

Sept. 27, 1966

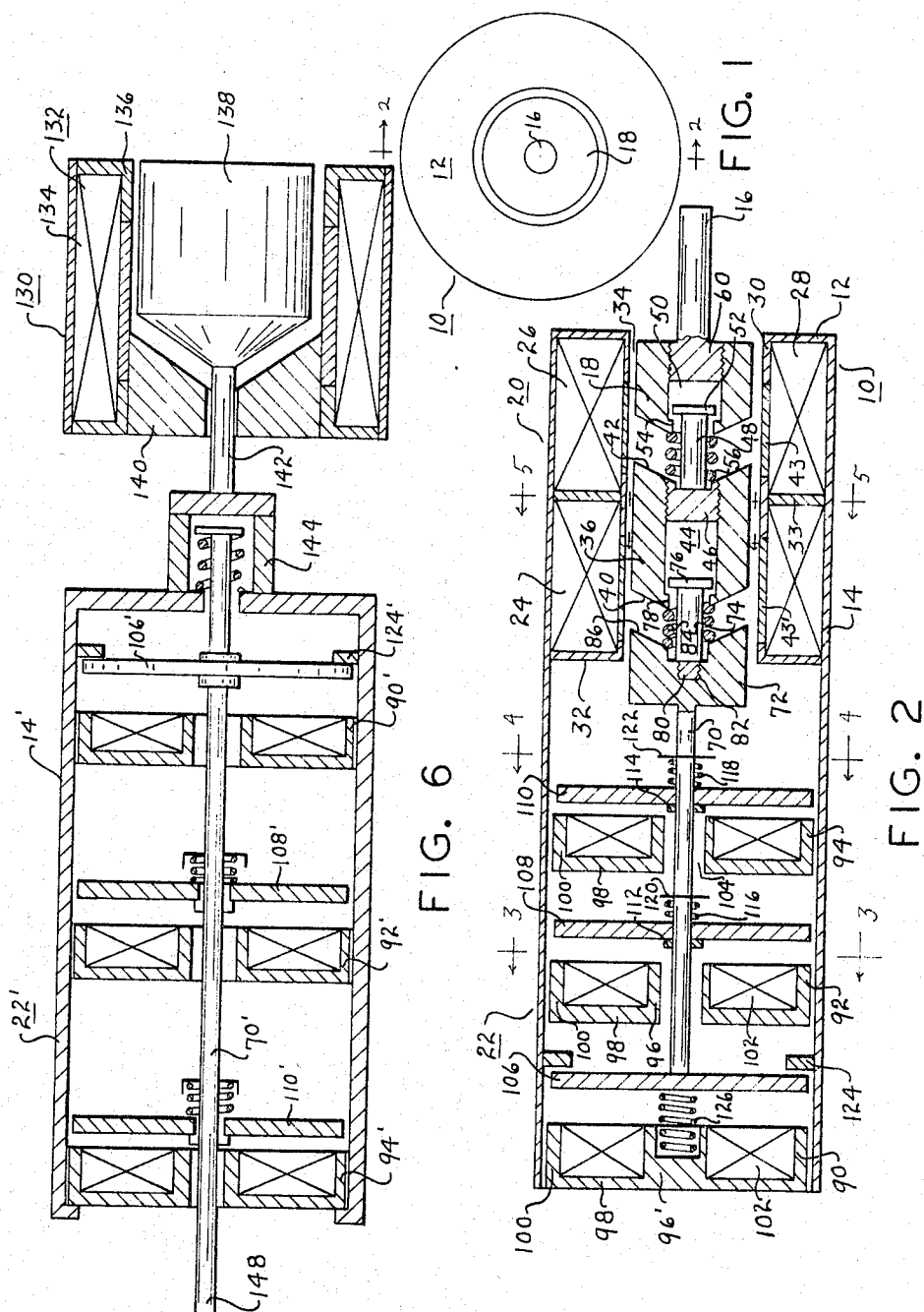
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3,275,964

