May 14, 1968 J. F. BERNINGER ETAL 3,382,770

MECHANISM FOR CONTROLLING A FLUID MOTOR

Filed Oct. 1, 1964 2 Sheets-Sheet 1

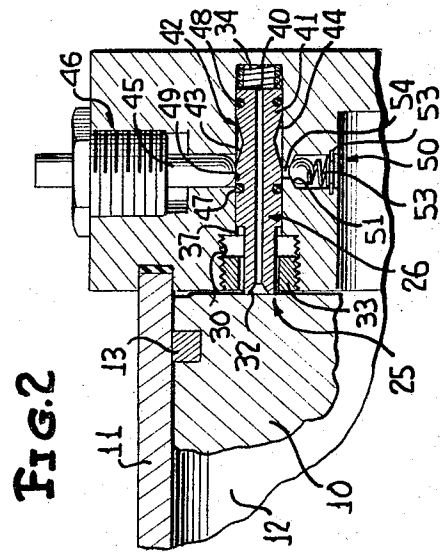


FIG. 2

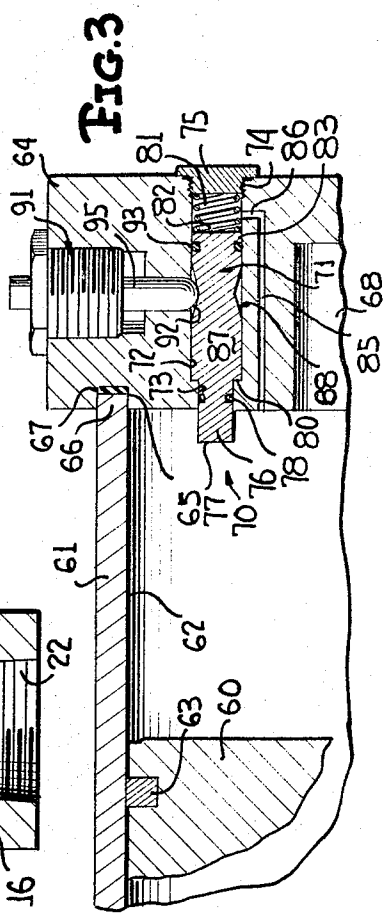


FIG. 3

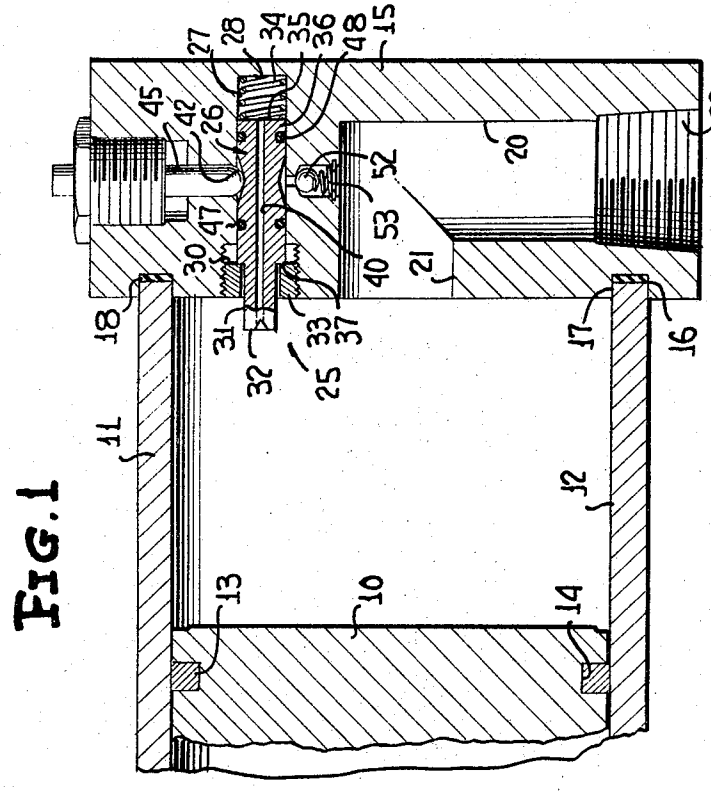


FIG. 1

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FIG. 4

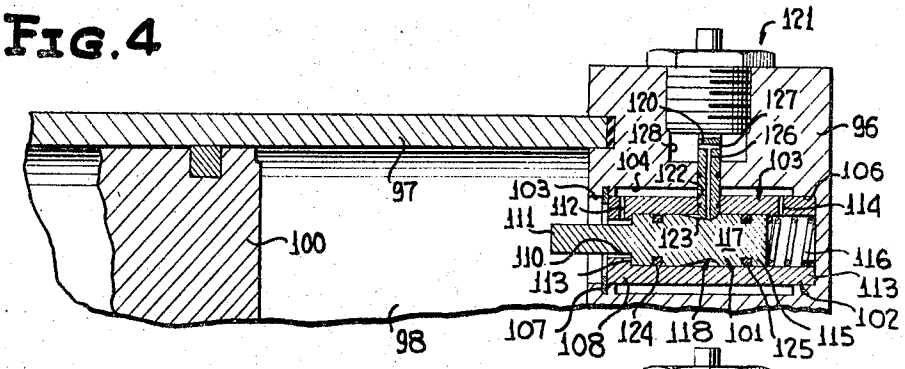
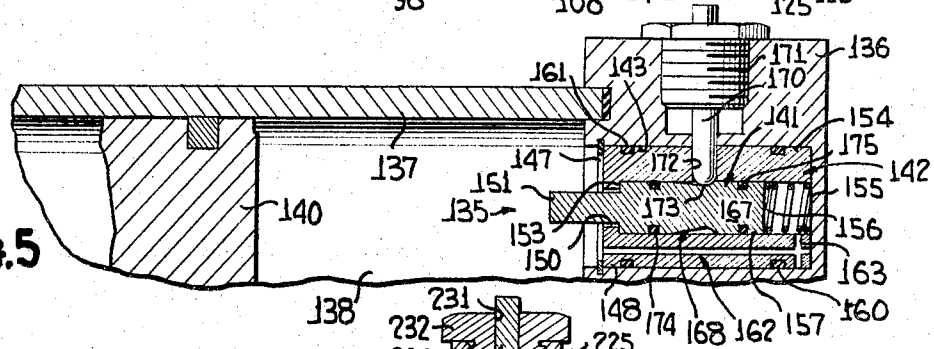


