United States Patent [19]

Nolden

[11] **3,828,556**

[45] **Aug. 13, 1974**

[54] **HYDRAULIC ACTUATOR**

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[73] Assignee: **Johnson Service Company,** Milwaukee, Wis.

[22] Filed: **Jan. 26, 1973**

[21] Appl. No.: **326,855**

[52] **U.S. Cl.** **60/432**

[51] **Int. Cl.** **F15b 11/12,** F15b 15/18

[58] **Field of Search** 60/432; 318/657; 137/487.5

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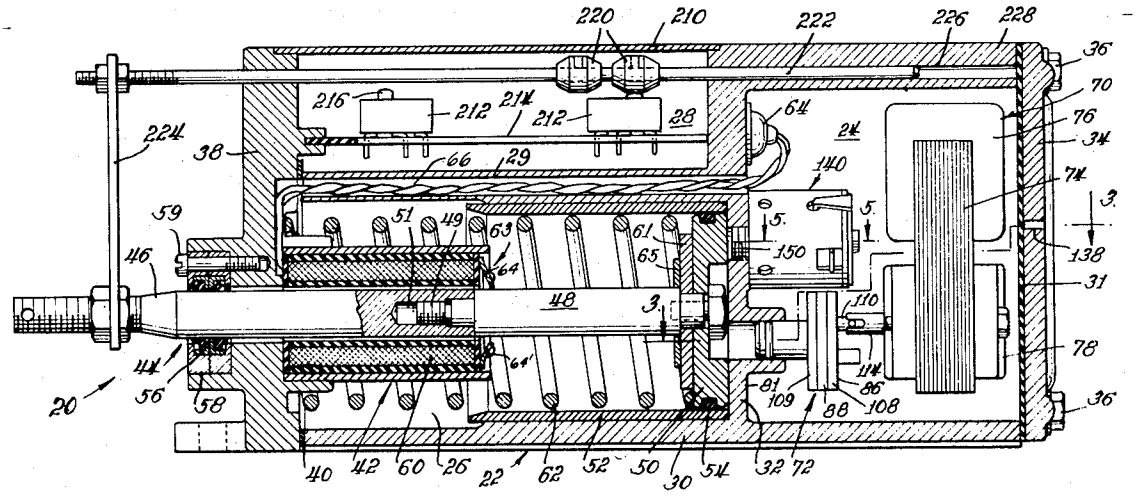
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Primary Examiner—Edgar W. Geoghegan
Assistant Examiner—William F. Woods
Attorney, Agent, or Firm—Johnson, Dienner, Emrich, Verbeck & Wagner

[57] **ABSTRACT**

A hydraulic actuator is constructed in an enclosed housing having an internal wall member which divides its interior into forward and rear chambers. An elongated actuator element is slidably supported in the forward chamber with its forward nose portion extending outwardly through an opening in the wall of the housing. A piston is transversely supported on the rear end portion of the actuator element and is in slidable sealing engagement with a cylindrical wall contained within the forward chamber to define an expandable chamber with this cylindrical wall and the internal wall member. A spring means constantly urges the piston towards the internal wall member. Pump means contained in the rear chamber introduces a fluid under pressure through a passageway formed through the internal wall member into the expandable chamber to force the piston and associated actuator element outwardly of the housing to an extended position. The relative location of the actuator element is detected by a position sensing means which provides a variable control signal in response to the movement of the actuator element for energizing the pump means.

