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Krehbiel et al.

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[45] **Feb. 5, 1974**

[54] **REMOTE HYDRAULIC CONTROL**

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[21] Appl. No.: **168,002**

[52] **U.S. Cl.** .... **91/358 A**, 91/388, 91/461, 91/414

[51] **Int. Cl.** **F15b 13/16**

[58] **Field of Search** ...... 91/461, 358 A; 137/625.63

[56] **References Cited**

UNITED STATES PATENTS

3,400,634	9/1968	Wirtz	91/358 A
2,974,639	3/1961	O'Connor et al.	91/461
3,129,645	4/1964	Olmsted	91/461
3,220,318	11/1965	McGuire	91/461
3,340,897	9/1967	Nevulis	91/461

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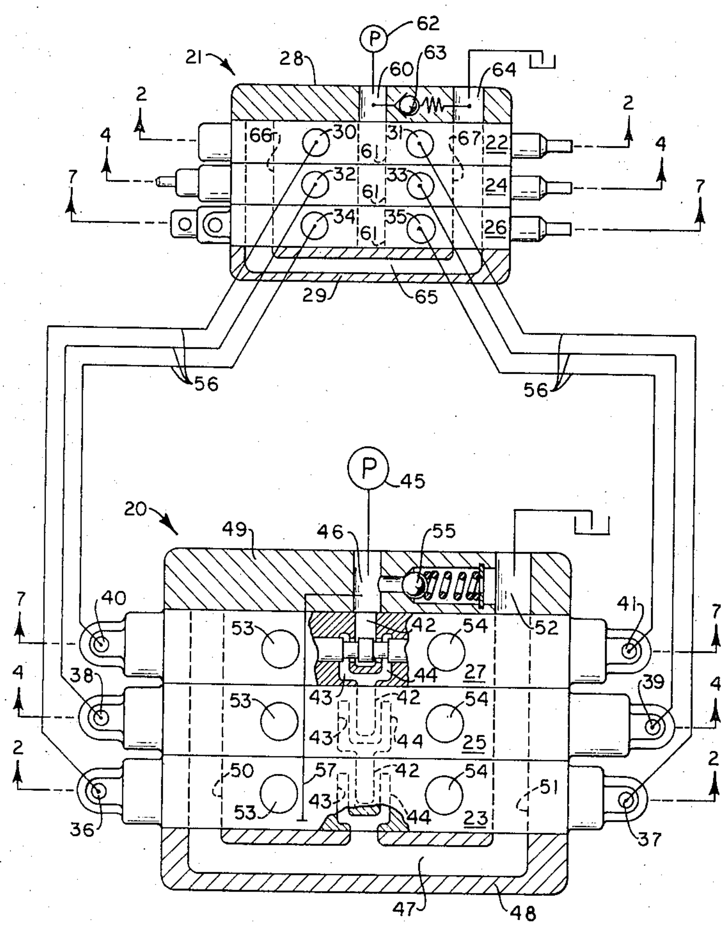
[57] **ABSTRACT**

A closed center remote control system selectively modulating pressure at either end of a reciprocal spool control valve so as to incrementally position the valve spool with such precision to attain spool metering and speed control. The various embodiments include diverse special operating modes such as float and automatic return-to-neutral. The remote system is equally useful in conventional closed center and open center spool valves essentially identical to manually operated valves.