FIG. 5



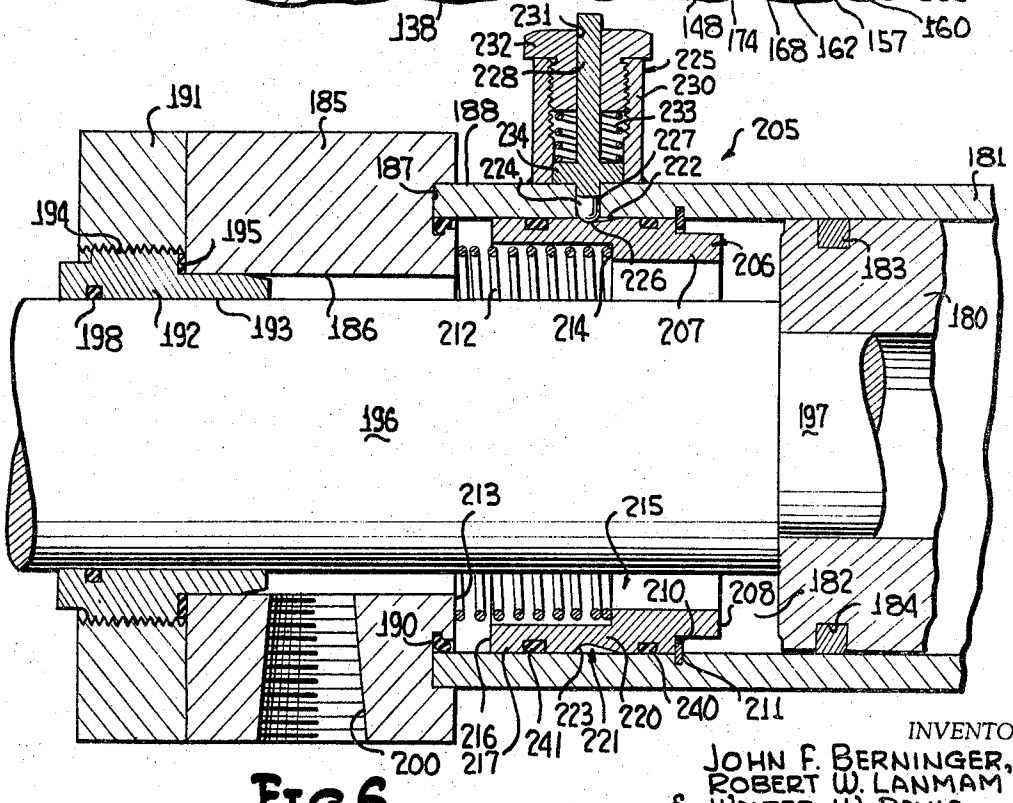


FIG. 6

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MECHANISM FOR CONTROLLING A FLUID MOTOR

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26 Claims. (Cl. 91—275)

This invention relates to a novel mechanism for controlling a fluid motor, and in particular, to a novel mechanism which includes a pressure balanced plunger installed at each end of a cylinder and cooperative with an associated movable switching arm whereby movement of a piston in the cylinder alternately contacts and moves the plungers to sequentially and alternately actuate the switching arms to automatically reverse the direction of movement of the piston.

One of the many problems of conventional mechanisms for reversing the direction of travel of a piston in a cylinder is the inability to obtain substantially uniform reversing action of the piston due to the premature activation of these conventional control mechanisms under the influence of fluid pressure in the piston chamber. In such conventional mechanisms a movable element is generally positioned adjacent each end portion of the cylinder and is exposed to the interior of the cylinder chamber for actuation by the moving piston. However, as the piston approaches the movable element the fluid pressure build-up in the chamber portion to which the movable element is exposed tends to move the element prior to actual contact between the piston and the element. This premature movement of the element correspondingly causes premature actuation of the switching arm associated therewith and a resultant inefficient reversal of the piston.

Such conventional mechanisms also generally fail to provide a means for isolating the switching arms thereof from the fluid pressure in the chamber, and premature actuation of the switching arms under the influence of the chamber pressure often result even though the movable elements associated therewith are not prematurely actuated by fluid pressure build-up in the chamber of the cylinder.

Accordingly, it is an object of this invention to provide a novel mechanism for reversing the direction of travel of a piston, the mechanism being constructed of a minimum number of component parts and including a plunger actuated by a piston, and means for placing both end portions of the plunger in fluid communication with a chamber in which the piston is movable whereby force balancing or slight unbalancing of the plunger is effected to prevent premature movement of the plunger under the influence of chamber pressure.

A further object of this invention is to provide a novel mechanism of the type just described including a switch arm operable by the movement of the plunger and means for isolating the switch arm from the working pressure in the chamber to prevent premature actuation of the switch arm which might otherwise occur in the absence of such isolating means.

Still another object of this invention is to provide a novel mechanism of the type just described in which the swtich arm includes a cam follower portion contactable by a cam surface portion of the plunger for effecting actuation of the switch arm between first and second positions thereof to provide a substantially uniform reversing action of the piston.

A further object of this invention is to provide a novel mechanism including each of the components set forth above, and further including valve means for venting fluid

which has leaked passed the isolating means to insure efficient operation of the switch arm.

A further object of this invention is to provide a novel mechanism of the type described in which the switch arm includes passage means for venting fluid from an area of contact between the cam and cam follower means to an area remote therefrom whereby substantially uniform reversing action of the piston is achieved by the movement of the switch arm regardless of variations in fluid pressures tending to prematurely actuate the switching arm or increase the movement thereof during a switching operation.

A further object of this invention is to provide a mechanism of the type described in which the pressure balancing of the plunger is effected by an axial passage opening through opposite end portions thereof, or by mounting the plunger in a sleeve and providing suitable passages in the sleeve for placing an end portion of the plunger remote from the cylinder chamber in fluid communication therewith.

A further object of this invention is to provide a novel mechanism of the type which includes a plunger having an axial passage therethrough for pressurizing opposite end portions of the plunger, the passage being of a size sufficient to internally telescopically receive a rod of the piston whereby the mechanism can be mounted in the cylinder at a rod end thereof.

Other objects in the invention will be apparent from the following description and from the drawings in which:

FIGURE 1 is a fragmentary sectional view of the blind end of a cylinder, and illustrates a novel mechanism of this invention mounted in a head of the cylinder, and clearly illustrates an axial passage in a plunger and a switch arm mounted for movement by the plunger.

FIGURE 2 is a fragmentary sectional view similar to FIGURE 1, and illustrates the actuated position of the switch arm upon movement of the plunger under the influence of the piston.

FIGURE 3 is a fragmentary sectional view of the blind end of another cylinder, and illustrates another embodiment of the invention in which a passage in a head of the cylinder introduces working pressure from a chamber of the cylinder adjacent one end portion of the plunger to effect slight unbalancing thereof.

FIGURE 4 is a fragmentary sectional view of another embodiment of this invention, and illustrates a plunger similar to the plunger of FIGURE 3 mounted for reciprocal movement in a sleeve provided with radial passages for pressure balancing the plunger and a vent passage in a switching arm.

