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ELECTROMAGNETIC CONTROL DEVICE

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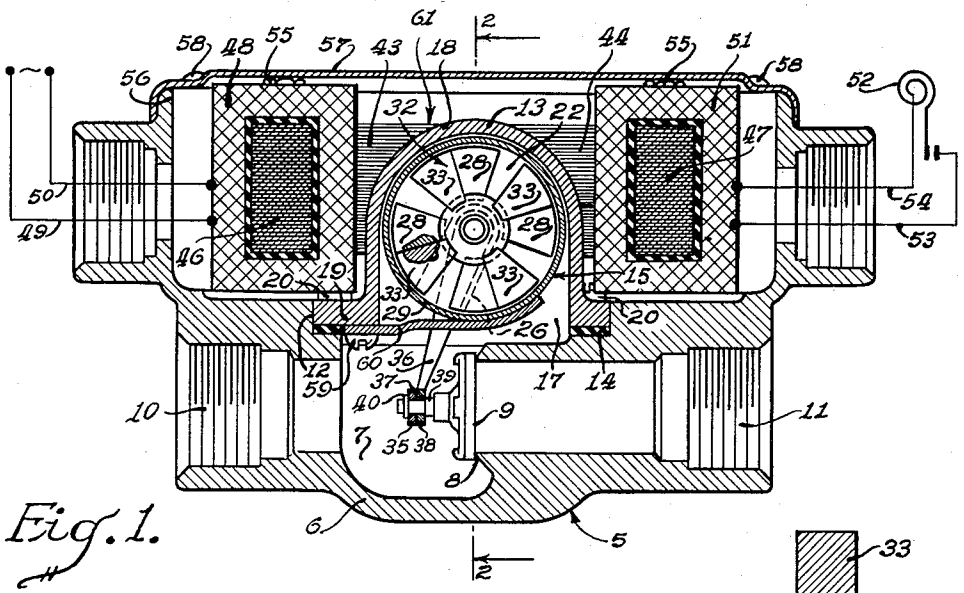


Fig. 1.

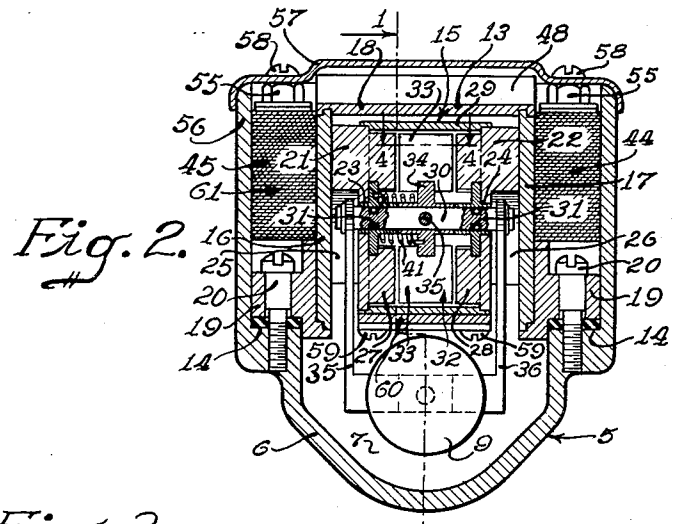


Fig. 2.

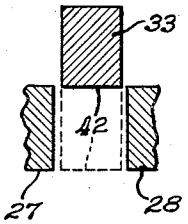


Fig. 4.

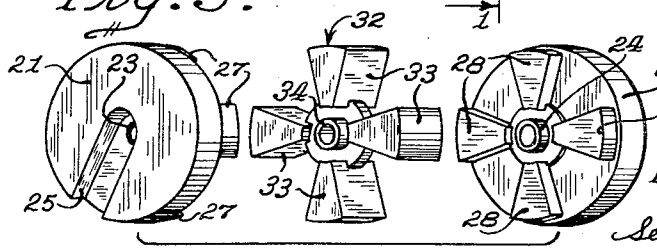


Fig. 3.

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ELECTROMAGNETIC CONTROL DEVICE

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12 Claims. (Cl. 317—197)

This invention relates to improvements in control devices, and more particularly to improved electromagnetically operated valves and the like of novel construction and coaction and having particular utility in controlling the flow of fluids, for example, the flow of gaseous fuel to a gas burner.