13 Claims, 8 Drawing Figures



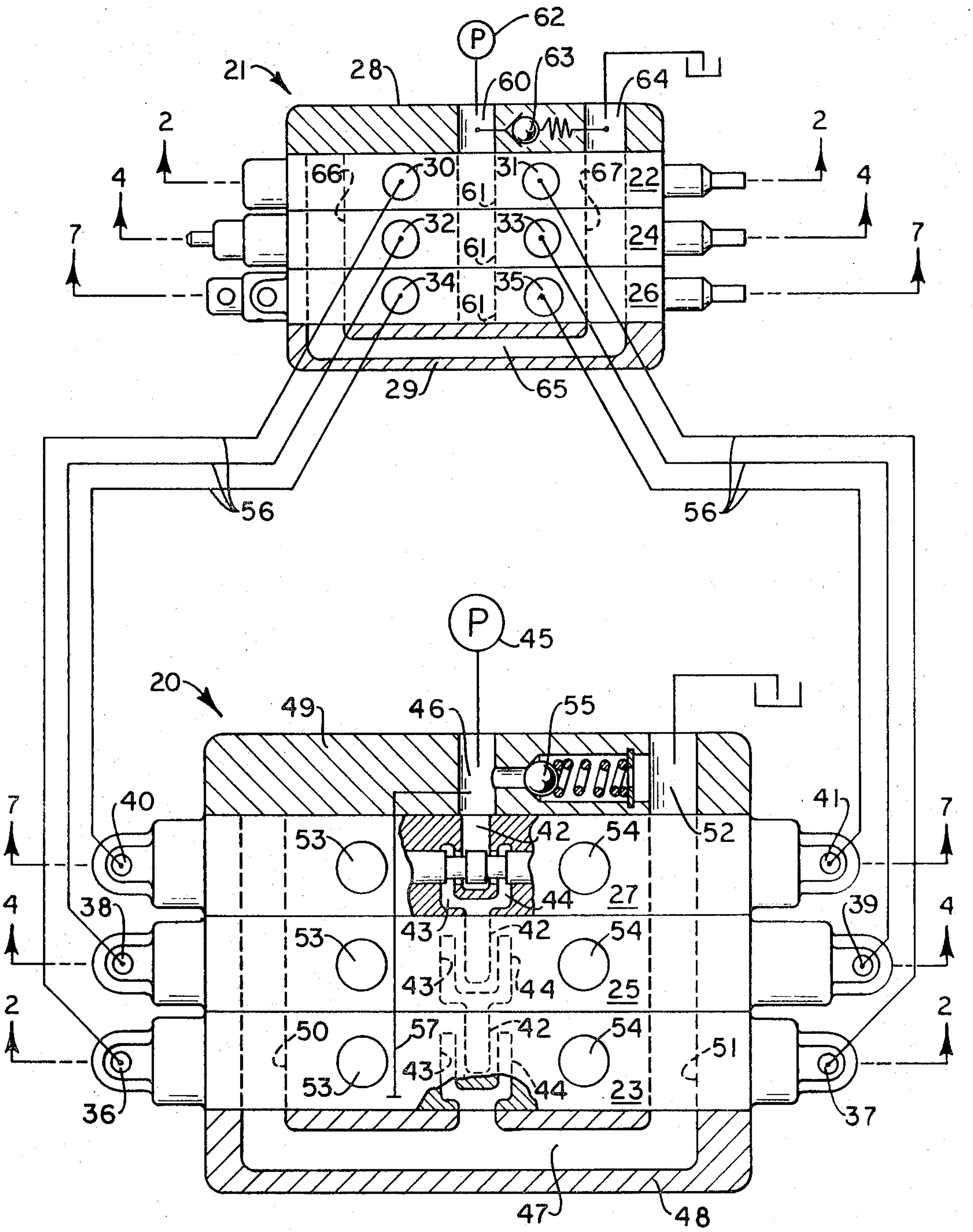


FIG. 1

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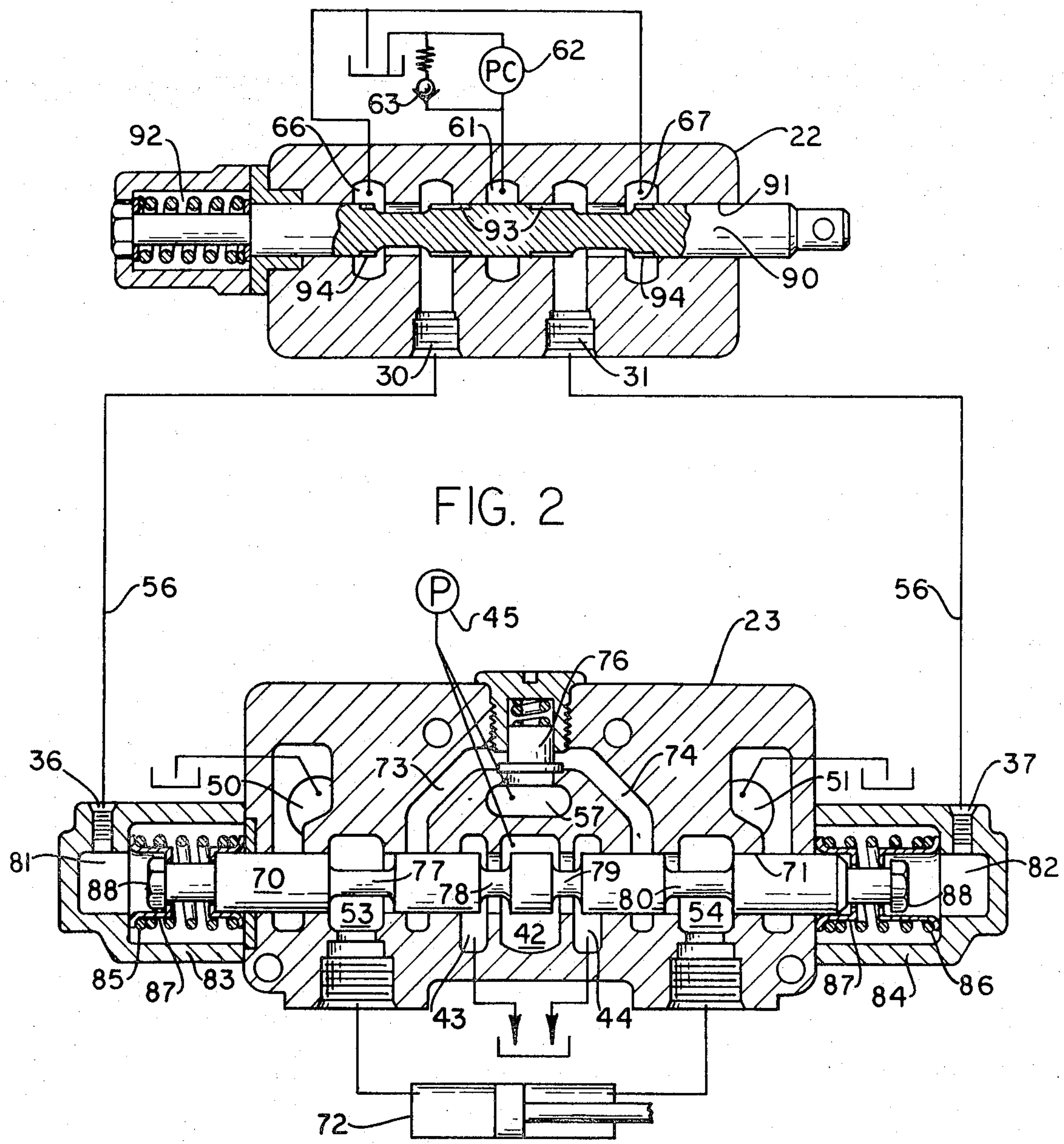

FIG. 2

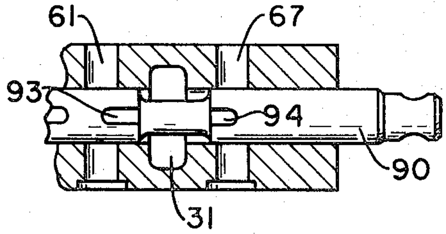

FIG. 3

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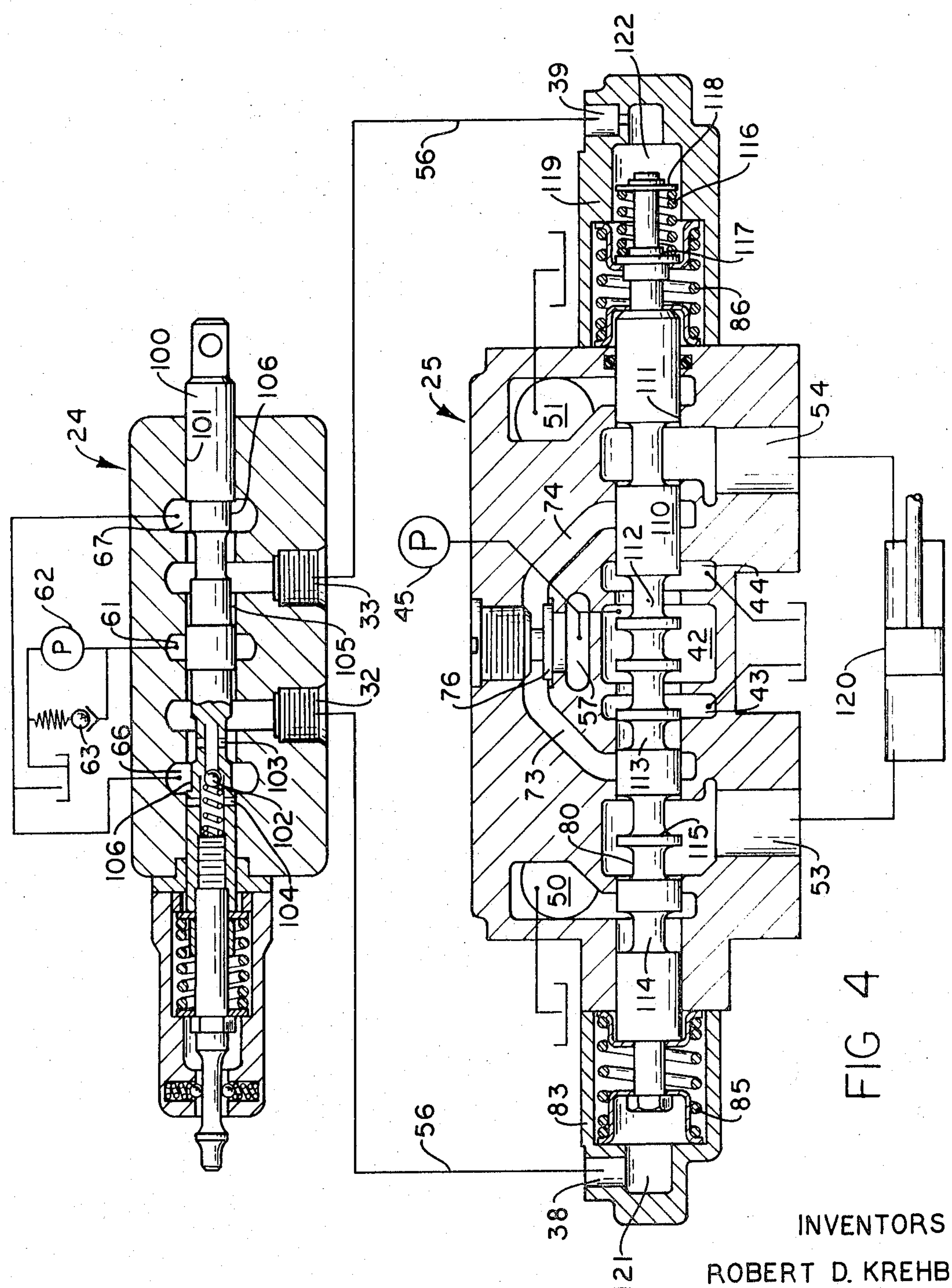