MULTIPLE POSITION SOLENOID DEVICE

Filed Jan. 6, 1964

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

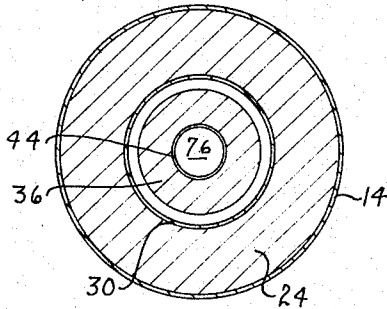


FIG. 5

FIG. 4

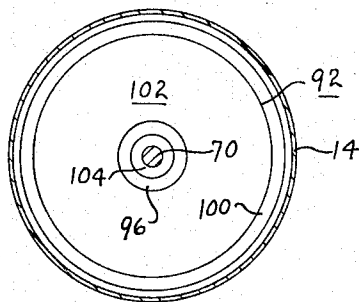
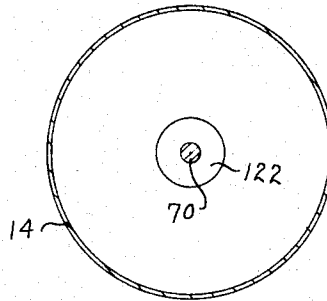


FIG. 3

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MULTIPLE POSITION SOLENOID DEVICE

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10 Claims. (Cl. 335-259)

The present invention relates to solenoids and more particularly to a multiple position solenoid device.

In recent years, with the development of digital computers and sophisticated machine tools, a demand has been created for actuating and control mechanisms which can give a number of preselected positions accurately in either direction, and which responds instantaneously to the input signal. In the past, the actuating or control mechanism has been primarily either a hydraulically operated system in which valves and hydraulic servo-motors are employed to obtain the various desired positions, or a plurality of linear type standard or conventional solenoids are used progressively or simultaneously to obtain the desired positions. The hydraulic actuating or control mechanisms are often bulky and too large to be conveniently installed in the complicated and compact mechanisms, and at times are not sufficiently responsive to the signal to meet demands. Likewise, the plurality of individual linear solenoids are too large and cumbersome to be easily incorporated in various places in the sophisticated digital computers, so that their application is often limited by physical requirements of the mechanisms or the delicacy of the elements or components of the mechanisms controlled thereby. It is therefore one of the principal objects of the present invention to provide a multiple position solenoid device which is relatively light in weight, compact and rugged in structure, and which has a relatively large number of predetermined positions capable of being obtained instantaneously by the operation of the device in either direction.

Another object of the present invention is to provide a servo-motor of the solenoid type which positively selects any one of a number of predetermined positions in response to an input signal or signals, and which accurately finds the desired position without hunting and without having first to dwell at any intermediate positions in reaching the desired position.

Still another object of the present invention is to provide a multiple position solenoid device which can be readily installed in confined places as a single unit and readily connected to the control mechanism or line without interfering with other closely spaced components of the principal mechanism or apparatus.

Still another object of the present invention is to provide a solenoid device of the aforesaid type which is capable of operating a controlled element over a wider range and at greater distances than can be done by standard or conventional linear solenoids, and which is adapted to be operated over the entire range as a substantially single stroke or in multiple strokes or positions as required by any particular operation.

Another object of the invention is to provide a relatively simple multiple position solenoid device which can be easily fabricated using primarily standard materials, and thereafter installed without the use of special tools or special power input lines.

Another object of the present invention is to provide a solenoid which can instantaneously position an element or instrument repeatedly over long periods of time without servicing and which is readily adapted for a variety of different types of operations without requiring any change in the basic structure of the device.

Additional objects and advantages of the present in-

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vention will become apparent from the following description and accompanying drawings, wherein:

FIGURE 1 is an end elevational view of the solenoid embodying the present invention;

FIGURE 2 is a longitudinal cross sectional view of the solenoid shown in FIGURE 1, the section being taken on line 2-2 of the latter figure;

FIGURE 3 is a transverse cross sectional view of the solenoid shown in FIGURES 1 and 2, the section being taken on line 3-3 of FIGURE 2;

FIGURE 4 is a transverse cross sectional view of the solenoid shown in the preceding figures, the section being taken on line 4-4 of FIGURE 2;

FIGURE 5 is an offset transverse cross sectional view of the present solenoid, the section being taken on line 5-5 of FIGURE 2; and

FIGURE 6 is a longitudinal cross sectional view of a modified form of the present solenoid, the section being similar to that shown in FIGURE 2.

