Feb. 11, 1947. J. A. MULLER ET AL 2,415,603

HYDRAULIC CONSTANT SPEED CONTROL SYSTEM FOR PARALLEL-CONNECTED HYDRAULIC MOTORS

Filed Aug. 26, 1943 2 Sheets-Sheet 1

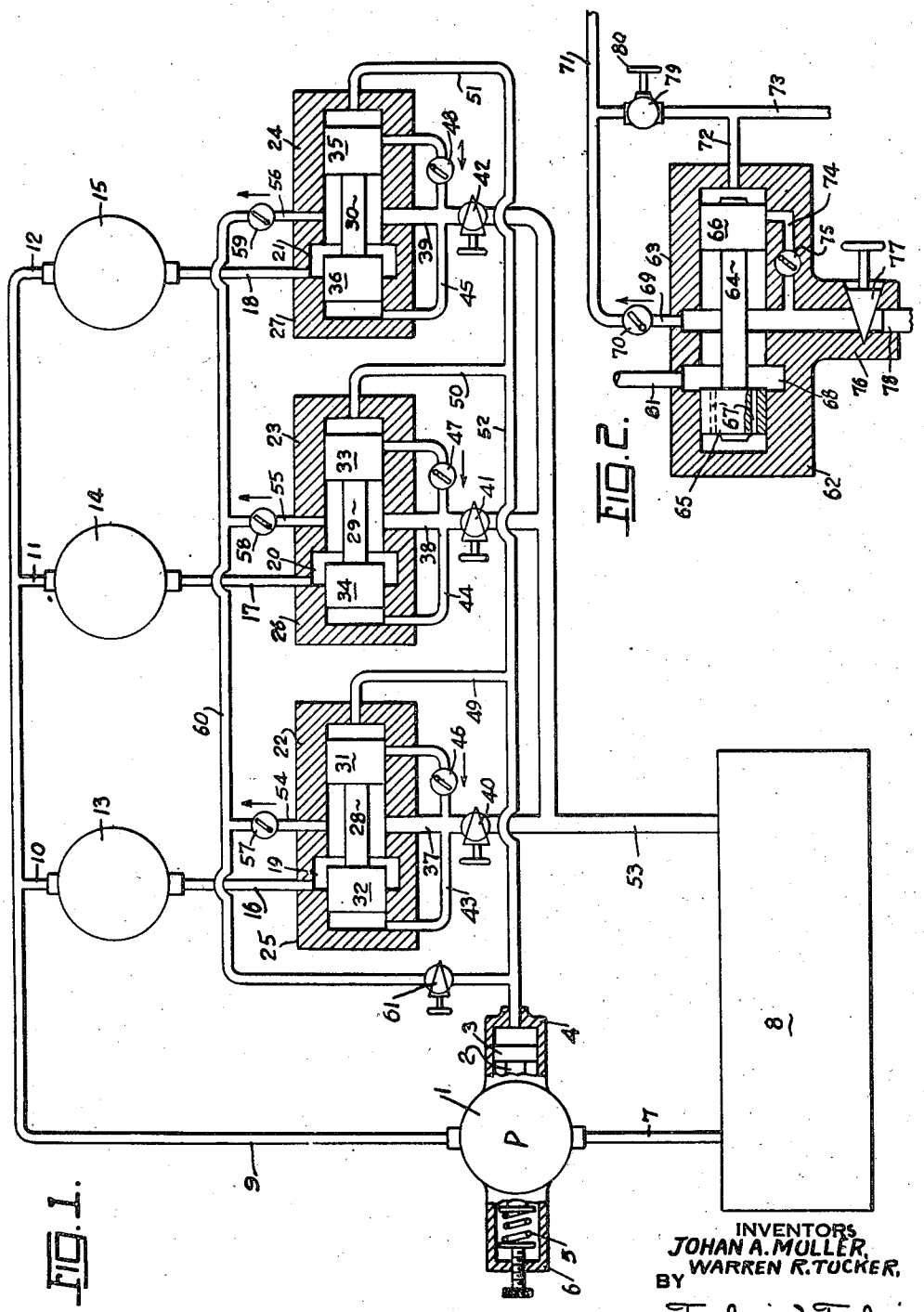


FIG. 1.

FIG. 2.

