Aug. 26, 1952 V. V. BLASUTTA ET AL 2,608,182

CONTROL MECHANISM FOR HYDRAULIC APPARATUS

Filed April 15, 1948 5 Sheets-Sheet 1

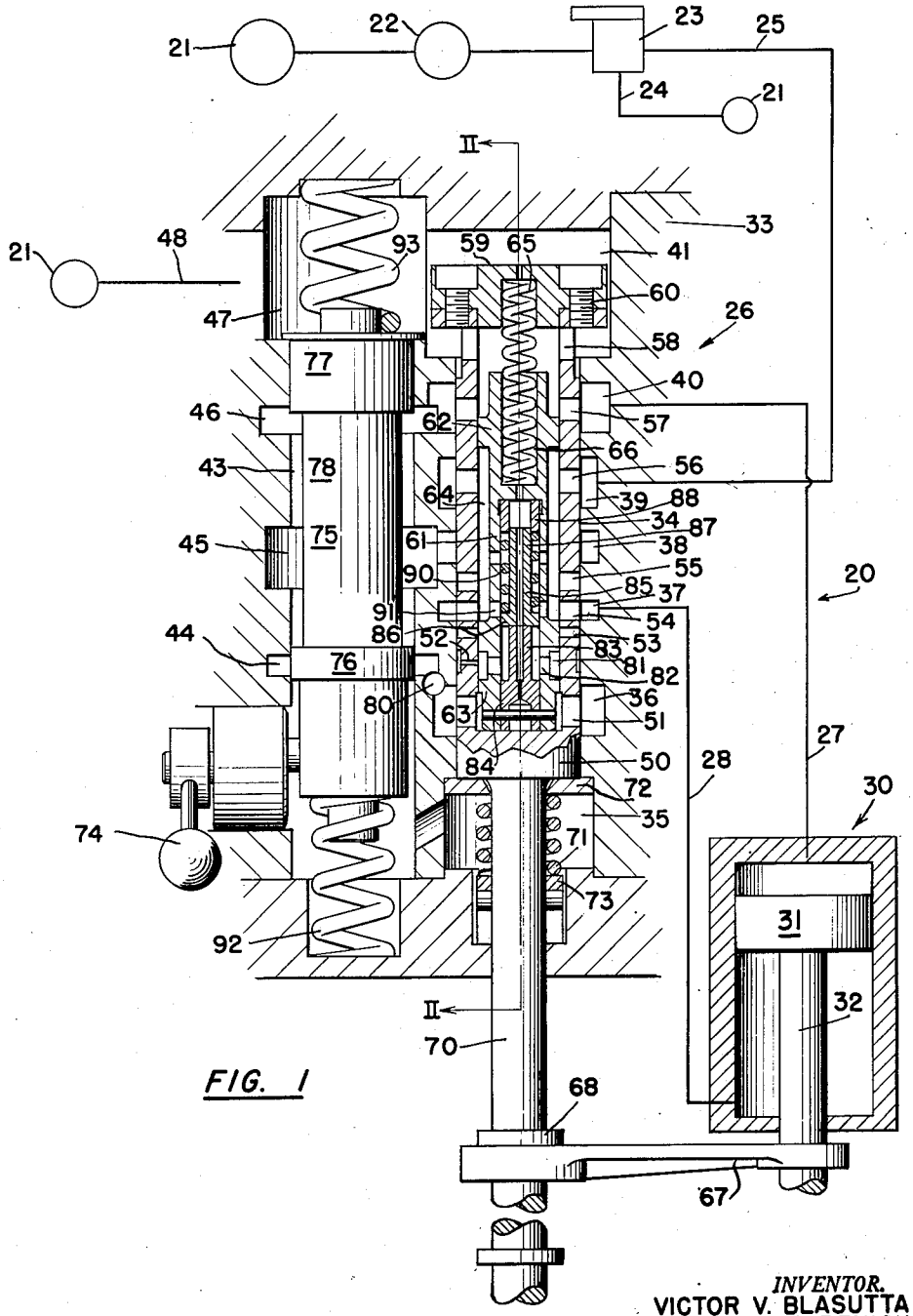


FIG. 1

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CONTROL MECHANISM FOR HYDRAULIC APPARATUS