FIG 4

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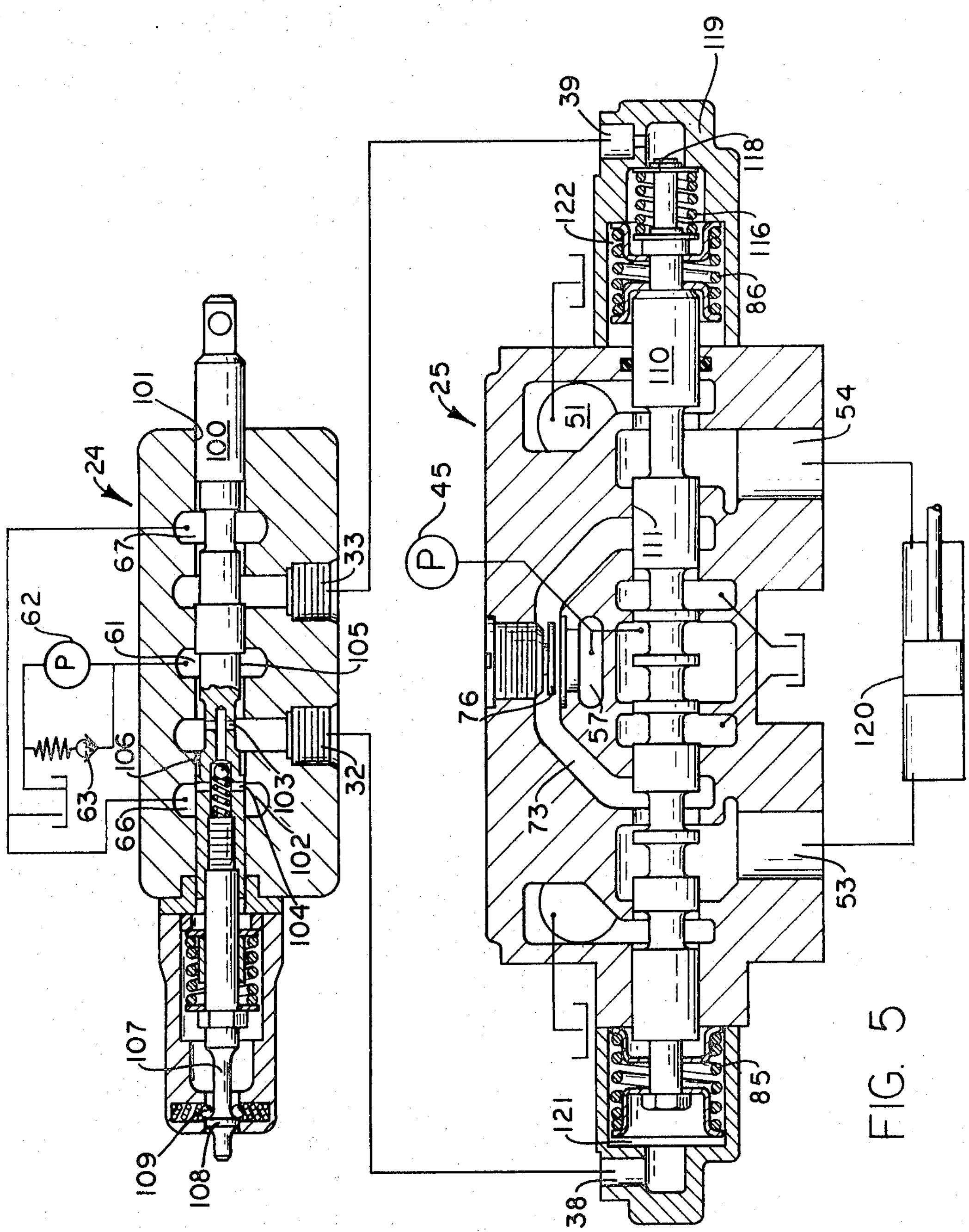

FIG. 5

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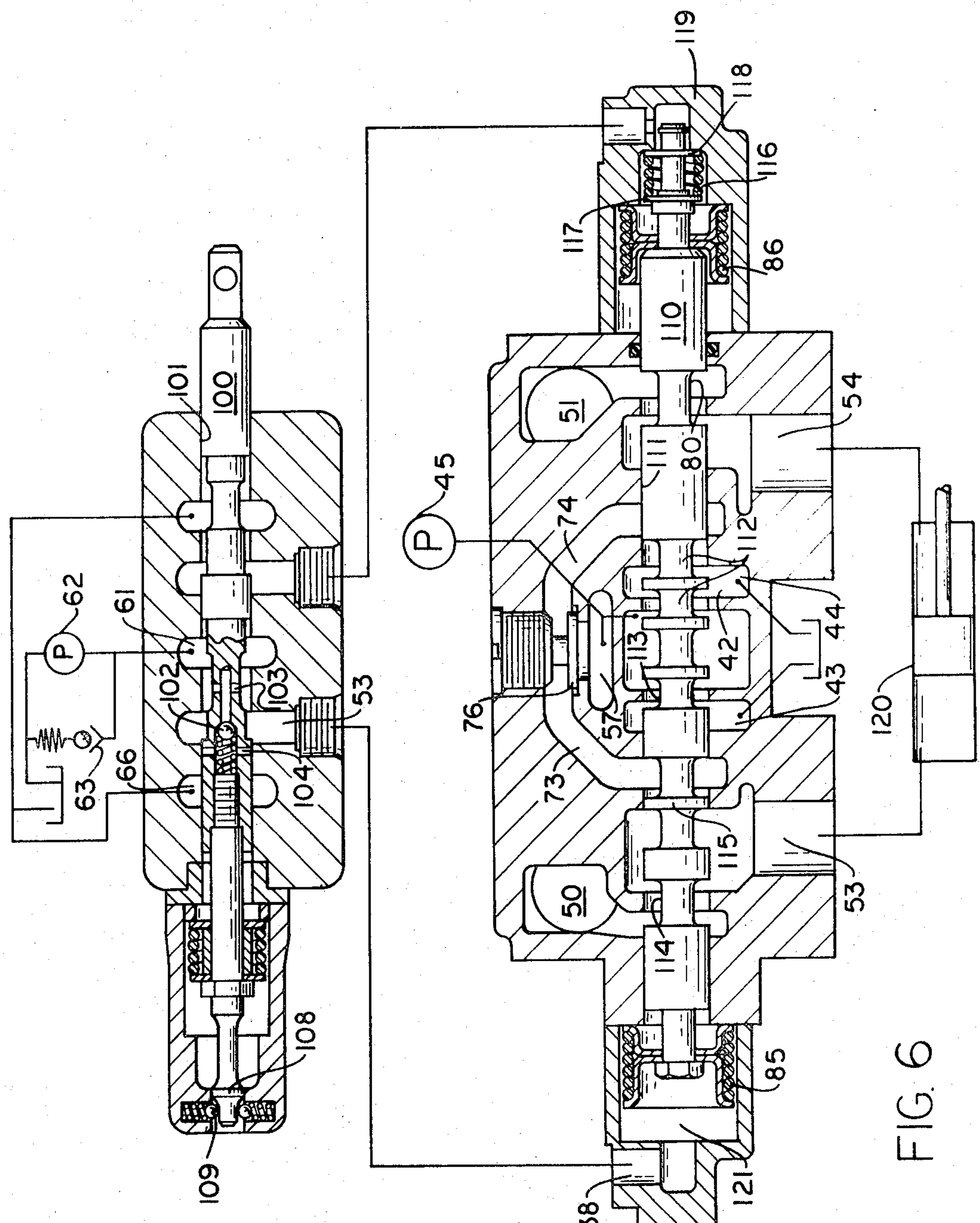