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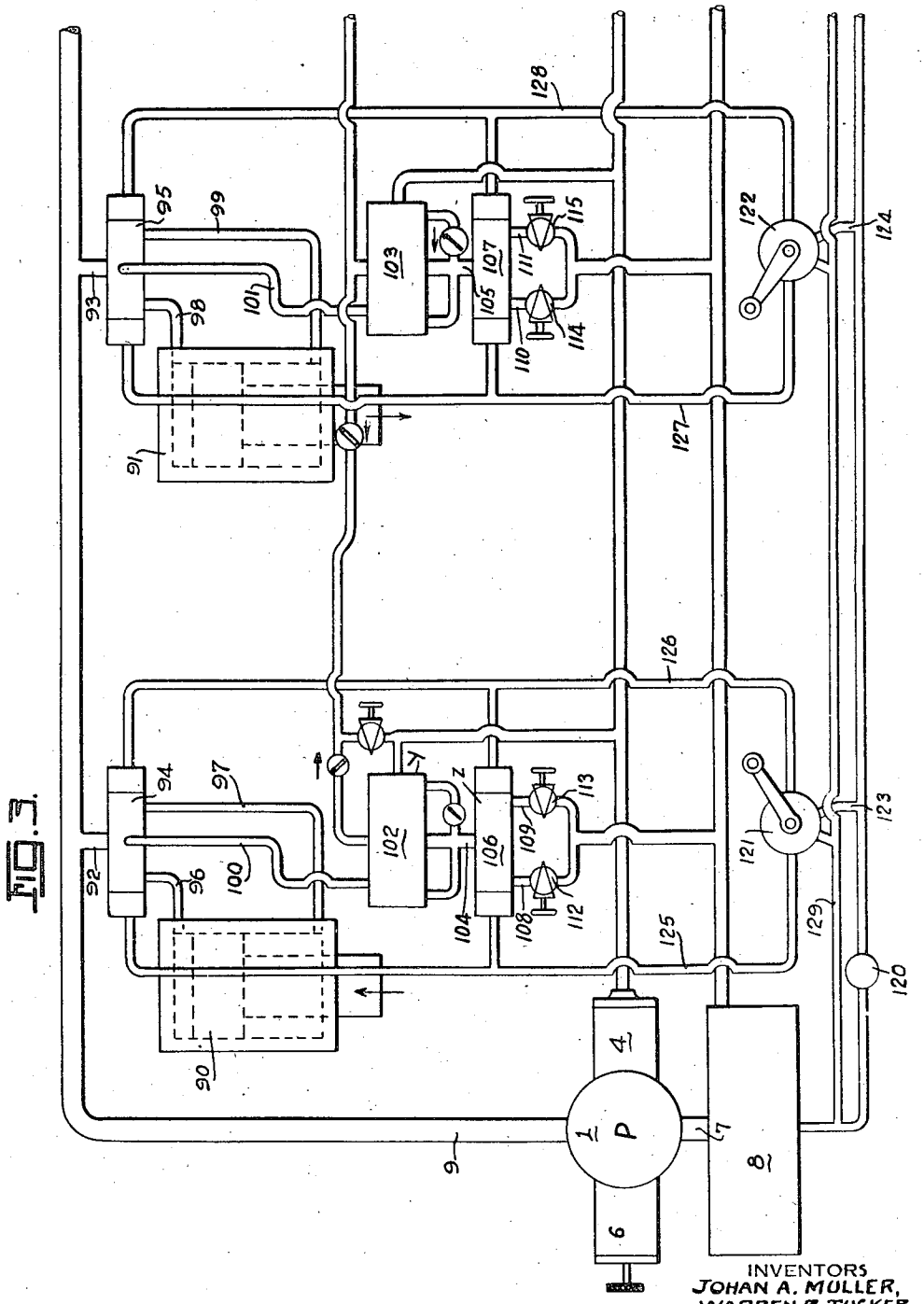


FIG. 3.

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HYDRAULIC CONSTANT SPEED CONTROL SYSTEM FOR PARALLEL-CONNECTED HYDRAULIC MOTORS

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Application August 26, 1943, Serial No. 500,068

9 Claims. (Cl. 60—97)

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This invention relates to hydraulic machinery and, in particular, to a control system for a plurality of hydraulic motors, i. e., for two motors or for any given number of motors, especially when said motors are actuated from a common fluid source.

When a plurality of hydraulic motors is supplied with pressure fluid from a common fluid source, the motor encountering the lowest resistance tends to run ahead of the other motor or motors and said motor which encounters the greatest resistance will either move in an erratic manner or it may even come to a stop.

It is an object of this invention to provide a hydraulic motor control system which will overcome the above-mentioned drawback, particularly to provide such a control system where two or more than two motors are operated from a single fluid source, although it will be understood that the system may be used with two motors.

It is another object of this invention to provide a hydraulic system including a plurality of fluid operable motors supplied with pressure fluid from a common fluid source, in which a change in resistance encountered by one motor will have practically no effect on the speed of one or more of the other motors of said system.