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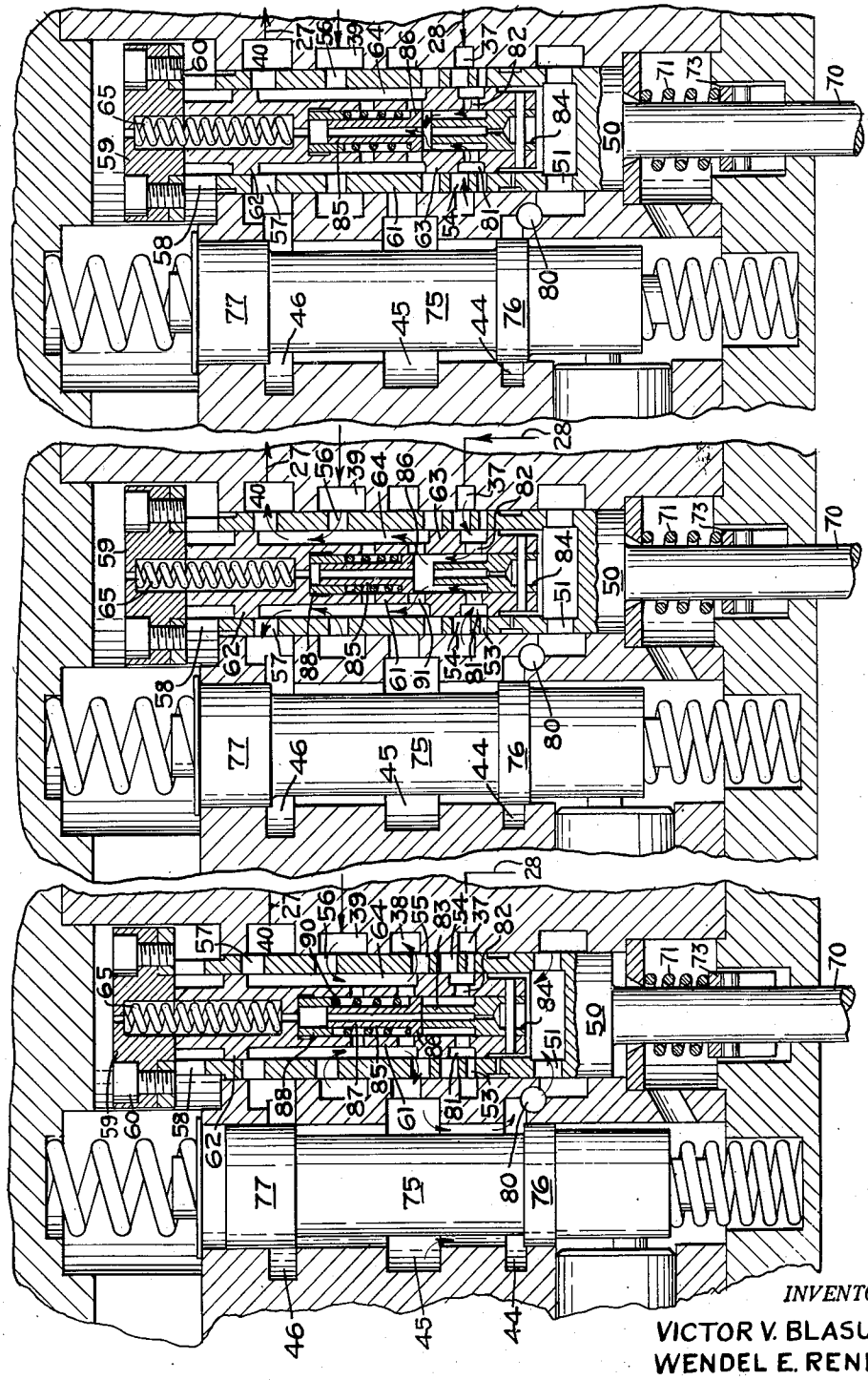


FIG. 1C.

FIG. 1B.

FIG. 1A.

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CONTROL MECHANISM FOR HYDRAULIC APPARATUS

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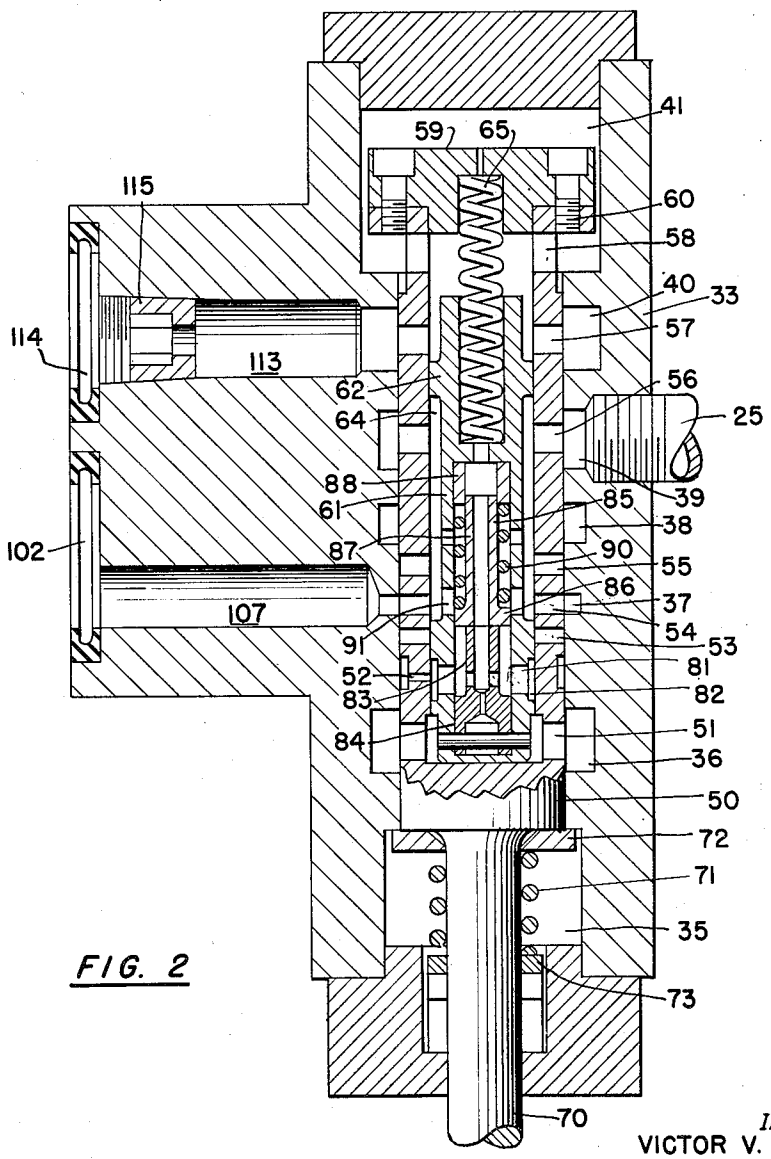


