in the cover members 24 and 25. The plates 35 and 36 serve as guide members and for insulating the bolts 30 and 31 from contact with the cover members. Members 38 and 39 having hex shaped heads are threaded to the ends of the bolts 30 and 31 for securing the insulating plate 35 to the cover member 24.

A lower insulating plate 45 is secured to the insulating member 35 and the corners of this plate are cut to fit and receive the edges of the hex shaped members 38 and 39 for the purpose of locking them in position, as best shown in Figure 5 of the drawings. Secured to the upper end of the bolts 30 and 31 are the washer members 50 and 51, respectively, and also the threadedly mounted members 52 and 53.

A switch denoted by the reference character 55 is housed within the top cover member 26. The switch consists of the contacts 56 and 57 carried by the blades 58 and 59 which are secured to the bolts 30 and 31 by the members 52 and 53, respectively. The blades 58 and 59 are biased in a direction to close the contacts 56 and 57. The switch contact blade 59 is operated to open the contacts by action of the pin 14 which reciprocates within the guideway in the core and stop member 13 when the armature member 4 is translated to its attracted position in cooperation with the stop member.

A pair of through bolts 62 and 63 extend through and in contact with each of the insulating and cover members. These bolts maintain the insulating and cover members in proper alignment and also serve as means for securing together the various parts of the casing means.

The members 47 and 48 are threadedly mounted on the lower end of the bolts 63 and 31, respectively, for cooperation with members

39 and 67 to form terminal members for the solenoid device.

The coil 1 is connected at one end 3 to the spool member 11 and is thus grounded to the cover member 24. The cover member 24 is in contact with the bolt and terminal member 63. The other end of coil 1 and one end of coil 2 are by a single soldered connection 33 joined through a common lead 33a to the bolt and switch member 30. The other end of the coil 2 is jointed at 34 by a lead 34a which is connected to the bolt and terminal member 31.

The spring guide cup 17 is secured to the lower portion of the casing means by the strip member 64 which is supported on the lower end portion of the through bolts 62 and 63 by the threaded members 66 and 67, respectively, as illustrated in Figures 2 and 5 of the drawings. The casing member 25 and the insulating member 36 are secured to the casing 23 by members 68 and 69 threadedly mounted on the bolts 62 and 63. The top cover member of the casing means 5 is secured with respect to the casing by the members 70 and 71 threadedly mounted on the bolts 62 and 63, respectively.

The circuit for operation of the solenoid is schematically illustrated in Figure 6 wherein like reference characters have been applied to the coil and switch contact elements. In the operation of the device the switch 80 is employed to control the supply of power to the solenoid from any suitable source of power such as the battery 81.

With the switch member 80 in open position the armature 4 is in the retracted position to which it is biased by the spring 18 as illustrated in Figure 1, and when the switch 80 is closed the device is so energized as to cause the armature to be translated to the attracted position in cooperation with the adjustable magnetic stop member and to maintain the armature in this position, as illustrated by the dotted lines appearing in Figure 1. To supply the magnetic field for the initial and sustained movement of the plunger to the attracted position, a circuit is established through coil 1 which consists of relatively few turns of wire of relatively low resistance. After the armature has been translated to its magnetically attracted position in cooperation with the magnetic plug 13 the magnetic force required to maintain the armature in this position is substantially reduced. The coil 2 consists of a relatively large number of turns of fine wire of relatively high resistance which when connected in series with the coil 1 serves to reduce the magnetic force produced by the combined coils to the value desired for maintaining the armature in the attracted position and to correspondingly decrease the power consumed in the operation of the solenoid.

When the switch 80 is operated to the closed position a circuit is established that includes the battery 81, or any suitable source of power, terminal 47, conductor 82, ground connection 83, coil 1, conductor 84, switch 85 through contacts 56 and 57, conductor 89 of relatively low resistance which serves as a shunt connection for coil 2, the conductor 90, terminal 48, switch 80, conductor 91 and return to the battery. As indicated above, the coil 1 is thus energized to produce the magnetic force required to provide for movement of the armature 4.