FIG. 6

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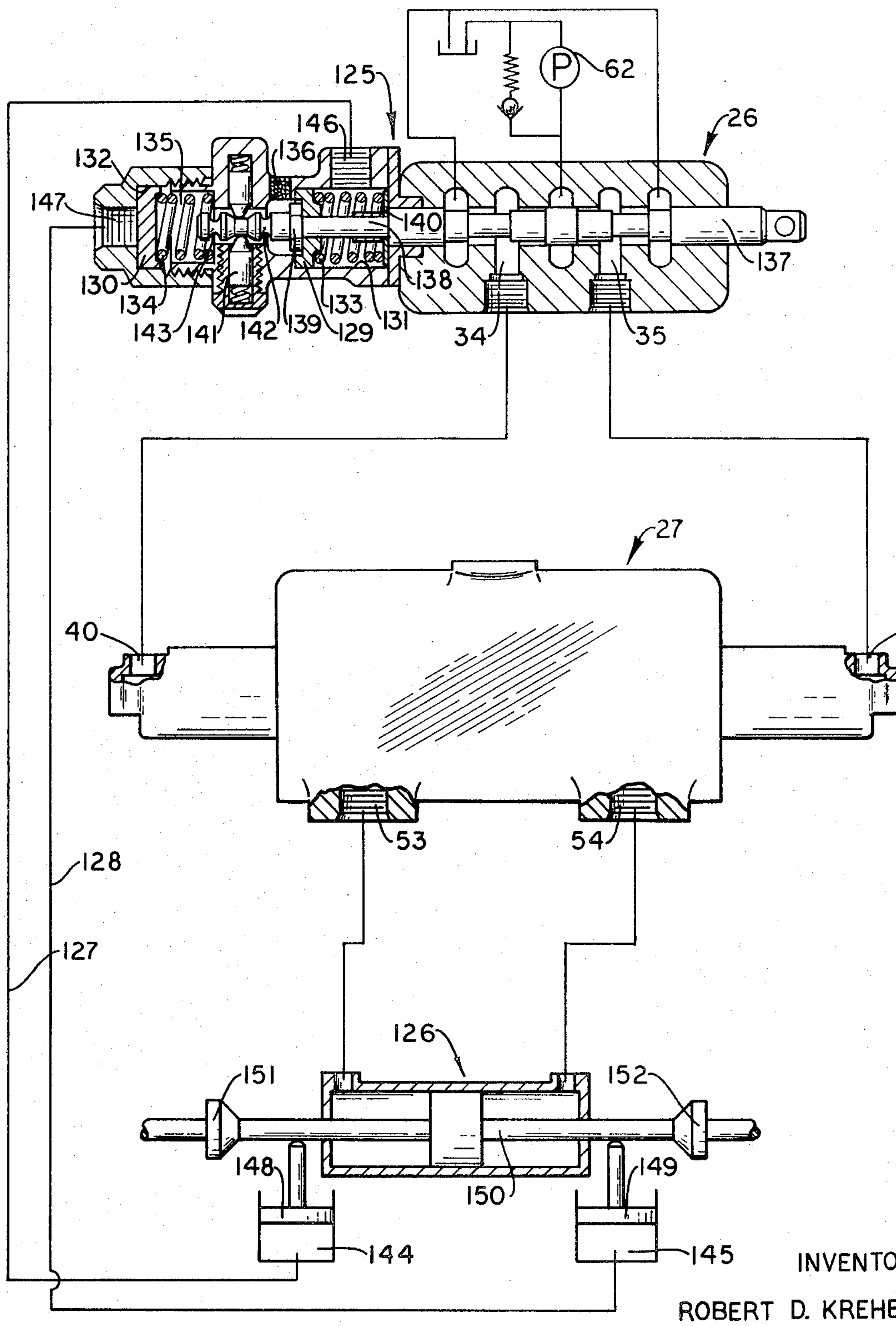

FIG. 7

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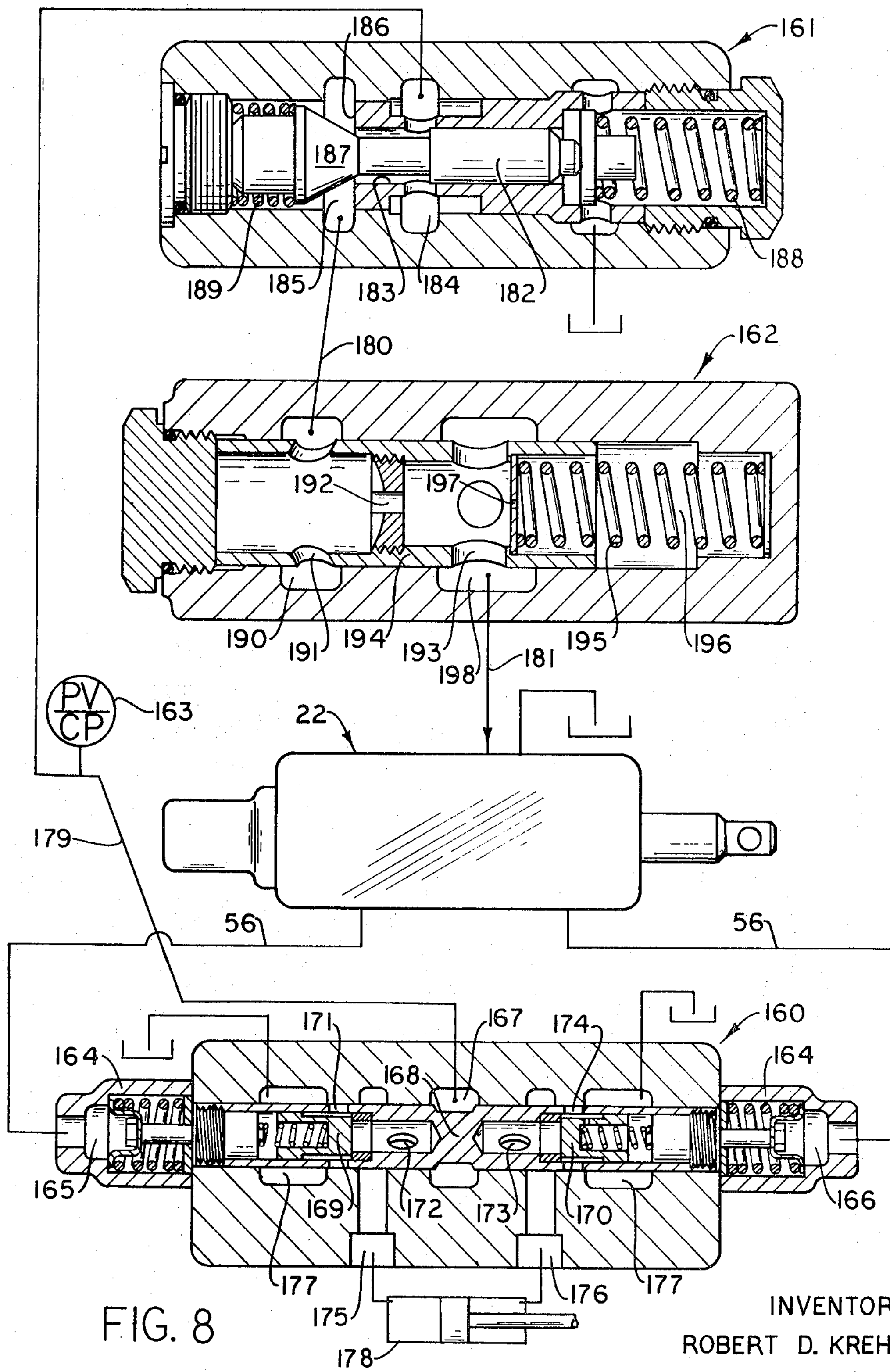

FIG. 8

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REMOTE HYDRAULIC CONTROL

BACKGROUND OF THE INVENTION

This invention relates to hydraulic longitudinal spool control valves and more particularly to improved remote control systems precisely positioning the valve spool.