FIG. 2

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CONTROL MECHANISM FOR HYDRAULIC APPARATUS

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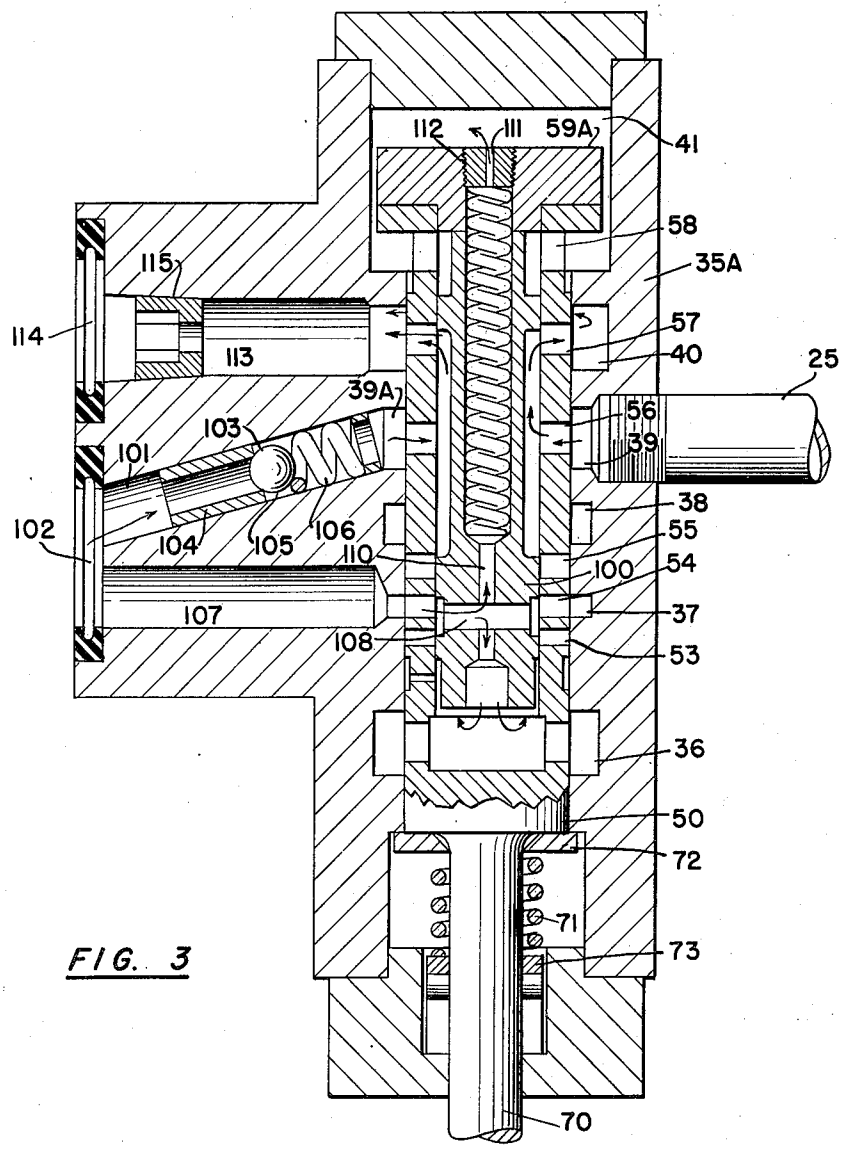


FIG. 3

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CONTROL MECHANISM FOR HYDRAULIC APPARATUS

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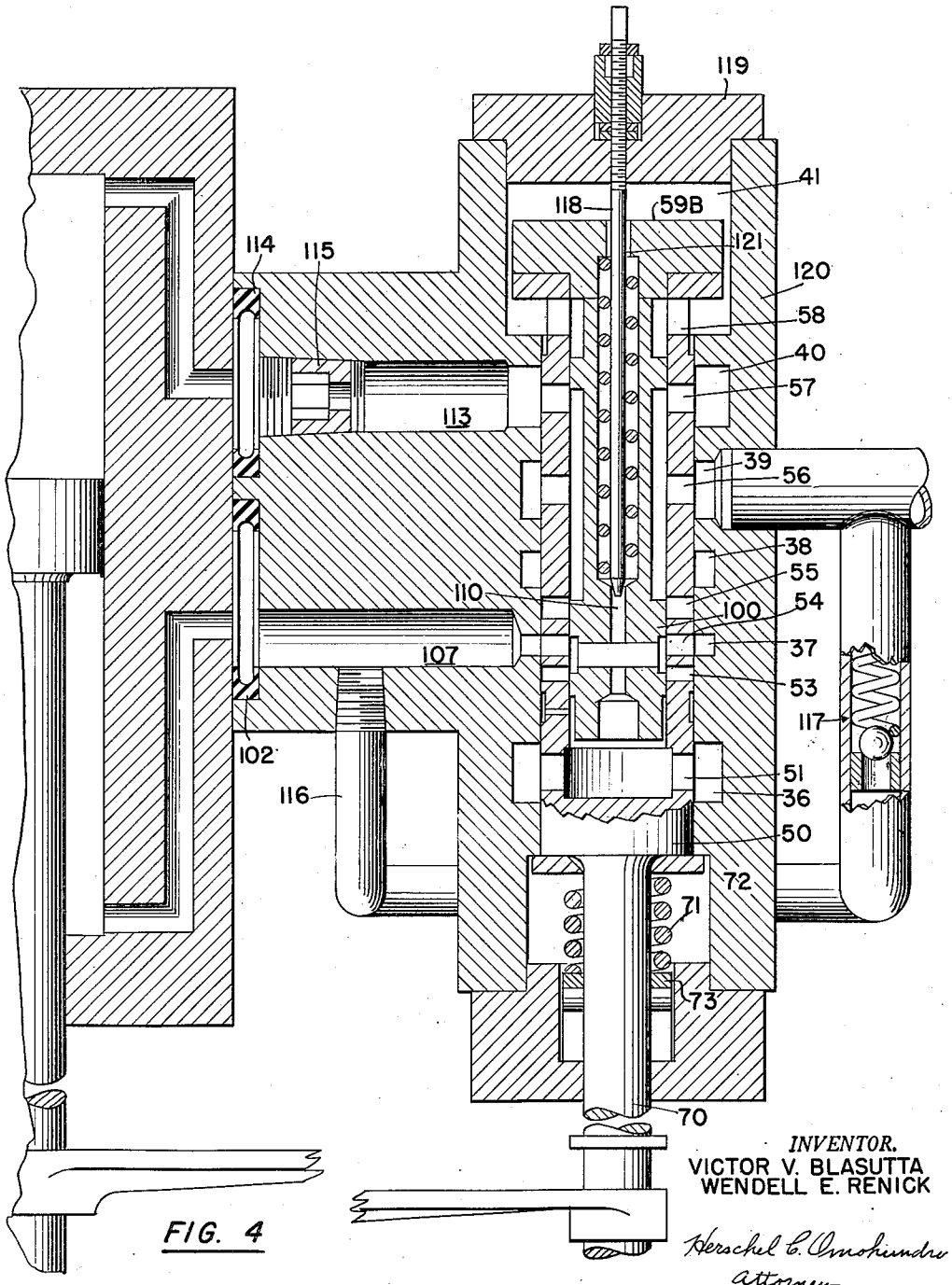


FIG. 4

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UNITED STATES PATENT OFFICE

2,608,182

CONTROL MECHANISM FOR HYDRAULIC APPARATUS

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Application April 15, 1948, Serial No. 21,166

7 Claims. (Cl. 121—38)

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This invention relates generally to hydraulic apparatus and is particularly directed to control valve mechanism and hydraulic circuits for hydraulic motors particularly of the reciprocating piston type.