16 Claims, 10 Drawing Figures



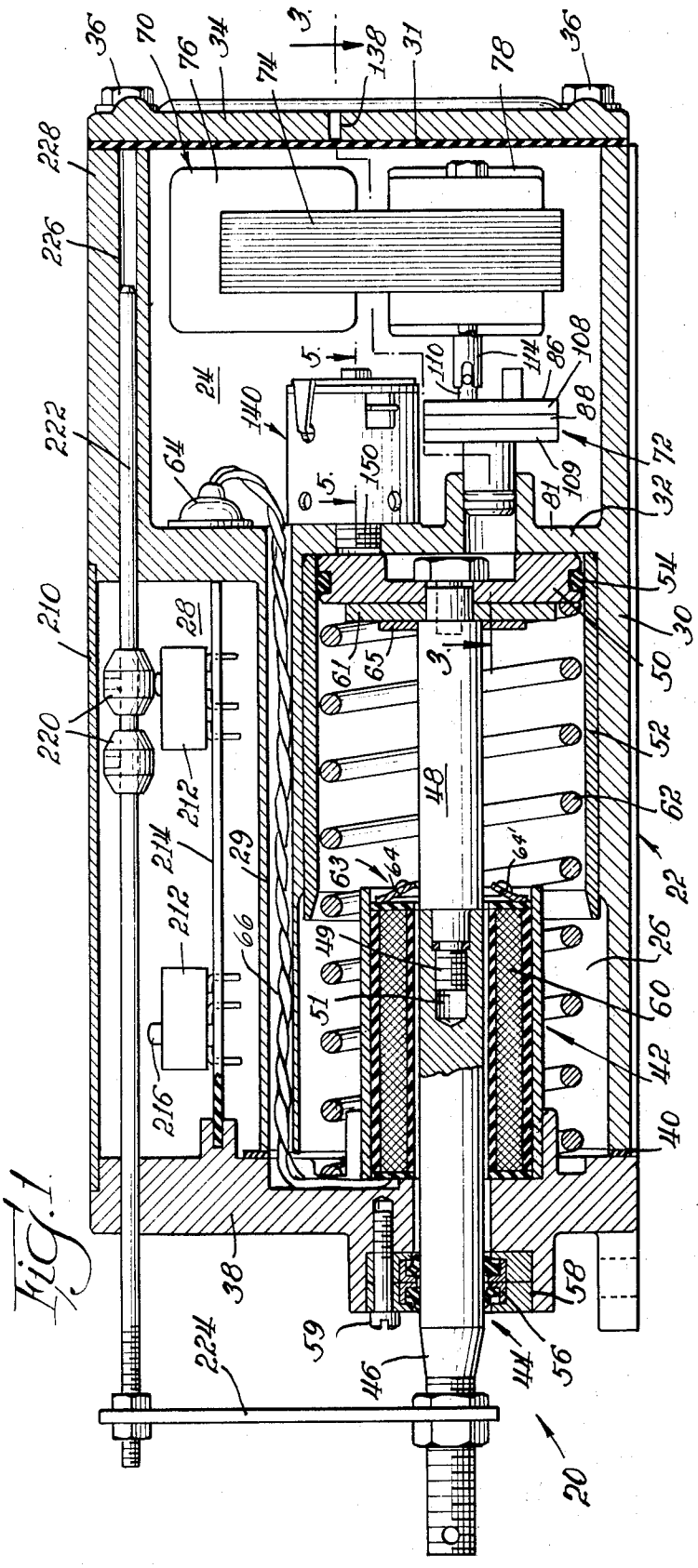


Fig. 1

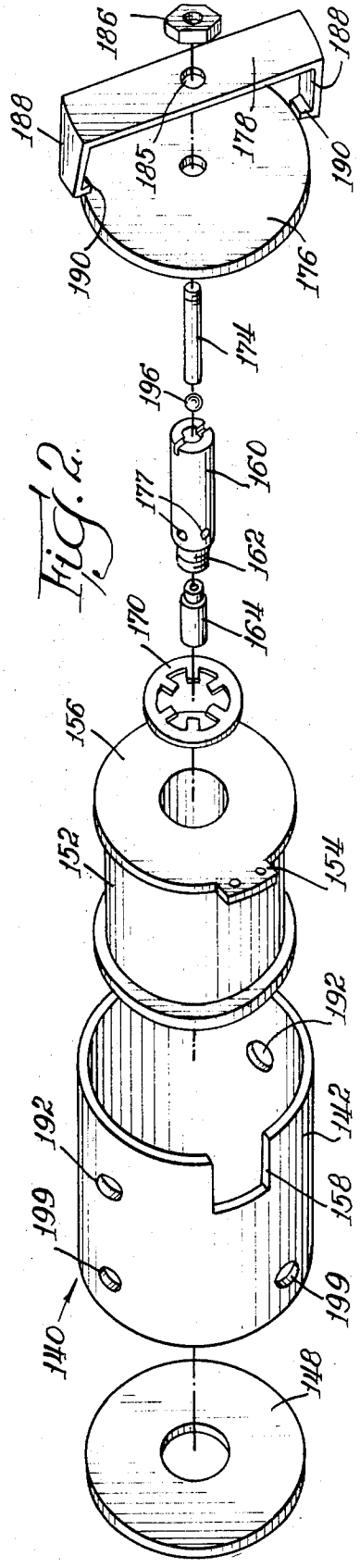


Fig. 2

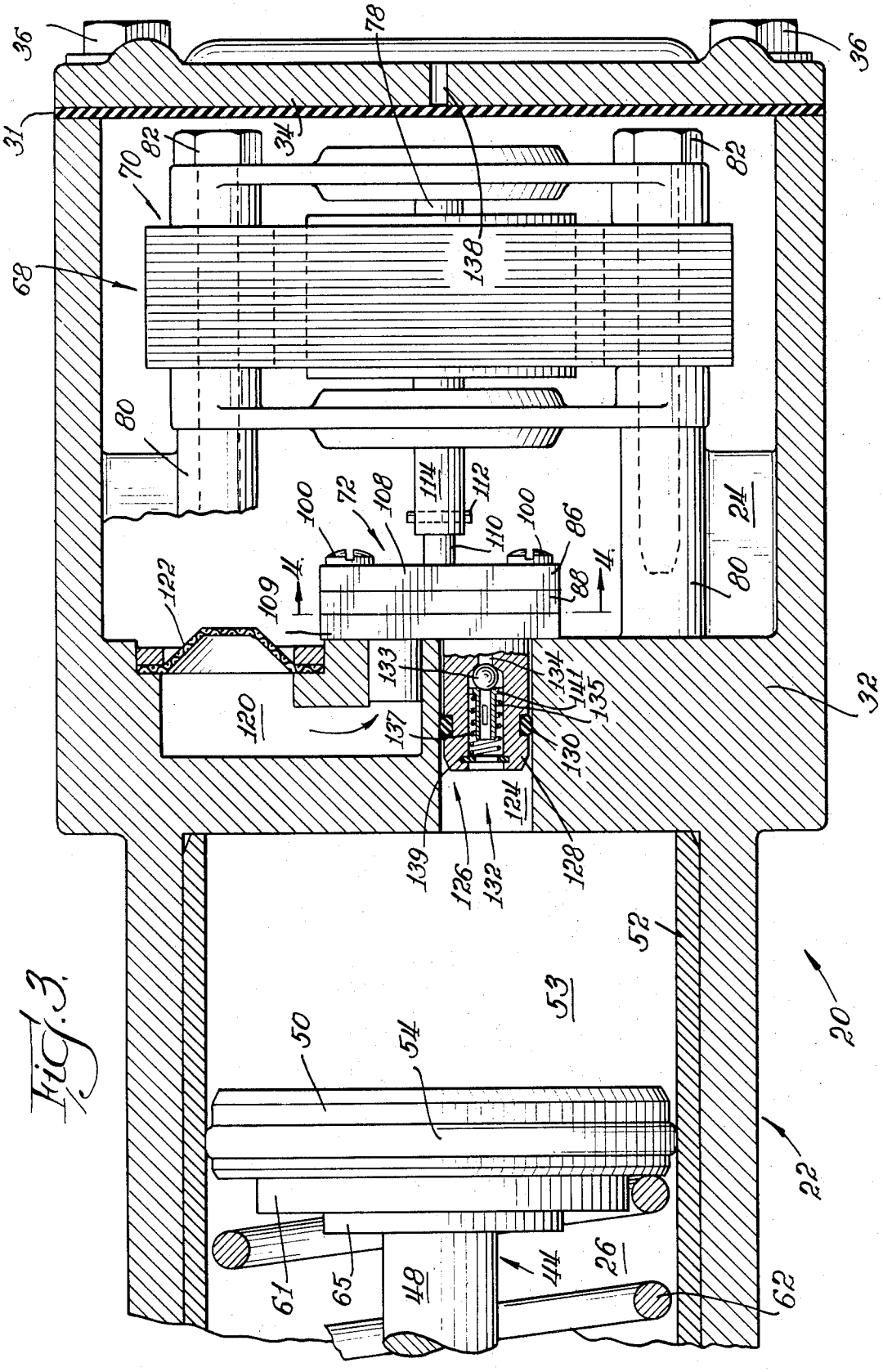

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Fig. 3.

Fig. 4.

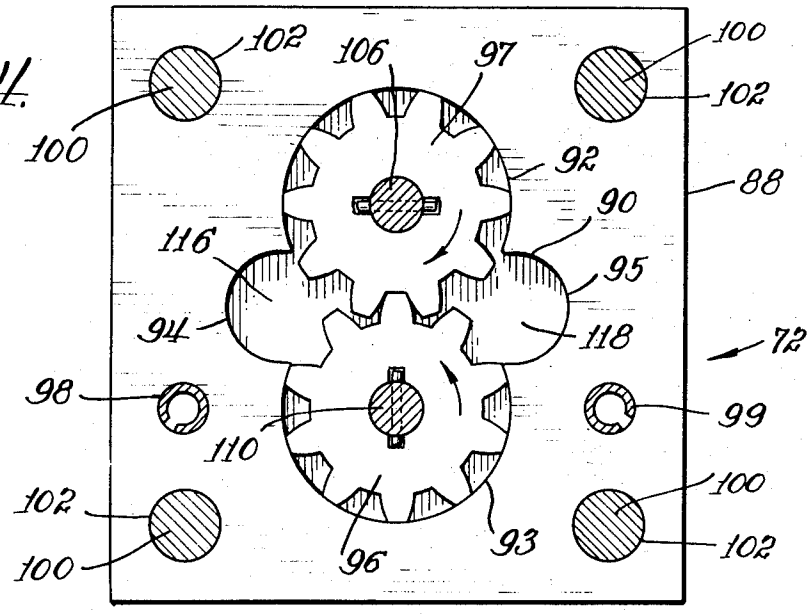


Fig. 5.