FIGURE 5 is a fragmentary sectional view of the blind end of a cylinder and illustrates another mechanism similar to the mechanism illustrated in FIGURE 4, and illustrates a passage in a sleeve placing a remote end portion of a plunger reciprocally mounted in the sleeve in fluid communication with a chamber of the cylinder.

FIGURE 6 is a fragmentary sectional view of the rod end of a cylinder, and illustrates another mechanism constructed in accordance with this invention mounted in a chamber of the cylinder and an enlarged axial passage in the plunger which effects pressure balancing thereof and permits the passage therethrough of a reciprocal piston rod.

Referring to FIGURES 1 and 2 of the drawings, a piston **10** of a double acting cylinder **11** is mounted for reciprocal movement in a chamber or bore **12** in a conventional manner. A seal **13** mounted in a circumferential groove **14** of the piston **10** maintains a fluid-tight seal between the piston **10** and the interior surface (unnumbered) of the cylinder **11**.

FIGURE 1 illustrates the blind end of the cylinder **11** which is closed by a head **15**. The head **15** is pro-

vided with an annular groove 16 opening outwardly toward and receiving an end portion 17 of the cylinder 11. A seal 18 effects a fluid-tight connection between the cylinder 11 and the head 15.

An inlet port 20 includes a portion 21 opening axially into the chamber 12 of the cylinder 11. An internally threaded portion 22 of the port 20 is provided for coupling engagement with an externally threaded coupling of a fluid conduit (not shown) which is in turn connected to a conventional source of pressurized fluid (also not shown). At such time as fluid is introduced into the chamber 12 through the inlet port 20 and the portion 21, the piston 10 is urged from right-to-left as viewed in FIGURE 1 of the drawings in a well known manner. The rod end (not shown) of the cylinder 11 is provided with conventional port means (not shown) for similarly urging the piston 10 from left-to-right toward the head 15.

A mechanism for controlling the introduction of pressurized working fluid sequentially into the rod end and head end of the cylinder 11 and thus control the reciprocation of the piston 10 is generally referred to by the reference numeral 25 in FIGURES 1 and 2. The mechanism 25 comprises an elongated generally cylindrical plunger or spool 26 reciprocally and slidably mounted in housing means 27 of the head 15. The housing means 27 is preferably a relieved portion or bore 27 having a closed end 28 and a threaded counterbored end 30 opening into the chamber 12. The axes of the bore 27 and the plunger 26 are concentric to each other and generally parallel to and radially offset from the axis of the cylinder 11 and the piston 10, as is clearly illustrated in FIGURE 1 of the drawings.

The plunger 26 includes a reduced first end portion 31 having an end face 32 which is diametrically relieved by a V-shaped notch (unnumbered). The first end portion 31 of the plunger 26 is slidably received in a bore (unnumbered) of an externally threaded adjusting collar 33 threaded into the counterbore 30 of the head 15. The end portion 31 is not in sealing engagement with the surface defining the bore (unnumbered) of the adjusting collar 33, and fluid pressure in the chamber 12 is permitted to act against an annular shoulder 37 for a purpose to be described more fully hereafter. Spring means 34 in the form of a compression spring is housed between the closed end 28 of the bore 27 and an end face 35 of a second end portion 36 of the plunger 26 to bias the annular shoulder or face 37 of the first end portion 31 against the adjusting collar 33. The biasing force exerted by the spring 34 upon the plunger 26 can be increased or decreased by suitably manipulating the adjusting collar 33.

Passage means 40 in the form of an axial passage or passageway in the plunger 26 places the portion of the bore 27 adjacent the second end portion 36 of the plunger 26 in fluid communication with the chamber 12 of the cylinder 11. The fluid pressure acting against the end face 35 of the plunger 26 is substantially equal to the fluid pressure acting against the end face 32 and the annular shoulder 37 of the first end portion to at all times maintain the plunger 26 pressure-balanced axially regardless of the pressure in the chamber 12. Because of this pressure balancing, the spring 34 maintains the plunger 26 in the position illustrated in FIGURE 1 and premature movement of the plunger 26 under the influence of the fluid pressure in the chamber 12 is precluded.

A central portion 41 of the plunger 26 is provided with cam means 42 in the form of a circumferential groove having conically slanted or radially outwardly diverging surfaces 43 and 44. A switching arm or member 45 of a switch 46 has a rounded end portion 49 defining a cam follower surface cooperating with the cam means 42 of the plunger 26. The switch arm 45 is normally biased to a first lowermost position (FIGURE 1) at which the surface 49 is received in the cam means or groove 42 of the plunger 26. The downward biasing of the arm 45 is effected by constructing the switch 46 identical to the switch shown in FIGURE 6 of the drawings, and reference is made to the description of this figure for a complete understanding of the switch 46.

As the piston 10 moves from left-to-right from the position illustrated in FIGURE 1 toward the position shown in FIGURE 2, the end face 32 of the plunger 26 is contacted by the piston 10, and upon continued movement the plunger 26 is urged to the position shown in FIGURE 2 against the biasing force of the compression spring 34. During this movement, the cam surface 43 of the groove 42 urges the rounded end portion 49 of the switching arm 45 upwardly to a second position. In this position the switch arm 45 actuates a solenoid valve (not shown) or other conventional control means in the conduit (not shown) connected to the inlet port 20 to introduce fluid under pressure into the interior of the chamber 12 for driving the piston 10 from the position shown in FIGURE 2 toward the rod end (not shown) of the cylinder 11. A mechanism corresponding to the mechanism 25 can be similarly mounted at the rod end of the cylinder 11 for actuation by the piston 10 to introduce working fluid into the rod end portion of the chamber 12 to again drive the piston 10 toward the blind end of the cylinder 11. In this manner continuous sequential reversing of the piston 10 is effected without premature operation of either the plunger 26 or the switch arm 45.

The switch arm 45 is preferably isolated from the fluid pressure in the chamber 12 by isolating means in the form of a pair of axially spaced O-ring seals 47, 48 received in grooves (unnumbered) of the plunger 26 at opposite sides of the groove 42 and the switch arm 45. The isolating means or O-rings 47, 48 prevent actuation of the switch arm 45 which might otherwise occur in the absence of these O-rings. The isolating means 47, 48 also prevent fluid pressure from leaking beyond either of the plunger end portions 31, 36 toward the central portion 41 in the area of the circumferential groove 42 to prevent axial unbalancing of the plunger 26.

Over periods of prolonged operation of the mechanism 25, fluid may leak past either or both of the O-rings 47, 48, and means 50 is provided to vent such fluid into the inlet port 20. The means 50 comprises a bore (unnumbered) in the head 15 defining a valve seat 51 upon which is normally seated a ball 52 under the influence of a compression spring 53 to normally close off fluid communication between the groove 42 and the inlet port 20 through a port 54. A conventional retainer 55 secures the ball 52 and spring 53 in the bore (unnumbered) of the head 15 in a conventional manner.