One of the objects of the invention is to provide a control valve mechanism which may be employed in a hydraulic circuit to govern the operation of a hydraulic motor whereby the movable element of the motor, such as a piston of a piston and cylinder type motor, may be caused to move rapidly during a portion of the working stroke of the motor and thereafter develop a predetermined tonnage, the movable member operating at a slower rate during the exertion of the predetermined force.

Another object of the invention resides in providing a control valve mechanism for a hydraulic press which valve mechanism will permit the connection of both ends of the power cylinder with the source of supply of fluid pressure during a portion of the power stroke of the press ram and then automatically interrupt communication between one end of the power cylinder and the source of fluid pressure to cause the ram to develop a desired force during the remainder of the stroke.

A further object of the invention is to modify a control valve of the types shown in the copending application of Cecil E. Adams, Serial No. 589,163, filed April 19, 1945, now Patent 2,491,355, dated December 13, 1949, to secure rapid movement of a press ram during its approach toward the work in a press operation and automatically change over to slow speed and increased force after the work has been engaged by the ram.

A further object of the invention is to provide a control valve mechanism having a casing and a pair of movable elements, which elements are movable relative to the casing and to one another to alternately direct fluid from a source of pressure to opposite ends of a power cylinder to effect the reciprocation of a piston therein, certain of the elements being so constructed and cooperating with the other elements that one end of the power cylinder will be connected with the fluid pressure source during a portion of the time the other end of the power cylinder is connected thereto, the decrease in fluid pressure in the first mentioned end due to the engagement of the ram with the work and the consequent reduction in the rate of travel thereof, causing an adjustment of the valve parts to connect the said one end of the power cylinder to exhaust whereby the full

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supply of fluid pressure from the source will be directed to the other end of the power cylinder to cause the exertion of the maximum force by the ram.

A still further object of the invention is to provide a four-way valve having a casing with a chamber, a sleeve valve disposed for reciprocation in the chamber, the sleeve valve having ports registering with recesses in the valve body, a spool valve mounted for movement in the sleeve valve to control communication between sets of ports in the latter and a valve stem carried by the casing and cooperating with a passage in the spool valve to interrupt communication between certain ports in the sleeve valve and casing, the spool valve being normally urged toward one position and responsive to fluid pressure to move in opposition to the urging means to another position, a decrease in the fluid pressure permitting the spool valve to move to a third position wherein the passage in the spool valve will not be affected by the valve stem carried by the valve casing.

A still further object of the invention is to provide a valve of the type set forth in the preceding paragraph wherein the valve stem carried by the casing is eliminated and a reduced diameter orifice substituted therefor, the valve mechanism operating in substantially the same manner.

Another object of the invention is to provide a control valve mechanism having a casing with a bore for the reception of a sleeve valve, the casing having a plurality of recesses spaced longitudinally of the bore, the sleeve valve having longitudinally spaced sets of ports for registration with the recesses in the casing, the sleeve valve receiving a spool valve which is normally urged toward one position to connect certain of the ports in the sleeve valve and responsive to fluid pressure to move in opposition to the urging means to another position to connect other ports in the sleeve valve, the spool valve in turn receiving a slidable valve element which is also urged to a position to interrupt communication between certain ports in the first spool valve, the slidable valve element also being responsive to fluid pressure to move to a position to establish communication between ports in the spool valve, a reduction in the fluid pressure permitting the last mentioned valve element to return to the position in which communication between the ports in the spool valve is interrupted.

Further objects and advantages of the present invention will be apparent from the following

description, reference being had to the accompanying drawings wherein a preferred form of embodiment of the invention is clearly shown.

In the drawings

Fig. 1 is a diagrammatic view of a control valve formed in accordance with the invention with parts shown in section to illustrate the control valve mechanism and the power cylinder, the operation of which is governed by the control valve mechanism, the parts of the valve being shown in the positions occupied during the retraction of the ram of the power cylinder.

Figs. 1–A, 1–B and 1–C are similar views showing the control valve mechanism in different stages of operation, Fig. 1–A showing the valve parts positioned to initiate an operation of the ram; Fig. 1–B shows the parts in position to cause a rapid advance of the ram; Fig. 1–C shows the valve parts in the positions occupied when the ram is exerting its maximum force while advancing.

Fig. 2 is a detail vertical sectional view taken through the control valve mechanism on the plane indicated by line II—II of Fig. 1.

Fig. 3 is a similar view taken through a modified form of the control valve mechanism, and

Fig. 4 is also a similar view taken through a still further modified form of the control valve mechanism.

Referring more particularly to the drawings, the numeral **20** designates the completed hydraulic circuit. This circuit includes a source of fluid pressure having a reservoir **21**, a motor driven pump **22** and a relief valve **23**, the latter being of any suitable type for limiting the maximum pressure to be generated in the hydraulic system. An exhaust line **24** leads from the relief valve **23** to the reservoir **21** to carry fluid bypassed by the relief valve when the pressure in the system reaches a predetermined maximum value.

Line **25** extends from the relief valve to the valve mechanism **26** forming the subject matter of the present invention. A pair of lines **27** and **28** lead from the control valve mechanism **26** to the upper and lower ends of a power cylinder **30**. This power cylinder has a piston **31** disposed therein for reciprocation, a ram **32** projecting from the piston through the lower end of the power cylinder.