It is another object of this invention to provide a hydraulic system including a plurality of fluid operable motors and in which two or more motors may be supplied with pressure fluid from a common fluid source, and in which control means is provided adapted automatically to maintain the speed of each individual motor substantially constant.

Another object of this invention consists in the provision of a hydraulic system including two or more fluid operable motors supplied with pressure fluid from a fluid source common to all of said motors, in which the said control means is provided, in response to a decrease or increase in resistance encountered by one motor to bring about a corresponding change in the supply of pressure fluid to said motor to restore the speed of said motor while the speed of the other motor or motors is held substantially constant.

It is a still further object to provide a hydraulic system including two or more fluid operable motors supplied with pressure fluid from one and the same fluid source, in which means is provided for maintaining a desired back pressure at said motors, and in which, responsive to an increase or decrease in resistance encountered by one or more of said motors, the supply of actuating fluid to said motor or motors is decreased or increased

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respectively, while the speed of the other motor or motors is maintained substantially constant.

Another object of the invention consists in the provision of a hydraulic system including two or more operable motors supplied with pressure fluid from one and the same fluid source, in which the speed of one or more motors may selectively be varied without substantially affecting the speed of the other motor or motors.

Another object of the invention is the provision of a hydraulic system employing two or more motors which are operated from a single fluid source, and in which the motors may be either of the rotary or reciprocating type, or a combination of said types, and which motors need not have any relationship to each other as far as size or type are concerned.

A still further object of the invention consists in the provision of a hydraulic system including a variable delivery pump which drives two or more fluid motors and in which there is a control cylinder provided for each fluid motor which control cylinder is hydraulically connected with means which controls the amount of fluid delivered by the pump.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawings which illustrate, by way of example, an embodiment of the new control system.

The control system shown in the drawings comprises in general three hydraulic motors supplied with pressure fluid from a common variable delivery source, each motor being hydraulically connected with a pressure responsive variable choke valve, which in its turn is connected with means for creating back pressure in said motors, and is also in fluid communication with a control mechanism associated with the fluid source feeding said motors. The said control system is pressure responsive and adapted to vary the supply of pressure fluid to the motors.

A variation in resistance encountered by one of said motors reacts on its pressure responsive variable choke valve so as to cause the latter to create back pressure on its motor. In addition thereto, the delivery of fluid from said fluid source to said motors is changed. Then a new pressure condition prevails because the pressure created by the fluid source stands on all motors at a value determined by the greater motor load.

In the drawings:

Figure 1 is a side elevational view of one form

of the apparatus showing the valve casings and the control cylinder in vertical section,

Figure 2, a vertical section of a modified form of valve with conduits connected thereto, and

Figure 3 is a plan view of a modified form of apparatus wherein it is possible to determine the retraction speed as well as the forward speed of each of the controlled motors.

Referring now to the drawings in detail the structure shown in Figure 1 comprises a pump 1 of the variable delivery type, which may be a radial piston or radial vane pump. The flow control member of the pump 1 has connected thereto a control rod 2 with a piston 3 which latter is reciprocably mounted in a servomotor or control cylinder 4. The flow control member of the pump 1 is continuously urged by means of a spring 5 in a casing 6 in a direction to move the pump into flow delivery position. Casing 6 is connected to the pump 1 in any convenient manner.

The suction side of the pump is connected by means of a conduit 7 with a fluid reservoir or tank 8. The delivery side of the pump is connected by means of a conduit 9 to a plurality of branch lines 10, 11 and 12, to the hydraulic motors 13, 14 and 15. These motors 13, 14 and 15 may be of any suitable size, and may be either of the rotary or reciprocating type. It is not necessary that these motors bear any relationship to each other so far as size or type is concerned, i. e., any one of them may be of the rotary type and another of them may be of the reciprocating type, and each of them may vary as to size. The branch lines 10, 11 and 12 connect to the inlet side of these hydraulic motors. Connected to the exhaust side of said motors are a plurality of conduits 16, 17 and 18, which latter respectively lead to annular recesses 19, 20 and 21 in the valve casings 22, 23 and 24 of the pressure responsive variable choke valves generally designated 25, 26 and 27.

Reciprocably mounted in the valve casings are valve members 28, 29 and 30. The valve member 28 is provided with interconnected piston portions 31, 32, the valve member 29 is provided with similar piston portions 33, 34 and valve member 30 with similar piston portions 35 and 36.

The conduits 37, 38 and 39 connect the spaces between each pair of pistons to choke valves 40, 41 and 42. Bypass lines 43, 44 and 45 are connected intermediate their ends into conduits 37, 38 and 39. The left hand end of each bypass is connected into each valve casing near the left hand end of the cylinder bore of that casing so as to be uncovered during most of the movements of the left hand piston. The right hand end of the bypass is connected into the cylinder bore so as to be ordinarily covered by the right hand piston. Located in each bypass between the conduits 37, 38 and 39 are check valves 46, 47 and 48. These check valves may open so as to bypass fluid only in the direction indicated by the arrows.

