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3,022,400

TWO-WAY SOLENOID

Filed June 27, 1957

FIG. 1

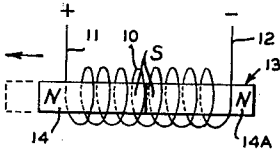


FIG. 2

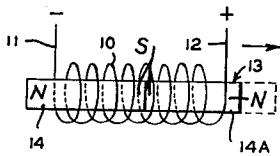


FIG. 3

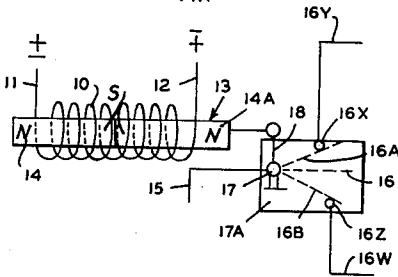


FIG. 6

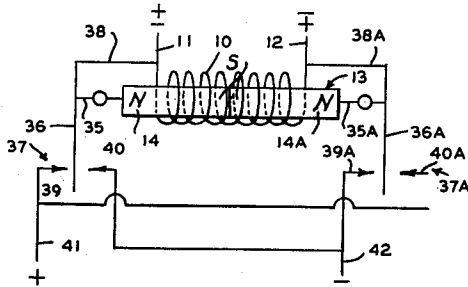


FIG. 8

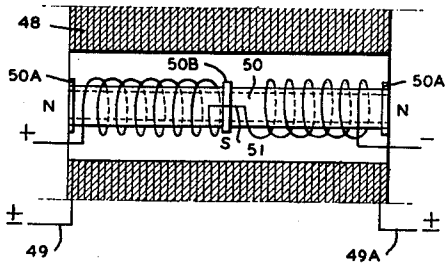


FIG. 4

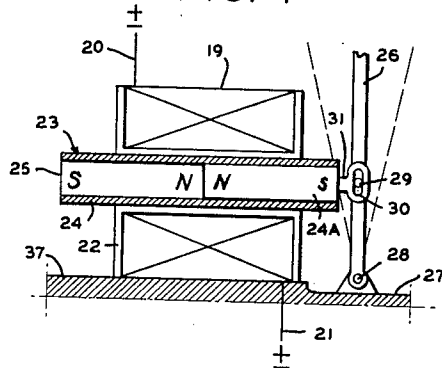


FIG. 5

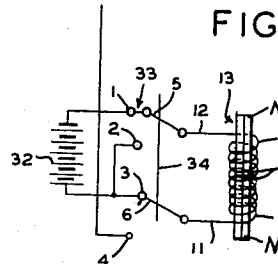
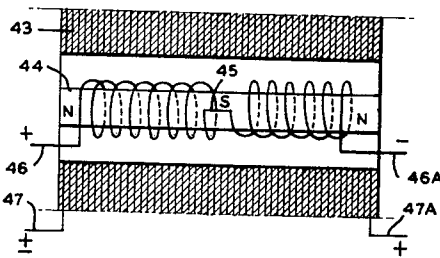


FIG. 7



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TWO-WAY SOLENOID

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The present invention relates to an electrically operated solenoid or servo-motor for producing movement in two opposite directions.

Heretofore it has been conventional to use a solenoid to draw a core or armature in one direction to obtain a mechanical response from an electric current. Usually the armature or core was biased in one direction by a spring or the like and moved in the opposite direction by the magnetic effect caused by the flow of current through the solenoid. Two solenoids have been used for obtaining movement in two directions and by suitable energization of one solenoid or the other movement can be obtained in the selected direction. In the previously known solenoids, the core has been drawn into the hollow solenoid coil and not pushed out. The previous solenoid operated structures have not completely solved such problems as directing guided missiles where weight is an important consideration.

An object of the present invention is to overcome the problems enumerated above and to provide a single solenoid or servo-motor which will operate in two directions by the application of electric current in one direction or the other.

Another object is to provide a solenoid with a core moveable out of the solenoid.

A further object is to provide greater force and shorter response time for the same weight and input energy for solenoid operation.

