Oct. 5, 1971 R. L. HOFFMAN 3,610,100

TELESCOPIC ACTUATOR

Filed June 12, 1969 2 Sheets-Sheet 1

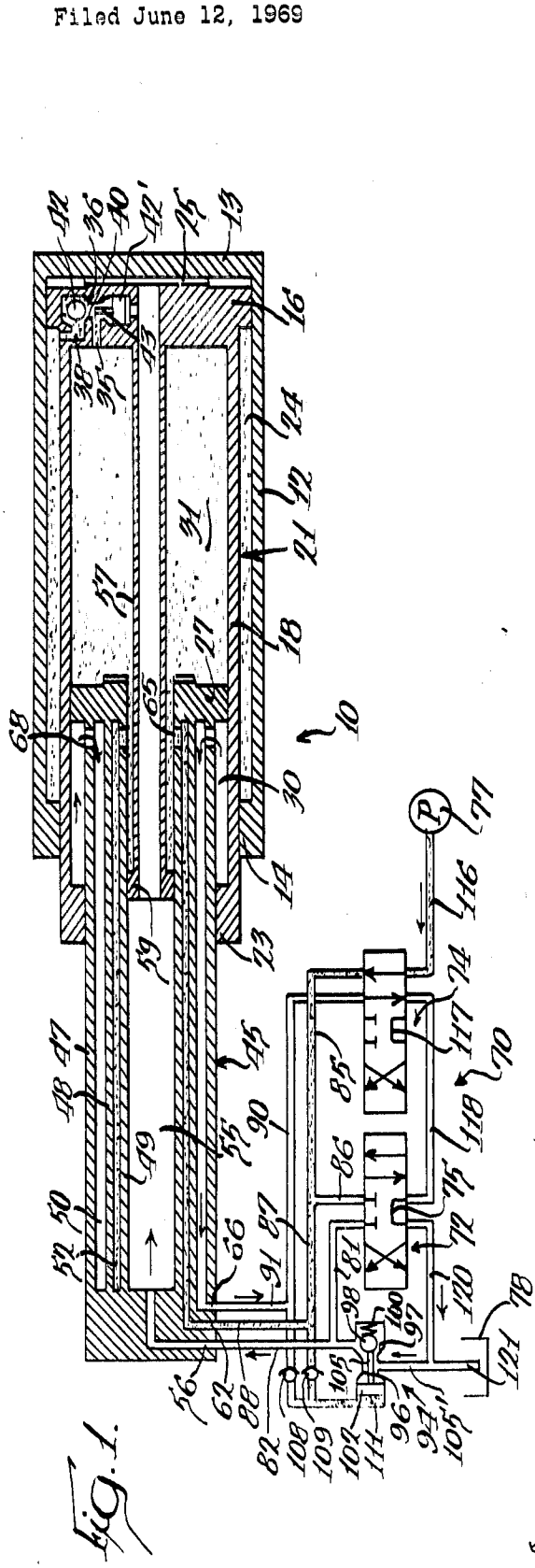


Fig. 1.

