

Jan. 7, 1941.

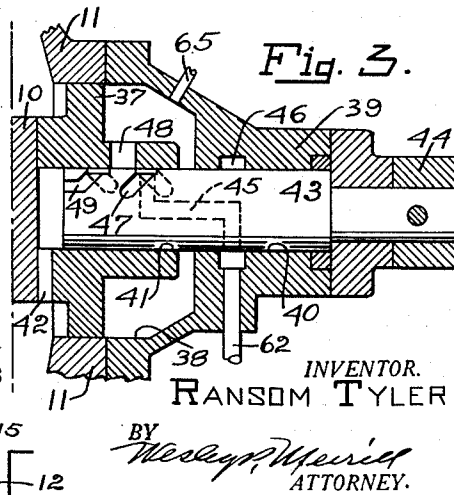
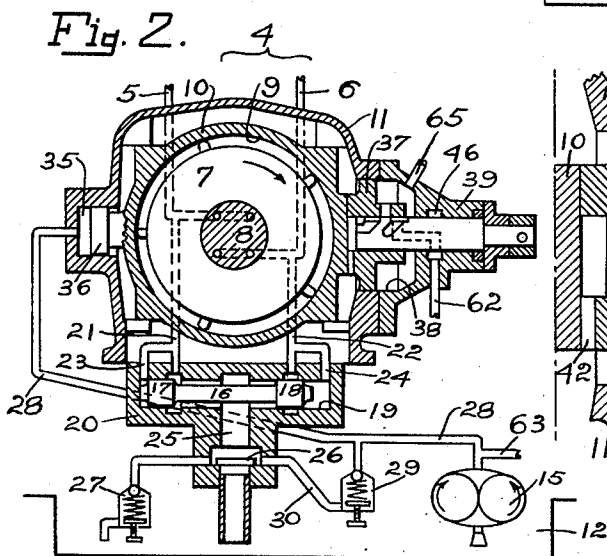
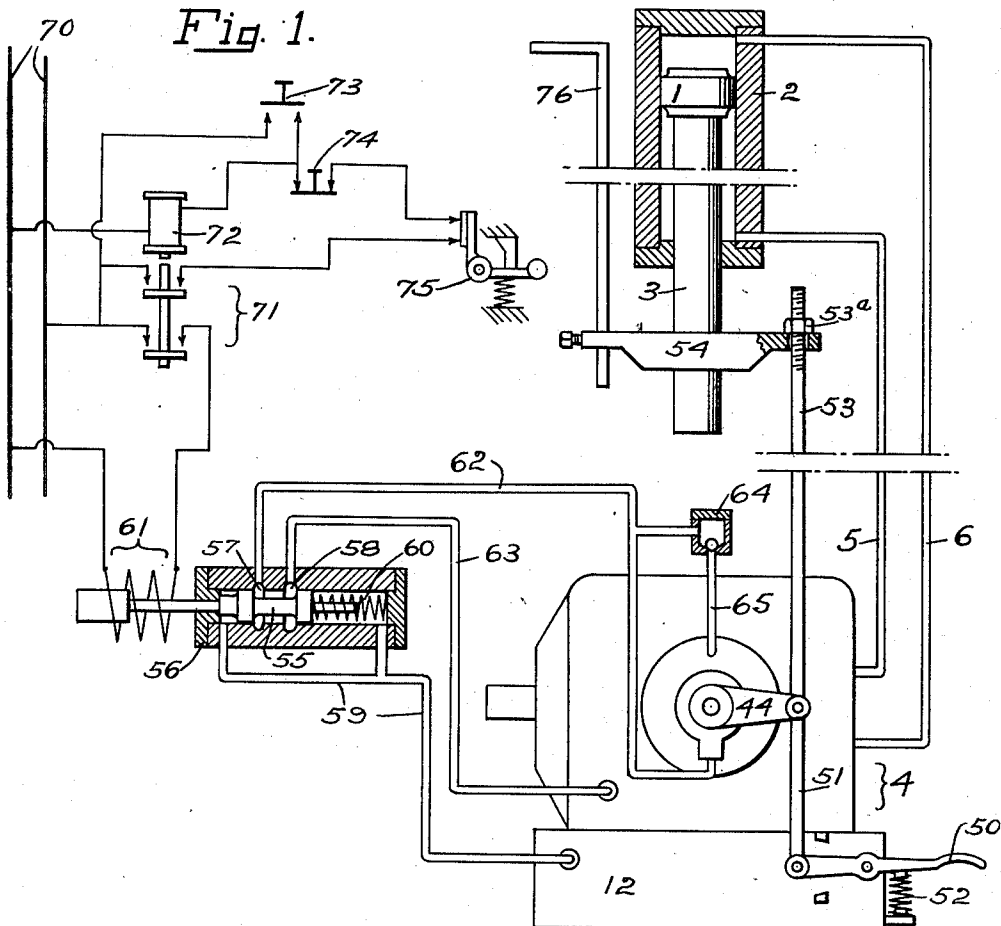
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2,227,814

CONTROL FOR HYDRAULIC TRANSMISSIONS

Filed Oct. 10, 1938

2 Sheets-Sheet 1



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CONTROL FOR HYDRAULIC TRANSMISSIONS

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2 Sheets-Sheet 2

Fig. 5.