Further objects will be apparent as the description proceeds and upon reference to the accompanying drawing wherein:

FIG. 1 is a diagrammatic illustration of one form of the invention showing a solenoid with a core of two permanent bar magnets fixed in end to end relation with like poles together;

FIG. 2, a diagrammatic illustration similar to FIG. 1 with the current applied in the opposite direction;

FIG. 3, a diagrammatic illustration of the device applied as a double throw switch mechanism or polarity control;

FIG. 4, a transverse section of a solenoid with multiple permanent magnets forming the core with the north poles fixed together and showing a mechanical connection to a lever or control vane;

FIG. 5, a diagrammatic illustration of a source of direct current connected by a double-pole double throw switch with the blades connected to the leads of a solenoid having a magnetic core of two permanent magnets with their south poles together;

FIG. 6, a protection device for direct current equipment to assure proper polarity of the supply of electricity to the electrical equipment or for use as a rectifier device;

FIG. 7, another embodiment of the invention having a core of magnetizable material with a coil wound on the core to produce north poles at each end and a south pole in the center; and

FIG. 8, a further modification in which the core consists of a coil wound on a non magnetic core and being located within a solenoid.

Briefly the present invention comprises a servo-motor or control device including a solenoid having a hollow center in which an armature or moveable core is moveably mounted or the core may be fixed and the coil moveable. The armature is formed of two or more permanent bar

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magnets arranged in end to end relation with like poles in substantially abutting relation and with the bar magnets fixed together by any suitable means, the mounting of the armature permitting movement in both directions in said solenoid. The application of direct current in one direction to the solenoid energizes the solenoid causing the moveable core to move in one direction and the reverse application of direct current to the solenoid energizes the solenoid causing the moveable core to move in the opposite direction whereby controlled movement in two directions can be obtained from a single motor control or device. Suitable connections are provided between the moveable core and a lever or the like to be operated by such moveable core, the lever may be connected to the coil and the core fixed whereby the moveable coil operates the lever or other moveable element.

Referring more particularly to the drawing, a more or less conventional solenoid coil 10 having leads 11 and 12 is formed around a suitable hollow core in a conventional manner and within such solenoid a moveable core or armature 13 is mounted for longitudinal moveable relative to the solenoid. The armature or core 13 is shown as formed of two bar magnets 14, and 14A which are arranged in end to end relation with their south poles together, by suitable means to maintain such end to end relation. Some of the means which may be used are sleeves of plastic or non-magnetic alloy materials, adhesive, silver solder, a non-magnetic rod of brass or other material extending through holes in the bar magnets, and it may be possible to make a magnet of an integral piece of magnetic material so as to have like poles together.

Upon application of the current to the solenoid 10 in one direction as indicated by the + and - signs on the leads 11 and 12, the armature 13 will move to the dotted line position of FIG. 1. Upon reversal of the current as shown in FIG. 2, the armature 13 is caused to move in the opposite direction. In tests which have been made, the force resulting from the energization of the solenoid produces a substantially flat curve when force is plotted as the vertical coordinate and the displacement is plotted as the horizontal coordinate. The force exerted by the solenoid on the armature core of the present invention builds up rapidly and also drops off rapidly. This is materially different from the characteristics of a conventional solenoid with an unmagnetized core.

In a series of tests made with samples of the present invention the speed of travel of a core of permanent bar magnets arranged end to end with like poles together was approximately $\frac{1}{3}$ to $\frac{1}{2}$ faster than the speed of a conventional solenoid core thereby showing the advantages of speed as well as increased force obtained by the present invention.

The device according to the present invention can be used where greater displacements and/or forces are required and for movement in either one or two directions and where more rapid response is required. The invention is useful for latching core solenoids as the core will hold magnetically to a suitable stop and also with cased, boxed, cored, or plugged solenoids.

Upon reference to FIG. 3, a polarity control relay or switch mechanism is provided with a switch plate 16 pivotally mounted on a pivot 17 on an insulated base 17A. A lever 18 fixed to the switch 16 is pivotally connected by a link 19 to the armature 13 whereby movement of the armature 13 causing the switch plate 16 to be moved to the dotted line position 16A where the switch blade will engage contact 16X connected to a lead 16Y, the switch plate 16 being moveable to the dotted line position 16B to engage contact 16Z connected to a lead 16W whereby the single pole double throw switch can be operated by the single solenoid 10 which can be

actuated for movement in both directions. It will therefore be seen that applicant has provided a polarity control relay means for electric circuits by means of a single solenoid having a moveable permanent magnetic core therein.

