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ROTARY ELECTROMAGNETIC ACTUATOR

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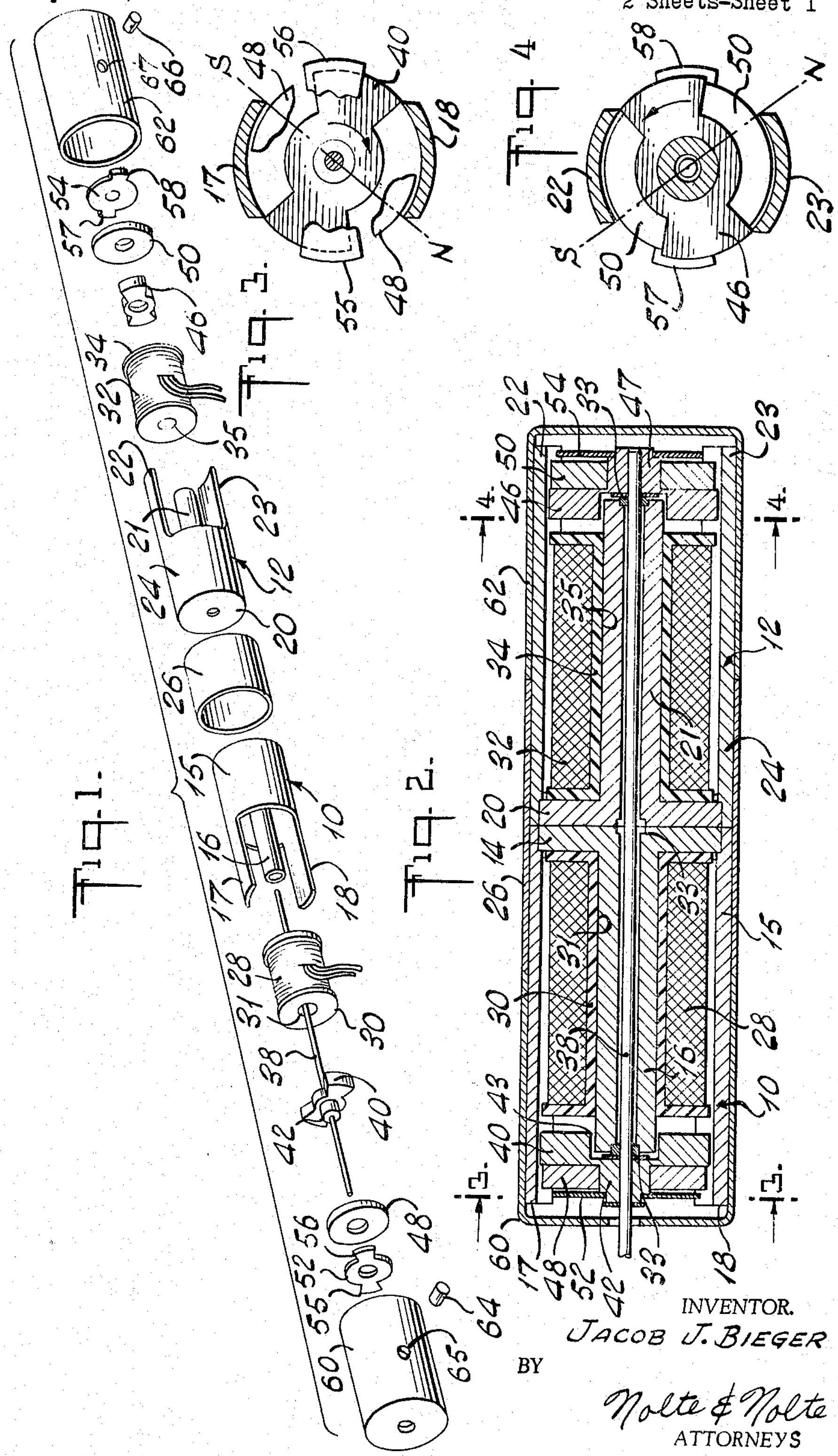

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Fig. 5.