At such time as the pressure of the leakage fluid in the groove 42 exceeds the biasing pressure of the spring 53, the ball 52 will unseat and the leakage fluid will vent into the inlet port 20.

Referring to FIGURE 3 of the drawings, a piston 60 of a double acting cylinder 61 is mounted for reciprocal movement in a chamber or bore 62 and a seal 63 carried by the piston 60 maintains a fluid-tight seal between the piston 60 and the interior surface (unnumbered) of the cylinder 61.

The end portion of the cylinder 61 of FIGURE 3 is closed by a head 64 which is provided with an annular groove 65 opening outwardly toward and receiving an end portion 66 of the cylinder 61. A seal 67, corresponding to the seal 18 of FIGURE 1, provides a fluid-tight connection between the cylinder 61 and the head 64.

An inlet port 68, corresponding to the inlet port 20 of FIGURE 1, opens axially into the chamber 62 of the cylinder 61. The inlet port 68 is preferably placed in fluid communication with a conventional source of pressurized fluid (not shown) in the manner heretofore described with reference to the embodiment of the invention illustrated in FIGURE 1.

A mechanism for controlling the introduction of pressurized working fluid sequentially into the rod and head ends of the cylinder **61** and thereby controlling the reciprocation of the piston **60** is generally referred to by the reference numeral **70**. The mechanism **70** comprises an elongated generally cylindrical plunger or spool **71** reciprocally and slidably mounted in housing means **72** of the head **64**. The housing means **72** is preferably a relieved portion or bore having a reduced bore portion **73** opening into the chamber **62** of the cylinder **61** and an opposite internally threaded portion **74** closed by an externally threaded plug **75**. A conventional washer or similar sealing means (unnumbered) effects a fluid-tight connection between the plug **75** and the head **64**. The axes of the bore **72** and the plunger **71** are concentric to each other and generally parallel to and radially offset from the axis of the cylinder **61** and the piston **60**.

The plunger **71** is completely solid and includes a reduced first end portion **76** having an end face **77**. The first end portion **76** of the plunger **71** is slidably received in the reduced bore portion **73** of the head **64**. The first end portion **76** includes an outwardly opening circumferential groove (unnumbered) in which is housed a seal **78** for preventing fluid pressure in the chamber **62** from acting against an annular shoulder **80**, for a purpose to be described more fully hereafter. Spring means **81** in the form of a compression spring is housed between the plug **75** and an end face **82** of a second end portion **83** of the plunger **71** to bias the annular shoulder or face **80** of the first end portion **76** against an opposing surface (unnumbered) between the reduced bore portion **73** and the bore **72**.

A passage **85** in the head **64** places the portion of the bore **72** between the plug **75** and the end face **82** of the plunger **71** in fluid communication with the chamber **62** of the cylinder **61**. The passage **85** may be slanted or parallel to the axes of the plunger **71** and the bore **72**, and may include a short radial passage portion **86**. The force caused by fluid pressure acting against the end face **82** of the plunger **71** is at all times slightly greater than the force caused by pressure acting against the lesser area of the end face **77**, noting that pressure is prevented from acting against the annular shoulder **80** by the seal **78**, and the plunger **71** is thus slightly unbalanced axially in a direction toward the piston **60** regardless of the pressure in the chamber **62**. This slight unbalancing of the plunger **71** augments the biasing force of the spring **81** to maintain the plunger **71** in the position illustrated in FIGURE 1 and premature movement of the plunger **71** under the influence of the fluid pressure in the chamber **62** is precluded.

A central portion **87** of the plunger **71** is provided with cam means **88** corresponding identically to the cam means **42** of the mechanism **25**. A switching arm or member **90** of a switch **91** has a rounded end portion or surface **92** defining a cam follower cooperating with the cam means **88** of the plunger **71** in a manner identical to that heretofore described with respect to the mechanism **25** of FIGURES 1 and 2.

The switch arm **90** is isolated from the fluid pressure in the chamber **62** by isolating means comprising the seal **78** carried by the first end portion **76** of the plunger **71** and a seal **93** carried by an outwardly opening circumferential groove (unnumbered) in the second end portion **83** of the plunger **71**. The seals **78** and **93** are at opposite sides of the cam means **88** and the switch arm **90**, and both prevent premature actuation of the switch arm **90** which might otherwise occur in the absence of these seals, and prevent fluid pressure from leaking beyond either of the plunger end portions **76**, **83** toward the central portion **87** to either balance the plunger **71** or increase the slight unbalance thereof toward the piston **60**.

The operation of the mechanism **70** and a corresponding mechanism (not shown) installed at the rod end of the cylinder **61** to control the reciprocation of the piston **60** is similar to the operation of the mechanism **25** except that a slightly greater force must be applied by the piston **60** against the end portion **76** of the plunger **71** to move the same from left-to-right in FIGURE 3 because of the unbalancing of the plunger **71** heretofore noted. The plunger **71** is correspondingly more quickly returned to the position illustrated in FIGURE 3 upon the retraction of the piston **60** because of the pressure differential acting against the end faces **77**, **82**.

Another mechanism constructed in accordance with this invention for controlling the operation of a double acting cylinder or a similar fluid motor is illustrated in FIGURE 4 of the drawings and is generally designated by the reference numeral **95**. The mechanism **95** is installed in a head **96** of a cylinder **97** defining a chamber **98** in which is conventionally housed a reciprocal piston **100**. The construction of each of the components **96–98** and **100** is generally identical to the corresponding components illustrated in FIGURE 1 of the drawings.

The mechanism **95** is a cartridge-type structure which comprises an elongated generally cylindrical plunger or spool **101** reciprocally and slidably mounted in a housing means or sleeve **102** which is in turn mounted in a relieved portion or bore **103** in the head **96**. The bore **103** includes an enlarged central bore portion **104** which defines an annular passage or gap with the exterior surface (unnumbered) of the sleeve **102**. Opposite bore portions **105**, **106** are reduced slightly in comparison to the enlarged central bore portion **104** and form seats for the sleeve **102**. An annular washer **107** received in a circumferential groove opening outwardly through the bore portion **105** retains the sleeve **102** in the bore **103** in a manner clearly illustrated in FIGURE 4.

The sleeve **102** includes a first end portion **108** having a radially inwardly directed flange (unnumbered) defining a passage or bore **110** through which projects a first end portion **111** of the plunger **101**. An annular gap or space (unnumbered) is defined between the exterior surface of the plunger first end portion **111** and the bore **110** of the sleeve **102**. This gap is placed in fluid communication with the annular space between the exterior of the sleeve **102** and the central bore portion **104** by a generally radial first passage **112** is the first end portion **108** of the sleeve **102**. The gap between the bore **110** and the first end portion **111** of the plunger **101** also permits fluid pressure in the chamber **98** to act against an annular shoulder or face **113** of the plunger **101**.