The valve mechanism **26** includes a casing **33** in which a longitudinally extending bore **34** is formed, the casing having annular grooves **35** to **41**, inclusive, formed therein and spaced longitudinally of the bore **34**. The casing has a second bore **43** disposed in parallel relationship to the first bore, the casing having annular recesses **44** to **47**, inclusive, formed therein and spaced longitudinally of the second bore. Recesses **38** and **45** are connected at adjoining portions as are recesses **40** and **46**, and, **41** and **47**. As illustrated in Fig. 1, recess **39** is directly connected with the source of fluid pressure by the line **25**, while lines **27** and **28** directly connect the upper and lower ends of the power cylinder with the top and bottom cylinder ports or recesses **40** and **37**, respectively. Recess **47** is connected by a line **48** with the reservoir **21**. The bore **34** is formed for the reception of a sleeve valve **50**, in which longitudinally spaced sets of laterally directed ports **51** to **58**, inclusive, are formed, certain of these sets of ports being disposed in registration with certain of the grooves or recesses in the casing.

The sleeve valve **50** is closed at its upper end by a cap **59**, which is secured to the sleeve valve by machine screws **60**. The sleeve valve in the first form of the invention illustrated, receives a shuttle valve spool **61**, which has upper and lower land portions **62** and **63** defining a groove **64**, which establishes communication between certain ports in the sleeve valve in different positions of movement of the spool **61** therein. Normally the valve spool **61** occupies the position shown in Fig. 1, which is at the lower end of the chamber in the sleeve valve **50**, being yieldably urged towards this position by a coil spring **65** disposed in a socket **66** formed in the upper end of the valve spool and a mating socket formed internally of the cap **59**. When the spool valve occupies the position shown, the groove **64** establishes communication between ports **56** which are then in communication with the fluid pressure source and ports **54**, which register with the groove **37**, the latter being connected as above-mentioned with the lower end of the power cylinder by line **28**. At this time fluid pressure from the source may flow to the lower end of the power cylinder to urge the piston **31** in an upward direction. Fluid discharged from the upper end of the power cylinder during the upward movement of the piston will flow through line **27** to recess **40** from which it will flow through ports **57** to the interior of the sleeve valve at the upper end thereof. This fluid will flow outwardly through ports **58** to recess **41** from which it will flow by way of recess **47** and line **48** to reservoir **21**.

When the piston approaches the upper end of the power cylinder, an arm **67** secured to ram **32** will engage a collar **68** fixed on a shipper rod **70** which depends from the lower end of the sleeve valve **50**. When the collar **68** is engaged by the arm, it will move the shipper rod and the sleeve valve **50** in an upward direction in opposition to spring **71**, which is disposed between a washer **72** in recess **35** and a collar **73** surrounding shipper rod **70** in the lower end of the recess **35**. The ram will continue to move in an upward direction until, as shown in Fig. 1–A, ports **54** are moved out of registration with recess **37**. At this time fluid flow to the lower end of the power cylinder will be discontinued and the ram will stop moving.

When the sleeve valve is moved upwardly, as mentioned above, until communication between ports **54** and groove **37** is interrupted, communication will be established between ports **55** and recess **38** also as shown in Fig. 1–A. At this time valve **75** will be in the position shown in Fig. 1 and fluid admitted to the interior of the sleeve valve through the ports **56** will flow outwardly through ports **55** to recess **38**, from which it will flow to recess **45**. This fluid will flow upwardly in bore **43**, refer to Fig. 1, to recess **46** from which it will flow through connecting recess **40**, ports **57**, the interior of the sleeve valve **50** and ports **58** to recess **41**. The fluid will be discharged from this recess through recess **47** and line **48** to reservoir **21**. The pump **22** will then operate under a minimum load.

When it is desired to initiate a pressing stroke of the ram **32**, a control handle **74** is operated to move a spool **75** disposed for adjustment in bore **43** to a position, see Fig. 1–A, to interrupt communication between grooves **45** and **46** and establish communication between grooves **45** and **44**. This operation is made possible by providing spool **75** with spaced land portions **76** and **77**, which define a groove **78** in the exterior

of the spool 75. When grooves 44 and 45 are in communication fluid flowing from the power source through line 25, recess 39, ports 56 and 55 to recess 38 will be directed through grooves 45, 78 and 44 to a hole 80, which connects groove 44 with groove 36. The fluid thus introduced to groove 36 will flow through ports 51 to the interior of the sleeve valve 50 beneath shuttle valve 61.

The pressure of this fluid will move the shuttle valve 61 upwardly in opposition to the spring 65 to a position, see Figs. 1–A, 1–B and 1–C, wherein the groove 64 in the shuttle valve will establish communication between ports 56 and 57. The source of fluid pressure will then be directly connected with the upper end of the power cylinder and fluid from the pump will flow into the cylinder above piston 31. This fluid will cause the piston to move in a downward direction, exhausting fluid from the lower end of the power cylinder through line 28 to groove 37. At this time ports 53, see Fig. 1–A, in sleeve valve 50 will be in registration with the groove 37 and fluid will flow to the interior of the sleeve valve 50 through these ports and to an annular groove 81 formed in land 63 of shuttle valve spool 61.

Groove 81 is connected with the interior of the shuttle valve spool by ports 82 and the fluid will flow through these ports to a space surrounding a reduced projection 83 formed on a plug 84, which is pinned in the center bore of the shuttle valve spool. Immediately above the projection 83, the center bore of the shuttle valve spool receives for sliding movement, a valve element 85 which has a headed lower end 86 and a reduced extension 87 projected upwardly therefrom this reduced extension being slidably received in a bushing 88 which is pressed into the center bore of the spool 61. A coil spring 90 surrounds the reduced portion 87, the ends of this spring engaging the bushing 88 and the head 86. Normally this spring maintains the element 85 in its lowermost position, as illustrated in Figs. 1 and 1–A, wherein the head 86 engages the projection 83. When, however, fluid is discharged from the lower end of the power cylinder and this fluid is introduced into the interior of the shuttle valve through ports 82, a pressure will be generated which will move the element 85 against the opposition of the spring 90 until communication is established between the space surrounding extension 83 and the central bores formed in the plug 84, the valve element 85 and the spool 61. Since during the initial portion of the stroke of the ram 32 only a minimum of opposition to movement is encountered, the ram and piston will move rapidly discharging a rather large volume of fluid through line 28. The flow of this large volume to exhaust is resisted by the reduced passages and openings formed in the valve element 85 and cap 59 causing an increase in the back pressure until valve element 85 is moved to a position, see Fig. 1–B, establishing communication between ports 91 and 82. At this time fluid discharged from the lower end of the power cylinder will combine with the fluid supplied from the pressure source and will flow to the upper end of the power cylinder. The back pressure is transmitted through the center opening in plug 84 to the fluid in the sleeve beneath the shuttle valve spool, this pressure operating to retain the shuttle valve in its elevated position wherein the source of fluid pressure is connected with the upper end of the power cylinder. The shuttle valve spool will be held elevated by the back pressure even though the valve spool 75 is returned to the normal position, see Fig. 1–B, by its springs 92 and 93, thus discontinuing the flow of fluid pressure from the source to the space beneath the shuttle valve.