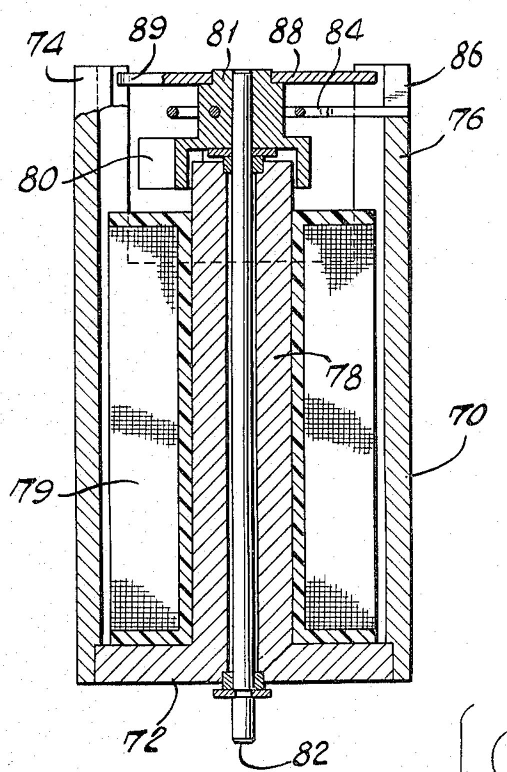


Fig. 7

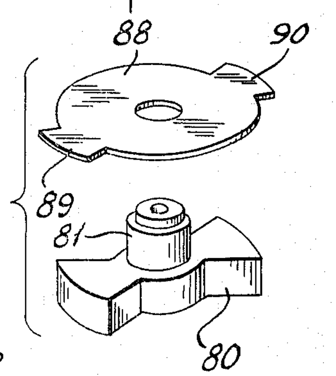
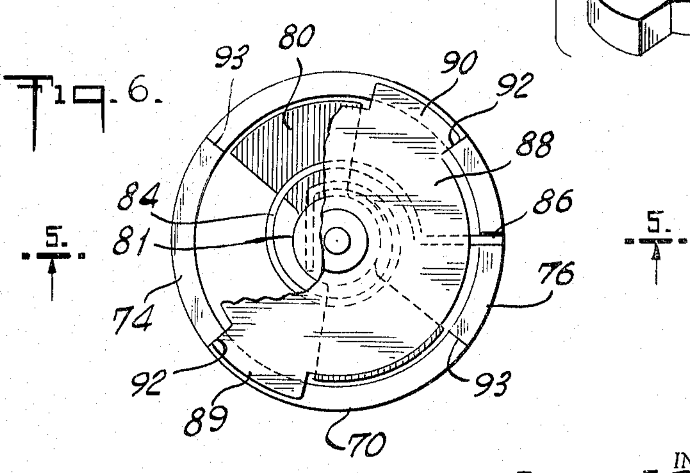


Fig. 6.



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ROTARY ELECTROMAGNETIC ACTUATOR

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This invention relates to rotary electromagnetic actuators. More particularly, this invention relates to solenoids having rotatable armatures which may be angularly displaced to one of three distinct positions.

The type of solenoid to which the present invention pertains has particular utility as an indicating device in electrical circuits. It is often necessary to give a visual indication to show which of a plurality of circuits has been energized. As a specific example, it might be desirable to indicate which of two circuits is in an energized state or whether neither has been energized. For purposes of simplicity and economy, such a visual indication may be readily given by placing the coils of a rotary electromagnetic actuator, or solenoid, in the separate circuits whereby a visual indicator may be rotated in one of two directions depending on which circuit is energized. If the indicator remains in its initial position, this would mean that neither circuit has been energized.

Accordingly, it is an object of this invention to provide an improved three-position rotary solenoid.

Another object is to provide a rotary solenoid which is rugged in design, simple in construction and economical to manufacture.

The objects of the invention are accomplished by providing two oppositely disposed stator sections, a rotor shaft extending therethrough, and a pair of rotors rotatably displaced from one another and associated with respective stators, the rotors being individually operable to rotate the shaft in a given direction when the coil of its associated stator is energized. A return means, which may comprise a pair of permanent magnets operative in conjunction with the outer pole pieces of the stators, biases the rotor shaft to its center position, so that when neither coil is energized the shaft will maintain its initial position.

The manner in which these objects are accomplished will be further explained with reference to the following specification and drawings, wherein:

FIG. 1 is an exploded view of the three-position actuator according to the invention;

FIG. 2 is a side view in section of the rotary actuator;

FIG. 3 is a view along the line 3—3 of FIG. 2;

FIG. 4 is a view along the line 4—4 of FIG. 2;

FIG. 5 is a cross sectional view of another embodiment of the invention;

FIG. 6 is a cut-away top view of the embodiment of FIG. 4; and

FIG. 7 is an exploded view of the rotor and stop member of the second embodiment.

In FIGS. 1 to 3, the three-position rotary solenoid is shown comprising first and second stator sections **10** and **12**, respectively. Stator section **10** includes a base **14**, a cylindrical wall **15** press-fit thereover, and an outwardly extending center pole piece **16** integrally formed with base **14**. In addition, stator section **10** includes two oppositely disposed, outer pole piece members **17** and **18** integrally formed with wall **15**. Stator section **12** is constructed identically as stator **10** and includes a base **20**, a center pole piece **21**, and two outer pole pieces **22** and **23** extending from a cylindrical wall portion **24**. The stators are made of a material which will provide suitable flux paths when the solenoid is energized. As shown in FIG. 2, the stators of the assembled solenoid are arranged in end-to-end relationship with base **14** abutting against base

20, and pole pieces **17** and **18** of stator **10** aligned with pole pieces **22** and **23**, respectively, of stator **12**.