Also connected into the valve casings 22, 23 and 24 are conduits 49, 50 and 51, respectively, which lead from the right hand end of the valve bores to a line 52 and which leads into the control cylinder 4.

All of the conduits 37, 38 and 39 are connected to a return conduit 53 which leads into the tank 8.

In order to allow the pump 1 to shift through its complete stroke without having to rely on the displacement of fluid from the valve casings, an extra line is provided to the control cylinder 4 consisting of short conduits 54, 55 and 56, connected into the midpoints of the valves 22, 23 and 24 respectively, and each having a check valve 57, 58 and 59, respectively. These check valves will only open in the direction indicated by the arrows. Each of these short conduits connects into the line 60, and interposed between the fluid which flows out of the short conduits 54, 55, 56 and the control cylinder 4 is a choke valve 61.

In Figure 2 there has been illustrated a modification of the pressure responsive variable choke valve shown in Figure 1. The pressure responsive variable choke valve shown in Figure 2 is designated generally by 62 and includes casing 63. Located within the casing is a valve member 64 having piston portions 65 and 66. The piston 65 is provided with its own bypass which consists of a plurality of passageways 67 which extend from one side of the piston to the other. The interior of the casing is provided with an annular recess 68.

Leading into the cylinder between the pistons 65 and 66 and which corresponds to the short conduits 54, 55 and 56, is a conduit 69 which is provided with a check valve 70, which latter may only open in the direction of the arrow. Conduit 69 connects with the conduit 71 which latter corresponds to the conduit 60, Fig. 1, and which may lead back through a suitable choke valve 79, corresponding to 61, to the control cylinder 4. Connected to the interior of the casing 63 adjacent the right hand thereof is a short conduit 72 which is connected into the return conduit 73. The conduit 72 of Fig. 2 corresponds to conduit 49 of Fig. 1 and conduit 73 corresponds to conduit 52 of Fig. 1, and said conduit 73 connects into the control cylinder 4.

There is a bypass 74 and check valve 75 which corresponds to the bypass located to the right in Fig. 1 and to the check valve 46. The casing also has an extension 76 in which is located choke valve 77 and a pipe 78 which connects to the tank 8 and which corresponds to the conduit 53 in Fig. 1.

The valve 79 indicates a manually adjustable choke valve, the function of which is to replace choke valve 61. It will be noted that it is in the same position in the circuit, namely between the right hand and the central chambers of the valve 62.

Numeral 81 indicates a conduit corresponding to conduit 16 and is connected to the exhaust of the hydraulic motor 13 which may be either reciprocating or rotary type of hydraulic motor.

Furthermore it will be understood that the pressure responsive variable choke valve shown in Figure 2 may be substituted for one or more of the valves 25, 26 and 27.

Operation

It may be assumed that the pump 1 has been started, and that fluid is flowing from the pump 1 through conduit 9 into branches 10, 11 and 12 to the hydraulic motors 13, 14 and 15. Exhaust fluid from each of the hydraulic motors leads to the interior of the valve casings 22, 23 and 24. The pump control cylinder 4 is assumed to be of sufficient size to shift the pump to neutral or idling position at a predetermined low pressure, of, say, about 50 pounds per square inch. Inasmuch as the return line 52 from the control cylinder 4 is connected to the valve casings 22, 23 and 24 and into the space between the right hand casing wall and the right hand face of each piston 31, 33 and 35, the pressure within

these spaces will be the same as the pressure against the piston 3 within the control cylinder 4. In order to balance the valve members pressure must be the same in the spaces between the left hand ends of the valve casings and the left hand ends of the piston portions 32, 34 and 36, and the pressure between each pair of pistons such as 31, 32 must also be the same inasmuch as the conduits 37, 43; 38, 44, and 39, 45 are interconnected. This is also true of the construction disclosed in Figure 2 as the passageways 67 connect the opposite ends of the piston 65.

The chokes 40, 41 and 42 will always maintain a back pressure in the valve casings 22, 23 and 24.

The spring 5 on the pump tends to force the pump into full stroke position. The control piston 4, when it is moved toward the right, forces fluid through the line 52 and conduits 49, 50 and 51, thereby moving the valve members 28, 29 and 30 to the left so as to completely uncover the annular recesses 19, 20 and 21 to which are connected conduits 16, 17 and 18 from the hydraulic motors 13, 14 and 15, respectively.

