

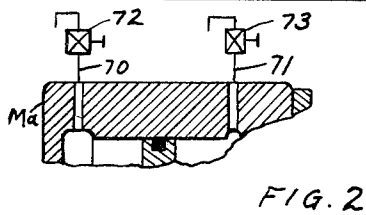
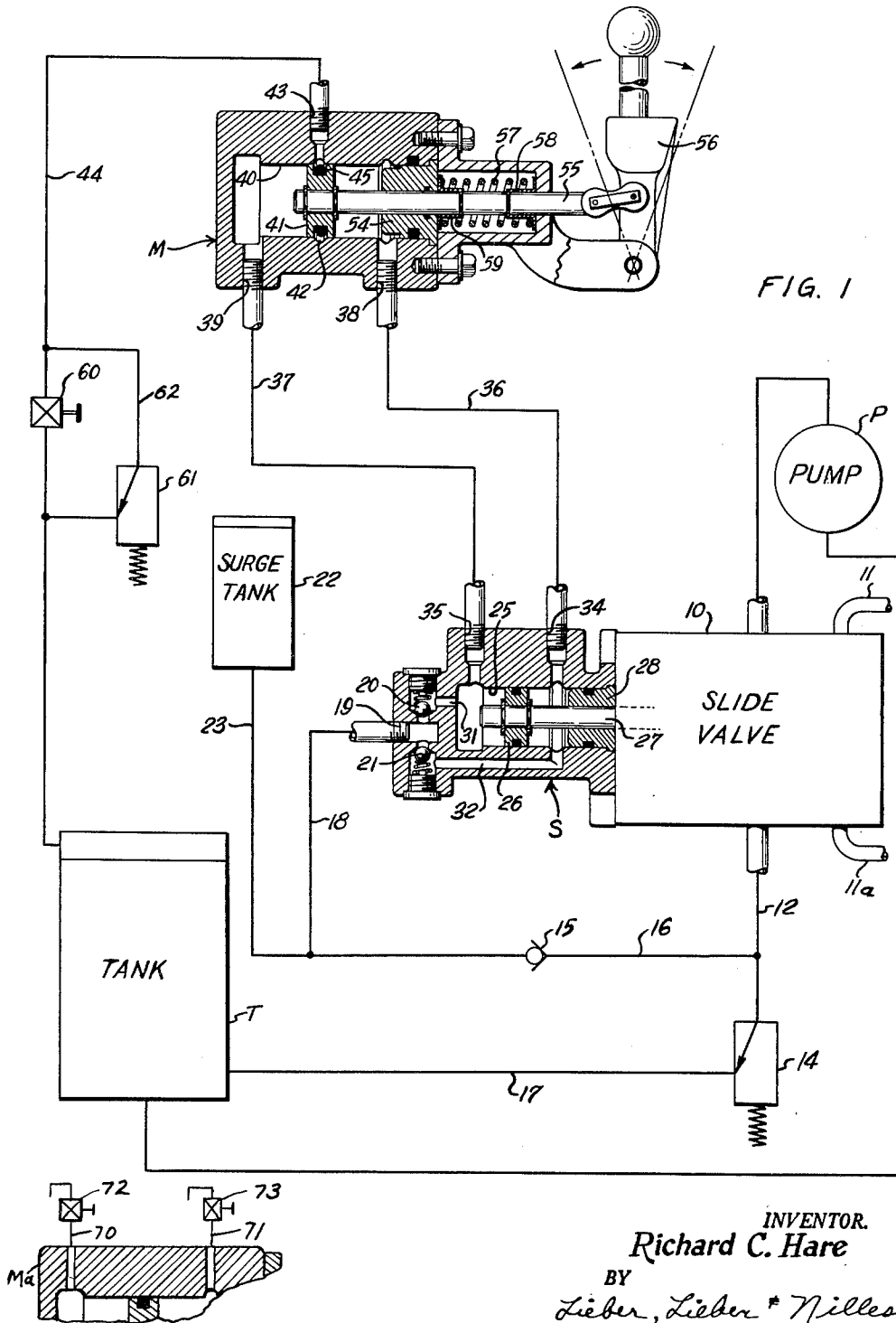
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HYDRAULIC CONTROL SYSTEM

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## HYDRAULIC CONTROL SYSTEM

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This invention relates to control systems of the type employing master and slave cylinder units for controlling various types of actuators or valves.

One of the shortcomings of prior art devices of this general type is the entry of air into the system which causes malfunctioning and even nonfunctioning of various parts and of the system itself.

Accordingly, the present invention provides an improved master and slave control system and also an improved slave cylinder unit therefor, which eliminates air from the system and results in a positive acting and trouble-free control system.

More specifically, the entire system is purged by supercharging it and either continually bleeding off fluid pressure and entrained air or periodically manually bleeding off entrained air. This is accomplished by maintaining solid columns of fluid between the units and maintaining positive or super atmospheric pressure in the master cylinder. When the continually bleeding embodiment is used, even when the control system is in the neutral condition a continual and positive flow occurs through the master unit.