At this time a magnetic circuit is established by the coils which extends from the adjustable magnetic core member through the annular mag-

netic sleeve member 10 to the lower extended and tapered sleeve portions thereof located adjacent to the tapered end portion of the armature, and is completed by the armature. The magnetic circuit of relatively low reluctance is thus readily completed through the magnetic members and the relatively narrow gap of the adjacently positioned and tapered end portions of the magnetic sleeve and armature. As the armature is thus attracted to further close and concentrate the flux produced in the circuit, it moves upwardly to a position approaching the lower tapered and extended end portions of the magnetic core and stop member 13 to complete the magnetic circuit through the plug and armature members. The armature is thus further and successively attracted to the position in which the tip is in direct contact and cooperation with the interior and central portion of the magnetic core 13.

As the armature is translated through its stroke to the attracted position in contact with the core member 13, the switch operating pin 14 is reciprocated to a position in which it engages switch blade 59 and separates the switch contacts 56 and 57. At this time the switch 85, as shown in Figure 6, and which corresponds to switch 55, is opened and a circuit is established from battery 81, conductor 82, ground connection 83, coil 1, coil 2, conductor 90, switch 80, and the conductor 91 for return to the battery. The operation of the switch in opening contacts 56 and 57 to thus place coils 1 and 2 in series reduces the magnetic force to a value sufficient to maintain the armature in the attracted position and also reduces the power required for operation of the solenoid, as explained above.

The invention as applied to a relay device is illustrated in Figures 7 and 8 of the drawings. The relay structure consists of the core 100, the coil means 101 having terminal members 102 and an armature 103. The armature 103 may be mounted in any well known manner for cooperation with the core and as illustrated is pivotally mounted at 104 to the extended lower end portion of the core 100. The upper end portion 108 of the core is tapered for cooperation and contact with the upper end portion of the armature 103. Extension members, or flanges, of magnetic material 110 and 111 are secured to the upper end of the armature and are preferably tapered in the manner shown for cooperation with the tapered end portion 108 of the core 100. The magnetic flange members 110 and 111 serve to reduce to a minimum the magnetic force required for the translation of the armature from the retracted position illustrated to the attracted position in cooperation with the core, also to so concentrate the magnetic flux established by energization of the core as to provide a relatively constant force throughout the stroke of the armature and further serve as guide means for these cooperating members. Armature actuated means 105 secured to the armature 103 may be employed to operate such devices as valve mechanisms, relay contacts, switch members or locking devices, not shown. The means 105 may be employed to particular advantage for actuating devices of a type that require a long throw and the application of a relatively constant force through the entire stroke. Upon initial energization of the coil means 101 a magnetic circuit is established from the core 100 and the tapered end 108 thereof, to the tapered and extended end portions of the flanges and through the flange members 110 and 111, and is completed through

the armature 103. The magnetic reluctance of the circuit is obviously greatly reduced by employment of the flanges and by the resultant substantial reduction in the gap existing between the end 108 of the core and the upper end of the armature. As the armature approaches the fully attracted position the magnetic circuit is established between the tapered surface of the core and flange members and ultimately is established directly between the core and armature members as the armature is guided between the flange members to the fully attracted position.

It is apparent that when the armature has been translated to its attracted position the circuit for the coil means 101 may be modified by actuation of switching means associated with the relay armature, in the manner described above with reference to the solenoid coil means, for the purpose of reducing the power required for operation of the relay to a value sufficient to maintain the armature in the attracted position.

In the operation of both the solenoid and relay devices illustrated, it will be noted that an armature having a tapered end is preferably employed and also that the ends of the magnetic plug and magnetic sleeve of the solenoid are tapered, whereas the magnetic flange members of the relay are tapered and set at an angle with respect to the core member. In the operation of each of the devices when the coil means is energized a magnetic circuit is at all times established between and including the armature and core members.

During the course of the movement of the armature the initial tractive force is exerted through the magnetic circuit that includes the tapered end portions of the armature and sleeve members. This force serves without sudden increase or loss in power to raise the armature to a position in which the magnetic circuit cooperates with the succeeding tapered end portion of the plug member or the flange member at a point in which the gap and magnetic reluctance is decreased and to thus by a series of sustained forces move the armature further to its attracted position in engagement with the core.

When the armature moves into engagement with the core, the magnetic field is greatly increased and the coil means may be so operated as described above to maintain the members in this position by a reduced field and a corresponding reduction in the power consumed by the devices.

It will be obvious that the invention is susceptible of various embodiments and may be changed in various ways within the spirit and scope of the appended claims.