Spool type control valves have long found wide acceptance as the most efficient flow control device for hydraulic systems and have reached a highly developed state in reliability, performance and diversity of function. The control spool is incrementally movable to direct and meter flow to hydraulic motors to control direction and speed of motor movement. The ever-increasing power requirements of hydraulic systems limit the use of manually actuated control spools as high flow and high pressure create large forces on the spool making manual actuation difficult and impractical. Accordingly, remote slave actuating systems have been developed to operate the control spools, such systems including pilot valves hydraulically actuating the main spool valve to direct flow, and further devices for metering flow to determine motor speed. None of the prior art pilot systems known are capable of precise positioning of the control spool so that it alone controls both direction and speed of motor movement.

SUMMARY OF THE INVENTION

The invention contemplates a remote pilot control system which incrementally positions a spool valve to control and vary direction and speed of motor operation. The manually operated pilot valve modulates pressure exerted at either end of the spool which opposes gradient spring biasing means so as to incrementally position the spool in relation to the developed pilot actuating pressure. The pilot control system is of the closed center, variable flow type with a constant pressure fluid source. The pilot control member is incrementally movable in one direction to meter flow from the constant pressure source into a port connected to a fluid chamber at one end of the main control spool. At the same time, the pilot control member also meters a certain flow from the port to a low pressure drain to create a pressure in the control port and main spool chamber in relation to the position of the pilot control member. The pilot system thus modulates pressure in the main spool chamber in accordance with movement of the pilot control member. One or more spring means bias the main control spool in opposition to the hydraulic force of the pilot actuating pressure. The spring means are of the gradient type, exerting greater force as compressed, such that modulation of the actuating pressure incrementally positions the main control spool in proportion to original movement of the pilot control member. Selective movement of the pilot control member in a second, opposite direction modulates pressure exerted on the other end of the main spool to control spool travel in the opposite direction. A selectively actuable pressure relief valve in the pilot system can be used to position the main control spool to a special function position such a float operation. Automatic return of the pilot control member to neutral can be accomplished by a hydraulic piston selectively engaging the pilot control member.

It is a broad object of the invention to provide improved remote controls for hydraulic valves, particularly those of the longitudinal spool type.

It is a further object of the invention to provide a main spool subject to gradient force biasing means and a remote control system modulating pressure exerted on the spool in opposition to the biasing means so as to incrementally position the main spool.

Another objective in accordance with the preceding is a remote system having both manually actuated and automatic pressure control means for varying pressure at the main spool so as to effect a desired travel of the main spool.

With these broad objectives in view, further more specific objects and advantages of the present invention are set forth or will become apparent from the following detailed description and accompanying drawings of the preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** shows in partial cross-section and in part schematically a bank of main control valves and a remote hydraulic actuating system in accordance with the present invention;

FIG. **2** is a cross-section taken along lines **2—2** of FIG. **1** showing a remote pilot valve and the corresponding main spool valve, with portions of the circuitry shown schematically;

FIG. **3** is a partial right angle view of the remote control valve of fIG. **2** showing the spool **90** in a pressure modulating position;

FIG. **4** is a view similar to FIG. **2**, taken along lines **4—4** of FIG. **1** showing a main valve and remote control valve with "float" positions, both valves being in a neutral position;

FIG. **5** is a view similar to FIG. **4** with both valves in the "raise" position;

FIG. **6** is a view similar to FIG. **4** with both valves in the "float" position;

FIG. **7** is a partially schematic view of a fluid control system with remote actuation and automatic return-to-neutral provisions, with the remote valve and main valve shown in cross-section taken along lines **7—7** of FIG. **1**; and

FIG. **8** is a schematic representation of a closed center flow control system with the remote valve shown in full and the remaining valves shown in cross-section.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Throughout the specification and drawings, like reference numerals refer to corresponding or duplicate elements. Referring now specifically to FIG. **1**, depicted is a bank **20** of longitudinal reciprocating spool control valves, whose general construction and operation are well known within the art. A bank **21** of remote control valves includes individual valve sections **22, 24** and **26** sandwiched between end plates **28** and **29.** The work ports **30–35** of the remote valves respectively communicate through conduits **56** with control chamber ports **36–41** at opposite ends of the corresponding main valve sections **23, 25** and **27.**

Each main valve includes interconnecting central zigzag passages **42, 43** and **44,** those of valve **27** shown in full with the remaining shown by dashed lines, which provide a free flow path in the neutral positions for fluid to flow from pump **45** and port **46** directly to return drain passage **47** in end plate **48.** FIG. **1** also shows schematically the interconnected pressure feed ducts **57** of each valve which extend parallel to the zig-zag passages. Ducts **57** connect directly with pressure inlet port **46** of port plate **49** and are dead-headed at the other end plate **48.** The individual valves **23, 25, 27** also have interconnected drain passages **50** and **51,** and the communication of passage **47** with ducts **50** and **51** carries fluid to the drain port **52** in port plate **49.** Each main valve has a pair of work ports **53, 54** which connect with opposite ends of hydraulic motors not shown in FIG. **1.** A high pressure relief valve **55** in port plate **49** limits the main valve inlet pressure.

The remote control system includes a constant pressure source of fluid to inlet port **60** of port plate **28** which connects with the communicating pressure ducts **61** of each pilot valve section. The source illustrated is a constant displacement pump **62** limited in pressure, relatively low in comparison to that which can be developed by main pump **45,** by a relief valve **63** which normally diverts pressure fluid from inlet **60** to outlet port **64.** The remote system is closed center, i.e., end plate **29** blocks pressure ducts **61** so that they continually carry the pressure determined by valve **63.** Passage **65** interconnects the through drain passage **66, 67** of each remote valve.

FIG. **2** clearly illustrates the detailed construction of main control valve **23** and its associated pilot actuating valve **22.** Main valve **23** has a control spool **70** reciprocal within longitudinal bore **71** that is intercepted by the drain passages **50, 51,** the work port passages **53** and **54** and the neutral zig-zag passages **42, 43, 44.** The work ports connect through conduits with opposite ends of a working cylinder motor **72.** The valve also has pressure feed branch passages **73, 74** intersecting the spool bore adjacent the work ports and whose communication with pressure feed duct **57** is controlled by one-way lift check valve **76** as well known to the art. Spool **70** has several spaced flow control grooves **77–80** of which grooves **78, 79** interconnect the zig-zag grooves **42–44** in the neutral position shown.