In this position of the valve members there will be a relatively free flow of fluid into the space between the pistons of each valve member and from this space to the choke valves 30, 41 and 42. The pressure drop depends upon the size of the valve members and other factors such as the rate of flow, etc.

Assuming that the discharge of the pump flows to the hydraulic motors and that all of the chokes have been set at the required speed, if there is no work resistance met by the several motors they tend to speed up. The speed up of the motors will increase the flow from the conduits 16, 17 and 18 into the annular recesses 19, 20 and 21 and from the spaces between each pair of pistons of each valve member and into the pipes 37, 38 and 39 to the chokes 40, 41 and 42. This results in a building up of pressure ahead of the choke, and this pressure will act on the left hand side of each piston 32, 34 and 36 thereby moving the valve members to the right and partially closing annular recesses 19, 20 and 21. This action will produce a secondary pressure drop between the space between each pair of pistons and the conduits 16, 17 and 18.

Movement of the valve members to the right has moved fluid through conduits 49, 50 and 51 and line 52 against piston 3 in the control cylinder thereby compressing spring 5 and decreasing the output of the pump. Fluid will also flow from the spaces between the pistons of each valve member through the conduits 54, 55 and 56, check valves 57, 58 and 59, line 60, choke 61 to the right hand side of piston 3.

It will be understood that the line 60, together with its conduits 54, 55 and 56, as well as the bypasses 43, 44 and 45 permit the pump to go through its complete stroke, i. e. to shift from full delivery position to no delivery position, without having to rely solely on the displacement of fluid within the valve member. In other words the volume of fluid within the control cylinder need not be the same as the combined volumes of fluid in the valve casings 22, 23 and 24.

The purpose of the individual chokes 40, 41 and 42 is to be able to manually adjust the speed of each hydraulic motor which it controls. Assuming motors 13, 14 and 15 are running at the same speed and it is desired to run motor 14 at its maximum speed and to decrease the speed of motors 13 and 15, to accomplish this result chokes 40 and 42 are moved so as to be more nearly

closed and choke 41 is open to substantially its maximum extent.

As the choke 41 is opened, the pressure between the pistons 33 and 34 and on the left hand side of piston 34 drops. This will cause the valve member 29 to move to the left and it may even move in this direction to such an extent as to uncover the right hand connection of the bypass line 44 which connects through the check valve 47 to the interior of the valve casing adjacent the right hand end thereof. Fluid will simultaneously flow through the conduit 38, return conduit 53 to the tank 8 and pressure will be relieved in the line 52 through the connection 50 into the valve casing and through the bypass, and out the pipe 38 and conduit 53 to the tank 8. This will momentarily drop pressure in the cylinder 4 and, through the action of the spring 5, cause the pump to move to increased stroke position.

As the velocity of the motor 14 increases the back pressure also increases to a certain extent and will cause the valve member 29 to move to the right so as to control the motor 14.

Valve members 28 and 30 will also find their equilibrium at substantially the same time as valve member 29.

It will be apparent that the bypass connection at the right hand end of the valve 23 is effective to permit the spring 5 to move the pump on full stroke, if necessary, the fluid thus displaced from the cylinder 4 passing through the conduit 51, the conduit 50, the check valve 47, conduit 38, choke valve 41 and conduit 53 to the tank 8. Also, the fluid communication from the cylinder 4 through the choke valve 61 and the choke valves 57, 58 and 59 to the valves 22, 23, and 24 is effective to permit the pump to move substantially to neutral, if necessary, regardless of the fluid displaced from the said valves, providing the pressure at the center of any one of the valve is great enough.

The volume of oil displaced by the control system is therefore not dependent upon the volume of oil displaced by the valve members.

It will therefore be understood that the structure disclosed herein provides a means whereby the speed of two or more hydraulic motors which are driven from a single pressure source may be controlled.

This is achieved by the provision of a pressure responsive variable choke valve attached to the exhaust side of each hydraulic motor, the value of which is determined by the pressure drop across an adjustable choke, one of which is provided with each pressure responsive variable choke valve. The valve member of the pressure responsive variable choke valve will move to a position such that pressure drop across it will hold back pressure on the hydraulic motor which it controls and thereby maintain the speed of the hydraulic motor constant. The speed at which each hydraulic motor is to be run may be adjusted by means of the manually controlled adjustable choke. Therefore the individual speed of each of two or more motors driven from the same pressure source may be accurately controlled so that the speed of each motor will stay at a predetermined value even under great variations in loads.

It should further be noted that the variable delivery source of fluid pressure is variable only as necessary to correct momentary changes in motor speeds and will always return substantially to its original position regardless of load conditions on the motors and regardless of

changes in position of the pressure responsive variable choke valve. The delivery of the pump is changed permanently only by a change in setting of one or more of the manually adjustable chokes.