Referring more specifically to the drawings, and to FIGURES 1 and 2 in particular, numeral 10 designates the present solenoid generally, 12 the end of solenoid housing 14, and 16 an operating shaft mounted on and secured to an armature 18 of one of the solenoid elements incorporated in the present device. The size and specific shape of the present solenoid may be changed or modified to adapt the solenoid to various operations and functions. Further, in certain installations it may be desirable to completely close and hermetically seal the solenoid to prevent any possibility of the electrical components of the solenoid from creating a fire hazard, particularly when the solenoid is used in conjunction with control mechanisms for liquid or gaseous fuels.

The solenoid shown in FIGURES 1 through 5 consists of two basic sections 20 and 22, section 20 consisting of two ring-shaped coils 24 and 26 mounted rigidly in one end of housing 14. The two solenoid sections may be of standard or conventional construction, consisting briefly of wire coil 28 on core 30 which, together with the external side walls of housing 14 and end 12, forms a magnetic path for coil 26 and, in combination with the external side wall of housing 14 and annular end member 32, forms a magnetic path for coil 24, the two coils being separated by a magnetic barrier 33. The two coils 24 and 26 are substantially identical in construction and are wound on the same core 30 forming an integral unit which can be inserted into the end of housing 14. Reciprocally disposed in center opening 34 of core 30 are two armatures 36 and 18 for coils 24 and 26, respectively. Armature 36 consists of a generally cylindrically-shaped body having a frusto-conically shaped end 40 and a conically shaped recessed end 42. A nonmagnetic tubular member 43 and 43' forms part of the inner wall of core 30 to form the magnetic path through the two armatures. The armature has a hollow center 44 in which a plug 46 is threadedly secured, the plug having a stem 48 secured thereto and extending into the hollow center 50 of armature 18. The stem is provided with a head 52 which interlocks with internal flange 54 on the inner end of armature 18, thus forming a lost motion connection between armatures 36 and 18. The inner end of armature 18 is frusto-conically shaped to correspond to the shape of the frusto-conical recessed end 42, and a coil spring 56 is interposed between the two armatures to urge the two armatures apart when the coil 26 is not energized. Shaft 16 is secured to the outer end of armature 18 by an enlarged threaded portion 60 threadedly received in the outer end of hollow center 50, and is adapted to move with armature 18. Armature 36 is operatively connected to solenoid mechanism section 22 by shaft 70 having a head 72 thereon

with a stem 74 connected thereto and extending into the hollow center 44 of armature 36. Head 72 and armature 36 are connected to one another by a lost motion connection consisting of head 76 on the end of stem 74 seated in hollow center 44 and adapted to engage an internal flange 78 on armature 36. The stem 74 is secured to head 72 by threaded end 80 received in threaded hole 82 in head 72, head 72 and armature 36 being urged apart by a coil spring 84 disposed around stem 74 and contacting head 72 at one end and armature 36 at the other end. A recess 86 of the same size and shape as conical end 40 is provided on the adjacent surface of head 72. When solenoid 26 is energized, armature 18 moves to the left, endeavoring to seat on armature 36, thereby moving shaft 16 to the left. When solenoid 24 is energized independently of solenoid 26, head 52 of stem 48 engages shoulder 54 and pulls armature 18 inwardly, thereby moving stem 48, armature 18 and shaft 16 to the left to position the shaft at one of its intermediate positions.

Solenoid mechanism section 22 consists of three substantially identical coils 90, 92 and 94 spaced longitudinally and secured rigidly in housing 14. Coils 92 and 94 are identical in construction, each consisting of a core 96, end wall 98 and outer member 100 forming a magnetic path and substantially enclosing a coil of wire 102. Coil 90 is the same in construction as coils 92 and 94 except core 96' does not have a center opening. Shaft 70 extends through center openings 104 of coils 92 and 94 and has disc-shaped armatures 106, 108 and 110 mounted thereon and adapted to move to and from the respective coils 90, 92 and 94 as those coils are energized and deenergized. Armature 106 is mounted rigidly on the end of shaft 70 and armatures 108 and 110 are mounted for axial movement on the shaft and are resiliently held against collars 112 and 114, respectively, by springs 116 and 118, reacting against fixed collars 120 and 122, respectively. The three coils are held in a fixed position by an annular stop member 124 rigidly secured to the inner surface of housing 14, and the armatures are moved away from the respective coils by spring 126 urging shaft 70 to the right, as viewed in FIGURE 2.

