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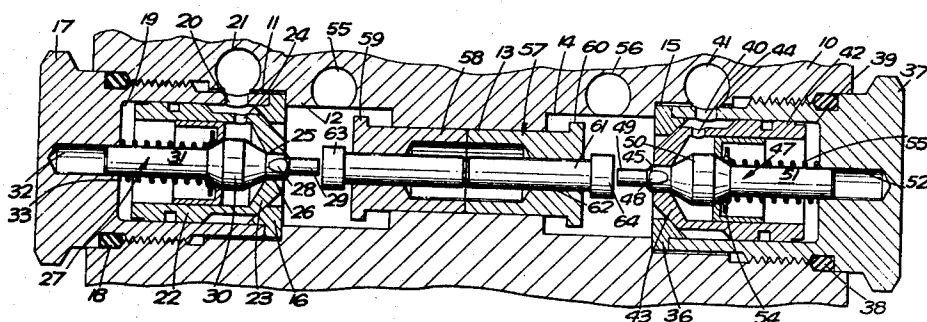
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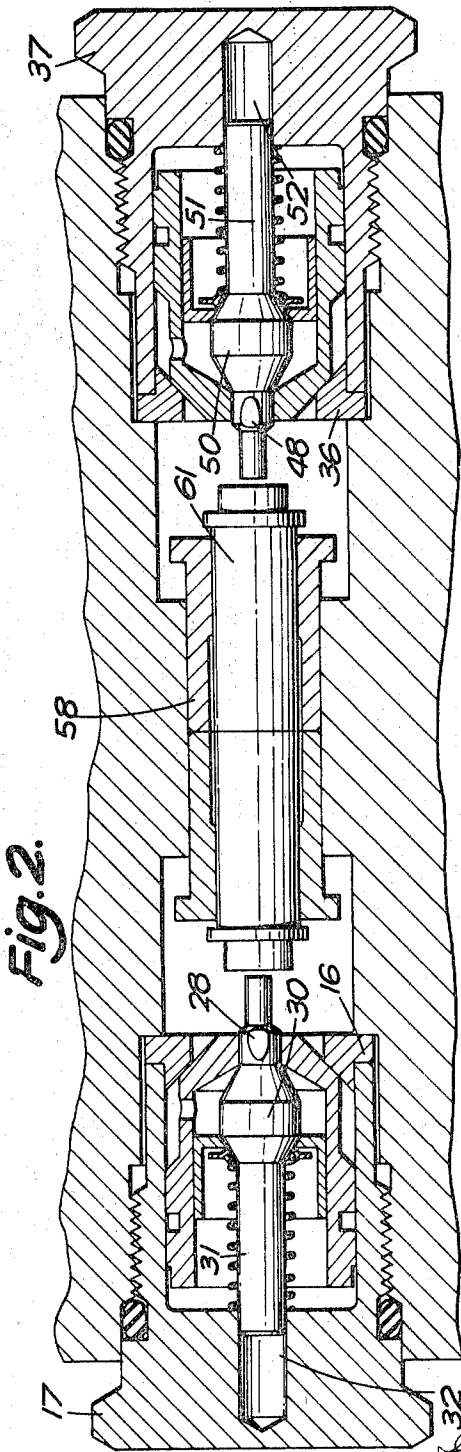