Upon reference to FIG. 4, a solenoid coil 19 shown in section and having leads 20 and 21 extending therefrom is wound or mounted on a flanged spool 22 in which an armature 23 is mounted for slideable movement, said armature 23 being formed of permanent bar magnets 24 and 24A with such bar magnets arranged in end to end relation with their north poles together, such bar magnets being secured to one another by a sleeve 25 of any suitable type, the connection being shown as a sleeve surrounding the north ends of the bar magnets the sleeve being formed of any suitable non-magnetic material and fixed to the bar magnets 24 and 24A by any suitable means.

A lever 26 is pivotally mounted on a suitable support 27 on which the solenoid coil 19 may also be mounted, the pivotal connection being indicated at 28. The lever 26 is shown as provided with a stud 29 which is received in a yoke 30 which is connected by a stud 31 to the armature 23 whereby movement of the armature will cause corresponding movement of the lever 26 and such lever can therefore be used for controlling any desired equipment or device, for example, guided missiles or the like.

Upon reference to FIG. 5 the solenoid coil and armature are identified by the same reference numerals as are used in FIGS. 1, 2, 3, whereby repetition of description is avoided. A source of electric current such as a battery 32 provides current to the contacts 1, 3, 4, and 2, respectively of a double pole double-throw switch 33 while the blades 5 and 6 are electrically connected to the leads 12 and 11 of the solenoid 10, such blades being connected by an insulated operating bar 34 whereby movement of such operating bar 34 causes the blades 5 and 6 to move from contacts 1 and 3 to contact 2 and 4 resulting in reverse flow of current in solenoid 10 thereby producing movement of the core in the opposite direction.

Upon reference to the modification shown in FIG. 6 the solenoid and armature core are identified by the reference numerals used in FIGS. 1, 2 and 3, and additional connections are provided to obtain the desired direction of the flow of current to a load from the source of power to the solenoid so that no damage can be caused to delicate instruments or equipment by the reverse application of current. To the north ends of permanent magnets 14 and 14A insulated links 35, 35A, are connected to blades 36, 36A of single pole double-throw switches 37, 37A, current being supplied to the blades 36 and 36A by leads 38 and 38A, respectively, from the power supply leads 11 and 12 of the solenoid respectively. Contacts 39 and 40 of switch 37 and contacts 49A and 39A of switch 37A are connected to load lines 41 and 42 respectively.

Upon reference to FIG. 7, conventional solenoid windings 43 surround a core 44 of magnetizable material and such core is wound from the center point 45 of the right portion of a wire toward both ends terminating in leads 46, 46A which may be energized from a source of direct current to obtain north poles at each end and a south pole at the center point 45. Said wound core may be used for the same purpose as the permanent magnets previously described. It will also be apparent that the core can be held stationary and the solenoid coil can be moved by the energization of the windings of the solenoid coil by means of its leads 47 and 47A.

It will also be apparent that suitable control switches can be used for producing the reversal of the flow of current in the solenoid coil or in the windings of the core or in both the solenoid and the windings of the core.

Referring to FIG. 8, solenoid coil windings 48 are shown with leads 49, 49A for energization thereof to obtain polarity. The movable core is shown as a coil formed on a tubular core 50 of non-magnetic material having flanges 50A at its end and a center flange 50 upon which core con-

ductive windings are provided with the windings having a common center point 51 from which the conductor is wound in opposite directions toward the left and right portions of the core 50 with the windings in the right portion separated from the windings in the left portion until the desired number of turns are obtained to effect the polarity shown by the N's indicating the north polarity at the ends and the south polarity being indicated by the letter S at the center point 51. The core when energized with electricity will produce the desired polarity in the core and relative movement between such core and the solenoid windings will be obtained. With this arrangement suitable flexible connections and the like would be provided for the movable element.

From the above description it will be apparent that applicant has provided a servo-motor of general utility having a wide application in controls of all types. It will also be apparent that the invention can be used to rectify alternating current in the modification shown in FIG. 6.

It will be obvious to those skilled in the art that various changes may be made in the invention without departing from the spirit and scope thereof and therefore the invention is not limited by that which is illustrated in the drawings and described in the specification, but only as indicated in the accompanying claims.