In the operation of the solenoid illustrated in FIGURES 1 through 5, energization of coil 24 causes armature 36 to move to the left, thereby through stem 48 and head 52 moving armature 18 and shaft 16 to the left to the first position. Energization of solenoid 26 moves armature 18 and shaft 16 further to the left to a second position. When the two coils 24 and 26 are energized, energization of coil 94 moves armature 110, which is seated against stop 114, to the left, thereby moving shaft 70, head 72, armatures 36 and 18, and shaft 16 further to the left to a third position. Energization of coil 92 moves armature 108 to the left, moving shaft 70, head 72, armatures 36 and 18, and shaft 16 further to the left to a fourth position. Since armature 110 was seated on coil 94 when this coil was energized, the further movement of shaft 70 by coil 92 and armature 108 causes spring 118 to be compressed, thereby permitting the shaft to slide through the center opening of armature 110. Energization of coil 90 moves armature 106 further to the left, pulling shaft 70, head 72, armatures 36 and 18, and shaft 16 to the left to a fifth position and further compressing spring 118 and compressing spring 116, thus permitting shaft 70 to move while armatures 108 and 110 are seated on the face of coils 92 and 94. Operation of any one of the coils between 24 and 90 will position shaft 16 in any intermediate position to satisfy requirements. When all of the solenoids have been deenergized, spring 126 returns shaft 70 and head 72 to their original position, and springs 84 and 56 return armatures 36 and 18 and shaft 16 to their original positions.

The solenoid mechanism shown in FIGURE 6 is essentially the same as solenoid mechanism section 22 and solenoid section 130 has replaced solenoid section 20

and is adapted to move the entire housing 14'. Since the construction of the solenoid mechanism section 22' is substantially the same as that of solenoid mechanism section 22, the same numerals with primes will be given to the corresponding elements and these elements will not be described in detail herein.

The solenoid section 130, which is anchored and shifts housing 14' to the left when energized, consists of a coil 132 having wire 134 wound on hollow core 136. An armature 138 is disposed in the hollow center of core 136 and is adapted to move longitudinally therein to and from pole piece 140. A stem 142 rigidly connects the inner end of armature 138 to the end of extension 144 of housing 14', so that as armature 138 is moved to the left and right as coil 132 is energized and deenergized, housing 14' will be moved correspondingly to the left and right, as seen in FIGURE 6. The element or instrument to be operated and positioned by the solenoid mechanism shown in FIGURE 6 is connected to shaft 70' by an extension 148 of shaft 70', the extension extending through the center of coil 94' and projecting outwardly therefrom.

In the operation of the solenoid mechanism, as shown in FIGURE 6, energization of solenoid section 130 moves armature 138 to the left, thereby, through stem 142, moving housing 14' and extension 148 to the left to a first position. Thereafter, energization successively of coils 94, 92 and 90 moves extension 148 successively to second, third and fourth positions. When all of the coils have been deenergized, a spring or other resilient means urges extension 148, shaft 70' and housing 14' to the right and applies sufficient pressure on stem 142 to return armature 138 to its original position preparatory to the next positioning operation.

While only two embodiments of the present invention have been described herein, various changes and modifications may be made to satisfy requirements.

I claim:

1. A multiple position solenoid device, comprising a cylindrically-shaped housing, first and second coils mounted in one end of said housing and having hollow cores, two axially movable plunger-like armatures disposed in said cores and spaced from one another for relative axial movement, a lost motion connection between said armatures, a stem on one of said armatures for connection with an element to be operated by said device, a plurality of additional coils having cores with hollow centers spaced from one another in axial alignment in said housing, a shaft extending through the cores and having a head thereon, a lost motion connection between said armatures and said head, a disc-shaped armature on said shaft for each of said last mentioned coils, each being spaced progressively further from its respective coil when the coils are deenergized, and a lost motion connection between said shaft and each of said last mentioned armatures except the one having the greatest distance to travel to its respective coil when the coil is energized.

2. A multiple position solenoid device, comprising a housing, first and second coils forming a first section, mounted in one end of said housing and having hollow cores, two axially movable plunger-like armatures disposed in said cores and spaced from one another for relative axial movement, a lost motion connection between said armatures, a stem on one of said armatures for connection with an element to be operated by said device, first, second and third coils spaced from one another in axial alignment and forming a second section, the cores of the first and second coils of said second section having hollow centers, a shaft extending through the hollow centers of said cores, a lost motion connection between said armatures and the adjacent end of said shaft, a disc-shaped armature on said shaft for each of the coils of said second section, each being spaced progressively further from its respective coil when the coils are deenergized,

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and a lost motion connection between said shaft and each of the armatures for said first and second coils.