It is a general object of the present invention to provide an improved control device including an electromagnetic operator of novel construction having an actuatable member, the operating force afforded said actuatable member not only being at a maximum at the initiation of movement of said member, but also being greater than that produced by known devices of comparable size. This large initial force may be utilized for overcoming the large initial force required in "cracking" or opening a valve, the increased initial force supplied by the improved operator permitting actuation of larger valves, or conversely, permitting a reduction in size of the operator for a given valve size.

Another object of the invention is to provide an improved control device of the class described wherein the moving parts of the operator may be sealed within the control body, there being novel means for effecting actuation of said moving parts by energy supplied from a source external to said control body, said energy supply being effected without the need for electrical conductors, conduits or the like extending through the control body walls.

Another object of the invention is to provide an improved control device of the aforementioned character in which the energy delivered from the external source to the moving parts of the operator within the control body takes the form of magnetic flux rather than electric current.

Another object of the invention is to provide an improved control of the character described having an improved electromagnetic operator comprising an energizable unit removably mounted within the control body and an energizing unit mounted externally of said body, said energizable unit comprising an enclosure in which the moving parts thereof are sealed from the fluid within said body, said enclosure including a tubular cylindrical side wall of non-magnetic material and a pair of oppositely disposed magnetically permeable end walls forming pole pieces provided with inwardly directed pole faces separated by air gaps, there being a magnetically permeable rotor within said enclosure pivotally mounted for rotation from a first position to a second position in response to flux flow across said air gaps.

Another object of the invention is to provide an improved control device of the aforementioned character wherein the control body is provided with a pair of magnetically permeable wall portions magnetically insulated from each other by non-magnetic wall portions, the end walls of said energizable unit being in removable flux-conducting engagement with the inner surfaces of said magnetically permeable wall portions, and said energizing unit being provided with a magnetically permeable frame

removably mounted on said control body and having portions in flux conducting engagement with the outer surfaces of said magnetically permeable body wall portions.

A more specific object of the invention is to provide an improved control device of the class described wherein the energizable unit of the operator is removably mounted within and is carried by a generally cup-shaped cover portion of the control body, said cover also including the magnetically permeable body wall portions.

Another object of the invention is to provide a control device of the character described wherein the energizing unit of said operator comprises an energizing coil and a flux diverting coil wound on said magnetically permeable frame, closure of the circuit of said flux diverting coil causing diversion of magnetic flux from said frame into said energizable unit, the voltage in said flux diverting circuit being relatively low to render said circuit well adapted for use as a control circuit.

Another specific object of the invention is to provide an improved electromagnetic operator providing increased initial torque by virtue of a novel pole piece and rotor structure, each of the pole pieces being provided with a plurality of corresponding spaced pole faces radially arranged about a common axis, said pole pieces being spaced to provide axial air gaps between opposing pole pieces, the magnetically permeable rotor being provided with a plurality of spaced segments radially arranged around said common axis and each coacting with one of said axial air gaps, said rotor being disposed with only a portion of each segment thereof presented to an adjacent air gap when said operator is de-energized, said rotor segments being moved into registry with said pole faces in response to flux flow across said air gaps.

Another object of the invention is to provide an improved control device of the character described wherein upon energization of the energizable unit, the rotor moves to actuated position, and in doing so, quietly finds its own place of rest without requiring the use of stop means for defining said actuated position.

Another object of the invention is to provide an improved control device of the character described which is highly efficient in operation and which, being immune to the force of gravity, operates equally well in any desired position.

Other objects and advantages of the invention will appear as the description proceeds, reference being had to the accompanying drawing illustrating a complete embodiment of one form of the invention wherein like characters of reference indicate the same parts in all of the views. In the drawings:

Figure 1 is a longitudinal vertical sectional view of the improved control device illustrated in the form of an electromagnetically operated valve, said view being taken approximately along the line 1—1 of Figure 2;

Figure 2 is a transverse vertical sectional view taken approximately along the line 2—2 of Figure 1;

Figure 3 is an exploded perspective view showing the pole pieces and the rotor of the eelctromagnetic operator; and

Figure 4 is an enlarged fragmentary sectional view taken along the line 4—4 of Figure 2.