When the back pressure on the fluid exhausted through line 28 moves valve element 85 to a position establishing communication between ports 91 and 82, the fluid being exhausted through line 28 will combine with the fluid from the pressure source, as mentioned above, and flow to the upper end of the power cylinder. The effective area of the piston 31 will thus be reduced to the area of the ram 32, the full pump volume being effective over this reduced area to cause movement of the ram. Initial movement of the piston will cause the arm 67 to move from the collar 68, permitting spring 71 to move the shipper rod 70 and sleeve valve 50 downward, until the end of the sleeve valve engages the washer 72, as shown in Figs. 1–B and 1–C.

At this time ports 54 will register with groove 37 and fluid discharged from the power cylinder will then flow through ports 54. The rapid movement of the piston 31 will continue until the ram meets an obstruction which will offer sufficient resistance to the force exerted by the ram with the reduced effective area to reduce the speed of ram motion. This reduction in rate of motion of the ram will reduce the volume of fluid being exhausted through line 28, which in turn will reduce the pressure in the bore in the shuttle valve beneath the valve element 85 and in the sleeve valve beneath the shuttle spool 61. Spring 90 will thus be permitted to move valve element 85 toward a position, see Fig. 1–C, to interrupt communication between ports 82 and 91 and the shuttle valve spool will be moved by spring 65 to a position wherein the upper end of the shuttle valve will be spaced from cap 59. After the element 85 has moved the distance necessary to interrupt communication between ports 82 and 91 the full pump volume will be available over the entire upper surface of the piston 31 rendering this surface effective to cause movement of the ram. With the increased effective area of the ram a greater force will be exerted which will cause the ram movement to continue until the ram meets an obstruction which will offer sufficient resistance to movement of the piston 31 as to cause the relief valve 23 to vent the entire pump volume to the tank or reservoir 21. At this time the ram will be exerting the tonnage for which the relief valve had previously been adjusted.

When the relief valve spills fluid to reservoir 21, ram 32 will cease to move and exhaust flow of fluid through line 28, will also cease. The fluid beneath the shuttle valve, will be dissipated through the center openings in the plug 84, valve element 85 and shuttle valve 61, permitting spring 65 to move the shuttle valve back to its lowermost position, as shown in Fig. 1, wherein groove 64 establishes communication between the source of fluid pressure and the line leading to the lower end of the power cylinder. At this time, the ram will move in an upward direction, discharging fluid from the upper end of the power cylinder, through line 27 as previously described. The final stage of the return movement of the ram will cause the upward movement of the shipper rod 70 and sleeve valve 50, also as previously described, until fluid flow to line 28 is discontinued, the fluid from the pressure

source then being directed through ports 55 to grooves 38 and 45 from which the fluid will be exhausted to the reservoir as outlined previously.

If continuous operation of the ram is desired the valve spool 75, may be retained in a position to establish communication between grooves 44 and 45, so that when fluid is supplied to groove 45 after the upward movement of sleeve valve 50 a subsequent ram operation will be initiated automatically.

In the form of the invention illustrated in Fig. 3, the valve mechanism is substantially the same as that shown in Figures 1 and 2, except the shuttle valve spool 100 does not contain the valve element 85, nor, the plug 84, neither, is the shuttle valve 100 provided with the ports 91.

In the form of invention shown in Fig. 3, the valve body 35A is provided with a passage 101, which extends from the bottom cylinder port 102, to the groove 39A which communicates with the line 25 leading from the fluid pressure source. Passage 101 contains a spring pressed check valve 103 which comprises a valve seat 104, a ball valve 105 and a spring 106, the check valve 103 serving to prevent fluid flow from the groove 39A to the bottom cylinder port 102, but permitting flow in the opposite direction.