The above supercharging and purging of the system is possible by the use of a novel slave unit having a check valve at each of its inlet sides from the source of fluid for continually furnishing pressure fluid through the slave unit and system.

With the above arrangement a two-stage amplifier control system is provided which has solid columns of pressure fluid between its various parts, and can be supercharged and bled so that air cannot accumulate or become entrapped.

These and other objects and advantages of the present invention will appear hereinafter as this disclosure progresses, reference being had to the accompanying drawings, in which:

FIGURE 1 is a schematic diagram of a system using the present invention in a continually bleeding or purging system, the master and slave units being shown in cross-section; and

FIGURE 2 is a fragmentary, sectional view showing a modified form of the invention.

Referring in greater detail to the drawings and particularly to FIGURE 1, a slide valve 10 has been shown as an illustration of one of many various control units that may be operated by means of the present invention. While the valve 10 is a hydraulic control element, the invention is not to be limited to the field of hydraulics or to any particular type of unit to be actuated. For purposes of this disclosure, it is believed sufficient to say that valve 10 may be of the type shown in my co-pending U.S. patent application, Serial Number 670,440, filed July 8, 1957, and entitled, "Slide Plate Type Hydraulic Valve," issued on September 6, 1960, as Patent Number 2,951,505. The pump P furnishes fluid to the valve, and the latter may then direct fluid to and receive fluid from the load (not shown) in the well known manner through conduit 11 and 11a.

A conduit 12 extends from the valve 10 and directs fluid, when the valve is in neutral, to the relief valve 14 and also to the check valve 15 in conduit 16. Valve 14 is set at a predetermined pressure to dump excess fluid pressure to the reservoir or tank T via conduit 17. For

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purposes of illustration only, say the valve 14 is set to open at 35 p.s.i. and check valve 15 is set at 3 p.s.i. Conduit 16 is connected via conduit 18 to the slave unit S, more particularly, it is in fluid delivering communication, via a supercharger port 19 in the housing, with the spring biased, check ball valves 20 and 21 located in the housing of unit S.

It should be appreciated that a separate source of fluid could be used to furnish fluid to the slave unit S via conduit 18, and the invention should not be limited to the illustration shown wherein the fluid is supplied by the pump P.

A surge tank 22 is connected by its conduit 23 to the conduit 18 and acts to store pressure fluid in the well known manner to prevent fluctuating or surging in the system. This surge tank, however, is not essential to the invention, but it does contribute to a smoothly operating system.

The slave, cylinder-piston, unit S includes a large bore 25 formed in the housing which defines a cylinder in which the piston 26 can reciprocate. A control stem 27 forms the piston rod and may extend into the valve 10 for controlling the latter. A plug 28 closes the rod end of the cylinder, and the stem 27 reciprocates in this plug. A passage 31 in the housing places the downstream side of check valve 20 in fluid communication with the head end of the cylinder, and passage 32 likewise connects valve 21 with the rod end of the cylinder.

The check valves 20 and 21 are shown as being located in the housing of unit S but they could of course be located on conduits which lead to the unit, it being necessary only that a supply of fluid is continually available to each end of the slave unit.

The slave unit also has ports 34 and 35 which place conduits 36 and 37 respectively in communication with the rod end and head end of the cylinder 25. Movement of the master piston causes a corresponding indexing movement of the slave piston to actuate the central element 10 in the known manner.

Conduits 36 and 37 connect the slave unit with the rod end master port 38 and head end master port 39, respectively, of the master unit M, now to be described.

The master, cylinder-piston, unit M includes a housing 45 having a bore 40 therein that constitutes a cylinder in which piston 41 reciprocates. An annular groove 42 is formed around a generally central or intermeditate portion of the bore and a bleed off port 43 places groove 42 in fluid communication with conduit 44 extending from port 43. Thus groove 42 and port 43 constitute a bleed-off passageway.

The piston 41 carries an O-ring seal 45 around its periphery which sealingly slides in the cylinder.

When the piston is in the position shown, fluid may leak from either end of the cylinder, under piston, into groove 42 and out conduit 44 to tank T. Thus the master unit M constitutes an open center unit. The master unit also has a plug 54 which seals the rod end of the cylinder and through which the piston rod 55 sealingly reciprocates. The rod 55 is shown as being of the manually operated type by means of a pivoted control handle 56. A spring 57 acts between the washers 58 and 59 secured to the rod to urge the piston to the center, neutral position, as shown.

The master unit M can also continually bleed into conduit 44, when the piston is shifted, from either its rod or head end, depending on the location of its piston in the cylinder 40. An explanation of the operation will illustrate this feature.

In operation, when the lever 56 is shifted to the left, as viewed in the drawing, the piston moves to the left, exposing the groove to the rod end of the cylinder. Pressure fluid in the head end of the cylinder is forced

through conduit 37 to the head end of the slave unit S. This causes piston 26 to shift to the right, actuating the control element 10. At the same time, fluid is transmitted from the rod end of the slave unit, via conduit 36, to the rod end of the master unit. This fluid then flows freely into the completely exposed groove 42 and back to the reservoir. In addition, fluid is at the same time admitted via check valve 21 to the rod end of the slave unit and through conduit 36, out groove 42 and to the reservoir. Thus a bleeding of fluid takes place when the system is being used to actuate element 10.