Referring more particularly to the drawing, the illustrated embodiment of the improved control device takes the form of an electromagnetically operated valve 5 comprising a valve body 6 having a cavity 7 therein provided with an annular valve seat 8. A valve member 9 coacts with the seat 8 to control the flow of fluid through the valve body from an inlet connection 10 to an outlet connection 11. The valve body 6 is provided with an opening 12 communicating with the chamber 7, and has a generallly inverted cup-shaped cover portion 13 of

novel construction removably closing said body opening, sealing of said closure being effected by a gasket 14.

The cover portion 13 of the valve body 6 comprises a pair of spaced parallel wall portions 16 and 17 of magnetically permeable material, said wall portions being magnetically insulated from each other by an intermediate wall portion 18 of arcuate form and constructed of non-magnetic material. The wall portion 18 also includes a non-magnetic annular attaching flange 19 with which the cover is adapted to be secured to the valve body, as by the screws 20. In effect, the wall portions 16 and 17 are magnetically permeable inserts in a non-magnetic portion of the valve body. The purpose of the permeable wall portions 16 and 17 will become apparent hereinafter.

An electromagnetic operator of novel construction comprises an energizable unit 15 mounted within the body 6 and having an actuating connection with the valve member 9, said operator also comprising a flux-generating or energizing unit 61 mounted external to the cover portion 13 and enclosed within a chamber provided by an upstanding peripheral valve body flange 56 and a cover 57 secured thereto, as by screws 58.

In the illustrated embodiment, the energizing unit 61 of the operator comprises a magnetically permeable frame 43 of laminated construction and rectangular configuration. The frame 43 has a pair of parallel side legs 44 and 45 and a pair of parallel end legs 46 and 47. An energizing coil 48 is wound on the end leg 46 and has its opposite ends connected in circuit with a source of electrical energy, for example an alternating current source, as by conductors 49 and 50. A flux diverting coil 51 is wound on the end legs 47 and has its opposite ends connected to a condition responsive circuit controlling device 52, for example a thermostat, as by conductors 53 and 54.

The frame 43 is removably connected to the valve body 26, being fixed thereto as by screws 55 extending through corner portions of said frame. The frame 43 surrounds the cover 13, and intermediate wall surface portions of the side legs 44 and 45 are in removable flux-conducting contact with the outer surfaces of the magnetically permeable wall portions 16 and 17 of the cover, as shown in Figure 2.

The energizable unit 15 of the electromagnetic operator comprises a pair of magnetically permeable end walls or pole pieces 21 and 22, the shape of which is shown most clearly in Figure 3. The members 21 and 22 may take the form of powdered metal type castings having non-magnetic coaxial bearing sleeves 23 and 24 cast integral therewith. The outer surfaces of the pole pieces 21 and 22 are formed with radial grooves 25 and 26, and said pole pieces are also formed with inwardly directed radially arranged spaced segments 27 and 28, the segments of each end wall having coplanar inner surfaces providing spaced pole faces. The pole pieces 21 and 22 form opposite end walls for a cylindrical sleeve 29 of non-magnetic material which is sealingly fixed to said pole pieces around the periphery thereof, holding the latter in coaxial spaced relation. Corresponding segments 27 and 28 are in alinement so that an axial air gap is provided therebetween. A shaft 30 is mounted for rotation in the sleeve bearings 23 and 24, and within each of said bearings the shaft 30 is formed with a circumferential groove to receive an O-ring type seal 31. It is apparent therefore that the pole pieces 21 and 22 and the sleeve 29 provide a hermetically sealed casing or enclosure.

Fixed on the shaft 30 between the end walls 21 and 22, and with said shaft comprising an actuatable member, is a rotor 32 having spaced radially arranged segments 33 of magnetically permeable material fixed to a non-magnetic tubular hub 34. The rotor 32 is suitably fixed on the shaft 30, as by a set screw 35 extending diametrically through said hub and shaft. The segments

33 of the rotor are preferably of the same general shape as the segments 27 and 28 and are radially arranged in a similar manner. The surfaces of the segments 33 on one end of the rotor are coplanar, and the surfaces of the segments on the opposite end of said rotor are also coplanar, the planes of said surfaces being spaced from and parallel with the planes of the pole faces of segments 27 and 28.