The theory of this system is that each motor operates independently of all the others and a change in the speed of one motor does not necessarily mean a change in speed of the others; instead a variation in speed of one motor causes a change in the pressure conditions prevailing in the control system which affects the pressure responsive variable choke valve of the varying motor, to restore its speed, affects the pump stroke to help restore the speed of this motor, and affects the pressure responsive variable choke valves of the other motors to maintain their speed by opposing the change in pump delivery. For example, if motor **15** should slow down the action is as follows:

a. The pressure drops in the groove **21** because of reduced flow.

b. The pressure drops on the left side of valve member **30**, due to (*a*) and the valve shifts to the left decreasing the restriction at **21**.

c. The movement of the piston **30** to the left allows fluid to flow in conduit **52** putting the pump on increased stroke.

d. The valve members **28** and **29** shift to the right for the same reason that the pump stroke is influenced, namely the removal of fluid from conduit **52** by movement of the valve member **30**, increasing the restrictions at **19** and **20** and thereby neutralizing the effect of the increased pump delivery on the motors **13** and **14**.

It is apparent that the slowing down of motor **15** has caused changes in the system tending to correct the speed thereof, and that these changes also act to cause motors **13** and **14** to be unresponsive to the correcting influences. Now all of this is temporary and after a short time all of the original speed conditions are restored and the pump stroke returns to normal. The only permanent change in the system is a new location of the valve member **30** to compensate for the changed load on motor **15**.

The movable element of each pressure responsive variable choke valve, i. e., members **28**, **29** and **30** will all be in the same position, such as indicated in Figure 1, provided the speeds and loads of each hydraulic motor are identical.

The function of the manually operated choke valve **61** is to damp out small variations in the pressure that occur in the pressure responsive variable choke valves in order to prevent the pump **1** from fluctuating too much whenever the load changes in one or more of the hydraulic motors **13**, **14** or **15**. This valve **61** also helps to establish a pressure differential between the two ends of one of the pressure responsive variable choke valves during a change of condition of its hydraulic motor, i. e., when the load either increases or decreases in the corresponding motor of the corresponding pressure responsive variable choke valve.

The partial closing of any one of the choke valves **40**, **41** or **42** will slow down the operation of its corresponding fluid motor **13**, **14** or **15**. Should one of these choke valves be partially closed the speed of that motor will be slowed down but the speed of the other motors will be unaffected.

To sum up: Assuming all of the motors are operating under the same conditions of speed and load, should one of the motors encounter a

change of load its speed is momentarily affected but due to the foregoing operation its speed will be restored to normal. Should it be desired, however, to increase or decrease the speed of any one of the motors, this can be accomplished by the manual operation of its corresponding manually operated choke valve **40**, **41** or **42**.

The second sheet of drawings shows an embodiment of this invention as applied to reciprocating motors. In this view, means are provided whereby a plurality of reciprocating motors may be controlled by the mechanism of this invention in such a manner that the operation of one motor is absolutely independent of the others. In fact, as stated before, the motors need not be reciprocating motors but could be rotary motors or any arrangement of rotary and reciprocating motors. Such a situation might arise in the event of several hydraulically actuated machines, individually and separately operated, being supplied with pressure fluid from a common source.

This view, Figure 3, also shows a means for extending the control to the retraction stroke of a reciprocating motor.

This is accomplished as follows:

The motors **90** and **91** are supplied with pressure fluid by means of the conduit **9** from the pump **1**, the fluid passing through conduits **92** and **93** into pilot operated, four way valves **94** and **95** and thence through conduits **96**, **97**, **98** and **99** into the motors **90**, **91** where the fluid pressure is converted into mechanical force by means of the working surfaces of the pistons.

Fluid is exhausted from the motors through the four way valves and into conduits **100**, **101**, whence it passes into the balancing valves at **102**, **103**. These valves are identical with those of Figure 1.

The discharge from the pressure responsive variable choke valves passes through conduits **104** and **105** into pilot operated three way valves **106** and **107**. These last mentioned valves are for the purpose of interconnecting the conduits **104** and **105** with either conduits **108** and **110** respectively or with conduits **109** and **111** respectively.

Each of the conduits **108**, **109**, **110**, **111**, has a choke valve **112**, **113**, **114**, **115** therein, the functions of which are identical to the functions of the choke valves **40**, **41**, **42** in Figure 2.

A pilot pump **102** is provided for the purpose of supplying pressure fluid for the purpose of shifting the valves **94**, **95**, **106** and **107**. Pilot valves **121** and **122** are provided for the purpose of selecting the desired position of valves **94**, **95**, **106** and **107**. Pilot fluid is supplied to the pilot valves through conduits **123** and **124** and conducted therefrom to the controlled valves by means of conduits **125**, **126**, **127** and **128**. Exhaust fluid is conducted from the pilot valves to the reservoir by means of a conduit **129**.