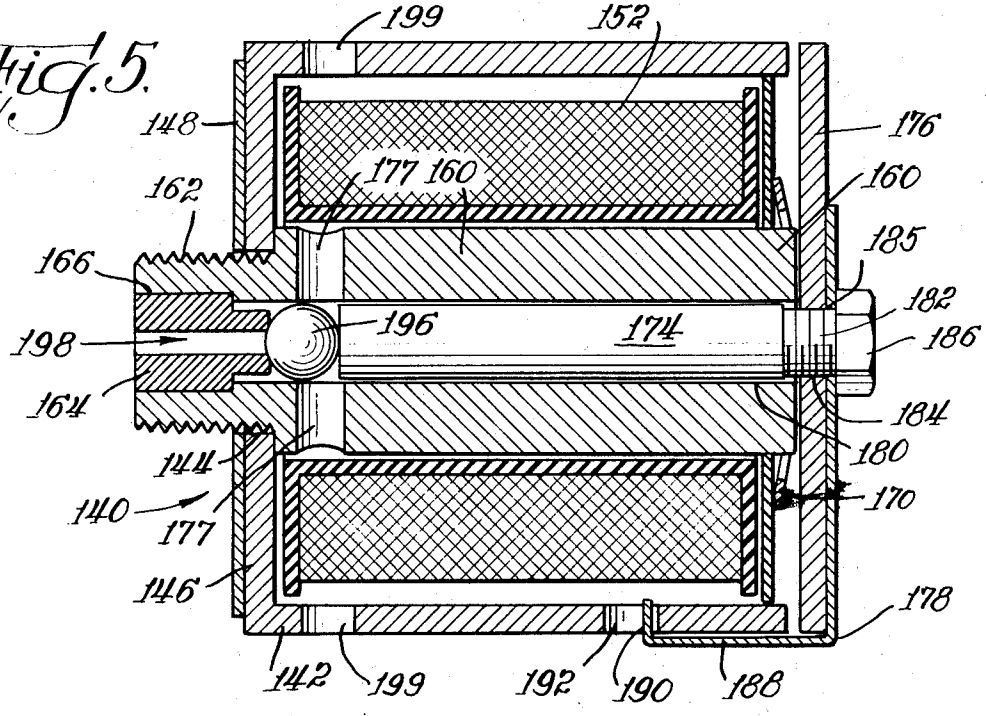


Fig. 6.

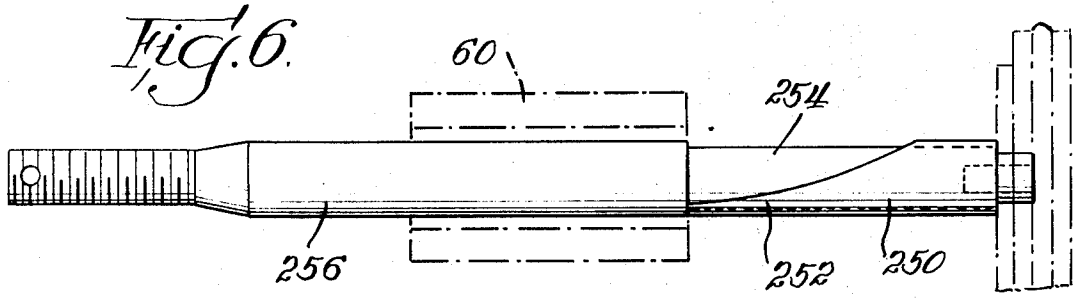


Fig. 7

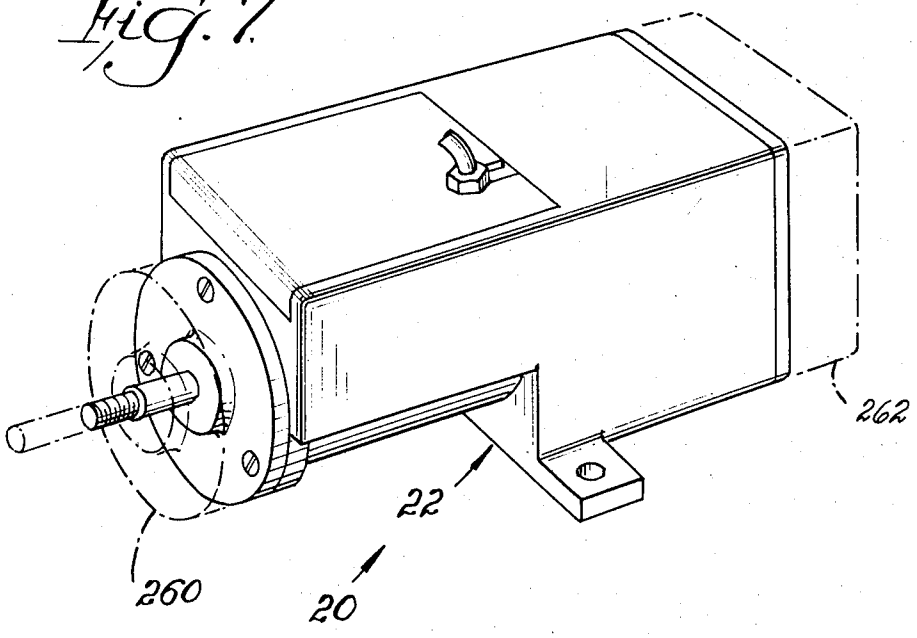
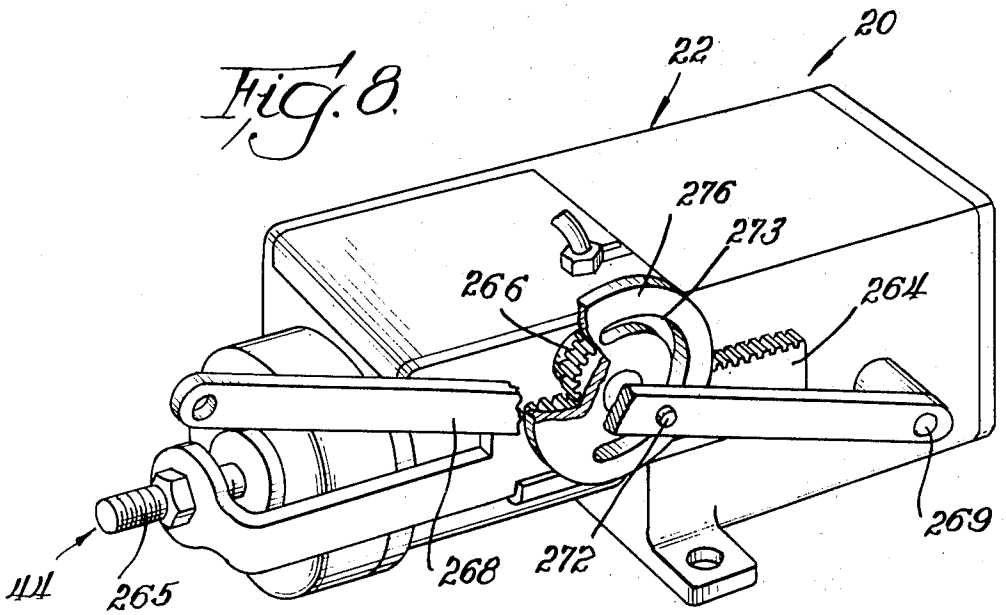