The opposite ends of spool **70** extend into interior fluid chambers **81, 82** of the caps **83, 84** affixed to the valve housing. Bolts **88** are secured to the spool ends so that springs **85, 86** act through cup-shaped washers **87** to bias the spool. In the neutral position, only left spring **85** is acting on the spool to hold it in neutral position since right end washer **87** does not engage the right end of the spool in neutral. Control ports **36, 37** respectively connect chambers **81, 82** with remote valve ports **30** and **31.**

The small pilot valve **22** similarly has a longitudinal control spool **90** reciprocal within a bore **91** intercepted by port passages **30, 31,** pressure passage **61** and drain ducts **66, 67.** The right end of the spool extends outside the pilot valve body to facilitate manual actuation, and the other end incorporates a conventional spring centering assembly **92** which lightly resists the manual actuation so as to return spool **90** to the neutral position upon release of the spool. The spool also has metering notches **93** and **94,** clearly shown in FIG. **3,** respectively controlling pressure flow from inlet **61** to the outlet ports and flow from the outlet ports to the drain passage. For instance, FIG. **3** shows spool **90** moved slightly inwardly so as to meter pressure flow into port **31** and simultaneously meter a predetermined flow out of port **31** to drain **67.** Gradual leftward movement of spool **90** uncovers a greater portion of inlet notch **93** while reducing the portion of notch **94** open to drain **67.** Pressure in port **31** is accordingly a function of spool movement, continually increasing with farther leftward spool travel. The other outlet port **30** is similarly pressure modulated with spool travel right of neutral.

In operation of control valve **23,** travel of spool **70** away from the neutral position blocks communication of central passages **43, 44** with duct **42** so that pressure from pump **45** builds in parallel feeder duct **57** to life check valve **76** and deliver motive fluid to branch passages **73, 74.** When spool **70** shifts leftwardly, pressure fluid from branch **74** passes through groove **80** to work port passage **54** and drives the cylinder motor **72** leftwardly. Spool **70** meters pressure flow at the bore between passages **74** and **54** to control motor speed, with further leftward spool travel permitting greater flow and faster motor actuation. Fluid displaced from the motor **72** returns to port **53** to be metered by spool **70** as it flows to drain passage **50** via spool groove **77.** Similar operation occurs with rightward spool travel to meter flow from branch **73** to port **53** to dictate rightward movement and speed of motor **72.** The foregoing flow control operation of valve **23** is well known within the art and further discussion is not believed necessary.

Main spool **70** moves in response to the balance between the hydraulic forces of control chambers **81, 82** at opposite ends of the spool and the mechanical bias forces exerted by spool springs **85, 86.** Spring **85** biases spool **70** to the neutral position when both control chambers **81, 82** communicate, as shown, with low pressure reservoir through conduits **56** and remote spool return passages **66, 67** via ducts **30, 31** and spool bore **91.** Upon movement of main spool **70** by introduction of pressure into one of the actuating chambers, spring **85** begins to compress and exerts greater force on the spool in opposition to the pressure force. Sufficient movement of spool **70** picks up spring **86** so that it complements spring **85** in opposing the pressure. For a predetermined pressure in one of the control chambers **81, 82,** the spool travels until the springs **85, 86** compress sufficiently to balance the pressure, the spool remaining in such position until the actuating control chamber pressure changes.

With a constant pressure source, pilot valve **22** can reliably modulate pressure in the control chamber **81, 82** so that movement of pilot spool **90** to a predetermined position will repeatedly produce substantially the same pressure in control chamber **81** or **82.** Thus, the leftward movement of spool **90** shown in FIG. **3** will create a certain pressure in port **31** and connected end chamber **82,** the other end chamber **81** then being at low pressure as a result of being drained through interconnected pilot passages **30** and **66.** In response to the pressure magnitude in chamber **82,** main spool **70** moves a certain distance and meters a specified rate of flow to port **54** and the motor. The farther leftwardly pilot spool **90** moves, the greater is the pressure in chamber **82** to move main spool **70** farther leftwardly and meter more flow to the motor. It will be apparent that this remote actuating system accurately duplicates manual shifting of main spool **70** so that motor operation can be reliably controlled.

The use of a remote actuating valve **22** permits the location of main control valve **23** closer to the motors.

The high pressure circuitry from pump **45** to the motors can be reduced, minimizing the lengths of the pressure carrying conduits and lines. Greater travel of spool **70** is available, and higher forces on spool **70** will cause no problems as the spool is not manually operated. The availability of longer spool travel and higher spool forces permit, of course, the main valve to be larger and to a certain extent makes the valve simpler and more economical to develop as these problems are eliminated as factors in the valve design.

The remote valve **22** may be mounted near the operator for convenience. This pilot valve is miniature in comparison to the main valve, with its short travel of spool **90** and light force of centering spring **92** permitting finger-tip control. The remote valve uses little power, requiring low pressure and flow from its source **62.** It may utilize the same or separate fluid reservoir as the main control valve system, whichever is desired. By being closed center and modulating pressure in the control chambers **81, 82,** the remote valve produces accurate spool travel of the main valve to provide excellent metering characteristics. Another important advantage derived from the present system is that it requires no substantial alteration in known spool valve design nor does it require extra elements in the system, but rather uses the main valve to control direction and velocity of motor operation. The remote control system of the present invention, due to pressure modulation, also oversteps the various problems of fluid leakage, proper phasing, etc., inherent to other types of remote servo and power assist systems.

FIGS. **4** and **6** show a remote valve **24** and main control valve **25** which have an additional operating position, a "float" position which simultaneously connects both ends of the cylinder motor with drain so that the motor moves freely or floats in response to external forces. The detailed constructions of pilot valve **24** and main valve **25** are quite similar to those of FIG. **2** as shown by like numerals for similar elements. In addition, the pilot spool **100** is provided with an interior ball-type relief valve **102** that controls fluid flow between spool crossbores **103, 104.** The spool also has different type of metering means: slightly reduced diametral portions **105** on either side of pressure ducts **61** and similar sections **106** adjacent each drain duct **66, 67.** The spool **110** of main valve **25** has additional control grooves **112, 113, 114** and an additional land **115** in the middle of groove **77** defining groove **80.** A third spring **116** also biases spool **110,** acting between flange **117** fixed to the spool and a washer **118** movable relative to the spool. The spool left end is covered by a cap **83** like that in FIG. **2** while a slightly longer cap **119** accommodating the additional spring **116** covers the right end.

Operation of valves **24, 25** is as described with reference to FIG. **1** upon left and right movement of pilot spool **100** to the "lower" and "raise" positions actuating motor **120** in opposite directions. Displacing pilot spool **100** away from neutral meters communication of one of ports **32, 33** with pressure and drain at sections **105, 106** so as to modulate pressure in the communicating control chambers **121, 122** and accurately position the spool **110** against the bias of springs **85, 86.**

FIG. **5** shows remote spool **100** shifted to the maximum velocity "raise" position wherein main spool **110** is positioned to permit maximum flow rate from pressure branch passage **73** to port **53** and the motor. Pressure developed in remote valve port **32** and connected control chamber **121** is now determined by internal relief valve **102** instead of flow metering by sections **105, 106.** Spool **100** is so positioned so as to block communication of port **32** with drain **66** through spool bore **101.** Flow from port **32** now passes through crossbore **103** to open relief **102** and drain through bore **104** to passage **66.** The predetermined opening pressure of relief **102** is less than that of maximum relief **63,** but is sufficient to move main spool **110** until washer **118** engages cap **119.** The left end of pilot spool **100** has an attached extension **107** with an enlarged lip **108** that engages lightly spring loaded pawls **109** as the maximum speed position is reached. The pawls exert a slight resistance to spool movement when so engaged to give the operator "feel" and signal that the maximum velocity position has been reached.