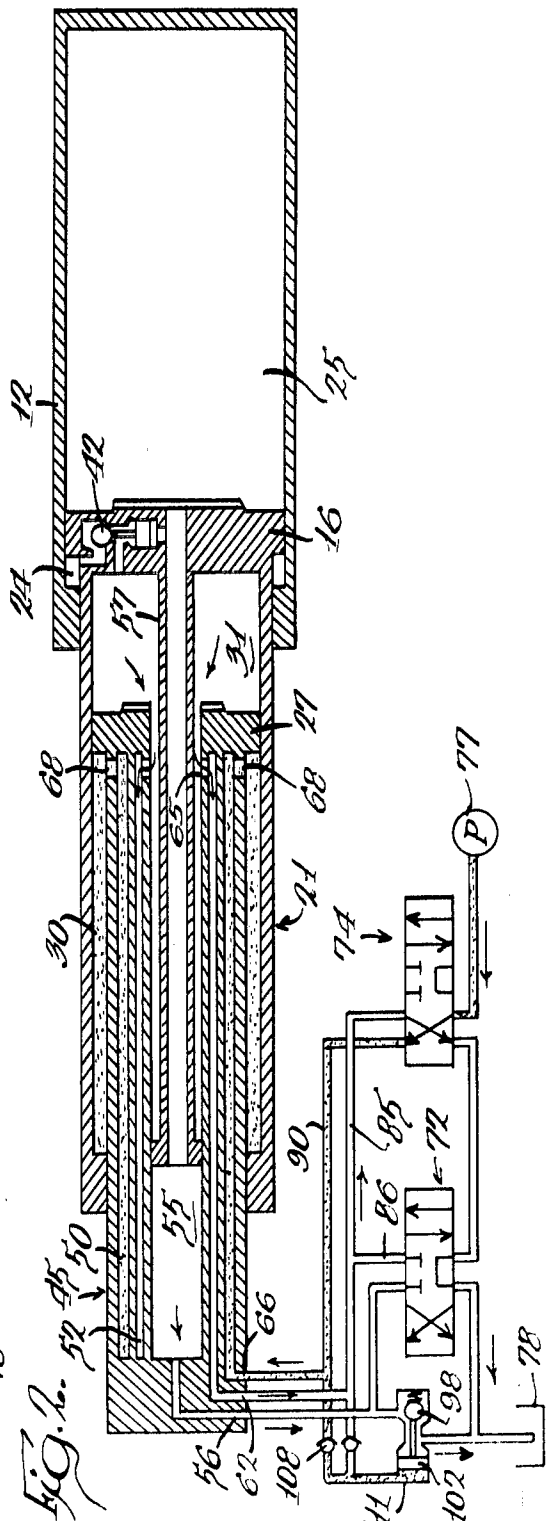


Fig. 2.

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Filed June 12, 1969 2 Sheets-Sheet 2

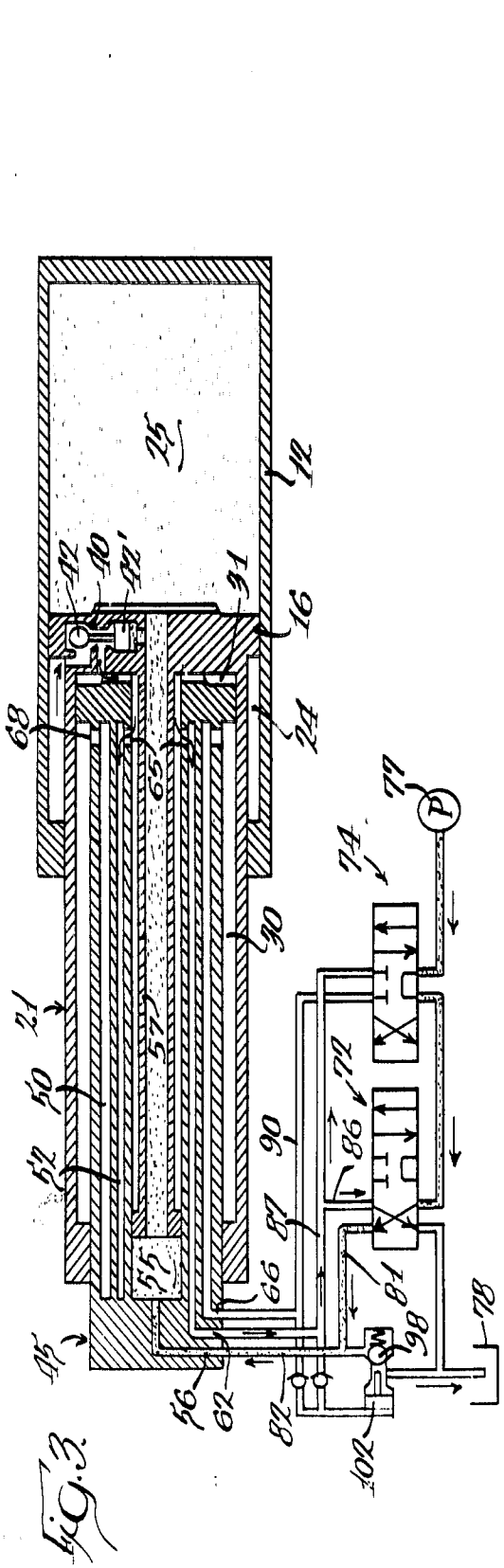


FIG. 3.