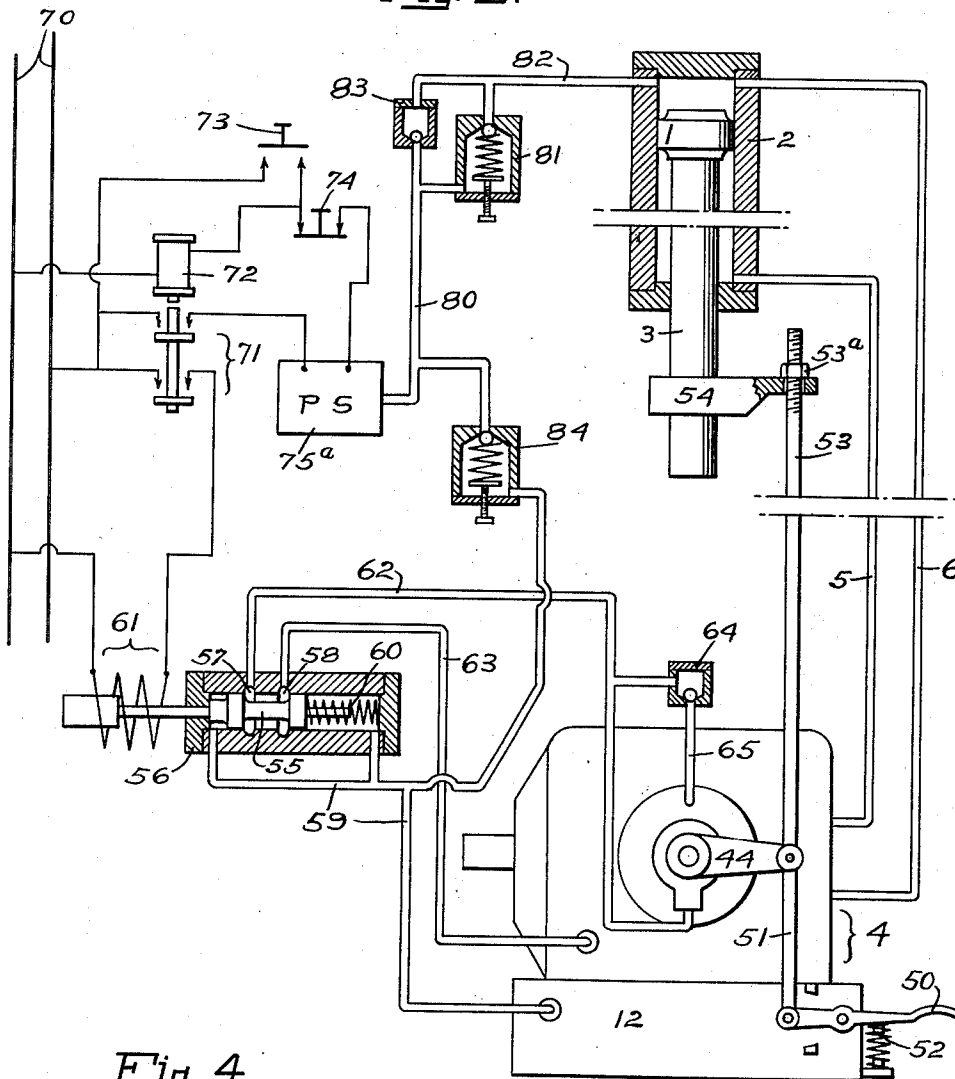
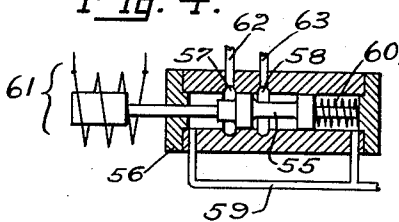


Fig. 4.



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## UNITED STATES PATENT OFFICE

2,227,814

## CONTROL FOR HYDRAULIC TRANSMISSIONS

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Application October 10, 1938, Serial No. 234,171

12 Claims. (Cl. 60--52)

This invention relates to controls for hydraulic transmissions of the type in which reversal of the motor is effected by reversing the pump discharge.

5 An object of the invention is to provide a control which is positive and precise in operation. Another object is to provide a control which is operable from a remote point.

10 Other objects and advantages will appear from the following description of the controls shown schematically in the accompanying drawings in which the views are as follows:

15 Fig. 1 is a diagrammatic view showing a hydraulic transmission provided with a control in which the invention is embodied and which causes the transmission to be reversed in response to an element moved by the transmission reaching a predetermined point.

20 Fig. 2 is a vertical transverse section through the pump shown in Fig. 1.

Fig. 3 is a view showing on a larger scale a part of the pump control mechanism shown in Fig. 2.

25 Fig. 4 is a view showing a control valve in a position different from that shown in Fig. 1.

Fig. 5 is a view similar to Fig. 1 but showing a control which will cause the pump to be reversed in response to pump pressure exceeding a predetermined maximum.

30 Figs. 1 to 3

The transmission shown in Fig. 1 includes a hydraulic motor, which has a piston 1 fitted in a stationary cylinder 2 and connected to a rod or ram 3, and a reversible pump 4 which is connected by channels 5 and 6 to the opposite ends of cylinder 2.

Any suitable type of pump may be employed but, for the purpose of illustration, pump 4 has been shown as being of the rolling piston type which is fully illustrated and described in Patent No. 2,074,068. It is deemed sufficient to state herein that pump 4 has its pistons and cylinders arranged radially in a cylinder barrel 7 which 45 rotates upon a stationary valve shaft or pintle 8 having formed therein ports and passages through which liquid flows to and from the cylinders, that the outer ends of the pistons react against an annular reaction surface 9 which in practice is formed in a separate rotatable thrust member carried by a slide block 10 but which has been shown as being formed in slide block 10, that pump 4 will discharge liquid in a direction and at a rate depending upon the direction and the distance the axis of reaction surface 55

9 is offset from the axis of cylinder barrel 7, and that slide block 10 is arranged in a casing 11 which permits it to be moved transversely of pintle 8 but prevents it from moving in any other direction.