I claim as my invention:

1. A device in combination comprising, coil means, plunger actuating means operable by said coil means for translation to a first position, electromagnetic means for accomplishing the translation of the plunger to said first position and retention thereof in said position, means including a switch and circuits operable to modify the operation of the coil means to decrease the magnetic energization from the value required for translation of the plunger to the first position to a value sufficient to retain the plunger in the first position, casing means including casing members, members extending into the casing means to form terminal connecting means for the coil and for securing the casing mem-

bers, and said securing members extending beyond the casing means to form terminal means for the supply of power to said coil means and to said switching means.

2. A device in combination comprising, coil means, plunger actuating means operable by said coil means for translation to a first position, means including a switch and circuits controlled thereby operable upon translation of the plunger to and from said first position, casing means for the said coil including means for securing the casing with respect to said coil and switch means, and said securing means including means extending within said casing for connection with the coil means and means extending beyond the casing to serve as terminal means for the supply of power to said coil means and to said switching means.

3. A device in combination comprising, actuating means including coil means, switching means, casing means for said actuating and switching means including a base member, a member for supporting the switching means adjacent to the coil means and a top member for housing the switching means, means extending within the casing and through the switch supporting and base members for securing the base and switch supporting members to the casing, said securing means forming terminal connecting means for the coil means within the casing, with the portion extending through the base member forming terminal means for the device, and the portion extending through the switch supporting means forming means for securing the switching means to the switch supporting member, and means extending within the casing and through the base and top members for securing the base and top members to the casing means.

4. A device in combination comprising, coil means, armature actuating means operable by said coil means for translation to a first position, electromagnetic core means for assisting in the translation of the armature to said first position and retention in this position, casing means including cover means therefor, means for securing the cover means to the casing, said securing means being connected within the casing to the said coil and extending beyond said casing to form terminal means for the supply of power to said device.

5. A device in combination comprising, actuating means including coil means, casing means for said actuating means including a base member and a top member, means extending within the casing and through the base and top members for securing the base and top members to the casing, said securing means forming terminal connecting means for the coil means within the casing and the portion of the securing means extending through the base member forming terminal means for the device.

6. A solenoid in combination comprising, coil means, a plunger operable by said coil means for translation to a first position upon energization of said coil means, electromagnetic stop means for assisting in the translation of the core to said first position and retention in this position by said coil means, electromagnetic means cooperating for the substantial provision of the tractive force for the initial movement of the core to its said first position, switching means adapted to control said coil means including circuits adapted to vary the operation of the coil means, said switching means being operative

upon energization of said coil means and translation of the plunger to said first position to decrease the magnetic energization by said coil means to a value sufficient for retaining the core in said first position, casing means for housing said solenoid and switching means including cover members for said coil means and means for securing the cover members and comprising terminal means for the said coil means and switching means, and means for covering the switching means including means for securing the switch covering means to the casing means.

7. A device in combination comprising, a plunger actuating means and coil means, switching means, casing means for said actuating and switching means including a base member, a member for supporting the switching means adjacent to the coil means and a top member for housing the switching means, spring guide and biasing means for cooperation with the plunger and a housing cup therefor, means extending within the casing and through the switch supporting and base members for securing the base and switch supporting members to the casing, said securing means forming terminal connecting means for the coil means within the casing with the portion extending through the base member forming terminal means for the device and the portion extending through the switch supporting means forming means for securing the switching means to the switch supporting member, means extending within the casing and through the base and top members for securing the base and top members to the casing means also for securing the spring housing cup to the base member of the casing, and to further serve as terminal means for the device, insulating members associated with the switch supporting and base members and through which the said means for securing the base and switch supporting members to the casing means extend and also through which the said means for securing the base and top members extend, and the said insulating means serving to insulate the means extending through the switch supporting and base members from the said casing members.

8. In an electromagnetic operator, a winding, an armature associated therewith and moved upon energization of said winding, a housing for said winding, control mechanism operated by said armature, a second housing for said control mechanism, threaded clamping members holding said housings together, electrical connections between said winding and said fastening members, and terminal members secured to said clamping members for securing electrical connections thereto.

9. A device comprising in combination, a pair of solenoid windings having a passage there-through, an armature movable within said passage, a first housing for said windings, terminal posts extending outside of said housing, means connecting a first of said windings between two of said posts, means connecting the other winding between one of said two posts and a third post, normally closed switching means connected between said two posts so as normally to short circuit said first named winding, means operable upon energization of said other winding to open said switching means and cause said windings to be connected in series, a second housing for said switching means, and means including said terminal posts for holding said first and second housings together.

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