Fig. 8



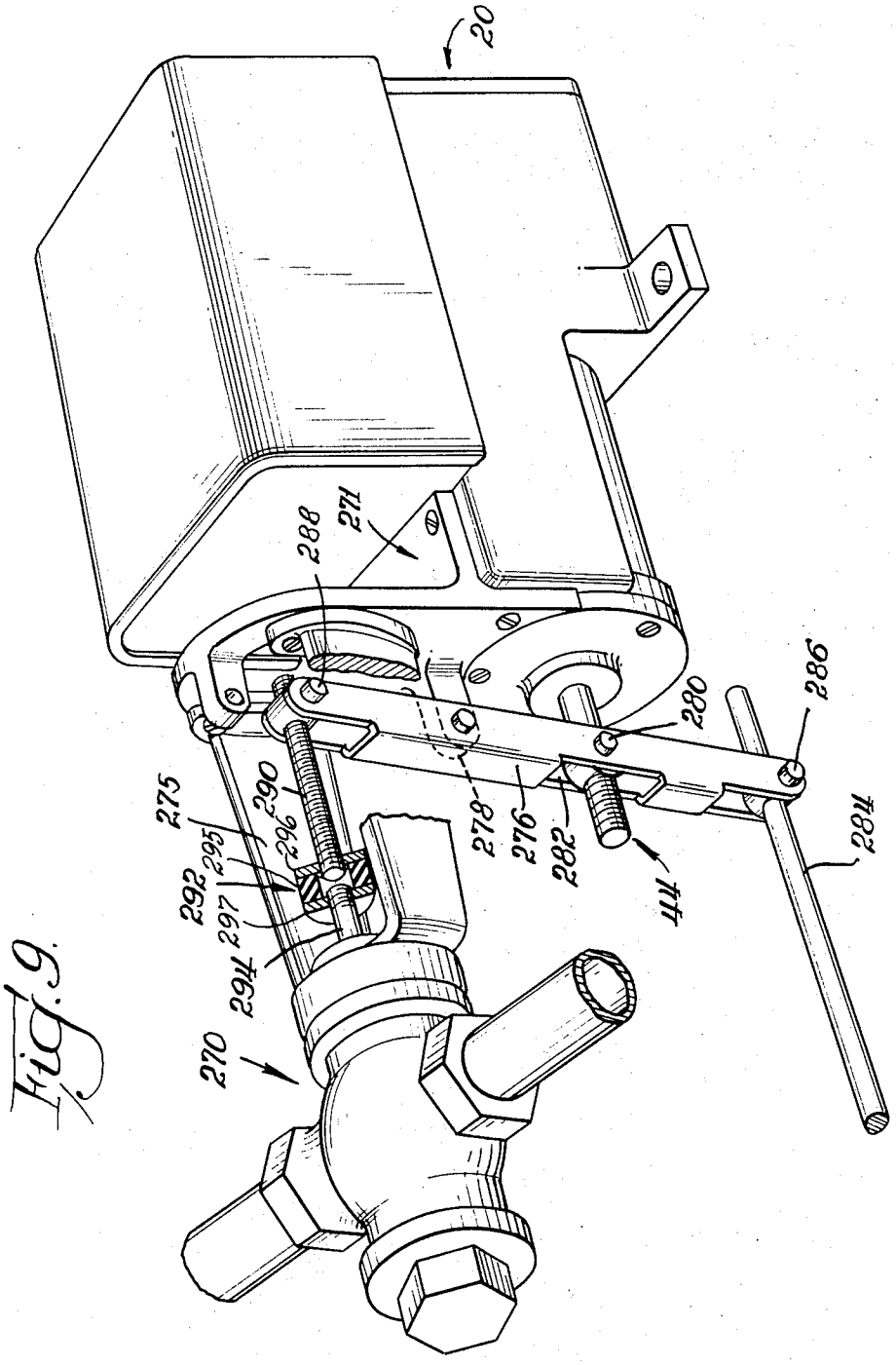

20
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274
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Fig. 9.

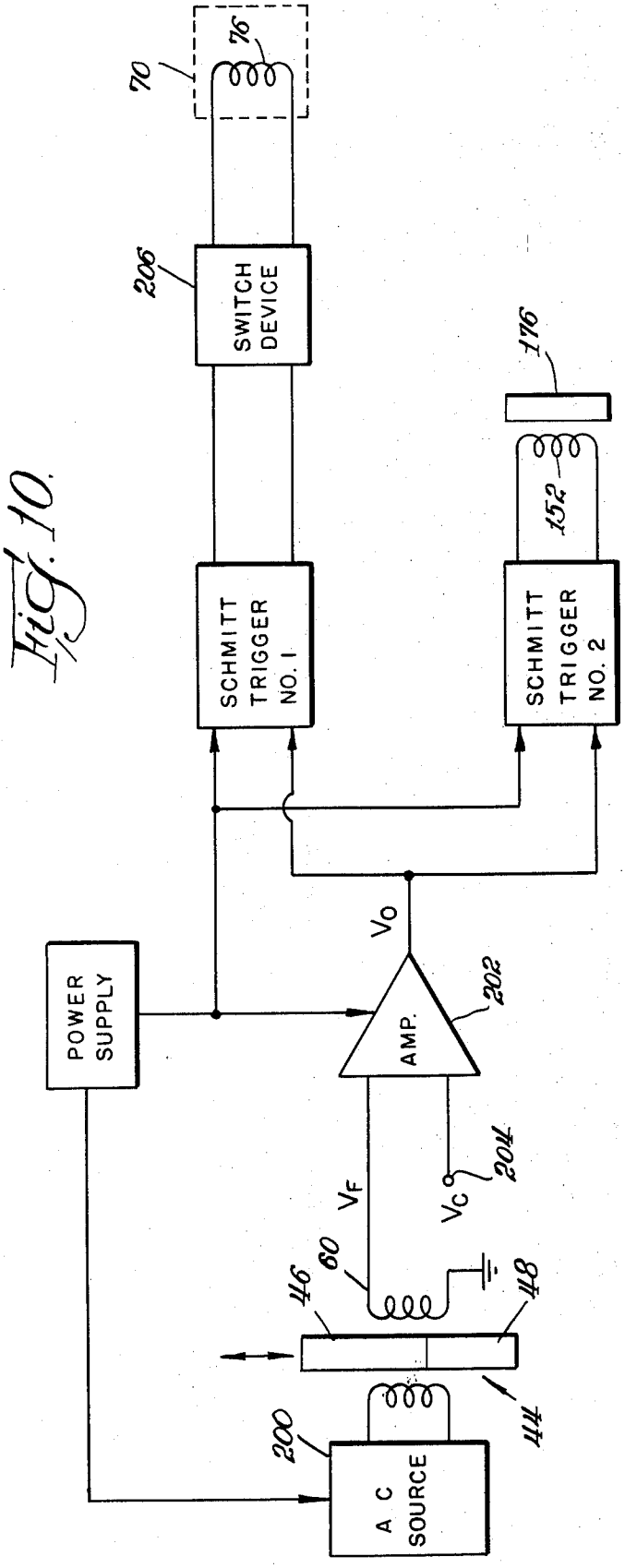

70
76
206
SWITCH DEVICE
176
152
SCHMITT TRIGGER NO. 1
SCHMITT TRIGGER NO. 2
V_O
POWER SUPPLY
AMP.
202
V_F
V_C
204
46
60
48
44
200
A C SOURCE

Fig. 10.