Channels 5 and 6 are connected to pump 4 in communication with the passages formed in pintle 8 so that, if cylinder barrel 7 is rotated in a clockwise direction as viewed in Fig. 2, pump 4 will discharge liquid into channel 6 and have liquid returned to it through channel 5 when slide block 10 is shifted toward the right from its central position, and it will discharge liquid into channel 5 and have liquid returned to it through channel 6 when slide block 10 is shifted 15 toward the left from its central position. When slide block 10 is in its central or neutral position, at which time reaction surface 9 is concentric with cylinder barrel 7, pump 4 is at zero stroke and no liquid will be delivered thereby.

20 In order to compensate for leakage losses and for the difference in volume delivered by pump 4 and the volume returned thereto from motor 1-2, pump 4 is provided with a reservoir 12 for liquid and means are provided to permit liquid 25 returned to the pump in excess of pump requirements to be discharged into reservoir 12 and, when the volume returned to the pump is less than pump requirements, to either permit the pump to draw the additional liquid required from reservoir 12 or to be supplied therefrom by a gear pump 15 which has been shown in Fig. 2 as a separate pump but which is ordinarily driven in unison with the main pump and arranged in the casing thereof according to the common 35 practice.

As shown, communication between pump 4 and reservoir 12 is controlled by an automatic valve 16 having two spaced apart heads or pistons 17 and 18 arranged thereon and closely fitted in a bore 19 formed in a valve casing 20 which is arranged below slide block 10 and has a part thereof extending into the liquid in reservoir 12.

Piston heads 17 and 18 on valve 16 control communication between bore 19 and two channels 21 and 22 which connect the channels 5 and 6 with bore 19 at two points spaced from the opposite ends thereof. The extreme left end of bore 19 is connected by a channel 23 to channel 21 intermediate the ends thereof, and the 50 extreme right end of bore 19 is connected by a channel 24 to channel 22 intermediate the ends thereof.

That part of bore 19 between channels 21 and 22 communicates with a chamber 25 formed in 55

the lower part of valve casing 20 and communicating with reservoir 12 through a check valve 26 which permits pump 4 to draw liquid freely from reservoir 12 but prevents liquid from being expelled from chamber 25 except through a low pressure relief valve 27 having its inlet connected to chamber 25.

Gear pump 15 draws liquid from reservoir 12 and discharges it into a low pressure supply channel 28 having connected thereto the inlet of a relief valve 29 the outlet of which is connected to chamber 25 by a channel 30.

A part of the liquid discharged by gear pump 15 is used for control purposes, as will presently appear, and the remainder is exhausted through relief valve 29 into chamber 25. The liquid discharged by gear pump 15 into chamber 25 in excess of the volume required to supercharge pump 4 is exhausted through relief valve 27 so that, except when pump 4 is drawing liquid from reservoir 12 through check valve 26, gear pump 15 is enabled to maintain in chamber 25 a pressure equal to the resistance of relief valve 27 and to maintain in channel 28 a pressure equal to the sum of the resistances of relief valves 27 and 29.

The arrangement is such that, when pump 4 starts to deliver liquid into channel 5, pressure extends from channel 5 through channels 21 and 23 to the left end of bore 19 and shifts valve 16 toward the right so that channel 21 is blocked by piston 17 and channel 22 is opened to chamber 25 through bore 19, and, when pump 4 starts to deliver liquid into channel 6, pressure extends from channel 6 through channels 22 and 24 to the right end of bore 19 and shifts valve 16 toward the left to the position shown so that channel 22 is blocked by piston 18 and channel 21 is opened to chamber 25 through bore 19.

Valve 16 thus operates to automatically block the pressure side of the pump from chamber 25 and to open the return side of the pump to chamber 25 in either direction of pump delivery so that pump 4 can at no time discharge freely into reservoir 12, liquid returned to the pump in excess of pump requirements can at all times be discharged through channels 21 or 22, bore 19, chamber 25 and relief valve 27 into reservoir 12, and any deficiency in the liquid returned to the pump from an external circuit can be made up by liquid supplied by gear pump 15 or by liquid drawn by pump 4 through check valve 26 from reservoir 12.

Pump 4 is caused to deliver liquid in one direction or the other by shifting slide block 10 in one direction or other from a central or neutral position. This is accomplished by hydraulically actuated means operated by liquid supplied thereto from gear pump 15 partly under the control of a valve which controls the rate, direction and extent of movement of slide block 10 and partly under the control of a second valve which renders the first valve effective or ineffective.

As shown in Fig. 2, slide block 10 is constantly urged toward the right by a hydraulic servo-motor consisting of a cylinder 35, which is formed integral with or connected to pump casing 11, and a piston 36 which abuts or is connected to the left side of slide block 10 and fitted in cylinder 35. Supply channel 28 is connected to cylinder 35 so that piston 36 is subjected at all times to gear pump pressure.

Slide block 10 is adapted to be moved toward the left by a hydraulic servo-motor consisting of a piston 37, which has a larger effective pres-

sure area than piston 36 and abuts or is connected to the right side of slide block 10, and a cylinder 38 which is formed integral with or connected to pump casing 11 and has piston 37 fitted therein.