Suitably fixed on the outer ends of the shaft 30 and extending within the grooves 25 and 26 is a yoke comprising a pair of L-shaped arms 35 and 36 having apertured end portions 37 and 38 which are overlapped as shown in Figure 1 with the apertures thereof alined to receive the shouldered stem 39 of the valve member 9. Suitable means is provided for securing the stem 39 and the overlapped valve arm portions 37 and 38 together, a snap ring 40 being utilized for this purpose in the illustrated embodiment.

The energizable unit 15 of the electromagnetic operator is removably positioned within the cover 13 with the outer surfaces of the pole pieces 21 and 22 in flux-conducting contact with the inner surfaces of the magnetic wall portions 16 and 17. The operator is held in operative position by a bracket 60 fixed, as by welding, to the sleeve 29 and secured to the cover 13, as by screws 59.

Within the energizable unit 15 a helical spring 41 surrounds the bearing 23 and is anchored at one end to said bearing, said spring also surrounding a portion of the hub 34 and being anchored to said hub as shown in Figure 2. The spring 41 biases the rotor 32 in a valve closing direction to insure positive sealing of the valve 9 when the operator unit 15 is deenergized and independent of the pressure of the fluid thereon or of the force of gravity. Being independent of the force of gravity, the improved valve 5 operates satisfactorily in any position in which it may be mounted.

When the valve member 9 is in the closed position shown in Figure 1, the rotor 32 is disposed with the segments 33 thereof off-set rotatably from the segments 27 and 28 as shown in Figures 1 and 4. In this position, only the leading edges 42 of the segments 33 are presented to the segments 27 and 28 and the air gaps separating the latter segments. As will be described in detail hereinafter, the energizing unit 61 of the operator is operable to cause flux flow across the air gaps between the pole faces of the segments 27 and 28. When said flux flow is effected, the segments 33 of the rotor are drawn into said air gaps and into substantial registry with said pole faces as indicated by the dotted lines in Figure 4. This segment movement causes turning of the rotor 32 and swinging movement of the valve yoke formed by the arms 35 and 36, said yoke thereby moving the valve member 9 away from its seat 8 to a wide open valve position (not shown).

The torque provided by the operator 15 is greatest at the beginning of the rotor movement because when the rotor is disposed in the position shown, the magnetic flux is concentrated in the gap between the leading edge portions 42 of the rotor segments and the adjacent edge portions of the segments 27 and 28. In this position the minimum area of the rotor segments is presented to the segments 27 and 28. However, as the segments 33 move into the air gaps, the area presented to the pole faces of the segments 27 and 28 increases and the torque exerted on the rotor correspondingly decreases. When the rotor segments 33 are in substantial alinement with the segments 27 and 28, as shown in dotted lines in Figure 4, the maximum area of the rotor segments is presented to the pole faces of the segments 27 and 28, and since further rotation would tend to move the rotor segments out of the air gaps and therefore reduce the area of the rotor segments presented to the pole piece segments 27 and 28, the rotor segments do not move beyond the dotted line position of Figure 4. This affords a magnetic

stop limiting the rotation of the rotor in a clockwise (valve opening) direction as viewed in Figure 1, and therefore no other stop means is provided, nor is such a stop means required to define the full open position of the valve member 9. It should be noted that the grooves 25 and 26 are sufficiently wide to permit the valve yoke to swing freely during opening and closing movement of the valve 9 and without engaging the sides of said grooves in either open or closed position.

The operational characteristic by virtue of which the unit 15 provides maximum torque at the beginning of rotor movement is particularly advantageous when said operator is utilized to actuate a valve, since substantially greater force is required to "crack" a valve from its seat than is required to move said valve to wide open position after cracking. Not only is the initial torque produced by the operator 15 greater than that available in most known devices because of the magnetic attraction principle involved, but this initial torque is increased by the utilization of multiple air gap-multiple rotor segment coaction. For example, the initial torque produced by the four segment rotor shown is substantially greater than that which could be produced by the same rotor having only two segments 33.