Conduits and valves interconnect the pressure responsive variable choke valves and the pump control cylinder in a manner identical to that shown in Figure 1.

Operation of the structure shown in Figure 3:

In Figure 3 the motor **90** is on the retraction stroke and the motor **91** is on the forward stroke.

Motor **90** has been placed on the retraction stroke by the operator of the machine, of which it is a part, by his positioning the pilot valve **121** to direct pilot fluid through conduit **125** to the left hand pilot cylinders of the valves **94** and **106** and motor **91** has been placed on forward

stroke by a similar manipulation of the pilot valve 122, by the operator of that machine, this manipulation causing pilot fluid to be directed through conduit 128 to the right hand pilot piston of the valves 95 and 107.

The shifting of the valves 94 and 95 causes pressure fluid from the pump to flow either to the forward area or the reverse area of the work ram and shifting of the valves 106 and 107 causes exhaust fluid from the motors to be directed through the proper choke.

In this manner it is possible to predetermine the retraction speed as well as the forward speed of the controlled motors.

It is obvious that the choke valve in conduit 112 must be different than that in conduit 113 since one must pass the fluid from the main chamber and the other must pass only the fluid from the retraction chamber.

While only two motors have been shown in Figure 3 it is evident that any number of motors, within the capacity of the pump 1, to supply fluid thereto, may be successfully operated and controlled by the system of this invention.

It will be understood that the invention is not limited to the particular structure shown in the drawings, but also embraces such modifications as come within the scope of the claims.

What is claimed is:

1. In a hydraulic system, a plurality of fluid motors having their inlets connected together; a variable restriction connected with the outlet of each of said motors; an adjustable restriction connected with the outlet of each of said variable restrictions; each of said variable restrictions comprising a first and a second fluid operable means adapted for urging said restriction into increased or decreased restricting condition respectively; means hydraulically connecting each of the first of said fluid operable means with the outlet of the associated restrictor; a common channel interconnecting all of said second fluid operable means; a check valve connected with the outlet of each of said variable restrictions and opening into said channel; and a fluid source connected to supply actuating fluid to said motor inlets and having associated therewith flow controlling means connected with said channel for varying the supply of fluid to said inlets inversely to the pressure in said channel.

2. In a hydraulic system, a fluid source; a plurality of motors having their inlets connected to receive fluid from said source; a variable restriction and an adjustable restriction serially connected in the discharge side of each of said motors with the variable restriction adjacent said motors; opposed fluid operable means for varying said variable restrictor, one of the fluid operable means of each of said variable restrictions being connected with the outlet thereof and the other of said fluid operable means being connected together by a common channel; a check valve connected with the outlet of each of said variable restrictions opening outwardly therefrom into a second common channel; a choke valve interconnecting said channels for supplying pressure fluid from one of the outlets of said variable restrictions to said second fluid operable means; and fluid pressure responsive flow control means for varying the supply of fluid from said source to said motor inlets connected with said second fluid operable means.

3. In a hydraulic system; a fluid source of variable delivery; a plurality of fluid motors having their inlets connected for simultaneously receiving fluid from said source; a variable restricting valve connected with each of said motor outlets for passing the entire discharge of the associated motor; an adjustable restricting valve connected with the outlet of said variable restricting valve for passing the entire discharge therefrom; said variable restricting valve comprising a first fluid operable area connected with the outlet thereof and adapted for urging said valve into increased restricting position, and a second fluid operable area adapted for urging said valve into decreased restricting position; a check valve connected with each of the outlets of said variable restrictors and opening outwardly therefrom into a common channel; means including a choke valve hydraulically connecting said channel with all of said second fluid operable areas; and fluid pressure responsive flow control means associated with said fluid source hydraulically connected with said second fluid operable areas whereby the speed of each motor is maintained substantially constant and independent of the speeds of the other of said motors and the delivery from said fluid source is varied in accordance with the speeds of said motors.

4. In a hydraulic system; a plurality of fluid operable motors having inlets and outlets; a fluid source for supplying fluid to said inlets; individual control means associated with said motor outlets operable automatically to maintain the individual speeds of said motors substantially constant irrespective of the variations in loads thereon, each of said control means comprising a variable flow restricting means and a restrictor connected between a motor outlet and exhaust in the order named, fluid operable means responsive to the discharge pressure of each variable flow restricting means for increasing the restriction thereof, other fluid operable means for decreasing the restriction of said variable flow restricting means, and means of selectively and continuously connecting said other fluid operable means with the inlet of the restrictor having the highest inlet pressure.