A second end portion **113** of the sleeve **102** is provided with a generally radial second passage **114** which places the interior of the sleeve **102** adjacent a second end portion **115** of the plunger **101** in fluid communication with the annular gap or passage between the exterior surface of the sleeve **102** and the surface defining the central bore portion **104** of the bore **103**. A spring **116** housed in the second end portion **113** of the sleeve **102** urges the plunger **101** to the position illustrated in FIGURE 4 of the drawings.

A central portion **117** of the plunger **101** is provided with cam means **118** in the form of a circumferential groove. A switching arm or member **120** of a switch **121** threadably mounted in the head **96** projects through a radial opening or bore **122** in the sleeve **102**, and includes a rounded end portion **123** defining a cam follower surface contacting the cam means **118** of the plunger **101**. The switch arm **120** is normally biased to the position illustrated in FIGURE 4 by a spring (not shown) corresponding to the spring **233** of FIGURE 6.

As the piston **100** moves from left-to-right from the position illustrated in FIGURE 4, an end face (unnumbered) of the plunger first end portion **111** is contacted by the piston **100** and the plunger **101** is urged to the right as viewed in this figure against the biasing force of the spring **115**. This movement reciprocates the switch arm **120** upwardly to actuate a solenoid valve or other

conventional control means (not shown) to introduce fluid under pressure from a conventional fluid pressure source (also not shown) into the interior of the chamber 98 for driving the piston 100 to the left as viewed in FIGURE 4. During the movement of the piston 100 toward the plunger 101 premature movement of the plunger 101 is precluded by the pressure-balanced condition of the plunger 101. This pressure balancing is achieved by the introduction of the chamber pressure into the interior of the sleeve 102 adjacent the second end portion 115 of the plunger 101 over a fluid path defined by the bore 105, the opening in the annular washer 107, the annular gap 110, the first radial passage 112, the annular passage between the central bore portion 104 and the exterior of the sleeve 102 and the second radial passage 114. The fluid pressure acting against the end face (unnumbered) of the plunger second end portion 115 is substantially equal to the pressure acting against the end face (also unnumbered) of the first end portion 111 and the annular shoulder 113 of the plunger 101 to at all times maintain the plunger 101 in a state of force or pressure balance axially regardless of the pressure in the chamber 98.

The switch arm 120 of the switch 121 is preferably isolated from the fluid pressure in the chamber 98 by isolating means in the form of a pair of axially spaced O-ring seals 124, 125 received in grooves (unnumbered) of the plunger 101 at opposite sides of the cam means 118. The isolating means or O-rings 124, 125 prevent actuation of the switch arm 120 in the manner heretofore described.

During periods of prolonged operation of the mechanism 95, working fluid from the chamber 98 may leak past either the O-rings 124, 125 or between the radial opening 122 and the switch arm 120 toward the central portion 117 of the plunger 101 in the area of the cam means 118. In order to vent this fluid, the switch arm 120 is provided with an axial passage 126 and a cross-bore 127 opening into a bore 128 housing a portion of the switch 121. The bore 128 is open to atmosphere and any fluid under pressure in the area of contact between the cam means 118 and the rounded end portion 123 of the arm 120 is freely vented through the passage 126 and the cross-bore 127 into the bore 128.

Another mechanism constructed in accordance with this invention for controlling the reciprocal movements of a piston is illustrated in FIGURE 5 of the drawings and is generally designated by the reference numeral 135. The mechanism 135 is installed in a head 136 of a cylinder 137 defining a chamber 138 in which is conventionally housed a reciprocal piston 140.

The mechanism 135 is similar to the cartridge-type mechanism 95 of FIGURE 4 and comprises a generally elongated cylindrical plunger or spool 141 reciprocally and slidably mounted in a housing means or sleeve 142 which is in turn mounted in a relieved portion or bore 143 in the head 136. An annular washer 147 received in a circumferential groove (unnumbered) retains the sleeve 142 in the bore 143 in the manner clearly illustrated in FIGURE 5.

The sleeve 142 includes a first end portion 148 having a radially inwardly directed flange (unnumbered) defining a passage or bore 150 through which projects a first end portion 151 of the plunger 141. An annular gap or space is defined between the exterior surface of the plunger first end portion 151 and the bore 150 of the sleeve 142 for permitting fluid pressure in the chamber 138 of the cylinder 137 to act against an annular shoulder or face 153 of the plunger 141.

A second end portion 154 of the sleeve 142 houses a compression spring 155 which bears against an end face 156 of a second end portion 157 of the plunger 141 to urge the same to the position illustrated in FIGURE 5. Suitable O-ring seals 160 and 161 received in circumferential grooves (unnumbered) of the sleeve 142 seals the same in the bore 143 of the head 136. The interior of the chamber 138 is placed in fluid communication with the interior of the second end portion 154 of the sleeve 143 by a passage 162 extending generally longitudinally of the sleeve 142 and terminating at a cross-bore 163. The passage 162 and the cross-bore 163 thus introduce chamber pressure into the interior of the sleeve second end portion 154 to effect axial pressure balancing of the plunger 141 in the manner heretofore described.

A central portion 167 of the plunger 141 is provided with cam means 168 in the form of a circumferential groove. A switching arm 176 of a switch 171 threadedly mounted in the head 136 projects through a radial opening or bore 172 in the sleeve 142, and includes a rounded end portion 173 defining a cam follower surface contacting the cam means 168 of the plunger 141. The switch arm 170 is normally biased to the position illustrated in FIGURE 4 by a spring (not shown).

The mechanism 135 also includes axially spaced O-ring seals 174, 175 received in circumferential grooves (unnumbered) in the plunger 141 at opposite sides of the cam means 168 and the switch arm 170 for isolating the area of contact between the cam means 168 and the switch arm end portion 173 from fluid pressure in the chamber 138.

The operation of the mechanism 135 is substantially identical to the operation of the mechanism 95 in FIGURE 4, and a complete description thereof is deemed unnecessary for an understanding of this invention.

Referring to FIGURE 6 of the drawings, a piston 180 of a double acting cylinder 181 is mounted for reciprocal movement in a chamber or bore 182 in a conventional manner. A seal 183 mounted in a circumferential groove 184 of the piston 180 maintains a fluid-tight seal between the piston 180 and the interior surface (unnumbered) of the cylinder 181.

FIGURE 6 illustrates the rod end of the cylinder 181 which is partially closed by a head 185 having an axial bore or passage 186. The head 185 is provided with an annular groove 187 opening outwardly toward and receiving an end portion 188 of the cylinder 181. A seal 190 provides a fluid-tight connection between the cylinder 181 and the head 185.