The stators may be held in this relationship by means of a cylindrical sleeve member **26** into which the bottoms of cylindrical walls **15** and **24** may be inserted and secured by friction.

A first coil **28** is wound around a plastic spool-like coil form **30** having a central bore **31** through which center pole piece **16** extends. Similarly, a second coil **32** is wound around a second spool-like coil form **34** having a central bore **35** into which center pole piece **21** extends.

The center pole pieces are slightly longer than their associated coil form, so that when the ends of coil forms **30** and **32** rest against the tops of bases **14** and **20**, respectively, the upper portions of the center pole pieces protrude from the coil forms.

A rotor shaft **38** extends through the center of coil forms **30** and **32** and is suitably journaled in bearings **33** in center pole pieces **16** and **21** of stator sections **10** and **12**, respectively. A first bow-shaped rotor **40** including an integrally formed hub member **42** is secured to shaft **38** immediately above center pole piece **16**. Rotor **40** may be made of solid magnetic material and includes a center recess **43** beneath hub **42** into which the protruding end of center pole piece **16** extends. In a similar manner, a second bow-shaped rotor **46** including an integral hub member **47** is secured to shaft **38** opposite rotor **40**. Rotor **46** is also centrally recessed, so that the protruding end of center pole piece **21** extends substantially into the rotor. When one of coils **28** and **32** is energized, a magnetic flux is generated in its associated stator wall and pole pieces. The respective rotor is attracted by the magnetic lines of flux passing transversely through the air gap (between the rotor and outer pole pieces) to the rotor. The salient poles of the rotor are attracted to the stator pole pieces of opposite polarity, thus imparting a rotary motion to the rotor. By utilizing recessed rotors and mounting the mover respective center pole pieces of each stator, the effect of the magnetic thrust which acts downwardly on the rotors, and thus tends to lessen the torque developed during rotation, is minimized. As shown in FIGS. 3 and 4, the rotors are rotatably displaced on shaft **38** with respect to each other so that energization of coil **28** will cause rotor **40** to rotate shaft **38** in a clockwise direction, while energization of coil **32** will cause rotor **46** to rotate the shaft in a counter-clockwise direction.

Rotor shaft **38** is returned to its initial position by means of a pair of flat, annular permanent magnets **48** and **50** which may be press fit to hub members **42** and **47**, respectively. Magnets **48** and **50** have magnetic fields as illustrated in FIGS. 3 and 4, which exert forces with respect to their associated outer pole pieces so that magnet **48** tends to rotate shaft **38** counterclockwise, while magnet **50** tends to rotate the shaft in a clockwise direction. Accordingly, when the solenoid is de-energized, the rotor shaft maintains a position in which the opposing magnetic forces are equal or balanced.

The solenoid also includes a pair of thin annular stop members **52** and **54** press fitted to the extremities of hubs **42** and **47**, respectively, for limiting the rotary movement of shaft **38**. Stop member **52** includes ears **55** and **56** adapted to abut against outer pole pieces **18** and **17**, respectively, when shaft **38** is rotated clockwise. Stop member **54** includes ears **57** and **58** adapted to abut against pole pieces **22** and **23**, respectively, when shaft **38** is rotated in a counterclockwise direction.

The entire solenoid may be enclosed in a pair of cylindrical end caps **60** and **62**. A small insulated tube **64** fits into aperture **65** of tube **60** to receive the leads of coil **28**, and, similarly, a tube **66** extends into aperture **67** of cap **62** to receive the leads of coil **32**.

One end of shaft **38** is shown extending outwardly of end cap **60** and may be connected to conventional indicating means. When current is applied to coil **28**, a magnetic field is established in the pole pieces of first stator section **10** which will cause rotor **40** to rotate in a clockwise direction until the movement is arrested by abutment of the ears of stop member **52** against outer pole pieces **17** and **18**. When the energization of coil **28** is removed, the unbalanced forces of the displaced magnets **48** and **50** return rotor shaft **38** to its original position at which point the forces of the two magnets are again balanced. Similarly, if current is passed through coil **32**, rotor **46** rotates shaft **38** in a counterclockwise direction, and when the current is removed, the unbalanced magnetic fields of magnets **48** and **50** return the shaft to its initial position.