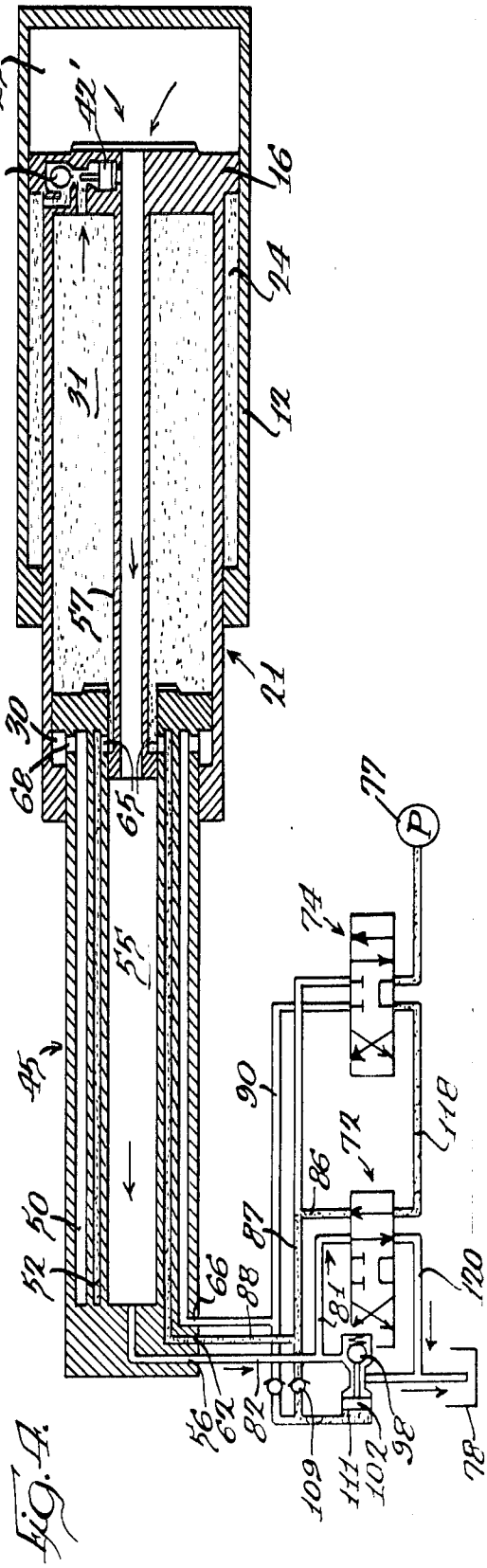


FIG. 4.

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TELESCOPIC ACTUATOR

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Int. Cl. F01b 7/20; F15b 11/08
U.S. Cl. 91—167 15 Claims

ABSTRACT OF THE DISCLOSURE

A hydraulic actuator of the type having multiple pistons and cylinders with porting and passages being provided so that each telescopic section may be independently extended with respect to the other, with a pilot operated check valve in one of the pistons providing selective communication between the fluid chambers and an external pilot operated check valve for recirculating fluid under low pressure to an extending portion of the actuator assembly.

BACKGROUND OF THE PRESENT INVENTION

The present invention relates to telescopic hydraulic actuators of a general type known in the prior art. These actuators include a primary cylinder assembly which receives a primary piston having a rod extending from the primary cylinder. This rod defines a secondary cylinder for a secondary piston also having a rod projecting therefrom. If the telescopic cylinder is rod fed, suitable ports are provided on the projecting end of the secondary rod for selectively delivering fluid to and from the actuator. If the actuator is cylinder fed, then supply and return ports are provided on the primary cylinder for selectively delivering fluid to and from the actuator. Of course, in the latter case the primary cylinder would be the stationary member of the actuator while in the former case, the projecting rod would be the stationary member.