Fig. 3 illustrates the parts of valve mechanism in the positions which they will occupy during the portion of the pressing stroke of the ram immediately following the initial movement of the ram, that is, after the ram has moved a distance sufficient to permit the spring 71 to move sleeve valve 50 downward until the lower end has engaged the washer 72. As the ram moves in a downward direction fluid will be discharged from the power cylinder to the bottom cylinder port 102, a portion of this fluid flowing through passage 107 to groove 37. Some of this fluid will be permitted to flow through ports 54 to a transverse passage 108 formed in the shuttle valve and outwardly therefrom through a longitudinal passage 110 provided in the shuttle valve. The flow of this fluid will be resisted by an orifice 111, formed in a plug 112, which is threaded into an opening provided in the cap 59A for the sleeve valve 50. Due to the resistance to flow offered by the orifice 111, a back pressure will be created on the exhaust fluid which back pressure will be transmitted through an opening in the lower end of the shuttle valve to the space in the sleeve valve 50, beneath this shuttle valve. The reaction of this fluid pressure will tend to retain the shuttle valve in its elevated position wherein the upper end of the shuttle valve is disposed in sealing engagement with the underside of the cap 59A. The back pressure on the exhaust fluid will also be applied to the ball valve 105 moving the same in opposition to the spring 106 to an open position wherein the exhaust fluid will combine with the fluid supplied from the pressure source and will flow through passage 113 to the top cylinder port 114 from which it will flow through line 27 to the upper end of the power cylinder. Passage 113 contains an orifice element 115, which insures a sufficient pressure on the operating fluid as to make the valve mechanism operate satisfactorily. The mechanism shown in the modified form has the same effect on the operation of the ram as the mechanism shown in the first form of the invention described, that is, when exhaust fluid flows through passage 101 and combines with the fluid pressure supply the effective area of the piston in the power cylinder will be reduced to the area of the ram, the entire pump volume being exerted on the reduced area to cause a rapid movement of the ram. Due to the reduction in the effective area the resultant force of the ram will be reduced and consequently when the ram engages an obstruction which offers sufficient resistance, the rate of movement of the ram will decline. Because of this reduction in the rate of movement, the back pressure on the exhaust fluid will be reduced permitting the shuttle valve spring to start to move the shuttle valve toward a lower position. When this movement occurs the upper end of the shuttle valve will move away from the under surface of the cap 59A, permitting the exhaust fluid to by-pass the orifice 111, which will further reduce the back pressure. After the back pressure falls sufficiently spring 106 will return ball valve 105 to its seat causing the exhaust fluid to cease flowing through passage 101, whereby, the effective area of the piston will be increased to the full diameter thereof. The full pump volume will then be exerted over the full area of the piston, causing the force exerted by the ram to increase, which will permit the ram to continue to move, although at a reduced rate. The flow of exhaust fluid will be sufficient to maintain the back pressure necessary to hold the shuttle valve in a partially elevated position to continue the communication between the fluid pressure source and the line leading to the upper end of the power cylinder. The shuttle valve will be held in this position until the resistance to movement of the ram reaches a magnitude sufficient to cause the relief valve to spill the pump volume to the reservoir 21, at which time the ram will stop, permitting the exhaust flow to cease also. The cessation of exhaust flow will cause the dissipation of the back pressure and permit the shuttle valve to move to its lower position wherein the source of fluid pressure will be connected with the lower end of the power cylinder. The ram will then be moved in its return stroke preparatory to starting a subsequent cycle of operation.

In the form of the invention illustrated in Fig. 4, the mechanism is substantially the same as that illustrated in Fig. 3, except that the passage 101, has been omitted and an exterior fluid conducting line 116, substituted therefor. This line contains a check valve 117 corresponding in function to the check valve 103. The same shuttle valve 100 is employed but the plug 112 with the orifice 111 has been eliminated, the function of these elements being performed by a valve stem 118, which is adjustably carried by the cap 119 for the casing 120 of the valve mechanism. Valve stem 118 projects downwardly through an opening 121 formed in cap 59B for spool 50, the lower end of the valve stem registering with the central longitudinal passage 110 of shuttle valve spool 100.

When this shuttle valve spool is elevated through the introduction of fluid pressure to the space beneath the same, the valve stem will restrict the fluid flow through the passage 110 causing a back pressure to be generated on the exhaust fluid which back pressure will be transmitted to the space beneath the shuttle valve spool to hold the spool elevated.

This back pressure will also be applied through the conduit 116 to the check valve 117 and will move this valve to an open position wherein the exhaust fluid from the power cylinder will combine with the fluid from the pressure source and

be conducted to the upper end of the power cylinder. The operation of the power cylinder will be substantially the same as with the other valve mechanisms above described, the combination of the exhaust fluid with the fluid from the pressure source serving to reduce the effective area of the piston in the power cylinder thus making the full pump volume available over a piston area equal to the ram area. When the rate of ram movement declines due to the fact that the ram is exerting a force insufficient to cause movement, the back pressure will fall, permitting the shuttle valve to lower a distance sufficient to allow the fluid flowing from the power cylinder to be discharge to the reservoir, rather than be combined with the pressure source.

The retraction of the ram when the modified valve mechanism shown in Fig. 4 is employed is the same as when the other forms of valve mechanisms are employed. It will be apparent from the foregoing description, that means have been provided for controlling the flow of fluid from a source of pressure to a fluid motor which will permit the effective area of the piston of the motor to be reduced whereby the full volume of the pressure source is available to cause a rapid movement of the piston.

A number of modifications of the valve mechanism have been shown. The operation of the fluid motor controlled by the various modifications is identical, the rapid rate of exhaust fluid flow from the power cylinder serving to create a back pressure, which is utilized to establish communication between the exhaust line and the inlet line, or, fluid pressure source and a diminution of sufficient back pressure, due to a reduction in the rate of movement of the piston of the motor, being employed to increase the effective area of the piston so that the full volume of the pressure source will be applied to the increased piston area to increase the force exerted. While the mechanism is different in each of the modifications the fundamental principles of operation are identical.

The claims which follow have been drawn with the object of covering all of the forms shown and any other modifications embraced thereby.

We claim:

1. In a hydraulic system, a motor of the cylinder and piston type; a source of fluid pressure; control valve mechanism between said source and said motor comprising a casing having a chamber and inlet, cylinder and exhaust ports; means establishing communication between said inlet port and said pressure source and between the ends of said cylinder and said cylinder ports; relatively movable valve elements in said chamber for alternately connecting the inlet and exhaust ports with said cylinder ports to cause the reciprocation of said piston in said cylinder; a passage providing for fluid flow from a selected cylinder port to said inlet port; a normally closed valve in said passage; a fluid flow resisting element cooperating with a selected movable valve element, when it is in a certain position, to limit the fluid flow from said selected cylinder port to exhaust to create a back pressure, said selected valve element being retained in said certain position and said normally closed valve being opened by such back pressure; and means for moving said selected valve element to a position to render said flow-resisting element ineffective upon diminution of said back pressure.

2. Control valve mechanism for a reversible fluid motor comprising a casing having a chamber and inlet, forward-and-reverse-motor, and exhaust ports communicating with said chamber; a primary valve element disposed for movement in said chamber, said primary valve element being tubular and having ports registering with the ports in said casing in various positions of said element in said chamber; a secondary valve element disposed for movement in said primary valve element to alternately connect said inlet and exhaust ports with said forward and reverse motor ports; resilient means normally urging said secondary valve element toward a position in which said reverse motor port is connected with said inlet and said forward motor port is connected with said exhaust; means for momentarily applying fluid at inlet port pressure to said secondary valve element to move the same in opposition to said resilient means to a position in which said forward motor port is connected with said inlet and the reverse motor port is connected with said exhaust; flow-restricting means between said reverse motor port and exhaust to create back pressure, said back pressure being applied to said secondary valve to retain the same against movement by said resilient means; a second flow-resisting means operative when said secondary valve element is held against movement by said resilient means to further increase the back pressure; a valve controlled passage extending between said reverse motor and inlet ports, the valve in said passage being responsive to the increased back pressure to permit flow from said reverse motor port to said inlet port.