The operation of the energizing unit 61 in effecting flux flow across the air gaps will now be described. When the coil 48 is energized by electrical current, and the contacts of the thermostat 52 are open as shown in Figure 1, the magnetic field produced by current flow through said coil causes magnetic flux to flow in the frame 43. The frame 43 provides a low reluctance external path for the flux from one end of said coil to the other, as well as a low reluctance path within the said coil. For example, during one half of the alternating current cycle the flux may flow from the end leg 46 into the side leg 44, thence into the end leg 47 and back to the end leg 46 via the side leg 45. However, when the contacts of the thermostat 52 are closed, current is induced in the flux diverting coil 51, and a magnetic field is established by this induced current, which field opposes the flow of the aforementioned flux in the end leg 47. Because of this opposition to flux flow in the end leg 47, the flux flowing in the frame 43 is diverted or shunted away from the end leg 47 and across the air gaps. For example, during one half of the alternating current cycle the diverted flux flows from the frame side leg 44 through the permeable cover portion 17, pole pieces 22, and across the air gaps to the pole pieces 21, thence through the permeable cover portion 16 and into the frame side leg 45, through which said flux returns to the end leg 46 to complete the magnetic circuit. Flux flow across the air gaps between the pole faces of the segments 27 and 28 causes actuation of the rotor 33 and valve member 9 in the manner previously described herein, the valve member 9 being held in open position as long as the flux continues to be diverted across the air gaps.

Upon opening of the thermostat contacts, current no longer flows in the flux diverting coil 51, and therefore the magnetic field opposing flux flow in the frame end leg 47 is dissipated. Since the end leg 47 provides a flux path of much lower reluctance than the air gaps, no substantial amount of flux flows across said air gaps after the thermostat contacts are opened. With cessation of flux flow across the air gaps, the rotor segments 33 are no longer held in said air gaps by magnetic attraction, and the spring 41 plus the pressure of the fuel on the valve member 9 returns the rotor and said valve to their positions shown in Figures 1 and 2.

The flux diverting coil 51 needs merely to be of such size as to afford an induced current of sufficient magnitude to provide the desired flux diversion, and as such, said coil supplies to the thermostat circuit a relatively low voltage, for example on the order of 24 volts. This relatively low voltage permits the wiring in the thermostat circuit to have relatively light insulation as compared with the heavier insulation required by normal line voltages. The inherently low voltage of the flux diverting coil 51 obviates the need for the step-down transformer commonly used in conventional fuel control systems to provide low voltage in the thermostat circuit.

It is apparent that the novel construction of the improved control permits the energizing unit 61 of the operator, including the frame 43 and coils 48 and 51, to be readily removed from the valve body 6 without in any way affecting the sealed condition of said valve body 6, there being no wires connecting said energizing unit to the energizable unit 15 of said operator. Likewise there are no shafts or other elements extending through the valve body 6 and requiring sealing means which provide a possible source of leakage of gas from the valve body 6. Upon removal of the energizing unit 61 from the body 6, the cover 13 can be readily removed from said body, and the energizable unit 15 can then be readily removed from said cover by simply loosening the screws 59.

While the energizable unit 15 of the operator is mounted within the valve body 6 and is exposed to the fuel therein, the air gaps and the actuatable mechanism of said unit coacting therewith are isolated from the gas in said valve body by virtue of the sealed casing provided by the pole pieces 21 and 22, and the cylindrical sleeve 29 connecting said pole pieces. The aforementioned casing completely encloses therewithin the rotor 34 and the pole piece segments 27 and 28, and said parts are thereby protected against contamination.

The specific illustrations and corresponding description are used for the purposes of disclosure only, and are not intended to impose unnecessary limitations on the claims, or to confine the patented invention to a particular use. Various changes and modifications may be made without departing from the spirit of the invention, and all of such changes are contemplated as may come within the scope of the claims.

What is claimed as the invention is:

1. An electromagnetically operated control device, comprising: a control body, an electromagnetic operator comprising a first unit within said body energizable by flux flow therethrough and including an actuatable member movable from a first position to a second position in response to such energization, said operator further comprising a flux-generating second unit outside of said control body, said control body having magnetically permeable wall portions magnetically insulated from each other and in flux conducting engagement with said first and second units to afford low reluctance flux paths between said operator units, said wall portions providing for energization of said first unit by magnetic flux from said second unit.