In FIG. **6** the pilot spool **100** has been displaced farther rightwardly, forcing the pawls **109** to ride over lip **108,** past the maximum raise position to the float position. Spool crossbore **104** is now blocked at bore **101** so that pressure builds in port **32** and chamber **121** to the maximum permitted by pilot relief **63** as internal relief **102** is now inoperative. The pressure in chamber **121** is now sufficient to overcome the combined bias of all three springs **85, 86** and **116.** Main spool **110** travels to its extreme rightward position abutting the end cover **119.** Land **115** on the spool blocks flow between branch **73** and port **53** to isolate the motor **120** from the actuating inlet pressure flow. Spool grooves **112, 113** connect the zig-zag passages **42-44** to re-establish the neutral bypass flow. Port **54** remains connected with drain duct **51** through groove **80,** and the other port communicates through groove **114** with drain **50** so that both cylinder ends connects with low pressure reservoir. The piston and rod of motor **120** now move freely in response to any external force imposed therein.

FIG. **7** further illustrates the adaptability of the present remote actuating system for hydraulic controls. The main control valve **27,** not shown in cross-section, is similar to valve **23** of FIG. **2** both in structure and operation. Remote valve **26** operates as valve **22** of FIG. **2** and has an additional detent and automatic centering mechanism **125.** The main valve work ports **53, 54** connect with opposite ends of a cylinder motor **126** having position sensing means connected by conduits **127, 128** to the centering mechanism **125** on remote valve **26.**

The centering device **125** includes a pair of pistons **129** and **130** slidable within bores **131, 132** and biased left-wardly by their respective springs **133, 134.** The chamber **135** formed between pistons **129, 130** is vented to atmospheric pressure through breather **136.** The left end of remote spool **137** has an attached rod **138** that extends through piston **129.** A nut flange **139** on the rod engages piston **129,** and washer **140** abuts a shoulder of the spool so that the bias of spring **133** urges spool **137** to the neutral position. In such position the inner ends of pawl detent **141** are intermediate grooves **142, 143.** Upon moving spool **137** to its maximum left or right positions the pawls **141** drops into groove **142** or **143** respectively to hold the spool in such position in spite of the bias of spring **133.**

Fluid passes from fluid chambers **144, 145** through conduits **127, 128** to ports **146, 147** to actuate pistons **129, 130** respectively. Depression of piston **148, 149** displaces the actuating fluid from chambers **144, 145** to the ports **146, 147.** The motor cylinder rod **150** carries actuating cams **151, 152** engaging the cam follower pistons **148, 149.**

In operation, spool **137** may be manually moved leftwardly to the maximum speed position where pawls **141** fall into groove **142** so that, unattended, the spool remains in such position. The left end of spool rod **138** is now near piston **130** in a position to be actuated by that piston. Operating as in FIG. **2,** valve **26** modulates pressure at main valve control port **41** so that maximum flow rate from work port **54** passes to the motor **126** to drive same leftwardly. As it nears the end of its stroke, the cylinder cam **152** depresses piston **149** to displace fluid to port **147.** Piston **130** moves rightwardly, forces the pawls out of groove **142** and returns spool **137** to the neutral position, cutting off flow from the main valve to the cylinder **126** and bringing it to rest. The operation is similar when spool **137** travels rightwardly to actuate the motor **126** rightwardly. The pilot spool detents in groove **143** and automatically returns to neutral upon depression of piston **148** by cam **151** to displace fluid to port **146** and force piston **129** and the spool back leftwardly.

Contrasted to the previous embodiments, FIG. **8** illustrates a closed center main flow control system having a main valve **160** remotely actuated by the same pilot valve **22** fully described above. The closed center system includes a variable volume, constant pressure fluid source **163** from which the remote valve **22** also derives its motive fluid. The pressure reducer valve **161** and flow control valve **162** regulate the input flow from pump **163** to valve **22.**

Valve **160** may be considered generally as a standard closed center design to which is added caps **164** covering the protruding spool ends to form the control chambers **165, 166** in which pressure is modulated by pilot valve **22** to actuate the main valve. The pressure compensated pump **163** provides a variable delivery, constant high pressure flow, for instance 2500 psi, to the inlet passage **167** that is blocked by spool **168** in the neutral position. The reciprocating spool has an interior spool bore containing movable check valves **169, 170** that each regulate flow between their respective cross-bores **171–174.** Upon rightward spool travel, cross-bore **172** directs the inlet flow from **167** to open and cross check valve **169** and through cross-bore **171** that is communicating with port **175** in order to drive motor **178** rightwardly. In such position the cross-bore **173** connects with port **176** and cross-bore **174** with the right drain passage **177.** The fluid displaced from motor **178** upon its rightward travel flows to port **176,** through bore **173,** to open lift check **170** and continue to drain **177.** Cross-bore **172** opens more to inlet **168** as the spool travels farther rightwardly to meter flow and create motor speed control dependent upon the position of spool **168.** Similar operation occurs upon leftward spool travel, cross-bores **173, 174** then metering motive flow to port **176** and the motor.

As noted before, the pilot valve **22** is a low power system requiring low pressure and low flow. To utilize a single source **163** for both primary working flow to main valve **160** as well as a pressure source for the remote pilot system, pressure reducer **161** limits pressure in downstream conduits **180, 181** to the maximum required for pilot valve **22,** e.g., in this case one-tenth the output pressure of pump **163** in line **179.** Flow control **162** limits the rate of flow in remote valve inlet conduit **181** to an acceptable level assuring no impairment of pilot operation. The pilot valve **22** operation is as discussed with respect to FIG. **2,** variable and precisely positioning the main spool **168** by modulating pressure in control chambers **165, 166.**

The pressure reducer **161** comprises a spool **182** shiftable in bore **183** to variably restrict flow from inlet **184** to outlet **185** at the opening forward between shoulder **186** and spool tapered face **187.** Spring **188** biases spool **182** to the full open position shown and is preset in tension to hold the pressure desired in outlet **185** and line **180.** Pressure in outlet **185** acts on the left end of spool **182** to oppose spring **188.** Excessive pressure in the outlet will drive the spool rightwardly to restrict flow more severely at tapered face **187** to reduce outlet **185** pressure to the desired level. Similarly, spring **188** forces the spool oppositely when outlet **185** pressure is too low, to permit greater flow and increase the outlet pressure. Spring **189** mitigates the gradient effects of the spring **188** which would otherwise require greater balancing force, i.e., higher-than-desired outlet pressure, when in a more compressed position.

This reduced pressure fluid flow enters valve **162** at passage **190** to pass through cross-bores **191,** orifice opening **192** and cross-bores **193** of movable spool **194.** A constant pressure differential across orifice **192** dictates a constant flow therethrough. Pressure upstream of orifice **192** biases spool **194** to the right in opposition to the combined forces of spring **195** and the downstream outlet pressure communicated to the spring-containing chamber **196** through damping orifice **197.** The spool forces will thereby be balanced when the pressure drop across orifice **192** is equivalent to the force exerted by spring **195.** The spool moves so as to maintain this force balance, holds a maximum pressure drop across orifce **192** and limits flow in conduit **181** to the required level. The spool shifts to the right in response to a high pressure drop across orifice **192** causes by excess flow, variably closing parts of cross bores **191** to reduce flow rate. The spool moves to the left when flow and the orifice pressure drop are low to open more of cross-bores **191** to passage **190** and increase flow to the required level. From outlet **198** the delivery of pressure and flow regulated fluid to conduit **181** and pilot valve **22.** Of course, when the pilot system requires no flow, spool **194** stays in its far left position shown by the urgings of spring **195.**

Having clearly described our invention with sufficient particularity that those skilled in the art may make and use it, we claim:

1. In a hydraulic system having valve means controlling communication of a fluid source with a fluid motor and a reciprocal flow control spool in the valve means incrementally shiftable from a neutral flow blocking position towards a position of maximum flow so as to meter flow between said source and said motor to control speed of motor actuation, remote spool positioning means comprising:

means forming a fluid chamber at one end of said spool, said chamber being in communication with a source of fluid control pressure acting to urge said spool in one direction;

spring means biasing said spool in the opposite direction including a first spring member urging the spool toward the neutral position and a second spring member urging the spool in the same direction as the first spring member only when the spool has reached a predetermined position away from the neutral position whereby said spool is incrementally positioned in relation to the magnitude of pressure in said chamber; and

remote spool control means interposed between said source of control pressure and said chamber and manually operable to modulate pressure in said chamber whereby said spool is incrementally positioned to effect flow metering in direct response to actuation of said remote spool control means.