5. In a fluid operable system; a plurality of fluid operable motors having inlets and outlets; a fluid source of variable delivery connected to said inlets for supplying actuating fluid to said motors, yielding means associated with said source for continuously urging the same toward increased delivery position, fluid operable means associated with said fluid source for urging the same toward reduced delivery position; control means associated with the outlet of each of said motors, each of said control means comprising a variable choke valve having its inlet connected with the outlet of said motor and an adjustable choke connected to the outlet of said variable choke valve, the outlet of said adjustable choke valve being connected with exhaust; a first fluid operable area associated with each of said variable choke valves for urging the same toward increased restriction position; a second fluid operable area associated with each of said variable choke valves for urging the same toward decreased restriction position; means hydraulically connecting each of said first fluid operable areas with the outlet of the associated valve; means hydraulically connecting all of said second fluid operable areas with the fluid operable means associated with said source; and means for automatically and continuously conducting fluid to said fluid operable means and to said second fluid operable areas only from the outlet of the variable choke valve having the greatest pressure.

6. In a fluid operable system, a plurality of fluid operable motors having inlets and outlets, a variable delivery pump connected with said inlets for supplying actuating fluid to said motors, fluid pressure responsive means associated with said pump and operable in response to a predetermined pressure to move said pump toward decreased delivery position; a flow control means associated with each of said motor outlets, each of said flow control means comprising a variable choke valve and an adjustable choke valve, said variable choke valve having its inlet connected with the exhaust of the associated motor and its outlet connected to the inlet of said adjustable choke valve and the outlet of said adjustable choke valve being connected with exhaust; a first and a second opposed area associated with said variable choke valve for moving the same, respectively, into increased or decreased restriction position; means hydraulically connecting the first of said areas with the outlet of said variable choke valve; a check valve opening from each of said variable choke outlets into a common channel, a choke valve having its inlet connected to said channel and its outlet connected with said second areas and with said fluid pressure responsive means.

7. In a fluid operable system, a plurality of fluid operable motors having inlets and outlets, a variable delivery pump connected with said inlets for supplying actuating fluid to said motors, fluid pressure responsive means associated with said pump and operable in response to a predetermined pressure to move said pump toward decreased delivery position; a flow control means associated with each of said motor outlets, each of said flow control means comprising a variable choke valve and an adjustable choke valve, said variable choke valve having its inlet connected with the exhaust of the associated motor and its outlet connected to the inlet of said adjustable choke valve and the outlet of said adjustable choke valve being connected with exhaust; a first and a second opposed area associated with said variable choke valve for moving the same, respectively, into increased or decreased restriction position; means hydraulically connecting the first of said areas with the outlet of said variable choke valve; a conduit connecting said second areas with said fluid pressure responsive means; check valves connected to open from each of the outlets of said variable choke valves into said conduit for supplying actuating fluid to said second areas and to said fluid pressure responsive means; and bypass means adapted for being made effective in response to the positioning of any of said variable choke valves in a predetermined position of lesser restriction for permitting the exhaust of fluid from said fluid pressure responsive means to permit said pump to move to full delivery position.

8. In a fluid operable system; a plurality of fluid operable motors having inlets and outlets, a fluid source for supplying fluid to said inlets; individual flow control means connected with the outlet of each of said motors for controlling the speed of said motors and each comprising a variable flow restricting means connected with the motor outlet and a choke between the variable flow restricting means and exhaust; each of said variable flow restricting means being responsive to increases in pressure at its discharge side for moving to increased restriction position, and also being continuously responsive to the highest pressure at any of said chokes for moving toward decreased restriction position.

9. In a fluid operable system; a plurality of fluid motors; each of said motors having a variable flow restricting means connected with its outlet, and each of said flow restricting means having a choke connected with its outlet; means responsive to the discharge pressure of each of said flow restricting means for increasing the effect thereof; means continuously and selectively responsive to the highest pressure at the inlet of any of said chokes for decreasing the effects of said flow restricting means; fluid supply means for supplying actuating fluid to the inlets of said motors; and flow controlling means for said fluid supply means connected to be responsive to said last mentioned pressure.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,166,940	Conradson	July 25, 1939
2,223,838	Tweedale	Dec. 3, 1940
2,238,061	Kendrick	Apr. 15, 1941
2,317,563	Tucker	Apr. 27, 1943
1,974,137	Ferris	Sept. 18, 1934
2,343,912	Lauck	Mar. 14, 1944
1,905,519	Soderberg	Apr. 25, 1933
2,374,630	Tucker	Apr. 24, 1945
2,009,608	Douglas	July 30, 1935

FOREIGN PATENTS

Number	Country	Date
549,211	British	of 1942