In these prior actuators various tubing and passages are provided between the sections for communicating the ports with the common sides of the two pistons. That is, one port would be connected to supply and return fluid relative to the rod sides of both pistons and the other port would be connected to supply and return fluid selectively to the other sides of both pistons, it being understood that the pistons are pressurized simultaneously in these prior constructions.

With this arrangement, the actuator assembly will extend and retract step by step, section by section, depending upon the area and the volume of fluid required to extend or retract each section. Thus, they extend or retract in a predetermined sequence that cannot be controlled by the operator. However, it is desirable in many cases that the operator be able to control the extension and in some cases the retraction of each of the sections independently of the other sections. For example, in some cases it might be desirable to extend only the second section while at other times it might be desirable to extend only the primary section, and such an alternative is not possible in these prior telescopic cylinder constructions.

In order to obviate this deficiency, there has been suggested a telescopic cylinder assembly in which each section may be independently extended and retracted. Such a telescopic actuator is shown and described in the copending application of John T. Parrett, Ser. No. 848,128, filed May 26, 1969 entitled "Multiple Cylinder Telescopic Actuator," assigned to the assignee of the present invention. This multiple piston actuator achieves independent extension by providing separate supply ports in either the projecting rod or the primary cylinder, depending upon whether the actuator is rod fed or cylinder fed, communicating through independent passages to supply hydraulic fluid to the extending sides of each of the pistons. The passages are defined in part by telescopic feed tubes for supplying fluid to one of the piston surfaces and annular passages in one of the rods for supplying fluid to the extending surface of the other piston.

The present invention represents an improvement over this prior independently extendible section actuator in that the number of passages in the actuator required to separately pressurize the two cylinders has been significantly reduced and provision is made for preventing fluid starvation in the feed tube assembly associated with the unit even though the feed tube be unpressurized.

SUMMARY OF THE PRESENT INVENTION

In accordance with the present invention, a movable cylinder hydraulic actuator is provided having a primary cylinder, a piston slidable in the primary cylinder, and having a rod defining a secondary cylinder within which a second piston is slidable having a rod projecting from the secondary cylinder. The number of passages in the actuator to effect independent extension and retraction of the cylinders has been reduced by providing a passage in the first piston interconnecting the rod chamber associated with the first cylinder with the large chamber associated with the secondary cylinder. A one-way check valve in this passage prevents flow from the primary rod end chamber to the secondary large fluid chamber unless opened by a pilot piston responsive to fluid pressure in the large primary cylinder chamber. Thus, when it is desired that the secondary cylinder be extended independently of the primary cylinder, the large chamber associated with the secondary cylinder is pressurized and this fluid pressure acts across the passage in the main piston and the normally one-way valve therein to pressurize the rod end of the primary cylinder. This has the effect of extending the secondary cylinder with respect to the secondary piston, but maintains the primary cylinder retracted with respect to the secondary cylinder. When the secondary cylinder is retracted with respect to the secondary piston, the valve in the primary piston prevents return flow from the rod end of the primary cylinder and prevents extension of the primary cylinder.

When the primary cylinder is extended independently of the secondary cylinder, the large chamber of the primary cylinder is pressurized and the rod end of the primary cylinder is connected to drain across the normally closed check valve through the large chamber associated with the secondary cylinder. The valve in the main piston would normally block fluid discharging from the rod end of the cylinder but under these conditions it is pilot operated to its open position permitting this discharge flow.

The primary piston provided with a feed tube which telescopically extends into the secondary rod for the purpose of supplying and discharging fluid relative to the large primary cylinder chamber. There are instances, for example when the secondary cylinder is extended without the primary cylinder, when this telescopic feed tube extends with respect to the secondary rod without the large primary cylinder chamber being pressurized. This ordinarily would cause a fluid starvation in the feed tube assembly. To obviate this problem there is provided in accordance with the present invention a recirculating circuit in the main valve control circuit which returns drainage fluid from a contracting fluid chamber in the actuator to the feed tube as it extends across a one-way check valve which is pilot operated. The circuit is arranged such that the valve is pilot operated to its open position when any of the chambers, except the large chamber associated with the main or primary cylinder, is pressurized.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration of the present hydraulic actuator and control circuit with the secondary cylinder extending and the primary cylinder held in position;