2. The system of claim **1** wherein said remote control means includes a manually shiftable element variably and simultaneously restricting communication of said fluid chamber with said pressure source and a reservoir such that the pressure in said chamber varies in direct response to the manually selected position of said element.

3. The hydraulic system of claim **2** further comprising a plurality of said valve means arranged in a bank and supplied by a common fluid source and common reservoir, each of said valve means controlling flow to separate fluid motors, and each associated with a remote spool control means incrementally positioning the associated spool by modulating pressure in its pressure chamber, said plurality of spool control means arranged in a second bank remote from said first bank whereby said remote pressure source and reservoir supplies all said remote spool control means.

4. The device of claim **2** wherein said shiftable element comprises a longitudinal spool manually shiftable within a bore of said remote spool control means, said bore being intercepted by spaced pressure, work and discharge passages, said spool having metering notches therein adapted to provide simultaneous communication of said work passage with the adjacent pressure and discharge passages, when said spool is shifted out of neutral, said communication incrementally variable with movement of said spool so as to modulate pressure in said work passage, and conduit means connecting said work passage with said chamber.

5. The device of claim **1** further including means defining a second fluid chamber at the opposite end of said spool and wherein said remote valve means communicates with both said chambers and selectively modulates pressure in one of said chambers while connecting the other with low pressure to selectively actuate said control spool incrementally in opposite directions.

6. In a hydraulic system controlling communication of a fluid source with a fluid motor; the system having a primary control valve with a longitudinal main bore, a fluid pressure inlet passage and a main work passage intercepting the main bore at spaced apart locations, a main control spool in the bore incrementally movable from a neutral position blocking flow between the inlet and the main work passage to a position directing maximum flow to said work passage, the travel of said main spool away from neutral determining the rate of flow metered to said main work passage, a pressure chamber enclosing one end of said spool and a first spring means biasing the main spool to neutral against the urging of pressure in said chamber, whereby said main spool is incrementally positioned in relation to the magnitude of pressure in said chamber and a second spring means biasing the main spool against the pressure in said chamber only when the main spool has reached said maximum flow position; remote means for incrementally positioning said main spool, including:

a constant pressure fluid source;

a remote valve having a bore intercepted by an inlet passage communicating with said constant pressure source, an output passage and a low pressure discharge passage;

conduit means interconnecting said remote output passage with said main valve pressure chamber;

a remote control spool reciprocal in said remote bore between various positions including a neutral positon blocking said constant pressure inlet at said remote bore and connecting said remote output passage with said discharge whereby said first spring means holds the main spool in its neutral positon and a maximum flow position blocking said discharge passage from said remote output passage and connecting the latter with said constant pressure inlet to develop pressure at said main valve pressure chamber shifting the main spool to its maximum flow position; and

said spool incrementally positionable between said neutral and maximum flow positions to variably restrict simultaneous communication of said output passage with both said constant pressure inlet and low pressure discharge passages whereby incremented displacement of said remote spool modulates pressure in said output passage and incrementally shifts said said main spool to meter flow from said main inlet to said main work passage.

7. The means according to claim **6** wherein said main spool is shiftable past said maximum flow position to another operative position in opposition to said second spring means, said remote means further including automatic pressure control means communicating with said output passage and limiting pressure therein to a predetermined value upon positioning said remote spool in said maximum flow position, said remote spool shiftable past said maximum flow position to override said automatic pressure control means and create pressure greater than said predetermined limit in said output passage to overcome the basis of said second spring means and move the main spool to said another position.

8. The means according to claim **7** wherein said pressure control means includes a pressure relief valve within said remote spool to control flow between first and second cross bores in said remote spool, said cross bores communicating respectively with said remote output passage and remote discharge passage upon positioning the remote spool to said maximum flow position whereby said relief valve limits output passage pressure to said predetermined value, said remote spool blocking flow through one of said holes to permit said remote output pressure to increase to that of the constant pressure source when said remote spool is shifted to said override position.

9. The means according to claim **8** wherein said remote control means includes detent means engaging said remote spool in said maximum flow position.

10. The means according to claim **6** wherein said main port communicates with said fluid motor to actuate same and said remote control means further include feedback means operatively associated with said motor and said remote spool and adapted to shift said remote spool to neutral to cause said main spool to return to neutral when the motor reaches a predetermined position.

11. The improvement of claim 10 wherein said feedback means includes a piston in a fluid chamber in said remote valve body, said piston when actuated engaging said remote spool and urging same to the neutral position.

12. The improvement of claim 11 wherein said feedback means further includes an accumulator hydraulically connected with said piston chamber and actuated upon the motor reaching said predetermined position to displace fluid to actuate said piston and urge the remote spool to neutral.

13. In a hydraulic system comprising a fluid pump and reservoir communicating with first and second ends of a fluid motor to actuate same, control means interposed between the pump, reservoir and motor having a control element shiftable in opposite directions from a neutral position blocking flow from the pump to both motor ends, to positions directing maximum flow from the pump to said first and second motor ends, said element metering fluid to dictate rate of flow to the respective motor ends as a function of travel of the element away from neutral, means forming first and second pressure chambers at opposite ends of said element whereby pressure in said first and second pressure chambers urges said element in opposite directions to meter flow to said first and second motor ends, and first compressible spring biasing means engaging said element to urge same to neutral and compressing upon travel of said element away from neutral whereby greater element travel requires higher pressure at said pressure chambers, a second compressible spring biasing means engaging said element at positions of maximum flow and urging said element along with said first spring biasing means against any further movement of the element away from the neutral position;

a manually actuated fluid valve for controlling communication between a constant pressure fluid source, a low pressure discharge and first and second pressure outlet ports respectively connected to said first and second pressure chambers, said valve operating to vary incrementally the pressure at said ports and comprising a valve body having a bore intersected at spaced positions by an inlet passage communicating with said source, first and second port passages extending to said outlet ports, and first and second return passages communicating with said discharge and located respectively adjacent said first and second port passages;

a spool in said bore manually shiftable from a central neutral position blocking said inlet passage at said bore and having grooves connecting both said ports with their adjacent

return passages in neutral;

said spool movable in a first direction freely connecting said second port with said second return while restrictively connecting said first port with both the inlet passage and first return passage, greater spool travel in said first direction more freely connecting the first port with the inlet while gradually reducing communication with said first return so as to modulate pressure at said first port as a function of spool travel in said first direction whereby the rate of flow metered by said main control element to said first motor end is substantially linearly proportional to spool travel in said first direction; and

said spool movable in a second opposite direction freely connecting said first port with said first return while restrictively connecting said second port with both the inlet passage and first return passage similarly as a function of spool travel in said second direction whereby the rate of flow metered by said main control element to said second motor end is substantially linearly proportional to spool travel in said second direction.

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