A plate 191 is secured to the head 185 by conventional fasteners (not shown). A sleeve 192 having a generally axial bore or passage 193 is threadably secured in a threaded bore 194 of the plate 191. A generally annular seal 195 forms a fluid-tight connection between the head 185 and the sleeve 192. A piston rod 196 having a reduced end portion 197 conventionally secured to the piston or piston head 180 is slidably received in the passage 193 of the sleeve 192. A seal 198 housed in a groove (unnumbered) of the sleeve 192 forms a fluid-tight connection between the sleeve 192 and the piston rod 196.

The piston 180 is reciprocated to the right as viewed in FIGURE 6 of the drawings by introducing pressurized working fluid into the chamber 182 through an inlet port 200 in the head 185. The inlet port 200 is internally threaded for coupling engagement with an externally threaded coupling of a fluid conduit (not shown) which is in turn connected to a conventional source of pressurized fluid (also not shown). The blind end (not shown) of the cylinder 181 is provided with a conventional inlet port, such as the inlet port 20 of FIGURE 1 for similarly urging the piston 180 from right-to-left toward the head 185.

A mechanism for controlling the introduction of working fluid sequentially into the rod end of the cylinder 181 and thus controlling the reciprocation of the piston 180 is generally referred to by the reference numeral 205. The mechanism 205 comprises an elongated generally cylindrical plunger or spool 206 reciprocally and slidably housed in the chamber 182 of the cylinder 181 adjacent the head 185.

The plunger 206 includes a reduced first end portion 207 having an end face 208 and an annular shoulder or face 210. An annular washer or retainer 211 carried by a groove (unnumbered) in the cylinder 181 normally abuts the annular shoulder 210 of the plunger 207 in the position illustrated in FIGURE 6 to limit the movement of the plunger 206 in a direction toward the piston 180. A slight annular gap or space (unnumbered) between the exterior surface of the first end portion 207 of the plunger 206 and the annular retainer 211 permits fluid pressure in the chamber 182 to act against the annular shoulder 210 in a manner and for a purpose to be described more fully hereafter.

Spring means 212 in the form of a compression spring is seated between a face 213 of the head 185 and an annular shoulder or surface 214 of a relatively large axial bore or passage 215 of the plunger 206. The spring 212 biases the plunger 206 to the position illustrated in FIGURE 6 with the annular shoulder 210 in abutment with the annular retainer 211.

The bore or passage 215 places the portion of the fluid chamber 182 to the right of the plunger 206 in fluid communication with both the annular shoulder 214 and an end face 216 of a second end portion 217 of the plunger 206. As the piston 180 is moved from right-to-left toward the position illustrated in FIGURE 6, the fluid pressure in the portion of the chamber 182 to the left of the piston 180 acting against the end face 208 and the annular shoulder 210 is substantially equal to the fluid pressure communicated through the bore 215 and acting against the end face 216 and the annular shoulder 214 of the second end portion 217. The force of the pressure fluid acting on these shoulders and faces maintain the plunger 206 pressure balanced axially regardless of the pressure in the chamber 182 to the left of the piston 180. Because of this pressure balancing, the spring 212 maintains the plunger 206 in the position illustrated in FIGURE 6, and premature movement of the plunger 206 to the left under the influence of the fluid pressure building up in the chamber 182 to the left of the piston 180 as the same moves toward the plunger 206 is precluded.

A central portion 220 of the plunger 206 is provided with cam means 221 in the form of a circumferential groove having a gradually sloping surface portion 222 and a relatively abruptly curved surface portion 223. A switching arm or member 224 of a switch 225 has a rounded stem or end portion 226 defining a cam follower surface cooperating with the cam means 221 of the plunger 206. The lower end portion of the arm 224 is mounted for reciprocal movement in a radial bore or opening 227 in the cylinder 181. A main body portion 228 of the switch arm 224 is housed in a sleeve 230 welded to the exterior of the cylinder 181. The main body portion 228 is slidably received in and projects outwardly of a bore 231 in a plug 232 threadably secured to the sleeve 230. A spring 233 encompasses the main body portion 228 of the switch arm 224 between the plug 232 and a peripheral flange 234 to normally urge the cam follower surface 226 into contact with the cam means 221 of the plunger 206.

As the piston 180 moves from right-to-left from the blind end of the cylinder 181 toward and beyond the position thereof illustrated in FIGURE 6, the end face 208 of the plunger 206 is contacted by the piston 180 and the plunger 206 is urged toward the head 185 against the biasing force of the compression spring 212. During this movement, the gradually sloping cam surface 222 of the cam means 221 urges the cam follower surface 226 of the switching arm 224 upwardly. This upward movement of the switch arm 224 is effected against the biasing force of the compression spring 233 of the switch 225. In the uppermost position of the switch arm 224, a solenoid valve (not shown) or other conventional control means in the conduit (not shown) connected to the inlet port 200 is actuated by a conventional connection between the exposed end portion of the switch arm 224 and the solenoid valve to introduce fluid under pressure into the interior of the chamber 182 for driving the piston toward the blind end of the cylinder 181. A mechanism corresponding to any one of the mechanisms shown in FIGURES 1 through 5 of the drawings is mounted at the blind end of the cylinder 181 for actuation by the piston 180 to introduce working fluid into the blind end of the chamber 182 to again drive the piston 180 and the rod 196 secured thereto toward the rod end of the cylinder 181. In this manner continuous sequential reversing of the piston 180 is effected without premature operation of either the plunger 206 or the switch arm 224.

The area of contact between the cam means 221 and the cam follower portion 226 of the switch arm 224 is isolated from the fluid pressure in the chamber 182 by isolating means in the form of a pair of axially spaced O-ring seals 240, 241 received in grooves (unnumbered) of the plunger 206 at opposite sides of the switch arm 224 and the cam means or groove 221. The isolating means or O-rings 240, 241 prevent actuation of the switch arm 224 in the manner heretofore described and also prevent fluid pressure from leaking beyond either of the plunger end portions 207, 217 toward the central portion 220 to prevent axial unbalancing of the plunger 206.

From the foregoing, it will be seen that novel and advantageous provisions have been made by carrying out the desired end. However, attention is again directed to the fact that additional variations may be made in this invention without departing from the spirit and scope thereof as defined in the appended claims.

We claim:

1. A mechanism for controlling a fluid motor comprising a cylinder, a piston mounted for movement in a bore of said cylinder, a plunger mounted for movement by and relative to said piston, a member mounted for movement by said plunger at an angle relative thereto, means for placing opposite end portions of said plunger in fluid communication with said bore whereby fluid pressure in said bore acts upon the opposite end portions of said plunger, and means for at all times isolating said member from the fluid pressure in said bore.