Cylinder 38 is closed at its outer end by a head 39 having a bore 40 (Fig. 3) formed therein in axial alignment with an axial bore 41 which extends through piston 37 and through an extension or hub formed upon the outer face of piston 37. The inner end of bore 41 communicates at all times with the interior of pump casing 11 as by means of one or more radial passages 42 formed in the inner end of piston 37.

Liquid for operating servo-motor 37-38 is supplied to cylinder 38 by gear pump 15 under the control of a rotary follow-up valve 43 which is closely fitted in bores 40 and 41 and provided at its outer end with a lever 44 for rotating it and for restraining it from axial movement.

Valve 43 is provided with an internal passage 45 having one end thereof in communication at all times with an annular groove 46 which is formed in the wall of bore 40 and adapted to be supplied with motive liquid from gear pump 15 as will presently be explained.

The other end of passage 45 opens into a spiral groove 47 which is formed in the peripheral surface of valve 43 adjacent a port 48 formed in the hub of piston 37. Port 48 is adapted, upon rotation of valve 43 in one direction or the other, to provide communication between the interior of cylinder 38 and either groove 47 or a spiral groove 49 which is formed in the peripheral surface of valve 43 and opens into the inner end of bore 41.

The arrangement is such that, when liquid is supplied to groove 46 from gear pump 15 and port 48 is in registry with groove 47, liquid will flow from groove 46 through passage 45, groove 47 and port 48 into cylinder 38 and act upon piston 37. Since the effective pressure area of piston 37 is greater than that of piston 36, the liquid entering cylinder 38 will cause piston 37 to move slide block 10 toward the left and piston 36 will expel liquid from cylinder 35 through relief valves 29 and 27. When port 48 registers with groove 49, cylinder 38 is open to drain and the liquid constantly supplied to cylinder 35 will cause piston 36 to move slide block 10 toward the right and cause piston 37 to expel liquid from cylinder 38 through port 48, groove 49, the inner end of bore 41 and passage 42 into pump casing 11.

Port 48 and grooves 47 and 49 are so proportioned that, when valve 43 is stationary, opposite edges or corners of port 48 aline with adjacent edges of grooves 47 and 49 so that the slightest relative movement between port 48 and grooves 47 and 49 axially of valve 43 will open communication between port 48 and one or the other of grooves 47 and 49.

Communication between port 48 and one or the other of grooves 47 and 49 may be established by rotating valve 43 in one direction or the other to thereby cause slide block 10 to be moved in one direction or the other. Since port 48 is formed in a part of piston 37 so that it moves therewith and with slide block 10, valve 43 and piston 37 constitute a follow-up valve mechanism which permits liquid to flow to or from cylinder 37 only while valve 43 is rotating. Consequently, movement of slide block 10 ceases at substantially the same instant that valve 43 ceases to rotate.

Valve 43 is adapted to be rotated manually

by means of foot lever 50 which is pivoted intermediate its ends and has one of its ends connected to the free end of lever 44 by a link 51, suitable stops being provided on opposite sides of lever 50 to prevent valve 43 from being rotated beyond its effective range.

By depressing the free end of lever 50, valve 43 will be rotated in a direction to open cylinder 38 to drain and permit servo-motor 35-36 to move slide block 10 toward the right so that pump 4 will deliver liquid to the upper end of cylinder 2 and cause piston 1 to move ram 3 downward as previously explained and, by raising the free end of lever 50, valve 43 will be rotated in a direction to permit gear pump liquid to enter cylinder 38 and cause piston 37 to move slide block 10 toward the left so that pump 4 will deliver liquid to the lower end of cylinder 2 and cause piston 1 to move ram 3 upward as previously explained.

In order that the transmission may operate semi-automatically, valve 43 is rotated to its neutral position in response to piston 1 reaching the limit of its up stroke and it is rotated in a direction to open communication between groove 46 and cylinder 38 in response to piston 1 starting its down stroke.

As shown, a spring 52 is arranged beneath lever 50, the free end of lever 44 is connected to one end of a rod 53 which extends loosely through a collar 54 fixed upon ram 3, and a nut 53<sup>a</sup> is arranged upon the upper end of rod 53 to be engaged by collar 54 as piston 1 approaches the end of its up stroke.

Servo-motor 37-38 is also controlled by a valve 55 (Figs. 1 and 4) arranged in a valve casing 56 and controlling communication between two ports 57 and 58, which are formed in the wall of casing 56, and between port 57 and a drain channel 59 which is connected to both ends of valve casing 56 and discharges into reservoir 12.

Valve 55 is urged by a spring 60 toward the position shown in Fig. 1, and it is adapted to be moved to the position shown in Fig. 4 by a solenoid 61 which has its core connected to the stem of valve 55.

Port 57 is connected to groove 46 by a channel 62, and port 58 is connected by a channel 63 (Figs. 1 and 2) to supply channel 28 so that groove 46 (Fig. 3) is supplied with motive liquid by gear pump 15 when valve 55 is in the position shown in Fig. 1.

Channel 62 communicates intermediate its ends with the outlet of a check valve 64 which has its inlet connected to one end of a channel 65 the other end of which is connected to cylinder head 39 and communicates with the interior of cylinder 38.