An alternate embodiment of the invention, in which a return spring is employed, is illustrated in FIGS. 5–7. Only one stator section is illustrated, since the second section could be substantially identical, as discussed above with reference to FIGS. 1–4. In fact, since the individual stator sections would have utility by themselves in any situation wherein only two separate angular positions are necessary, this embodiment will be described as a single stator, two position, rotary solenoid.

The stator of the second embodiment includes a base **72** and a cylindrical wall **70** press fit thereover. A pair of integral, curved pole pieces **74** and **76** extend upwardly from wall **70** at opposite ends of a diameter. A center pole piece **78** is integrally formed with base **72** and includes a suitable bore for receiving a rotor shaft **82**. A rotor **80** including hub member **81** (as shown in FIG. 7), is fixed to shaft **82** near the top thereof.

A spiral return spring **84** is wound around rotor-hub **81** immediately above rotor **80**. One end of spring **84** is secured to hub member **81** while the other end is secured to pole piece **76** through a slot **86** in the pole piece. Spring **84** exerts a force which tends to rotate rotor **80** in a clockwise direction.

A stop member, comprising a circular disc **88**, is secured to the top of hub **81** immediately above spring **84**. Disc **88** includes a pair of oppositely disposed ears **89** and **90** adapted to abut against edges **92** and **93** of pole pieces **74** and **76**. The stop member and rotor are slightly offset from one another so that when coil **79** is energized and the rotor is rotated counterclockwise from the deenergized position indicated in FIG. 6, the ears **89** and **90** abut against edges **93** of pole pieces **74** and **76**. When excitation is removed, spring **84** rotates the rotor clockwise to its initial position as determined by abutment of ears **89** and **90** against edges **92** of the outer pole pieces.

Although specific embodiments of the invention have been disclosed, many modifications thereof will be obvious to one skilled in the art and the invention is not to be limited except as defined in the following claims.

I claim:

1. A rotary electromagnetic actuator comprising a first coil and first pole pieces associated therewith, a second coil and second pole pieces associated therewith, a rotor shaft passing through said coils, first and second rotors secured to said shaft and operatively associated with said first pole pieces and said second pole pieces, respectively, said rotors being disposed relative to their respective pole pieces whereby energization of said first coil causes said first rotor to rotate said shaft to a first position and energization of said second coil causes said second rotor to rotate said shaft to a second position, and a means biasing said shaft to a third position intermediate said first and second positions.

2. A rotary electromagnetic actuator as recited in claim 1 wherein said biasing means include a permanent magnet.

3. A rotary electromagnetic actuator comprising, a first stator having a first coil and a first rotor associated therewith, a second stator having a second coil and a second rotor associated therewith, said first and second stators each including a central pole piece and a pair of oppositely disposed pole pieces, each of said central pole pieces extending into and being perpendicular to its respective rotor, a rotor shaft passing through said stators, said first and second rotors being secured to said shaft and disposed relative to their respective pole pieces whereby energization of said first coil causes said first rotor to rotate said shaft to a first position, and energization of said second coil causes said second rotor to rotate said shaft to a second position, stop means for limiting the rotation of said shaft in either direction, and means for returning said shaft to an initial position intermediate to said first and second positions when neither of said coils is energized.

4. A rotary electromagnetic actuator according to claim 3 wherein said return means includes magnetic discs secured to said rotor shaft and operatively associated with said first and second stators, the magnetic forces of said discs being directed so as to bias said rotor shaft to said initial position.

5. A rotary electromagnetic actuator according to claim 4 wherein said first and second stators are identical and include a cylindrical base integrally formed with its respective pole pieces, said stators being arranged in end-to-end fashion, one of said rotors being displaced in a counterclockwise direction with respect to its pole pieces, and the other rotor being displaced in a clockwise direction with respect to its pole pieces.

6. A rotary electromagnetic actuator according to claim 5 wherein said stop means includes a member secured to said shaft and adapted to abut against the pole pieces of one of said stators.

7. A rotary electromagnetic actuator comprising a cylindrical stator having three elongated pole pieces arranged in spaced locations, two of said pole pieces comprising opposing portions of the cylindrical surface of said stator, the other pole piece extending axially from the center of said stator, a rotor shaft rotatably mounted in said central pole piece, extending through the central pole piece of said stator, and beyond the opposing pole pieces, a rotor secured to said shaft adjacent the free end of said central pole piece, said central pole piece extending into and being perpendicular to said rotor, said rotor having outer faces arranged to rotate past the inside faces of said opposing pole pieces, electromagnetic means surrounding said central pole for energizing said pole pieces to rotate said rotor in one direction, spring return means to rotate the rotor in the opposite direction when said electromagnetic means is not effective and, stop means for limiting the rotation of the rotor, said stop means including a segmented disc-like member secured to said rotor having means to abut against one of said opposed pole pieces.

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