FIG. 2 is a schematic illustration of the present hydraulic actuator and control circuit with the secondary cylinder retracting and the primary cylinder held in position;

FIG. 3 is a schematic illustration of the present hydraulic actuator and control circuit with the primary cylinder extending and the secondary cylinder held in position; and

FIG. 4 is a schematic illustration of the present hydraulic actuator and control circuit with the primary cylinder retracting and the secondary cylinder held in position.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to the drawings and particularly FIG. 1, a multiple cylinder hydraulic actuator **10** is shown. The actuator **10** is of the rod fed type so that the projecting rod would conventionally be the portion of the actuator that is mounted on the associated equipment stationary with respect to the control circuit and pump, while the large primary cylinder is the member connected to move or position an extendible load, such as the boom of mobile equipment or the outrigger cylinders which serve to stabilize mobile equipment.

The telescopic actuator **10** is seen to consist of a primary cylinder **12** having an end wall **13** at one end and an annular inwardly extending portion **14** at the other end carrying suitable seals (not shown). Slidable within the primary cylinder **12**, is a primary piston **16** having a rod **18** extending therefrom defining a secondary cylinder **21**. The annular projection **14** sealingly engages the exterior surface of rod **18**. The piston **16** closes one end of the cylinder **21** and the other end has an annular inwardly extending portion **23** which carries seals (not shown).

The piston **16** defines within cylinder **12** a rod end chamber **24** and a larger chamber **25** on the opposite side thereof. Slidable within the secondary cylinder **21** is a secondary piston **27** which divides the primary cylinder into a rod end chamber **30** and a large chamber **31** opposite the rod end chamber.

The end chamber **31** associated with the secondary cylinder **21** communicates with the rod end chamber **24** associated with the primary cylinder through passage **35**, valve bore **36** and passage **38** all formed in the primary piston **16**. A valve seat **40** in the valve bore **36** is adapted to receive a ball check valve **42** which normally prevents flow from the primary rod end chamber **24** to the secondary large chamber **31**. Seated within an enlarged portion of bore **36** is a pilot member **42'** having a stem **43** which when moved to its upper position engages ball member **42** and moves it away from seat **40** permitting reverse flow from the rod end chamber **24** to the large secondary cylinder chamber **31** when a sufficient pressure differential exists therebetween.

Fixed to and extending from the secondary piston **27** is a secondary rod **45** which consists of a plurality of concentric sleeves **47**, **48** and **49** which define therebetween passages **50**, **52** and a central passage **55** all for the purpose of feeding fluid to and from the actuator **10**.

A first port **56** communicates with passage **55** in the rod **45**. Passage **55** communicates with the primary large cylinder chamber **25** through a feed tube **57** which is centrally fixed with respect to the primary piston **16** and extends into the secondary rod assembly **45** and has an enlarged portion **59** which sealingly and slidably engages the interior of tube **49**. Also defined in the end of rod assembly **45** is a second port **62** which communicates with passage **52**. The passage **52** communicates with the large secondary cylinder chamber **31** through ports **65** in sleeve **49** and around the reduced portion of the feed tube **57**.

Also formed in the end of rod assembly **45** is a third port **66** which communicates with annular passage **50**. Annular passage **50** in turn communicates with the secondary rod and chamber through ports **68** in sleeve **47**.

A control circuit **70** is provided for the purpose of selectively extending either the primary cylinder **12** or the secondary cylinder **21** with respect to the rod assembly **45**. The circuit **70** is seen to consist of a first control valve **72** and a second control valve **74**. Both of these valves are conventional four-way closed center control valves with an internal bypass on the supply side as indicated at **75** in the closed center position. For the purpose of supplying fluid under pressure to the system a pump **77** is provided and a reservoir **78** collects drainage fluid. For the purpose of supplying and returning fluid from the port **56** relative to the control valve **72**, passages **81** and **82** are provided. For the purpose of supplying and returning fluid relative to port **52** from either of the control valves **72** or **74**, passages **85**, **86**, **87** and **88** are provided.

For the purpose of supplying fluid to and from the port **66** from control valve **74**, passages **90** and **91** are provided.