The arrangement is such that, when valve 55 is in the position shown in Fig. 1, no liquid can enter cylinder 38 except under the control of rotary valve 43 and, when valve 55 is in the position shown in Fig. 4, it blocks communication between ports 57 and 58, to thereby prevent the delivery of any liquid to cylinder 38, and port 57 is open to drain channel 59 so that liquid can escape from cylinder 38. Consequently, when valve 55 is in the position shown in Fig. 4, servo-motor 35-36 will move slide block 10 toward the right and cause piston 37 to expel liquid from cylinder 38 through channel 65, check valve 64, channel 62, valve casing 56, and channel 59 into reservoir 12.

Solenoid 61 is adapted to be energized by current supplied thereto from a power line 70 under

the control of a magnetic switch 71 the electro-magnet 72 of which is controlled by a normally open push button switch 73, a normally closed push button switch 74 and a normally closed limit switch 75 the actuating member of which is arranged in the path of an actuator 76 carried by collar 54, switch 75 being so positioned and actuator 76 being so adjusted that actuator 76 will open switch 75 when ram 3 reaches the end of its down stroke.

The circuit connecting the power line, the solenoid and the several switches has been simplified in the drawing from which it will be obvious that, when push button switch 73 is closed, magnet 72 will be energized and close switch 71 and a circuit will be completed through solenoid 61 to energize it and a circuit will be completed through magnet 72 to energize it so that it will hold switch 71 closed after which push button switch 73 is released. It will also be obvious that, when push button switch 74 or limit switch 75 is opened, the circuit through magnet 72 will be broken so that magnet 72 will be deenergized and switch 71 will open and deenergize solenoid 61.

#### Operation

Assuming that motor 1-2 and ram 3 are parts of a hydraulic press, that pumps 4 and 15 are running and that the several parts are in the positions shown in Fig. 1, the press will operate as follows:

When switch 73 is closed, magnet 72 will be energized and close switch 71 to energize solenoid 61 which will shift valve 55 toward the right to the position shown in Fig. 4 so that cylinder 38 is connected to drain and servo-motor 35-36 permitted to shift slide block 10 toward the right to cause pump 4 to deliver liquid through channel 6 to the upper end of cylinder 2, thereby causing piston 1 to move ram 3 downward.

Downward movement of ram 3 from its upper limit permits spring 52 to swing the outer end of lever 44 downward and thereby rotate valve 43 in a direction to move groove 47 into registry with port 48 so that gear pump liquid may be supplied to cylinder 38 as soon as valve 55 is returned to the position shown in Fig. 1.

Switch 73 may be opened immediately after it was closed as magnet 72 will hold switch 71 closed until ram 3 reaches a predetermined point in its downward movement at which time actuator 76 will open limit switch 75, thereby deenergizing magnet 72 and permitting switch 71 to open and deenergize solenoid 61 so that spring 60 may then shift valve 55 to the position shown in Fig. 1.

Liquid from gear pump 15 may then flow through channel 63, valve casing 56, channel 62, groove 46, passage 45, groove 47 and port 48 to cylinder 38 and shift slide block 10 toward the left to cause pump 4 to deliver liquid through channel 5 to the lower end of cylinder 2 and thereby cause piston 1 to move ram 3 upward.

As ram 3 approaches the limit of its upward movement, collar 54 will engage nut 53<sup>a</sup> and raise rod 53 and the outer end of lever 44, thereby rotating valve 43 in a direction to move groove 45 into registry with port 48 so that liquid can escape from cylinder 38 and servo-motor 35-36 can move slide block 10 toward the right.

Rotation of valve 43 and movement of slide block 10 toward the right will continue until slide block 10 reaches its neutral position at which time further movement will cease and the press will come to rest with the parts thereof in the positions shown in Fig. 1.

FIG. 5

The transmission shown in this figure is exactly the same as the transmission shown in Fig. 1 except that it is reversed in response to the fluid pressure exceeding a predetermined maximum instead of in response to an element being moved to a predetermined point. Consequently, like parts have been indicated by like reference numerals and no further description thereof will be given.

As shown, reversal is obtained by means of a normally closed pressure responsive switch 75<sup>a</sup> which corresponds to limit switch 75 and is connected into the electric circuit in exactly the same manner. Pressure switch 75<sup>a</sup> is subjected to a pressure proportional to the pressure created by the pump when the motor is performing useful work.

In order that the pressure at which the transmission is reversed may be varied through a wide range, pressure switch 75<sup>a</sup> is adapted to operate at a predetermined low pressure and an adjustable resistance valve is connected between it and the pressure side of the pump. As shown, the pressure inlet of switch 75<sup>a</sup> is connected by a channel 80 to the outlet of an adjustable resistance valve 81 the inlet of which is subjected to pump pressure as by being connected to the upper end of cylinder 2 by a channel 82, and a check valve 83 is connected in parallel with resistance valve 81 and opens in the opposite direction to permit the pressure in channel 80 to fall as soon as the pump has been reversed so that pressure switch 75 can close. Also, in order to prevent possible damage to pressure switch 75<sup>a</sup>, a safety relief valve 84 is ordinarily connected to channel 80 and adjusted to open at a pressure but slightly higher than the pressure required to open pressure switch 75<sup>a</sup>.

A cycle of operation is started by closing switch 73 as previously explained. Ram 3 will advance until it is exerting sufficient force upon the work to cause pump pressure to rise high enough to open resistance valve 81 and then operate pressure switch 75<sup>a</sup> which will deenergize magnet 72 to effect reversal of pump 4. Otherwise, the transmission operates in exactly the same manner as the transmission shown in Fig. 1 operates.