3. Control valve mechanism for a reversible fluid motor comprising a casing having a chamber and inlet, forward-and-reverse-motor, and exhaust ports communicating with said chamber; relatively movable valve elements disposed in said chamber, said valve elements being operable in a first relative position of movement to connect the inlet and forward-motor ports and the reverse motor and exhaust ports, and to reverse such connections in a second relative position of movement; fluid flow controlling means for momentarily applying fluid at inlet port pressure to said valve elements to dispose them in the first relative position; fluid flow-resisting means operative when said valve elements are in said first relative position to limit fluid flow from said reverse-motor port to exhaust to create a back pressure; a valved passage extending between said reverse-motor port and said inlet, the valve in said passage being responsive to back pressure to permit fluid flow only in the direction from said reverse-motor port to said inlet; resilient means normally urging said valve elements toward said second relative position, initial movement of said valve elements from said first toward said second relative position rendering said flow-resisting means inoperative; and a second flow-resisting means operative to limit fluid flow from said reverse-motor port to exhaust when the first-mentioned flow-resisting means is inoperative to create a lesser back pressure, said back pressures being applied to said valve elements to oppose movement thereof by said resilient means.

4. Control valve mechanism for a reversible fluid motor comprising a casing having a chamber and inlet, forward-and-reverse-motor, and exhaust ports communicating with said chamber; relatively movable valve elements disposed

in said chamber, said valve elements being operable in a first relative position of movement to connect the inlet and forward-motor ports and the reverse motor and exhaust ports, and to reverse such connections in a second relative position of movement; an exhaust passage provided in one of said elements, said passage connecting said reverse motor port with said exhaust port in the first position of movement of said elements; a flow-resisting valve member at least partially obstructing said exhaust passage when said elements are in said first position of movement to limit such flow and create a back pressure; a valved passage extending between said reverse motor and said inlet port, the valve in said passage being responsive to such back pressure to permit fluid flow only in the direction from said reverse motor port to said inlet port; resilient means normally urging said valve elements toward said second relative position, initial movement of said valve elements from said first toward said second relative position serving to relieve the obstruction caused by said flow-resisting valve member to increase the exhaust flow through said exhaust passage and decrease the back pressure whereby flow from said reverse motor port through said valved passage to said inlet port will be discontinued.

5. Control valve mechanism for a reversible fluid motor comprising a casing having a chamber and inlet, forward-and-reverse-motor, and exhaust ports communicating with said chamber; valve elements in said chamber, said elements being movable relative to one another and said casing to alternately connect said inlet and exhaust ports with said forward and reverse motor ports to cause forward and reverse operation of said motor, one of said valve elements being responsive to fluid pressure to establish communication between said inlet and forward motor ports and between said outlet and reverse motor ports; a passage extending between said reverse motor port and said inlet port; flow resisting means between said reverse motor port and said exhaust port, said resisting means causing a back pressure; and yieldably closed valve means in said passage to prevent fluid flow from said inlet to said reverse motor port, said back pressure serving to retain said pressure responsive valve element in position to connect said inlet and forward motor port and to open said yieldably closed valve to establish communication between said reverse motor and inlet ports while the latter is connected with said forward motor port.

6. Control valve mechanism for a reversible fluid motor comprising a casing having a chamber and inlet, forward and reverse motor and exhaust ports; primary valve elements disposed in said chamber for movement relative to one another and said casing alternately connect said inlet and exhaust ports with said motor ports to cause forward and reverse operation of said motor, one of said primary valve elements being responsive to fluid pressure to establish communication between said inlet and forward motor port and between said exhaust and reverse motor ports; a passage extending between said reverse motor port and said inlet port; a secondary valve element in said passage; spring means yieldably urging said secondary valve element toward a passage closing position; flow resisting means between said reverse motor and exhaust ports, said resisting means causing a back pressure, said fluid pressure responsive primary valve element

and said secondary valve element being exposed to the back pressure to retain the former in position to establish communication between said reverse motor and exhaust ports and to open the latter to connect said reverse motor port with said inlet during connection thereof with said forward motor port; and spring means for urging said fluid pressure responsive primary valve element toward a position to interrupt the communication between said forward motor port and said inlet, the spring for said secondary valve element serving to move said secondary valve to close said passage before the other spring moves the primary valve element to a position to interrupt fluid flow between said inlet and the forward motor port.

7. Control valve mechanism for a reversible fluid motor comprising a casing having a chamber and inlet, forward and reverse motor and exhaust ports; a ported sleeve valve disposed for movement in said chamber; a ported shuttle valve disposed for movement in said sleeve valve to establish communication between certain sets of ports in said sleeve valve; a third valve element disposed for movement in said shuttle valve to control communication between the ports in said shuttle valve; spring means tending to yieldably retain said valves in predetermined positions wherein said inlet port is connected with said reverse motor port and said exhaust port is connected with said forward motor port; means for momentarily directing fluid pressure against said shuttle valve to move the same to a second position to connect the inlet port with said forward motor port and said reverse motor port with said exhaust port; and flow resisting means between said reverse motor and exhaust ports and operative when said shuttle valve is in said second position to resist fluid flow from said reverse motor port to exhaust to create a back pressure, such back pressure being applied to said shuttle valve to retain the same in said second position, said back pressure also being applied to said third valve to move the same to a position to establish communication between ports in said shuttle valve to connect said reverse motor port and said inlet while the latter is connected with said forward motor port, the spring for and the size of said third valve being so related to the spring for and size of said shuttle that a predetermined diminution of such back pressure will cause the closing of said third valve prior to the complete movement of said shuttle valve out of said last-mentioned position.

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