HYDRAULIC ACTUATOR

BACKGROUND OF THE INVENTION

This invention relates to hydraulic actuators, and more particularly to hydraulic actuators for longitudinally positioning a shaft.

A primary object of this invention is to provide a hydraulic actuator having a self-contained, closed-circuit hydraulic system which is designed to provide greater strokes and greater power at extremely low operating cost.

Another object of this invention is to provide a hydraulic actuator for longitudinally positioning a shaft having a pump-motor assembly that operates only on signal demand to substantially reduce the wear of the pump parts and power consumption.

These and other objects of the invention will become apparent with reference to the following description of the preferred embodiment and drawings.

SUMMARY OF THE INVENTION

A hydraulic actuator embodying the principles of my invention comprises an enclosed housing having first and second chambers separated by a dividing wall member. An elongated actuator element is slidably supported through an opening in the actuator housing and carries a piston which is in slidable sealing engagement with a cylindrical wall of one of the first chambers. A pump means disposed in the rear chamber when energized introduces fluid under pressure through a passageway formed in the dividing wall member into an expandable chamber defined by the piston and cylindrical wall to push the piston and associated actuator element outwardly against the biasing force of a compression spring. A dump valve means is provided for selectively bleeding the fluid from the expandable chamber to permit the actuator element and piston to be retracted. A piston sensing means detects the position of the actuator element as it slides, and provides a variable control signal in response to this sliding movement to selectively energize the pump means and the dump valve means.

DESCRIPTION OF DRAWINGS

For a better understanding of this invention, reference may be made to the accompanying drawings, in which:

FIG. 1 is a cross sectional view taken along the axis of housing of a hydraulic actuator embodying the principles of my invention;

FIG. 2 is an exploded view of the component parts which when assembled provide the dump valve assembly which is used in the hydraulic actuator of FIG. 1;

FIG. 3 is an enlarged cross sectional view taken along the line 3—3 of FIG. 1 and looking in the direction of the arrows;

FIG. 4 is a sectional view taken along the line 4—4 of FIG. 3 and looking in the direction of the arrows for the pump unit used in the hydraulic actuator of this invention;

FIG. 5 is a cross sectional view illustrating the dump valve assembly taken along the line 5—5 of FIG. 1 and looking in the direction of the arrows;

FIG. 6 is a side elevational view of a modified actuator element with the associated piston and transformer coil shown in dotted lines;

FIG. 7 is a front perspective view of the actuator element of FIG. 1;

FIG. 8 is a perspective view of the actuator element of FIG. 1 showing it being used to produce a vertical reciprocating movement;

FIG. 9 is a front perspective view of an actuator element embodying the principles of my invention being used to simultaneously operate a radiator valve and a damper element; and

FIG. 10 is an electrical schematic diagram illustrated in block diagram form for an electronic control system to operate the hydraulic actuator of FIG. 1.

DESCRIPTION OF PREFERRED EMBODIMENT

There is illustrated in FIG. 1 a cross sectional view of a hydraulic actuator embodying the principles of my invention and generally designated by the reference numeral **20**. The hydraulic actuator **20** is constructed to be assembled in an elongated housing **22** having rear and forward fluid-tight chambers **24** and **26**, and having an electronic component compartment **28** located above the forward liquid-tight compartment **26**. A narrow passageway **29** extending substantially the entire length of the forward chamber **26** interconnects the front and rear chambers.

The elongated housing **22** has a generally rectangular shaped body portion **30** with an internal wall **32** separating the front and rear chambers and is preferably made as a one-piece die-casting. The rear end of the body member **30** is closed by rear cover plate **34** which is attached thereto by a plurality of mounting bolts **36** and sealed by use of diaphragm **31**. Likewise, the front end of the body **30** is covered by front cover plate **38**. A gasket **40** is sandwiched between the front cover **38** and the body portion **30** to provide a sealed connection.

An actuator assembly **42** is contained within the forward chamber **26** and comprises a control element **44** slidably mounted axially through front chamber **26** and extending forwardly of the housing **22**. The control element **44** is constructed as a two-piece shaft in which the forward portion **46** is made of a non-magnetic permeable material and the rearward portion **48** is made of a magnetic permeable material. A threaded shank **49** extending from the forward end of rearward portion **48** is screwed into a conforming threaded aperture **51** formed in the rear end of forward portion **46**. A piston **50** is secured crosswise on the rear end of control element **44**. Piston **50** is adapted to reciprocate in the bore of a cylindrical piston cylinder **52**, which is mounted at the rear end of forward chamber **26**. A Quad-ring **54** provides a sliding sealing relationship between the piston **50** and the bore of cylinder **52**. The piston cylinder **52**, piston **50** and internal wall **32** define an expandable chamber **53**. The forward end of the control element **44** is adapted to slide through a bearing **56** which has a seal and is seated in the enlarged diameter stepped opening **58** of front cover plate **38**. The bearing **56** is mounted in place by means of a plurality of mounting bolts **59**.

The intermediate length of control element **44** moves through the center of a feedback coil assembly **60** as the control element **44** is extended and retracted, and the insertion of the magnetic permeable portion **48** of

control element 44 varies the inductance of the feedback transformer coil assembly 60 to provide a variable control signal as will be described hereinafter. The electrical leads 66 for feedback transformer coil assembly 60 pass through passageway 29 and are fed into electronic component compartment 28 through grommet 64. A compression spring 62 urges the piston 50 and associated control element 44 to their retracted position as illustrated in FIG. 1.

Outward displacement of control element 44 is effected by the energization of motor-pump assembly 68 which comprises a motor unit 70 and pump unit 72. The motor unit 70 has an upstanding core member 74 (FIG. 1) supporting an offset field coil 76 at its upper end and having an armature 78 extending transversely in its lower end. The motor 70 is mounted on a pair of spaced bosses 80 which extend horizontally from the internal side wall 81 of internal wall member 32. A pair of mounting bolts 82 are used to fasten the motor on the spaced bosses 80 which have threaded bores formed inwardly of their outer ends.