It is obvious that the controls shown in Figs. 1 and 5 could be combined so that the pump could be reversed either on distance or on pressure as desired. For example, the control shown in Fig. 5 could have a limit switch such as switch 75 connected in series with pressure switch 75<sup>a</sup> and ram 3 could be provided with an actuator such as actuator 76 for operating the limit switch. Then, by proper adjustments of actuator 76 and resistance valve 81, the pump could be reversed either in response to ram 3 reaching a predetermined point in its advance movement or in response to pump pressure exceeding a predetermined maximum.

The invention herein set forth is susceptible of various modifications and adaptations without departing from the scope thereof as hereafter claimed.

The invention is hereby claimed as follows:

1. The combination, with a reciprocable element, a hydraulic motor for reciprocating said element, a reversible pump connected in series with said motor for supplying liquid thereto to energize the same and having a displacement varying member shiftable in one direction or the other to one or the other of two predetermined positions in the first of which said pump

delivers liquid in a direction to cause said motor to advance said element and in the second of which said pump delivers liquid in a direction to cause said motor to retract said element, said member being also shiftable to an intermediate neutral position to reduce pump delivery to zero, means including a fluid actuated servo-motor for shifting said member, means for supplying motive fluid to said servo-motor, and a first valve for controlling operation of said member shifting means, of a second valve for controlling said member shifting means connected in series with said first valve, said second valve being shiftable to two positions in the first of which it renders said first valve effective and in the second of which it renders said first valve ineffective and causes said member shifting means to shift said member to its first position whereby said pump delivers liquid in a direction to cause said motor to advance said element, means for moving said first valve to a position in which when effective it will cause said member shifting means to shift said member toward its second position, and means operable at the end of the advance movement of said element for shifting said second valve to its first position.

2. The combination, with a reciprocable element, a hydraulic motor for reciprocating said element, a reversible pump connected in series with said motor for supplying liquid thereto to energize the same and having a displacement varying member shiftable in one direction or the other to one or the other of two predetermined positions in the first of which said pump delivers liquid in a direction to cause said motor to advance said element and in the second of which said pump delivers liquid in a direction to cause said motor to retract said element, said member being also shiftable to an intermediate neutral position to reduce pump delivery to zero, means including a fluid actuated servo-motor for shifting said member, means for supplying motive fluid to said servo-motor, and a first valve for controlling operation of said member shifting means, of a second valve for controlling said member shifting means connected in series with said first valve, said second valve being shiftable to two positions in the first of which it renders said first valve effective and in the second of which it renders said first valve ineffective and causes said member shifting means to shift said member to its first position whereby said pump delivers liquid in a direction to cause said motor to advance said element, means operable in response to said element starting its advance movement for moving said first valve to a position in which when effective it will cause said member shifting means to shift said member toward its second position, means operable at the end of the advance movement of said element for shifting said second valve to its first position to thereby cause said motor to retract said element, and means operable by said element as it nears the end of its retraction movement for so adjusting said first valve as to cause said member shifting means to move said member to its neutral position.

3. The combination, with a reciprocable element, a hydraulic motor for reciprocating said element, a reversible pump connected in series with said motor for supplying liquid thereto to energize the same and having a displacement varying member shiftable in one direction or the other to one or the other of two predetermined positions in the first of which said pump

delivers liquid in a direction to cause said motor to advance said element and in the second of which said pump delivers liquid in a direction to cause said motor to retract said element, said member being also shiftable to an intermediate neutral position to reduce pump delivery to zero, means including a fluid actuated servo-motor for shifting said member, means for supplying motive fluid to said servo-motor, and a first valve for controlling operation of said member shifting means, of a second valve for controlling said member shifting means connected in series with said first valve, said second valve being shiftable to two positions in the first of which it renders said first valve effective and in the second of which it renders said first valve ineffective and causes said member shifting means to shift said member to its first position whereby said pump delivers liquid in a direction to cause said motor to advance said element, means for moving said first valve to a position in which when effective it will cause said member shifting means to shift said member toward its second position, means for shifting said second valve, means operated by said element at the end of its advance movement for causing said valve shifting means to shift said second valve to its first position and thereby cause said element to be retracted, and means responsive to said element approaching a given point in its retraction movement for so adjusting said first valve as to cause said member shifting means to move said member to its neutral position.

4. The combination, with a reciprocable element, a hydraulic motor for reciprocating said element, a reversible pump connected in series with said motor for supplying liquid thereto to energize the same and having a displacement varying member shiftable in one direction or the other to one or the other of two predetermined positions in the first of which said pump delivers liquid in a direction to cause said motor to advance said element and in the second of which said pump delivers liquid in a direction to cause said motor to retract said element, said member being also shiftable to an intermediate neutral position to reduce pump delivery to zero, means including a fluid actuated servo-motor for shifting said member, means for supplying motive fluid to said servo-motor, and a first valve for controlling operation of said member shifting means, of a second valve for controlling said member shifting means connected in series with said first valve, said second valve being shiftable to two positions in the first of which it renders said first valve effective and in the second of which it renders said first valve ineffective and causes said member shifting means to shift said member to its first position whereby said pump delivers liquid in a direction to cause said motor to advance said element, means for moving said first valve to a position in which when effective it will cause said member shifting means to shift said member toward its second position, means for shifting said second valve, means responsive to the pressure in said motor exceeding a predetermined maximum for causing said valve shifting means to shift said second valve to its first position and thereby cause said element to be retracted, and means responsive to said element approaching a given point in its retraction movement for so adjusting said first valve as to cause said member shifting means to move said member to its neutral position.