3. A multiple position solenoid device, comprising a housing, a first coil mounted in one end of said housing and having a hollow core, an armature in said core, a stem connected to one end of said armature and extending from said housing, a plurality of additional coils having cores with hollow centers spaced from one another in axial alignment in said housing, a shaft extending through the last mentioned cores, a lost motion connection operatively connecting said shaft to said armature, a disc-shaped armature on said shaft for each of said additional coils, each being spaced progressively further from its respective coil when the coils are deenergized, and a lost motion connection between said shaft and each of said last mentioned armatures except the one having the greatest distance to travel to its respective coil.

4. A multiple position solenoid device, comprising first and second coils having hollow cores and forming a first section, plunger-like armatures disposed in said cores and spaced from one another for relative axial movement, a lost motion connection between said armatures, a stem on one of said armatures for connection with an element to be operated by said device, a plurality of coils forming a second section and having cores with hollow centers spaced from one another in axial alignment, a shaft extending through the cores and having a head thereon, a lost motion connection between said armatures and said head, a disc-shaped armature on said shaft for each of said second section coils, each being spaced progressively further from its respective coil when the coils are deenergized, and a lost motion connection between said shaft and each of said last mentioned armatures.

5. A multiple position solenoid device, comprising first and second coils forming a first section and having hollow cores, two axially movable plunger-like armatures disposed in said cores and spaced from one another for relative axial movement, a lost motion connection between said armatures, a stem on one of said armatures for connection with an element to be operated by said device, two additional coils having cores with hollow centers spaced from one another in axial alignment, a shaft extending through the last mentioned cores, a lost motion connection between said armatures and the adjacent end of said shaft, a disc-shaped armature on said shaft for each of said last mentioned coils, each being spaced progressively further from its respective coil when the coils are deenergized, and a lost motion connection between said shaft and each of said last mentioned armatures.

6. A multiple position solenoid device, comprising a first coil having a hollow core, a plunger-like armature in said core, a stem connected to one end of said armature and extending therefrom, a plurality of additional coils having cores with hollow centers spaced from one another in axial alignment, a shaft extending through the last mentioned cores and operatively connected to said armature, a disc-shaped armature on said shaft for each of said last mentioned coils, each being spaced progressively further from its respective coil when the coils are deenergized, a lost motion connection between said shaft and each of

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said last mentioned armatures and a lost motion connection between said shaft and said plunger-like armature.

7. A multiple position solenoid device, comprising a housing, a plurality of coils having cores with hollow centers spaced from one another in axial alignment in said housing, a shaft extending through said hollow centers, a disc-shaped armature on said shaft for each of said coils, each being spaced progressively further from the respective coil when the coils are deenergized, a lost motion connection between said shaft and each of said last mentioned armatures, a solenoid connected to said housing for moving said housing in the direction axially with respect to said shaft, and an extension on said shaft for connection with an element to be operated by said device.

8. A multiple position solenoid device, comprising a housing, two coils having cores with hollow centers spaced from one another in axial alignment in said housing, a shaft extending through the cores, armatures on said shaft for said coils, each being spaced progressively further from the respective coil when the coils are deenergized, a lost motion connection between said shaft and each of said last mentioned armatures, a solenoid connected to said housing for moving said housing in the direction axially with respect to said shaft, and an extension on said shaft for connection with an element to be operated by said device.

9. A multiple position solenoid device, comprising three coils spaced from one another, the first two coils having cores with hollow centers in axial alignment, a shaft extending through the cores of said first two coils, armatures on said shaft for said three coils, each being spaced progressively further from the respective coil when the coils are deenergized, a lost motion connection between said shaft and each of the armatures of said first two coils, and a positive connection between said shaft and the armature of said third coil.

10. A multiple position solenoid device, comprising a plurality of coils having cores with hollow centers and spaced from one another in axial alignment, a shaft extending through the cores, a disc-shaped armature on said shaft for each of said coils, each being spaced progressively further from the respective coil when the coils are deenergized, a lost motion connection between said shaft and each of said armatures, a solenoid for moving said coils and shafts bodily in the direction axially with respect to said shaft to vary the effective force thereof, and an extension on said shaft for connection with an element to be operated by said device.

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