The pump unit 72 has a housing 86 constructed by stacking three square-shaped plates together in side-by-side relation. The middle plate 88, as depicted in FIG. 4, is formed with a cloverleaf-shaped recess 90 in its middle section, in which the upper and lower arcuate portions 92, 93 are larger than the two lateral arcuate portions 94, 95. A pair of cooperating pump gears 96, 97 fit within the upper and lower arcuate portions in intermediate relation. The three plates are aligned by a pair of alignment pins 98, 99 extending through aligned openings in the three plates. The three plates are held together and mounted on the internal sidewall 81 by means of four mounting bolts 100 inserted through the four aligned corner apertures 102 provided in the three plates and screwed into threaded openings formed in the internal wall 32. The gear 97 is rotatably supported by means of an idle shaft 106 whose ends are supported by the outer plate 108 and inner plate 109. The gear 96 is keyed to a drive shaft 110 which is also supported by the plates 108, 109, and which extends outwardly of the outerplate 108 where its outer end is coupled by means of a clevis pin 112 to the bifurcated outer end of motor drive shaft 114. An opening provided in the inner plate 109, in alignment with arcuate recess 94 of middle plate 88, provides the inlet 116 (FIG. 4) for the pump unit 72. Similarly, an opening in the inner plate 109 in alignment with arcuate recess 95 of intermediate plate 88 provides the outlet for pump unit 72. When the pump unit 72 is mounted on the inner wall 81, the inlet 116 for pump 72 aligns with a pump inlet passageway 120 formed within internal wall member 32 of housing 22 which is in communication with the rear chamber 24 and has a filter screen 122 at its entrance to prevent foreign particles from entering the pump unit 72. Similarly, the pump outlet 118 aligns with a pump outlet passageway 124 formed through the internal wall member 32 and in communication with the forward chamber 26.

Mounted within pump outlet passageway 124 is a check valve unit 126 for preventing the return of the fluid through passageway 124. Check valve 126 comprises a fitting 128 having a diameter slightly smaller than the diameter of outlet passageway 124 with an O-ring 130 disposed about its outer perimeter for providing a sealing relationship therebetween and a spring loaded ball valve 132 for sealing off its inlet port 134. Ball valve 132 is made up of a ball 133 and a cylindrical ball guide 135 which are biased towards inlet port 134 by a compression spring 137 which acts between a retainer washer 139 and end collar 141 of cylindrical ball guide 135.

The forward and rear chambers 24, 26 are completely filled with a hydraulic fluid and when the motor 70 is energized by a control signal the pump unit 72 forces the fluid under pressure through the pump outlet passageway 124 into the area behind piston 50 to drive the piston 50 and associated actuator rod 44 outwardly against the force of compression spring 62. To accommodate the change in volume of forward chamber 26 caused by the outward displacement of actuator rod 44, a vent 138 (FIG. 1) is formed through the rear end plate 34 to permit the middle portion of diaphragm 31 to move inwardly as the control rod 44 is displaced outwardly.

As will be described in full detail hereinafter, the feedback coil assembly 60 provides a control signal to deenergize motor 70 in response to the movement of the magnetic permeable portion 48 of control rod 44 through its center. The linearity characteristics of the feedback control signal is improved by adding a magnetic disk 61 on the forward face of piston 50 which is in a coaxial relation with control rod 44.

When the motor 70 is deenergized, the control rod 44 will be held in a stationary position since the check valve 126 prevents the fluid from flowing back through the pump outlet opening 124. This manner of operation is a substantial improvement over prior art structures which require the motor pump assembly to be continuously operated when holding the actuator rod in a fixed extended position.

Because ambient temperature changes cause the end of the control rod stroke to be variable, limit switch means 63 is provided to remove power to motor 70 as the control rod 44 reaches the end of its extended stroke. Limit switch means 63 comprises a pair of switch contacts 64, 64′ mounted on the rearward end of feedback coil assembly 60 on diametrically opposite sides of control rod 44. A printed circuit board washer 65 carried on the forward end face of magnetic disk 61 provides a short circuit path between the switch contacts 64, 64′ whenever the control rod 44 reaches the extended stroke position. The switch contacts when short circuited provide a control signal to switch device 206 (FIG. 10) for deenergizing motor 70 with the result that a constant stroke is attained regardless of ambient temperature changes.

To permit the control rod 44 to thereafter be returned to its retracted position, dump valve assembly 140 is provided, which when deenergized provides a return passageway through the internal wall 32. Referring to FIGS. 1, 2 and 5, the dump valve assembly 140 is assembled in a cup-shaped housing 142 which has a central opening 144 in its end plate 146. A doughnut-shaped gasket 148 is abutted against the end plate 146 when mounted on the internal side wall 81 in alignment with inlet opening 150 is depicted in FIG. 1. A field coil 152 is seated within the cup-shaped housing 142 with tab 154 of its end flange 156 received in slot 158 at the outer end of cup-shaped housing 142. A cylindrical core 160 is inserted through the center of coil assembly 152 and its threaded end portion 162 is screwed through the threaded central opening 144 of cup-shaped housing 142. A valve fitting 164 is secured

within the central opening **166** of threaded shank portion **162.** A ring retainer **170** is frictionally urged over the outer end of core **160** and engages the outer end flange **156** of field coil **152** (FIG. **5**).

The actuator means for operating dump valve assembly **140** is provided by the combination of plunger **174,** armature **176,** and armature retainer **178.** The plunger **174** is slidingly mounted in the center axial opening **180** of core **160** and its threaded outer shank portion **182** extends through both circular aperture **184** in armature **176** and mounting aperture **185** at the center of retainer armature **178.** A nut **186** is screwed on the end of the threaded shank portion **182** to provide a unitary unit. The retainer armature **178** has a pair of forwardly projecting arm portions **188** having inturned fingers **190** which are inserted into a pair of diametrically opposite circular openings **192** in the peripheral side wall of cup-shaped housing **142.** The movement of the fingers **190** within the pair of openings **192** limits the extent of travel of plunger **174.** A ball **196** is inserted in the space between the inner end of plunger **174** and valve fitting **164** to provide a check valve which closes off port **198** upon armature **176** being pulled inwardly by the energized field windings of coil assembly **152.**

Upon the deenergization of field coil winding **152,** the attraction of armature **176** is terminated and fluid under pressure may pass through the inlet port **198,** radially outwardly through radial openings **177** of core **160** and pass into rear chamber **24** through a plurality of openings **199** formed about the cup-shaped side wall area and through the end spacing between the armature and cup-shaped housing.

The threaded shank **162** of core **160** is used to mount the dump valve assembly **140** in a threaded opening which defines inlet **150** in the side wall in the internal wall **32** as depicted in FIG. **1.** It will thus be appreciated that upon the deenergization of field coil winding **152** the fluid is then free to pass through the inlet port **198** and into the rear chamber **24** until the compression spring **62** returns the piston **50** to the retracted position of FIG. **1.**

The operation of hydraulic actuator **20** will now be described with reference to the control system depicted in block diagram form in FIG. **10.** The feedback coil unit **60** is energized by an A–C source **200** and its output V_F is one of the two input signals compared by an integrated circuit amplifier **202.** The other input signal is received at terminal **204** from a remote condition sensitive element (not shown) and designated as V_c. The integrated circuit amplifier **202** compares the control voltage V_c with the feedback voltage V_F and amplifies their difference to produce an output voltage V_o proportional to the difference of the two input voltages. Schmitt trigger No. 1 senses the output voltage level V_o and at a preselected voltage level provides a positive gating of the switch device **206.** The switch device **206** could, for example, use a Triac element to provide this positive gating operation, which energizes motor coil **76.** The Schmitt trigger circuit No. 2, likewise, senses the output voltage V_o and energizes the coil **152** of the dump valve assembly **140** at a preselected voltage level.