2. A mechanism for controlling a fluid motor comprising a cylinder, a piston mounted for movement in a bore defined by said cylinder, a plunger mounted for reciprocal movement between a first position spaced from said piston and a second position in contact with said piston, a member mounted for movement by said plunger at an angle relative thereto, said plunger having an outer peripheral portion, means operatively connecting the peripheral portion and the member to effect movement of the member upon movement of the plunger between said first and second positions, means for placing opposite end portions of said plunger in fluid communication with said bore whereby fluid pressure in said bore acts upon the opposite end portions of said plunger, and means at all times isolating said connecting means and said member from the fluid pressure in said bore.

3. A mechanism for controlling a fluid motor comprising a cylinder, a piston mounted for movement in a first bore portion defined by said cylinder, said cylinder including a second bore portion opening toward said first bore portion, a plunger mounted for reciprocal movement in said second bore portion between a first position spaced from said piston and a second position in contact with said piston, a member projecting into said second bore and mounted for movement by said plunger, cooperative cam means operable between said first and second positions for moving said member, means for placing opposite end portions of said plunger in fluid communication with said bore whereby fluid pressure in said bore acts upon the opposite end portions of said plunger, and means at all times isolating said cooperative cam means and said member from the fluid pressure in said bore.

4. A mechanism for controlling a fluid motor comprising a cylinder, a piston mounted for movement in a bore defined by said cylinder, a plunger mounted for movement by said piston, a member mounted for movement by said plunger at an angle relative thereto, said member contacting said plunger between axially opposite terminal faces thereof, means for placing opposite end portions of said plunger in fluid communication with said bore whereby fluid pressure in said bore acts upon the opposite end portions of said plunger, and seal means surrounding said plunger at axially opposite sides of the point of contact between the member and the plunger for isolating said member from the fluid pressure in said bore.

5. The mechanism as defined in claim 4 wherein said isolating means includes spaced sealing means carried by said plunger and a portion of said member is in contact with said plunger between said seal means thereby isolating said member from the fluid pressure in said bore and at opposite end portions of the plunger.

6. A mechanism for controlling a fluid motor comprising a cylinder, a piston mounted for movement in a first bore defined by said cylinder, a second bore in said cylinder opening radially into said first bore, a plunger mounted in said first bore for movement by said piston, a member projecting into said first bore through said second bore and mounted for movement by said plunger, said member and plunger including cooperable cam means for moving said member generally radially between first and second positions upon the movement of said piston between first and second positions, means for placing opposite end portions of said plunger in fluid communication with said first bore whereby fluid pressure in said bore acts upon the opposite end portions of said plunger, and means for isolating said member from the fluid pressure in said first bore.

7. A mechanism for controlling a fluid motor comprising a cylinder, a piston mounted for movement in a bore defined by said cylinder, a plunger in said cylinder mounted for movement by said piston, a member mounted for movement by said plunger, said member and plunger including cooperable cam means for moving said member between first and second positions upon the movement of said piston between first and second positions, said cam means including a cam follower forming a portion of said member and a cam surface of said plunger, means for placing opposite end portions of said plunger in fluid communication with said bore whereby fluid pressure in said bore acts upon the opposite end portions of said plunger, and means for isolating said member from the fluid pressure in said bore.

8. A mechanism for controlling a fluid motor comprising a cylinder, a piston mounted for axial reciprocal movement in a bore of said cylinder, a plunger mounted for reciprocal movement in a direction generally parallel to the movement of the piston, means normally urging the plunger to a first position toward but spaced from said piston, a member mounted for movement by said plunger, means for placing opposite end portions of said plunger in fluid communication with said bore whereby fluid pressure in said bore acts upon the opposite end portions of said plunger and said urging means maintains said plunger in the first position thereof irrespective of the fluid pressure in said bore tending to move said plunger to a second position thereof, said means placing opposite end portions of the plunger fluid communication with the bore being a passage in a wall portion partially defining said cylinder.

9. The mechanism as defined in claim 8 wherein said plunger is housed in a sleeve, the first end portion of said plunger projecting outwardly of said sleeve toward said bore, the second end portion of said plunger being located in said sleeve, and said fluid communication means comprising passage means in said sleeve opening into said bore and said sleeve adjacent said plunger second end portion.

10. The mechanism as defined in claim 8 wherein said plunger is housed in a sleeve, the first end portion of said plunger projecting outwardly of said sleeve toward said bore, the second end portion of said plunger being located in said sleeve, and said fluid communication means comprising first passage means passing generally radially through said sleeve adjacent said plunger first end portion, and second passage means passing generally radially through said sleeve adjacent said plunger second end portion.

11. The mechanism as defined in claim 8 including a means for isolating said member from the fluid pressure in said bore.

12. A mechanism for controlling a fluid motor comprising a cylinder, a piston mounted for axial reciprocal movement in a bore of said cylinder, a plunger mounted for reciprocal movement in a direction generally parallel to the movement of the piston, means normally urging the plunger to a first position toward but spaced from said piston, a member mounted for movement by said plunger, means for placing opposite end portions of said plunger in fluid communication with said bore whereby fluid pressure in said bore acts upon the opposite end portions of said plunger and said urging means maintains said plunger in the first position thereof irrespective of the fluid pressure in said bore tending to move said plunger to a second position thereof, means for isolating said member from the fluid pressure in said bore, and said means placing opposite end portions of the plunger in fluid communication with the bore is a passage in the plunger opening outwardly through the plunger end portions.

13. A mechanism for controlling a fluid motor comprising a cylinder, a piston mounted for axial reciprocal movement in a bore of said cylinder, a plunger mounted for reciprocal movement in a direction generally parallel to the movement of the piston, means normally urging the plunger to a first position toward but spaced from said piston, a member mounted for movement by said plunger, means for placing opposite end portions of said plunger in fluid communication with said bore whereby fluid pressure in said bore acts on the opposite end portions of said plunger and said urging means maintains said plunger in the first position thereof irrespective of the fluid pressure in said bore tending to move said plunger to a second position thereof, said means placing opposite end portions of the plunger in fluid communication with the bore in a passage in the plunger opening outward through the plunger end portions, said piston including a piston rod, and said piston rod being received in said passage.

14. A mechanism for controlling a fluid motor comprising a cylinder, a piston mounted for axial reciprocal movement in a bore of said cylinder, a plunger mounted for reciprocal movement in a direction generally parallel to the movement of the piston, said plunger including first and second opposite end portions, spring means adjacent the second end portion for normally urging the first end portion toward said piston, a member mounted for movement by said plunger, cooperative means between the first and second opposite end portions of said plunger and said member for moving said member between first and second positions upon the movement of said plunger between the first position thereof and a second position at which the force of said spring means at axially opposite sides of said cooperative means is increased, means for isolating said cooperative means from the fluid pressure in said bore, and means for placing the opposite end portions of the plunger in fluid communication with said bore.