A pilot operated valve assembly **94** is provided for permitting either the drainage of fluid from port **56** or for the purpose of permitting recirculation of fluid from the contracting fluid chamber in the actuator to the port **56** during extension of the feed tube **57** when chamber **25** is not pressurized. Toward this end, a valve bore **96** is provided having a valve seat **97** which receives a ball valve **98** biased to a closed position by a light spring **100**. When the valve member **98** is in its closed position drainage from the conduit **82** and port **56** is prevented and thus the valve member **98** acts as a one-way valve. For the purpose of opening the ball valve **98** a pilot piston **102** is seated in an enlarged portion of the bore and has a stem **105** which when moved to its right position shown in FIG. 1 moves valve member **98** away from seat **97** permitting flow from passage **82** to drain passage **105'** or from drain passage **105'** to passage **82** which occurs during the recirculating function described above. Pilot piston **102** may be actuated by high pressure fluid in either line **90** or line **87** through one-way check valves **108** and **109**, respectively, which on their downstream sides communicate the pilot chamber **111**.

The function of the above-described apparatus will be more clearly understood from a description of the operation of the present device in its various modes. To place the actuator **10** in its locked position wherein both cylinders **12** and **21** are locked with respect to rod **45** both of the valves **72** and **74** are placed in their center blocking position. This blocks flow relative to ports **56**, **62** and **66** and holds the cylinders in position. At this time fluid from the pump **77** is delivered to tank **78** through passage **116**, through passage **117** in valve **74**, passage **118**, bypass passage **75** in valve **72**, and passage **120** to tank discharge line **121**.

To extend the secondary cylinder **21** with respect to the secondary rod **45** and at the same time lock the primary cylinder **12** with respect to piston **16**, valve **74** is shifted to its left position and valve **72** is placed in its center closed position as shown in FIG. 1. This pressurizes port **62** through lines **88**, **87** and **85** across the control valve **74**. At the same time port **66** is connected to return through passages **91**, **90** and across the control valve **74**.

With port **62** pressurized, fluid flows through passage **52**, ports **65** into the secondary cylinder chamber **31** causing expansion of this chamber and an extension of cylinder **21**. At the same time, high pressure in chamber **31** opens the ball valve **42** pressurizing the primary cylinder rod and chamber **24** tending to maintain the primary cylinder in or toward a retracted position.

As the secondary large cylinder chamber **31** expands during extension of cylinder **21**, the rod chamber **30**

associated with the secondary cylinder discharges through ports 68, passage 50 and port 66 across control valve 74. This discharge flow passes through line or passage 118, through valve 72 to passage 120. Some of this fluid flows to tank 78, and some recirculates across valve member 98 to passage 88 and port 56 into chamber 55 which of course is expanding under these conditions because of the relative movement between feed tube 57 and the rod assembly 45. The valve member 98 is maintained open under these conditions to effect this recirculation by fluid pressure in line 87 opening check valve 109 and pressurizing pilot chamber 111.

To retract the secondary cylinder 21 with respect to the secondary piston 27 without significantly moving the primary cylinder 12 with respect to the secondary cylinder, valve 72 remains in its closed center position and valve 74 is shifted to its right position pressurizing line 90 and port 66, and connecting port 62 to drain across valve 74 as shown in FIG. 2. With port 66 pressurized fluid under pressure will flow through passage 50 and ports 68 into the secondary rod chamber 30 effecting expansion of that chamber and the consequent retraction of cylinder 21 with respect to the piston 27. As the cylinder 21 retracts the secondary cylinder chamber 31 discharges through passages 65, annular passage 52 and port 62 across valve 74. The retraction of the primary cylinder 12 with respect to the secondary cylinder 21 is prevented since ball valve 42 is closed preventing flow from the primary rod chamber 24 into the secondary cylinder chamber 31.

As cylinder 21 retracts the feed tube 57 moves inwardly in passage 55 decreasing the volume thereof. To accommodate this decrease in volmue fluid is discharged from passage 55 through port 56 and across valve 98 to tank 78. To open valve member 98 under these conditions, high pressure fluid in passage 90 opens check valve 108 pressurizing pilot chamber 111 urging valve member 98 to its open position shown in FIG. 2.