When the control voltage V_c exceeds the feedback voltage V_F by a preselected value, the difference is derived by the integrated circuit amplifier **202** and amplified to provide a voltage level of sufficient magnitude to switch on both Schmitt trigger circuits. Upon the switching "on" of Schmitt trigger No. 1, the motor **70** is energized. Simultaneously, Schmitt trigger No. 2 energizes coil **152** to attract armature **176** and thereby shut off the inlet port **198** of dumping valve **140.** The piston **50** and actuator element **44** are driven outwardly by the motor-pump assembly **70** until the magnetic permeable portion **48** moves part way through the center of coil **60.** The movement of magnetic permeable portion **48** through the center of coil **60** proportionally increases the efficiency of the feedback transformer **60** and consequently its output voltage V_F increases to approach the signal level of control voltage V_c.

When the control element **44** reaches a desired position, the output V_o of the integrated circuit amplifier **202** has decreased to less than the threshold voltage for Schmitt trigger No. 1 so that the switch device **206** and associated motor coil **76** are deenergized. The output voltage V_o at this time, however, has not decreased to the threshold voltage level for Schmitt trigger No. 2 so that dump valve **140** remains closed. Consequently, the control element **44** will be held in this stationary extended position until the control voltage V_c drops sufficiently in value to reduce the integrated circuit amplifier output voltage V_o to a value which will deenergize Schmitt trigger No. 2 and permit the dump valve inlet **198** to open. At this time, the hydraulic fluid bleeds out of the expandable chamber **53** permitting the actuator element to retract until the feedback voltage V_F is again slightly less than the control voltage V_c. The dump valve then recloses and holds the shaft position of actuator element **44** fixed until a further change in the control voltage V_c occurs.

It will be understood that the details of the electronic control system of FIG. **10** are not essential for an understanding of this invention. For a complete description of the circuits shown in block diagram form and their operation, reference may be made to the copending U.S. Pat. application Ser. No. 326,854 which was filed on Jan. 26, 1973, and is assigned to the same assignee as this invention.

The electronic components for providing the electronic control system of FIG. **10** may be assembled in the electronic components compartment **28** above the forward chamber **26.** A removable top cover **210** is provided over the upper open end of the compartment **28** to permit access to the electronic components mounted therein. Furthermore, one or more auxillary switches **212** can be supported within the electronic components compartment **28** on a printed circuit board **214** such that their switch contacts **216** are adapted to be actuated by one or more switch actuator members **220** as the control element **44** is extended or retracted. Each of the switch actuators **220** has a bead shape with a hollow center and is mounted on a switch actuator rod **222,** which extends parallel to the control element **44** and is connected to the control element **44** at its outer end by means of a cross bar **224.** The rear end of the switch actuator rod **222** is slidably received in a circular elongated recess **226** formed lengthwise in the top wall **228** of the housing **22.**

Referring to FIG. **6** there is shown a modified version of the actuator element illustrated with the embodiment of FIG. **1.** The actuator element of FIG. **6** differs from that shown in FIG. **1** in that the magnetic permeable portion **252** has a tapered nose segment **250** of magnetic permeable material. The magnetic permeable portion **250** is constructed from a sheet of magnetic

permeable material such as sheet metal, which is rolled into a cylindrical configuration and slipped over the reduced diameter portion **254.** The axial displacement of the actuator element of FIG. **6** would be the same when used in the FIG. **1** embodiment. By using a tapered nose segment of magnetic permeable material, the FIG. **6** actuator element changes the reluctance of the feedback transformer coil **60** at a much slower rate as the actuator element slides through the coil. Other characterized strokes can be obtained by shaping the nose segment to have any desired curve or step configuration to thereby vary the inductive feedback as desired.

There is illustrated in FIG. **7,** a front perspective view of the actuator element described with reference to FIG. **1.** By increasing the length of front cover plate **38** as shown in dotted lines **260** at the piston end of the actuator element, it is possible to increase the stroke of the actuator to any desired length. Similarly, by mounting a hollow end cap **262** on the rear open end of actuator housing, it is possible to increase the reservoir capacity of rear chamber and thereby increase its stroke length.

FIG. **8** illustrates one application of the actuator element **44.** A toothed rack slide **264** is attached to the threaded end **265** of the actuator element **44** and cooperates with a rotatably mounted toothed gear **266** for reciprocally driving in a vertical direction a lever **268** which is rotatably mounted at one end **269.** The intermediate portion of lever **268** has a follower roller **272** disposed within the arcuate slot **273** of the disk **276** fixed on the outer end of toothed gear **266.**

FIG. **9** shows another application of the hydraulic actuator of this invention. In the FIG. **9** illustration, the actuator element **44** is shown as conjointly operating a radiator valve **270** and a control rod **284** connected to a damper element (not shown). A mounting bracket **271** is supported on the front end of hydraulic actuator **20** and has a connecting frame **275** on its upper end extending outwardly and interconnected to the radiator valve **270** in a conventional fashion. An actuator lever **276** is pivotally supported along its intermediate portion on the upstanding boss **278** and is interconnected to actuator element **44** by a connecting pin **280** which extends crosswise through the actuator element **44** and actuator lever **276.** The control element **44** projects outwardly through a rectangular recess **282** formed in the actuator lever **276.** The lower end of the actuator lever **276** is pivotally connected to a damper element control rod **284** by a connecting pin **286.** Similarly, a connecting pin **288** connects the top end of the actuator rod **276** to a control rod **290** that operates radiator valve **270.**

In order to accommodate various tolerances and overtravel required in stroking valve **270,** an expandable and contractible coupler **292** is used to interconnect control rod **290** and valve stem **294.** Coupler **292** is constructed of an elastomeric member **295** vulcanized between end plates **296** and **297** which have threaded central openings for connecting to the threaded end portions of central rod **290** and valve stem **294,** respectively. By using coupler **292,** it is possible to have overtravel for both open and closed valve positions.

I claim:

1. A hydraulic actuator comprising an enclosed housing having a dividing wall separating the interior of said housing into first and second chambers, and elongated actuator element extending in said second chamber and slidingly supported through an opening in said housing for selective positioning at a plurality of discrete positions, a piston supported transversely on said actuator element and in slidable sealing engagement with the walls of said second chamber to thereby define an expandable chamber with said dividing wall, biasing means for urging said piston toward said dividing wall, pump means for introducing fluid under pressure through a passageway formed through said dividing wall into said expandable chamber, a separate dump valve means for selectively opening and closing a bleed passage formed through said dividing wall into said expandable chamber for bleeding the fluid in said expandable chamber when said bleed passage is opened to permit said actuator element and associated piston to retract under the force of said biasing means and to maintain said actuator element at any one of said plurality of discrete positions when said bleed passage is closed and means for providing a variable control signal which continuously indicates any one of said plurality of discrete positions at which said actuator element is located for use in the selective operation of said pump means and the selective operation of said dump valve means.

2. A hydraulic actuator as defined in claim **1,** wherein said pump means comprises a pump unit having an inlet in communication with said first chamber and an outlet in communication with said passageway, and check valve means to prevent the flow of fluid from said expandable chamber into said first chamber.