2. An electromagnetically operated control device, comprising: a sealed control body having a cavity therein, an electromagnetic operator comprising a sealed first unit within said body cavity, said unit being energizable by flux flow therethrough and including an actuatable member movable from a first position to a second position in response to such energization, a portion of said actuatable member sealingly extending from said unit into said cavity and being movable within said cavity, said operator further comprising a flux-generating second unit outside of said control body, and said control body including magnetically permeable portions in flux conducting engagement with said first and second units and affording low reluctance flux paths between said units to provide for energization of said sealed first unit by magnetic flux from said second unit.

3. An electromagnetically operated control device, comprising: a control body, an electromagnetic operator comprising a first unit within said body having a pair of permeable pole pieces separated by an air gap and including an actuatable member movable from a first position to a second position in response to flux flow across said air gap, said operator further comprising a flux-

generating second unit outside of said control body, and said control body including magnetically permeable portions in flux conducting engagement with said pole pieces and said second unit affording low reluctance flux paths between said second unit and said pole pieces whereby to afford flux flow across said air gap and movement of said actuatable member to said second position on generation of flux by said second unit.

4. An electromagnetically operated control device, comprising: a control body having magnetically permeable wall portions magnetically insulated from one another; and an electromagnetic operator comprising an energizable first unit within said body having a pair of permeable pole pieces in flux conducting contact with said wall portions and separated by an air gap, said unit also including a magnetically permeable rotor mounted for movement from a first position to a second position in response to flux flow across said air gap, said operator further comprising a flux-generating second unit outside of said control body and including a magnetically permeable frame having portions in flux conducting contact with said wall portions, said second unit also including means producing magnetic flux flow in said frame, through said wall portions and pole pieces, and across said air gap, whereby to turn said rotor to said second position in response to said flux flow.

5. An electromagnetically operated control device, comprising a control body adapted to be hermetically sealed and having a pair of magnetically permeable wall portions magnetically insulated from each other; and an electromagnetic operator comprising an energizable first unit within said control body in flux conducting contact with said permeable wall portions and energizable by flux flow therethrough, said first unit including a movably mounted actuatable member movable from a first position to a second position in response to such energization, said operator further comprising a flux generating second unit outside of said control body comprising a magnetically permeable core having spaced end legs and spaced side legs connected to said end legs, intermediate portions of said side legs removably engaging said permeable wall portions in flux-conducting relation, means producing magnetic flux flow in said core, and means for diverting magnetic flux flow from one of said core end legs through said wall portions and said first unit, whereby to cause movement of said actuating member to said second position.

6. An electromagnetically operated control device, comprising: a sealed control body having magnetically permeable wall portions magnetically insulated from each other, and an electromagnetic operator comprising a sealed energizable first unit within said body, said first unit including a pair of permeable pole pieces in flux-conducting contact with the inner surfaces of said body wall portions and also including an actuatable member having a portion sealingly extending from said unit for movement within said control body from a first position to a second position in response to flux flow between said pole pieces, said operator further comprising a flux generating second unit outside of said control body comprising a magnetically permeable frame having portions removably engaging the outer surfaces of said permeable wall portions in flux-conducting relation, and energizing coil wound on said frame for producing magnetic flux flow in said frame, and a flux diverting coil wound on said frame for diverting magnetic flux from said frame through said wall portions and pole pieces and between the latter, whereby to move said actuatable member to said second position.

7. In an electromagnetically operated control device: a sealed enclosure having spaced magnetically permeable walls each provided with an inwardly directed pole piece having a plurality of spaced pole faces radially arranged about a common axis, said pole pieces being axially spaced to provide axial air gaps between opposing faces thereof; a magnetically permeable rotor within said enclosure and between said pole pieces pivotally mounted for rotation on said common axis, said rotor having a plurality of spaced segments radially arranged around said common axis for coaction with the pole faces of said pole pieces, said rotor being disposed with only a portion of each segment thereof presented to an adjacent pole face when said operator is deenergized; and magnetic flux flow producing means external to said enclosure engaging the outer surfaces of the magnetically permeable wall portions thereof in flux-conducting relation and operable when energized to produce magnetic flux flow through said enclosure walls and pole pieces and axially across said air gaps from one of said pole pieces to the other to draw said rotor segments into registry with said pole faces and cause turning movement of said rotor with maximum force at the beginning of said rotor movement.