To retract the primary cylinder 12 and hold the secondary cylinder 21 in either its extended or retracted position, valve 74 is placed in its center blocking position and valve 72 is shifted to its right position as shown in FIG. 3. This ports fluid under pressure from pump 77 across valve 72 through lines 81 and 82 pressurizing port 56. At the same time port 62 is connected to drain through lines 87 and 86 across valve 72. Valve 74 acts to block flow relative to port 66 through line 90. With both lines 90 and 87 at low pressure valve member 98 will remain closed under the influence of spring 100 and high pressure fluid in line 82. The pressurization of port 56 provides the flow of fluid under pressure into passage 55, through feed tube 57 into the primary cylinder chamber 25. This causes extension of cylinder 12 with respect to piston 16. Fluid under pressure in the feed tube 57 enters the valve bore beneath pilot piston 42' urging ball valve member 42 upwardly away from seat 40.

With cylinder 12 extending and the ball member 42 held open by the pilot stem, fluid in the primary rod end chamber 24 discharges across valve 42 through the secondary cylinder chamber 31. This fluid drains through passages 65, annular passage 52 in rod assembly 45, through port 62; discharging through lines 87 and 86 across valve 72 to tank 78, with flow relative to the port 66 being blocked. Flow to or from the rod end chamber 30 associated with the secondary cylinder is blocked preventing retraction or extension of the secondary cylinder 21 at this time.

For the purpose of retracting the primary cylinder 12 with respect to the rod assembly 45 without retracting or extending the secondary cylinder 21 with respect to the rod assembly 45, valve member 75 is placed in its center blocking position and valve member 72 is placed in its left position shown in FIG. 4. Fluid under pressure is delivered from pump 77 through the closed center valve 74 across valve 72, through lines 86, 87 and 88 pressurizing port 62. At the same time port 56 is connected to drain either across valve 72 through line 81 or across the ball valve 98 which is held in its open position by the pressurization of pilot chamber 111 across check valve 109.

Valve 74 blocks flow relative to port 66 thereby blocking flow in chamber 30 and preventing flow relative to the chamber and maintaining the secondary cylinder 21 fixed with respect to the rod assembly 45.

With the pressurization of port 62 fluid flows through passage 52, ports 65 through secondary cylinder chamber 31 opening ball valve 42 in piston 16 and passes into rod end chamber 24 of the primary cylinder 12. This expands chamber 24 causing the retraction of the primary cylinder 12 with respect to piston 16. Under these conditions fluid in chamber 25 associated with the primary cylinder discharges through feed tube 57 into passage 55 and drains through port 56.

I claim:

1. A multiple cylinder hydraulic actuator, comprising: first cylinder means, first piston means slidable in said first cylinder means, first rod means extending from said first piston means and defining second cylinder means, second piston means slidable in said second cylinder means, second rod means extending from said second piston means and said second cylinder means, means for extending one of said cylinder means relative to said second rod means without extending the other cylinder means with respect to said second rod means including means for pressurizing the rod side of one of the piston means and the side opposite the rod side of the other of said piston means simultaneously, and passage means in one of said piston means providing communication between the rod side of one of said piston means and the side opposite the rod side of the other of said piston means to simultaneously pressurize said sides.

2. A multiple cylinder hydraulic actuator as defined in claim 1, including one way valve means in said passage means to prevent extension of the cylinder means associated with the piston means with the passage means therein, and pilot operated means for opening said one-way valve means and permitting pressure flow and the selective extension of said associated cylinder means.

3. A multiple cylinder hydraulic actuator as defined in claim 2, including means for extending and retracting the first cylinder means independently of said second cylinder means relative to said second rod means, means for extending and retracting the second cylinder means independently of said first cylinder means with respect to said second rod means including pilot valve means, valve means for selectively pressurizing and draining the opposite sides of said first piston means, and second valve means for selectively pressurizing and draining the opposite sides of said second piston means.

4. A multiple cylinder hydraulic actuator as defined in claim 3, including first port means communicating with the side of said first piston means opposite said first rod means, second port means communicating with the rod side of said first piston means and the side opposite the rod side of the second piston means, and third port means communicating with the rod side of said second piston means, both said first and said second valves being connected to selectively pressurize said second port means.