3. A hydraulic actuator as defined in claim **2,** wherein said pump means further comprises an electric motor for operating said pump unit, whereby the energization of said motor is effected by said variable control signal.

4. A hydraulic actuator as defined in claim **2,** wherein said pump unit comprises at least three plates stacked together in a side-by-side abutting relation to define a pump housing, one of middle of said plate including a central recess having two pairs of opposing arcuate portions, a pair of pump gears in intermeshing relation rotatably mounted between the two end plates and nested within one of said pairs of opposing arcuate portions, and a pair of openings formed through one of said end plates in alignment with said other pairs of opposing arcuate portions to define pump inlet and outlet.

5. A hydraulic actuator as defined in claim **1,** wherein said position sensing means comprises a transformer coil having an axial opening disposed in the path of said actuator element and having a cross sectional area larger than the cross section of said actuator element, and wherein said actuator element comprises a nonmagnetic permeable length portion and a magnetic permeable length portion.

6. A hydraulic actuator as defined in claim **5,** wherein said magnetic permeable length portion includes a tapered nose segment.

7. A hydraulic actuator as defined in claim **1,** wherein said dump valve means comprises a core member having an axial opening disposed in said first chamber, a valve fitting mounted in one end of said axial opening of said core member, a plunger slidably mounted inwardly of the other end of said axial opening, a ball valve disposed in said axial opening between said fitting

and said plunger, an armature member carried on said plunger outwardly of said axial opening, and a field coil disposed about said core member and producing sufficient magnetic force when energized to attract said armature causing said plunger to move against said ball valve with sufficient force to close the port in said valve fitting.

8. A hydraulic actuator comprising an enclosed housing having a dividing wall separating the interior of said housing into first and second chambers, an elongated actuator means including a magnetic permeable length portion member extending in said second chamber and slidingly supported through an opening in said housing for selective positioning at a plurality of discrete positions, a piston supported transversely on said actuator means and in slidable sealing engagement with the walls of said second chamber to thereby define an expandable chamber with said dividing wall, biasing means for urging said piston toward said dividing wall, pump means for introducing fluid under pressure through a passageway formed through said dividing wall into said expandable chamber, a separate dump valve means for selectively opening and closing a bleed passage formed through said dividing wall into said expandable chamber for bleeding the fluid in said expandable chamber when said bleed passage is opened to permit said actuator means and said piston to retract under the force of said biasing means and alternatively to maintain said actuator means at any one of said plurality of discrete positions when said bleed passage is closed, said actuator means being extensible to a different one of said plurity of positions in response to selective operation of said pump means and closing of said dump valve means, and means operative with said magnetic member for providing a variable control signal which continuously indicates any one of said plurality of discrete positions at which said actuator means is located for use in the selective operation of said pump means and the selective operation of said dump valve means.

9. A hydraulic actuator as defined in claim **8,** wherein said pump means comprises a pump unit having an inlet in communication with said first chamber and an outlet in communication with said first passageway, and check valve means to prevent the flow of fluid from said expandable chamber into said first chamber.

10. A hydraulic actuator as defined in claim **9,** wherein said pump means further comprises an electric motor for driving said pump unit, whereby the energization of said motor is effected by said variable control signal.

11. A hydraulic actuator as defined in claim **9,** wherein said pump unit comprises three plates stacked together in side-by-side abutting relation to define a pump housing, the middle of said plate including a central cloverleaf-recess having two pairs of opposing arcuate portions, a pair of pump gears in intermeshing relation rotatably mounted between the two end plates and nested within one of said pairs of opposing arcuate portions, and a pair of openings formed through one of said end plates in alignment with said other pairs of opposing arcuate portions to define a pump inlet and outlet.

12. A hydraulic actuator as defined in claim **8** wherein said means comprises a transformer coil having an axial opening disposed in the path of said actuator means and having a cross sectional area larger than the cross section of said actuator means to accommodate the movement of said actuator means relative to said transformer coil.

13. A hydraulic actuator as defined in claim **12,** wherein said magnetic permeable length portion includes a tapered segment.

14. A hydraulic actuator as defined in claim **8,** wherein said dump valve means comprises a core member having an axial opening disposed in said first chamber, a valve fitting mounted in said second passageway, a plunger slidably mounted inwardly of the other end of said axial opening, a ball valve disposed in said axial opening between said fitting and said plunger, an armature member carried on said plunger outwardly of said axial opening, and a field coil disposed about said core member and producing sufficient magnetic force when energized to attract said armature causing said plunger to move against said ball valve with sufficient force to close the port in said valve fitting.

15. A hydraulic actuator comprising an enclosed housing having a dividing wall separating the interior of said housing into first and second chambers, an elongated actuator means including a magnetic permeable length portion extending in said second chamber and slidingly supported through an opening in said housing for selective positioning at a plurality of discrete positions, a piston supported transversely of said actuator means and in slidable sealing engagement with the walls of said second chamber to thereby define an expandable chamber with said dividing wall, biasing means for urging said piston toward said dividing wall, pump means for introducing fluid under pressure through a passageway formed through said dividing wall into said expandable chamber, s separate dump valve means for selectively opening and closing a bleed passage formed through said dividing wall into said expandable chamber for bleeding the fluid in said expandable chamber when said bleed passage is opened to permit said actuator means and said piston to retract under the force of said biasing means and to maintain said actuator means at any one of said plurality of discrete positions when said bleed passage is closed, and means operatively connected with said pump means and said dump valve means including a transformer in said second chamber for providing a variable control signal which continuously indicates any one of said plurality of discrete positions at which said actuator means is located in response to sliding movement of said magnetic member, both said pump means and said dump valve means when energized effecting movement of said actuator means to at least one of said plurality of discrete desired positions as well as effecting movement of said magnetic member toward said transformer to provide a correspondingly different value control signal for use in repositioning said actuator means, said actuator means being maintained at a desired one of said plurality of discrete positions when said pump means is deenergized and said dump valve means is energized, subsequent deenergization of said dump valve means opening said bleed passage to effect movement of said actuator means and said magnetic member by said biasing means toward another of said plurality of discrete positions and the output of a correspondingly different signal by said transformer with such movement.

16. A hydraulic actuator comprising a housing having at least a first chamber, an expandable chamber, and a

biased actuator means extending in said first chamber for selective positioning at a plurality of discrete positions, pump means for introducing fluid under pressure into said expandable chamber to enable movement of said actuator means in a first direction including first input means for providing energizing power to said pump means, a separate dump valve means for selectively enabling fluid to be bled from said expandable chamber to permit movement of said biased actuator means in an opposite direction, and alternatively for selectively preventing bleeding of the fluid from said expandable chamber to maintain said biased actuator means at any one of said plurality of discrete positions including second input means for providing energizing power to said dump valve means, said biased actuator means being movable in said first direction towards a different one of said plurality of discrete positions in response to simultaneous energization of said pump means and said dump valve means, said actuator means being held at said different position with deenergization of said pump means, and means for providing a variable control signal which continuously indicates any one of said plurality of discrete positions at which said biased actuator means is located in response to movement of said biased actuator means in either of said first or opposite directions.

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