8. In an electromagnetically operated control device: a sealed enclosure having spaced magnetically permeable walls each provided with an inwardly directed pole piece having a plurality of spaced pole faces radially arranged about a common axis, said pole pieces being axially spaced to provide axial air gaps between opposing faces thereof; a magnetically permeable rotor within said enclosure and between said pole piece pivotally mounted for rotation on said common axis, said rotor having a plurality of spaced segments radially arranged around said common axis for coaction with the pole faces of said pole pieces, said rotor being disposed with only a portion of each segment thereof presented to an adjacent pole face when said operator is deenergized; and magnetic flux flow producing means external to said enclosure comprising a magnetically permeable frame having portions engaging the outer surfaces of said magnetically permeable walls in flux-conducting relation; an energizing coil wound on said frame for producing magnetic flux flow in said frame, a flux diverting coil wound on said frame for diverting magnetic flux from said frame through said enclosure walls and pole pieces and axially across said air gaps from one of said pole pieces to the other to draw said rotor segments into registry with said pole faces and cause turning movement of said rotor with maximum force at the beginning of said rotor movement, a low voltage control circuit supplied from said flux diverting coil, and control means in said circuit operable to control said flux diversion and hence the movement of said rotor.

9. An electromagnetically operated control device, comprising a control body having magnetically permeable wall portions magnetically insulated from each other; and an electromagnetic operator comprising an energizable first unit within said control body in flux conducting contact with said permeable wall portions and energizable by flux flow therethrough, said first unit including a movably mounted actuatable member movable from a first position to a second position in response to such energization, said operator further comprising a flux generating second unit comprising a magnetically permeable core having first spaced portions and second spaced portions connected to said first spaced portions, intermediate portions of said second spaced portions removably engaging said permeable wall portions in flux-conducting relation, means producing magnetic flux flow in said core, and means for diverting magnetic flux flow from one of said first spaced core portions through said wall portions and said first unit, whereby to cause movement of said actuating member to said second position.

10. An electromagmentically operated control device, comprising: a control body having magnetically permeable wall portions magnetically insulated from each other, and an electromagnetic operator comprising an energizable first unit, said first unit including a plurality of permeable pole pieces in flux-conducting contact with adjacent surfaces of said permeable body wall portions and also including an actuatable member having a portion

extending from said unit for movement from a first position to a second position in response to flux flow between said pole pieces, said operator further comprising a flux generating second unit comprising a magnetically permeable frame having portions removably engaging opposite surfaces of said permeable wall portions in flux-conducting relation, an energizing coil wound on said frame for producing magnetic flux flow in said frame, and a flux diverting coil wound on said frame for diverting magnetic flux from said frame through said wall portions and pole pieces and between the latter, whereby to move said actuatable member to said second position.

11. In an electromagnetically operated control device: a pair of spaced magnetically permeable walls each provided with a pole piece having a plurality of pole faces radially arranged about a common axis, said pole pieces being axially spaced to provide axial air gaps between opposing faces thereof; a magnetically permeable rotor between said pole pieces pivotally mounted for rotation on said common axis, said rotor having a plurality of spaced segments radially arranged around said common axis for coaction with the pole faces of said pole pieces, said rotor being disposed with only a portion of each segment thereof presented to an adjacent pole face when said operator is deenergized; and magnetic flux flow producing means comprising a magnetically permeable frame having portions engaging surfaces of said magnetically permeable walls in flux-conducting relation; and energizing coil wound on said frame for producing magnetic flux flow in said frame, a flux diverting coil wound on said frame for diverting magnetic flux from said frame through said enclosure walls and pole pieces and axially across said air gaps from one of said pole pieces to the other to draw said rotor segments into registry with said pole faces and cause turning movement of said rotor with maximum force at the beginning of said rotor movement, a control circuit supplied from said flux diverting coil, and control means in said circuit operable to control said flux diversion and hence the movement of said rotor.

12. An electromagnetically operated control device, comprising: a control body, an electromagnetic operator a portion of which is removable comprising a first unit within said body energizable by flux flow therethrough and including an actuatable member movable from a first position to a second position in response to such energization, said operator further comprising a removable flux-generating second unit outside of said control body, said control body having magnetically permeable wall portions magnetically insulated from each other and in flux conducting engagement with said first and second units to afford low reluctance flux paths between said operator units, said wall portions providing for energization of said first unit by magnetic flux from said second unit when the latter is engaging said control body.

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