Similarly, when the piston 41 is shifted to the right, fluid is bled through check valve 20, passage 31, conduit 37, groove 42, and conduit 44 to the reservoir. Pressure fluid at that time is forced through conduit 36 to shift piston 26 to the left and actuate valve 10 in that direction.

In this manner a continual purging or bleeding of air from the system occurs whether the system is in neutral or is acting to shift the control element in either direction.

Sealed columns of fluid between the units keep air out of the system. The circuit is held at a superatmospheric pressure, a positive pressure is maintained in the master cylinder.

Only one slave unit and one master unit have been shown in illustrating the invention, but any number of units may be banked together, for example, three master units may be banked together and bled off to a common bleed port, and control, respectively, three banked slave units.

Means are provided in the system for assuring proper operation thereof when the master unit is located at a considerable height above the rest of the system, as for example, when the master unit is located in an operator's cage at the free end of a vertically positionable boom. Such structure is often used in fruit pickers "squirrel cages," for example. Under such circumstances, when the boom is elevated, a considerable head is created due to the height of the master unit.

The pressure head thus created may be sufficient to nullify or overcome the supercharging pressure furnished to the slave unit. Therefore the following valving arrangement may be provided for this type of operation.

A hand operated valve 60 may be provided in line 44 and a relief valve 61 provided in a conduit 62 which forms a branch in conduit 44 and around the hand valve.

In the illustration of the invention shown, by way of example, valve 61 may be set at 20 p.s.i. to thereby create a back pressure necessary when the unit M is elevated. Before the unit M is elevated, however, the system may contain a considerable amount of air and if it is desired to purge the system quickly before elevating the unit M, then valve 60 may be momentarily opened.

Referring now to the modified form of the invention shown in FIGURE 2, the master cylinder unit Ma does not have a central groove for continual purging, nor the conduit 44 which leads to the tank, but otherwise the arrangement is as shown in FIGURE 1. Instead, separate conduits 70 and 71 are led from the head end and rod end, respectively, of the unit. Manually operated purge valves 72 and 73 are located in lines 70 and 71, respectively, and are periodically opened to purge the air or gas entrained in the system. In this modification, the purging valves are also useful to index between the master and slave units. Conduits 70 and 71 may be vented as desired, for example, to the tank T or to the atmosphere.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

I claim:

1. A hydraulic system comprising, a master cylinder unit including a cylinder having a head end and a rod end, means including an annular groove around an intermediate portion of said cylinder and between said ends for continually bleeding fluid from said master unit, a slave cylinder unit adapted to actuate a control member, said slave unit having a head end and a rod end in fluid communication with their respective ends of said master unit whereby said slave unit is indexable by said master unit, fluid source means in fluid delivering communication with each end of said slave unit, and a check valve between said source means and each of said slave unit ends.

2. A hydraulic system comprising, an open-center type master cylinder unit including a cylinder having a head end and a rod end, passageway means located generally centrally of said cylinder for continually bleeding fluid from said master unit, a slave cylinder unit adapted to actuate a control member, said slave unit having a head end and a rod end each in fluid communication with its respective end of said master unit whereby said slave unit is indexable by said master unit, fluid source means in fluid delivering communication with each end of said slave unit, and a check valve between said source means and each of said slave unit ends.

3. A hydraulic system comprising, a master cylinder unit including a cylinder having a head end and a rod end, and a piston reciprocable in said cylinder and having a peripheral seal for slidable and sealable engagement with said cylinder, said cylinder having an annular groove around an intermediate portion thereof, a bleed port in communication with said groove for conducting fluid from said master unit, said piston adapted to straddle said groove when in a neutral position whereby said seal does not sealingly engage said cylinder and fluid can bleed from said cylinder ends to said groove and bleed port, a slave cylinder unit adapted to actuate a control member, said slave unit having a head end and a rod end in fluid communication with their respective ends of said master cylinder unit whereby said slave unit is indexable by said master unit, fluid source means in fluid delivering communication with each end of said slave unit, and a check valve between said source means and each of said slave unit ends.

4. A hydraulic system comprising a master cylinder having a piston reciprocable between first and second ends thereof, an operating handle connected to said piston to stroke said piston between said first and second ends, passageway means located generally centrally of the ends of said cylinder for continually bleeding fluid from said master cylinder, a slave cylinder unit having a piston slidable therein defining first and second ends, a fluid connecting conduit between said first end of said slave cylinder and said first end of said master cylinder and a fluid connecting conduit between said second end of said slave cylinder and said second end of said master cylinder, a fluid source means in direct fluid delivering communication with each end of said slave unit wherein fluid is first introduced into said system via said slave cylinder and a check valve between said source means and each of said slave unit ends.

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