5. The combination, with a reciprocable ele-

ment, a hydraulic motor for reciprocating said element, a reversible pump connected in series with said motor for supplying liquid thereto to energize the same and having a displacement varying member shiftable in one direction or the other to one or the other of two predetermined positions in the first of which said pump delivers liquid in a direction to cause said motor to advance said element and in the second of which said pump delivers liquid in a direction to cause said motor to retract said element, said member being also shiftable to an intermediate neutral position to reduce pump delivery to zero, means including a fluid actuated servo-motor for shifting said member, means for supplying motive fluid to said servo-motor, and a first valve for controlling operation of said member shifting means, of a second valve for controlling said member shifting means connected in series with said first valve, said second valve being shiftable to two positions in the first of which it renders said first valve effective and in the second of which it renders said first valve ineffective and causes said member shifting means to shift said member to its first position whereby said pump delivers liquid in a direction to cause said motor to advance said element, means for moving said first valve in one direction to a position in which when effective it will cause said member shifting means to shift said member toward its second position, means operated by said element near the end of its retraction movement for moving said valve in the opposite direction to thereby cause said member shifting means to move said member to its neutral position, means including an electro-magnet for operating said second valve, means including a manual switch for energizing said magnet, and means including a limit switch operable by said element at the end of its advance movement for deenergizing said magnet.

6. The combination, with a reciprocable element, a hydraulic motor for reciprocating said element, a reversible pump connected in series with said motor for supplying liquid thereto to energize the same and having a displacement varying member shiftable in one direction or the other to one or the other of two predetermined positions in the first of which said pump delivers liquid in a direction to cause said motor to advance said element and in the second of which said pump delivers liquid in a direction to cause said motor to retract said element, said member being also shiftable to an intermediate neutral position to reduce pump delivery to zero, means including a fluid actuated servo-motor for shifting said member, means for supplying motive fluid to said servo-motor, and a first valve for controlling operation of said member shifting means, of a second valve for controlling said member shifting means connected in series with said first valve, said second valve being shiftable to two positions in the first of which it renders said first valve effective and in the second of which it renders said first valve ineffective and causes said member shifting means to shift said member to its first position whereby said pump delivers liquid in a direction to cause said motor to advance said element, means for moving said first valve to a position in which when effective it will cause said member shifting means to shift said member toward its second position, means operated by said element near the end of its retraction movement for moving said valve in the opposite direction to thereby cause said mem-

ber shifting means to move said member to its neutral position, means including an electromagnet for operating said second valve, means including a manual switch for energizing said magnet, and means including a pressure switch responsive to the pressure in said motor exceeding a predetermined maximum for deenergizing said magnet.

7. The combination, with a reciprocable element, a hydraulic motor for reciprocating said element, a reversible pump connected in series with said motor and having a displacement varying member shiftable to one side or the other of a neutral position to cause said pump to deliver liquid in one direction or the other and thereby cause said motor to move said element in one direction or the other, yieldable means for constantly urging said member in a direction to cause said pump to deliver liquid in a direction to cause said motor to advance said element, a fluid servo-motor adapted when energized to move said member in a direction to cause said pump to deliver liquid in a direction to cause said motor to retract said element, a source of motive fluid, and means for connecting said servo-motor to said source including a first valve adapted to direct liquid from said source to said servo-motor to energize it during movement of said valve in a given direction and to connect said servo-motor to drain to deenergize it during movement of said valve in the opposite direction, of a second valve shiftable to two positions in the first of which it directs fluid from said source to said first valve and in the second of which it connects said servo-motor to drain and blocks communication between said source and said first valve, means for shifting said second valve to its second position to thereby permit said yieldable means to shift said member and thereby cause said motor to advance said element, means operable in response to said element advancing for moving said first valve in said given direction, and means operable at the end of the advance movement of said element for causing said second valve to be shifted to its first position.

8. The combination, with a reciprocable element, a hydraulic motor for reciprocating said element, a reversible pump connected in series with said motor and having a displacement varying member shiftable to one side or the other of a neutral position to cause said pump to deliver liquid in one direction or the other and thereby cause said motor to move said element in one direction or the other, yieldable means for constantly urging said member in a direction to cause said pump to deliver liquid in a direction to cause said motor to advance said element, a fluid servo-motor adapted when energized to move said member in a direction to cause said pump to deliver liquid in a direction to cause said motor to retract said element, a source of motive fluid, and means for connecting said servo-motor to said source including a first valve adapted to direct liquid from said source to said servo-motor to energize it during movement of said valve in a given direction and to connect said servo-motor to drain to deenergize it during movement of said valve in the opposite direction, of a second valve shiftable to two positions in the first of which it directs fluid from said source to said first valve and in the second of which it connects said servo-motor to drain and blocks communication between said source and said first valve, means for shifting said second valve to its second position to thereby permit said yieldable means to shift

said member and thereby cause said motor to advance said element, means operable in response to said element advancing for moving said first valve in said given direction, means operable at the end of the advance movement of said element for causing said second valve to be shifted to its first position and thereby cause said pump to be reversed and cause said motor to retract said element, and means operable by said element as it nears the end of its retraction movement for moving said first valve in said opposite direction to thereby permit said yieldable means to move said displacement varying member to its neutral position.