15. A mechanism for controlling a fluid motor comprising a cylinder, a piston mounted for movement in a bore defined by said cylinder, a plunger mounted for

movement by said piston, a member mounted for movement by said plunger, means for placing opposite end portions of said plunger in fluid communication with said bore whereby fluid pressure in said bore acts upon the opposite end portions of said plunger, means for isolating said member from the fluid pressure in said bore, and valve means for venting fluid which has leaked past said isolating means.

16. A mechanism for controlling a fluid motor comprising a cylinder, a piston mounted for movement in a bore defined by said cylinder, a plunger mounted for movement by said piston, a member mounted for movement by said plunger, means for placing opposite end portions of said plunger in fluid communication with said bore whereby fluid pressure in said bore acts upon the opposite end portions of said plunger, means for isolating said member from the fluid pressure in said bore, said member having an end portion contactable with said plunger, and passage means for venting fluid from an area of contact between said member end portion and said plunger to an area remote therefrom.

17. A mechanism for controlling a fluid motor comprising a cylinder, a piston mounted for axial reciprocal movement in a bore of said cylinder, means housing a plunger for reciprocal movement in a direction generally parallel to the movement of the piston, said plunger including first and second opposite end portions, cam means between said first and second end portions, spring means in said housing means adjacent said second end portion for normally urging the first end portion toward said piston, a member mounted for movement by said plunger, said member including cam follower means cooperable with the cam means of said plunger for moving said member between first and second positions upon the movement of said plunger between the first position thereof and a second position at which the force of said spring means is increased, a passage in said plunger opening through the opposite end portions thereof whereby said plunger is pressure balanced in any position thereof, and sealing means between said plunger and said housing means at opposite sides of said cam and cam follower means thereby isolating the latter means from the fluid pressure in said bore.

18. The mechanism as defined in claim **17** wherein said piston is carried by a piston rod and said rod is telescopically received in said passage.

19. The mechanism as defined in claim **17** wherein said housing means includes a wall portion of said cylinder, a fluid port in said wall portion, and vent means between said fluid port and said sealing means for venting fluid which has leaked past said sealing means to said fluid port.

20. A mechanism for controlling a fluid motor comprising a cylinder, a piston mounted for axial reciprocal movement in a bore of said cylinder, means housing a plunger for reciprocal movement in a direction generally parallel to the movement of the piston, said housing means being a sleeve mounted in a relieved portion of said cylinder, said plunger including first and second opposite end portions, cam means between said first and second end portions, spring means in said housing means adjacent said second end portion for normally urging the first end portion toward said piston, a member mounted for movement by said plunger, said member including cam follower means cooperable with the cam means of said plunger for moving said member between first and second positions upon the movement of said plunger between the first position thereof and a second position at which the force of said spring means is increased, a passage in said sleeve opening through opposite end portions thereof into said bore, and into the interior of said sleeve adjacent said plunger second end portion whereby said plunger is pressure balanced in any position thereof, and sealing means between said plunger and said sleeve at opposite sides of said cam and cam follower means thereby isolating the latter means from the fluid pressure in said bore.

21. A mechanism for controlling a fluid motor comprising a cylinder, a piston mounted for axial reciprocal movement in a bore of said cylinder, a sleeve housing a plunger for reciprocal movement in a direction generally parallel to the movement of the piston, said plunger including first and second opposite end portions, cam means between said first and second end portions, spring means in said housing means adjacent said second end portion for normally urging the first end portion toward said piston, a member mounted for movement by said plunger, said member including cam follower means cooperable with the cam means of said plunger for moving said member between first and second positions upon the movement of said plunger between the first position thereof and a second position at which the force of said spring means is increased, a generally radial passage in said sleeve placing the interior thereof adjacent the plunger first end portion in fluid communication with the exterior of said sleeve, a generally radial passage in said sleeve placing the interior thereof adjacent the plunger second end portion in fluid communication with the exterior of said sleeve, the exterior of said sleeve being spaced from a surface defining said relieved portion whereby said radial passages and the second end portion of said plunger are in fluid communication, and sealing means between said plunger and said sleeve at opposite sides of said cam and cam follower means thereby isolating the latter means from the fluid pressure in said bore.

22. A mechanism for controlling a fluid motor comprising a cylinder, a piston mounted for axial movement in a chamber of said cylinder, a wall closing an end of said cylinder, a bore in said wall opening axially into said chamber through a counterbore, a solid plunger housed in said counterbore for reciprocal movement in a direction generally parallel to the movement of the piston, said plunger including a reduced first end portion projecting through said bore into said chamber, and a second end portion housing in said counterbore, spring means contacting said second end portion to normally maintain said first end portion projecting into said chamber, a first seal between said reduced first end portion and said bore, a second seal between said second end portion and said counterbore, said seals isolating a central portion of said plunger from fluid pressure in said chamber, a member mounted for movement by said plunger, said member and plunger including cooperable cam means for moving said member between first and second portions thereof upon the movement of said plunger under the influence of said piston contacting said first end portion, and a passage in said wall placing the chamber in fluid communication with said counterbore adjacent the second end portion of said plunger whereby the plunger is slightly overbalanced in a direction tending to move toward said piston.

23. A mechanism for controlling a fluid motor comprising a cylinder, a piston mounted for axially reciprocal movement in a bore of said cylinder, a plunger mounted for reciprocal movement in said cylinder in a direction generally parallel to the movement of the piston, said plunger including first and second opposite end portions, cam means between said first and second end portions, a member mounted for movement by said plunger, said member including cam follower means cooperable with the cam means of said plunger for moving said member between first and second positions upon the movement of said plunger, means placing axially opposite end portions of said plunger in fluid communication with said bore, and sealing means at opposite sides of said cam and cam follower means for isolating the latter means from the fluid pressure in said bore.

24. The mechanism as defined in claim **23** wherein said plunger is a solid member and the means for placing the axially opposite end portions of the plunger in fluid com-

munication with said bore is fluid passage means formed in said cylinder.

25. The mechanism as defined in claim 23 including biasing means disposed to one side of a terminal face of the end portion of said plunger remote from said piston, and at least one of said sealing means is disposed generally between said biasing means and said cam and cam follower means.

26. A mechanism for controlling a fluid motor comprising a cylinder, a piston mounted for movement in a bore of said cylinder, a plunger mounted for movement by and relative to said piston, a passage opening outwardly of said cylinder and disposed at an angle to the plunger axis, a member mounted for movement in said passage by said plunger, means for placing opposite end faces of said plunger in fluid communication with said bore whereby fluid pressure in said bore acts upon the opposite end faces of said plunger, and biasing means

to one side of an end face remote from said piston for normally biasing said plunger in a direction toward said piston.

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