5. A multiple cylinder hydraulic actuator, comprising: first cylinder means, first piston means slidable in said first cylinder means, first rod means extending from said first piston means and defining second cylinder means, second piston means slidable in said second cylinder means, second rod means extending from said second piston means and said second cylinder means, feed tube means in one of said cylinder means and slidably received in one of said piston means, said feed tube means being connected to convey fluid selectively to one side of one of said piston means, port means communicating with said feed tube means, valve means selectively pressurizing said port means, and a valve between said valve means and said

port means for supplying fluid to or draining said port means when said valve means is not pressurizing said port means.

6. A multiple cylinder hydraulic actuator as defined in claim 5, wherein said valve is connected to supply fluid under low pressure to said port means to fill the space occupied by said feed tube as the feed tube extends with respect to said second rod means without pressurizing said one side of said one of said piston means.

7. A multiple cylindrical hydraulic actuator as defined in claim 6, wherein said valve means includes first valve means for selectively porting fluid to either side of said first piston means and second valve means for selectively porting fluid to either side of said second piston means, said valve being responsive to fluid pressure from one of said valve means to port return fluid from one of the cylinder means to said port means.

8. A multiple cylinder hydraulic actuator as defined in claim 7, wherein said valve is a pilot operated one-way check valve.

9. A cylinder actuator, comprising: first cylinder means, first piston means slidable in said first cylinder means, first rod means extending from said first piston means, said first rod means defining second cylinder means, second piston means slidable in said second cylinder means, second rod means extending from said second piston means, feed tube means fixed to said first piston means and slidably received in said second piston means for communicating the side of said first piston means opposite said first rod means with the second rod means, valve means in one of said piston means selectively communicating one side of one of the piston means with one side of the other piston means, first port means communicating with the feed tube means, second port means communicating with the end of said second piston means opposite said second rod means, and third port means communicating with the rod side of said second piston means, first valve means for selectively porting fluid to said second and third port means, and second valve means for selectively porting fluid to said first and second port means.

10. A multiple cylinder hydraulic actuator as defined in claim 9, including an auxiliary valve communicating with said first port means for supplying fluid to said first port means when the feed tube means is extending.

11. A multiple cylinder hydraulic actuator as defined in claim 10, including passage means in said first piston means communicating the rod end of said first piston means with the side of said second piston means opposite said second rod, said valve means being in said passage means for selectively controlling flow relative to said rod end side of said first piston means.

12. A multiple cylinder hydraulic actuator, comprising: first cylinder means, first piston means slidable in said first cylinder means and defining therein first and second

chamber means on opposite sides of said first piston means, first rod means extending from said first piston means and defining second cylinder means, second piston means slidable in said second cylinder means and defining therein third and fourth chamber means on opposite sides of said second piston means, a one way valve between one chamber associated with the first piston means and one chamber associated with the second piston means permitting flow from one of said one chambers to the other but preventing flow in the reverse direction, and means for selectively extending or retracting said first piston means with respect to said first cylinder means or said second piston means with respect to said second cylinder means including three port means in said actuator, said three port means communicating with said first, second, third and fourth chamber means, and valve means for selectively pressurizing, connecting to drain, or blocking flow relative to said thre port means to either extend or retract said first piston means or said second piston means independently of each other.

13. A multiple cylinder hydraulic actuator as defined in claim 12, wherein one of said port means communicates with one of said chamber means, a second of said port means communicates with a second chamber means; and a third of said port means communicates with both of the remaining chamber means.

14. A multiple cylinder hydraulic actuator as defined in claim 13 wherein said one of said port means communicates with said chamber means on the non-rod side of the first piston means, the second of said port means communicates with the rod side of the second piston means, and the third of said port means communicates with both the rod side of the first piston means and the non-rod side of the second piston means.

15. A multiple cylinder hydraulic actuator as defined in claim 12 involving means for selectively opening said one way valve between said chambers to permit reverse flow therebetween.

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U.S. Cl. X.R.

91—173, 422; 92—108