9. The combination, with a reciprocable element, a hydraulic motor for reciprocating said element, a reversible pump connected in series with said motor and having a displacement varying member shiftable to one side or the other of a neutral position to cause said pump to deliver liquid in one direction or the other and thereby cause said motor to move said element in one direction or the other, yieldable means for constantly urging said member in a direction to cause said pump to deliver liquid in a direction to cause said motor to advance said element, a fluid servo-motor adapted when energized to move said member in a direction to cause said pump to deliver liquid in a direction to cause said motor to retract said element, a source of motive fluid, and means for connecting said servo-motor to said source including a first valve adapted to direct liquid from said source to said servo-motor to energize it during movement of said valve in a given direction and to connect said servo-motor to drain to deenergize it during movement of said valve in the opposite direction, of a second valve shiftable to two positions in the first of which it directs fluid from said source to said first valve and in the second of which it connects said servo-motor to drain and blocks communication between said source and said first valve, means for shifting said second valve to its second position to thereby permit said yieldable means to shift said member and thereby cause said motor to advance said element, means operable in response to said element advancing for moving said first valve in said given direction, other means for shifting said second valve, means operated by said element at the end of its advance movement for causing said other valve shifting means to shift said second valve to its first position and thereby cause said element to be retracted, and means responsive to said element approaching a given point in its retraction movement for moving said first valve in said opposite direction to thereby permit said yieldable means to move said displacement varying member to its neutral position.

10. The combination, with a reciprocable element, a hydraulic motor for reciprocating said element, a reversible pump connected in series with said motor and having a displacement varying member shiftable to one side or the other of a neutral position to cause said pump to deliver liquid in one direction or the other and thereby cause said motor to move said element in one direction or the other, yieldable means for constantly urging said member in a direction to cause said pump to deliver liquid in a direction to cause said motor to advance said element, a fluid servo-motor adapted when energized to move said member in a direction to cause said pump to deliver liquid in a direction to cause said motor to retract said element, a source of motive fluid, 75

and means for connecting said servo-motor to said source including a first valve adapted to direct liquid from said source to said servo-motor to energize it during movement of said valve in a given direction and to connect said servo-motor to drain to deenergize it during movement of said valve in the opposite direction, of a second valve shiftable to two positions in the first of which it directs fluid from said source to said first valve and in the second of which it connects said servo-motor to drain and blocks communication between said source and said first valve, means for shifting said second valve to its second position to thereby permit said yieldable means to shift said member and thereby cause said motor to advance said element, means operable in response to said element advancing for moving said first valve in said given direction, other means for shifting said second valve, means responsive to the pressure in said motor exceeding a predetermined maximum for causing said other valve shifting means to shift said second valve to its first position and thereby cause said element to be retracted, and means responsive to said element approaching a given point in its retraction movement for moving said first valve in said opposite direction to thereby permit said yieldable means to move said displacement varying member to its neutral position.

11. The combination, with a reciprocable element, a hydraulic motor for reciprocating said element, a reversible pump connected in series with said motor and having a displacement varying member shiftable to one side or the other of a neutral position to cause said pump to deliver liquid in one direction or the other and thereby cause said motor to move said element in one direction or the other, yieldable means for constantly urging said member in a direction to cause said pump to deliver liquid in a direction to cause said motor to advance said element, a fluid servo-motor adapted when energized to move said member in a direction to cause said pump to deliver liquid in a direction to cause said motor to retract said element, a source of motive fluid, and means for connecting said servo-motor to said source including a first valve adapted to direct liquid from said source to said servo-motor to energize it during movement of said valve in a given direction and to connect said servo-motor to drain to deenergize it during movement of said valve in the opposite direction, of a second valve shiftable to two positions in the first of which it directs fluid from said source to said first valve and in the second of which it connects said servo-motor to drain and blocks communication between said source and said first valve, valve actuating means for urging said second valve to its first position, an electro-magnet for shifting said second valve to its second position to thereby permit said yieldable means to shift said member to cause said motor to advance said element, means

operable in response to said element advancing for moving said first valve in said given direction, means including a limit switch operable by said element at the end of its advance movement for deenergizing said magnet to permit said valve actuating means to shift said second valve to its first position and thereby effect reversal of said pump and retraction of said element, and means operated by said element near the end of its retraction movement for moving said first valve in said opposite direction to thereby permit said yieldable means to move said member to neutral position.

12. The combination, with a reciprocable element, a hydraulic motor for reciprocating said element, a reversible pump connected in series with said motor and having a displacement varying member shiftable to one side or the other of a neutral position to cause said pump to deliver liquid in one direction or the other and thereby cause said motor to move said element in one direction or the other, yieldable means for constantly urging said member in a direction to cause said pump to deliver liquid in a direction to cause said motor to advance said element, a fluid servo-motor adapted when energized to move said member in a direction to cause said pump to deliver liquid in a direction to cause said motor to retract said element, a source of motive fluid, and means for connecting said servo-motor to said source including a first valve adapted to direct liquid from said source to said servo-motor to energize it during movement of said valve in a given direction and to connect said servo-motor to drain to deenergize it during movement of said valve in the opposite direction, of a second valve shiftable to two positions in the first of which it directs fluid from said source to said first valve and in the second of which it connects said servo-motor to drain and blocks communication between said source and said first valve, valve actuating means for urging said second valve to its first position, an electro-magnet for shifting said second valve to its second position to thereby permit said yieldable means to shift said member to cause said motor to advance said element, means operable in response to said element advancing for moving said first valve in said given direction, means including a pressure switch responsive to the pressure in said motor exceeding a predetermined maximum for deenergizing said magnet to permit said valve actuating means to shift said second valve to its first position and thereby effect reversal of said pump and retraction of said element, and means operated by said element near the end of its retraction movement for moving said first valve in said opposite direction to thereby permit said yieldable means to move said member to its neutral position.

RANSOM TYLER.