What is claimed is:

1. An electronic motor comprising a solenoid, a slideable core mounted in said solenoid for sliding movement, said core comprising at least two permanent magnets, said magnets being arranged in end to end relation with like poles at the adjacent ends and the opposite poles at the outer ends of each magnet, the outer ends of each magnet projecting toward the extremities of the solenoid, said core being moveable in one direction by the application of direct current to the leads of the solenoid, said slide being operative in the other direction by the reverse application of direct current to said solenoid.

2. A control device for causing movement in two directions, said control device comprising a solenoid, a core moveably mounted in said solenoid for movement in either direction, said core comprising a plurality of permanent magnets arranged in end to end relation, said permanent magnets being arranged with like poles in substantially abutting relation, a mechanical link connected to said core, a control element operatively connected to said mechanical link whereby longitudinal movement of said core results in corresponding movement of said control element in the direction of movement of said core, said element being controllable by the application of directional current in said solenoid.

3. A safety control for electrical instruments and the like comprising a solenoid, a core moveably mounted in said solenoid, said core comprising a plurality of permanent magnets arranged in end to end relation with each pair of abutting ends having like polarity, a double-pole double-throw switch mechanically connected to said core, the blades of said double-pole double-throw switch being connected to the leads of said solenoid whereby the application of directional current to said leads of said solenoid will produce a predetermined directional flow of current to the contacts of said double-pole double-throw switch.

4. A rectifier for alternating current comprising a solenoid, a core moveably mounted in said solenoid, said core including a plurality of permanent bar magnets arranged in end to end relation with like poles of adjacent magnets in approximately abutting relation, a switch connected to said core for movement therewith, the characteristics of said switch and said core being such as to produce operation of said switch in timed relation to the alternating current applied to said solenoid whereby said switch serves to rectify the alternating current to a direct current.

5. A servo motor for producing force and displacement in opposite directions comprising a hollow coil, a core moveably mounted within said coil, said core comprising

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a plurality of magnets arranged in end to end relation with like poles of adjacent magnets together whereby electric current applied to said coil will produce displacement of said core and the direction of displacement being controlled by the direction of application of current to said coil.

6. An electronic motor comprising a solenoid coil, a core within said solenoid, said core and solenoid being mounted for relative movement with respect to one another, a winding on said core, the winding on said core including a bight portion of a single conductor from which the coil is wound outwardly with opposite rotation and with the turns from the bight portion on one portion of the core being in compact relation, other windings from the bight portion arranged in compact relation on another portion of the core whereby magnetic fields will be obtained with like poles of such magnetic fields being together and the extreme ends of such core being of like polarity.

7. The invention according to claim 6 in which the core is made of magnetizable material.

8. The invention according to claim 6 in which the core is made of non-magnetic material.

9. The invention according to claim 1 in which the permanent magnets are made of Alnico with maximum density of lines of magnetic force.

10. A double acting solenoid for causing motion in two opposed directions comprising an armature for insertion in the solenoid, said armature having like poles at each end and the opposite pole substantially midway between the ends, a solenoid coil having an armature receiving slideway therethrough, the armature being slidably received within said solenoid coil for movement in two opposed directions, means connected to said armature for receiving the relative motion between said armature and said coil, said coil being wound with the turns thereof extending in one direction, and means to apply a directional current to the winding of said coil whereby the armature will be moved in one direction when the current is applied to flow in one direction and said armature will

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move in the opposite direction when current is applied to the coil to flow in the opposed direction whereby with a single pair of leads and a single coil motion can be obtained in two opposite directions.

11. A servo motor comprising a coil, a magnet cooperating with said coil, means to mount said magnet and said coil for relative movement along the axis of said coil, said magnet having a plurality of magnetic sections with the like poles of adjacent sections together whereby energization of said coil in one direction will move said magnet in one direction relative to said coil and energization of said coil in the other direction will move said magnet in the other direction relative to said coil.

12. The invention according to claim 11 in which the magnet is a permanent magnet.

13. The invention according to claim 11 in which the magnet is an electro magnet.

14. The invention according to claim 12 in which the permanent magnet is also provided with coils to obtain and maintain the same magnetism in each magnetic element.

15. The invention according to claim 11 in which the coil is stationary.

16. The invention according to claim 11 in which the magnet is stationary.

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