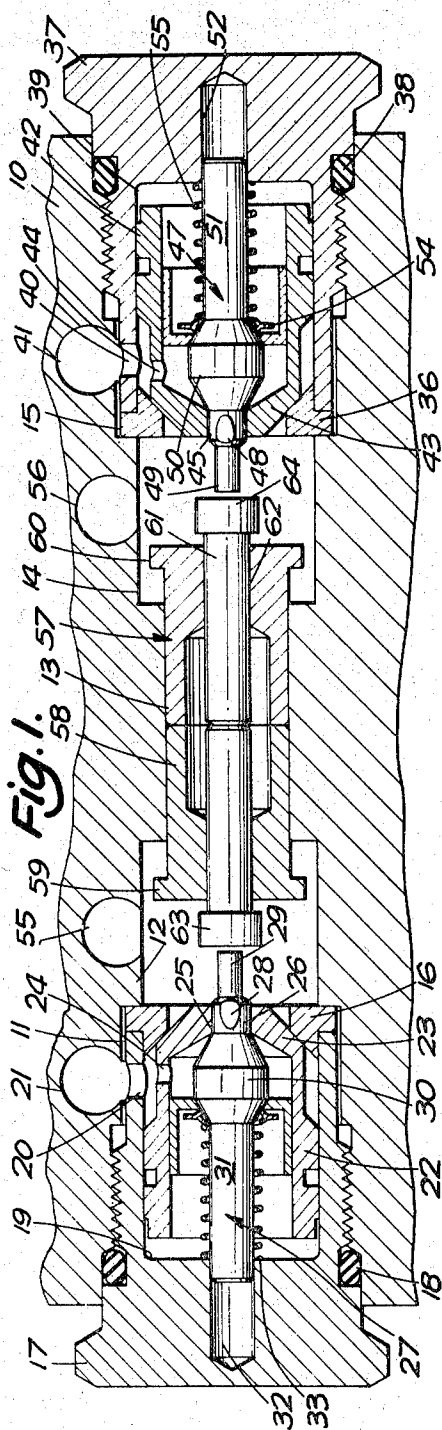
[54] **LOCK-OUT VALVE ASSEMBLIES FOR
HYDRAULIC CONTROL SYSTEMS**
12 Claims, 8 Drawing Figs.

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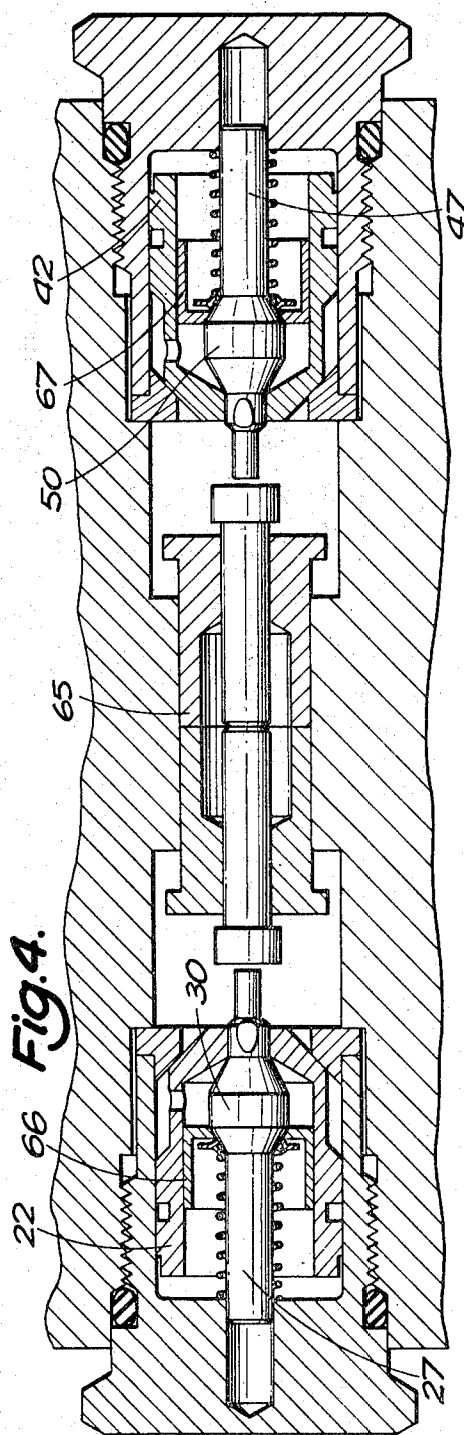
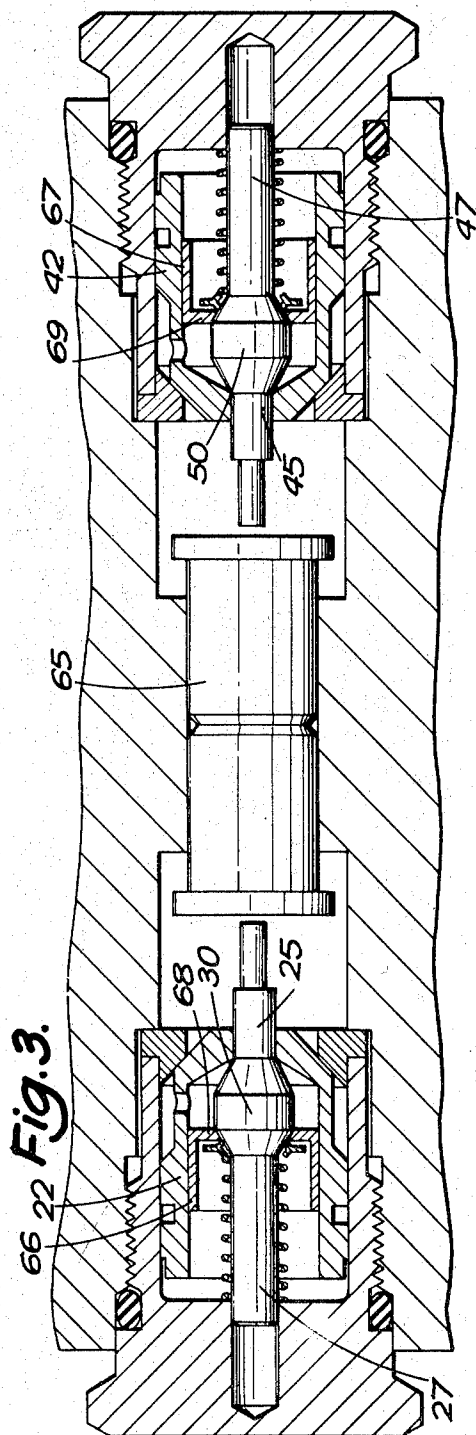
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ABSTRACT: A lockout valve assembly comprises first and second nonreturn valves, arranged to permit flow from a hydraulic control valve to the two sides respectively of a double-acting hydraulic ram. Each nonreturn valve comprises a chamber for communication with a service port of the hydraulic control valve, a movable main valve member engageable with a valve seat surrounding an outlet for communication with one side of the double-acting device, and a pilot valve member engageable with a pilot port in the main valve member, there being provided between the first and second nonreturn valves a reciprocable plunger assembly having one end thereof projecting into each valve chamber and arranged, when moved further into the chamber, to engage and move the pilot valve member in a manner to permit flow of hydraulic fluid through the pilot port. There is movable with each valve member a piston part reciprocable within a bore closed at one end there being a restricted passage through which hydraulic fluid can escape as the piston part moves towards the closed end of the bore and through which fluid must pass to enter the bore and cause closure of the pilot valve.





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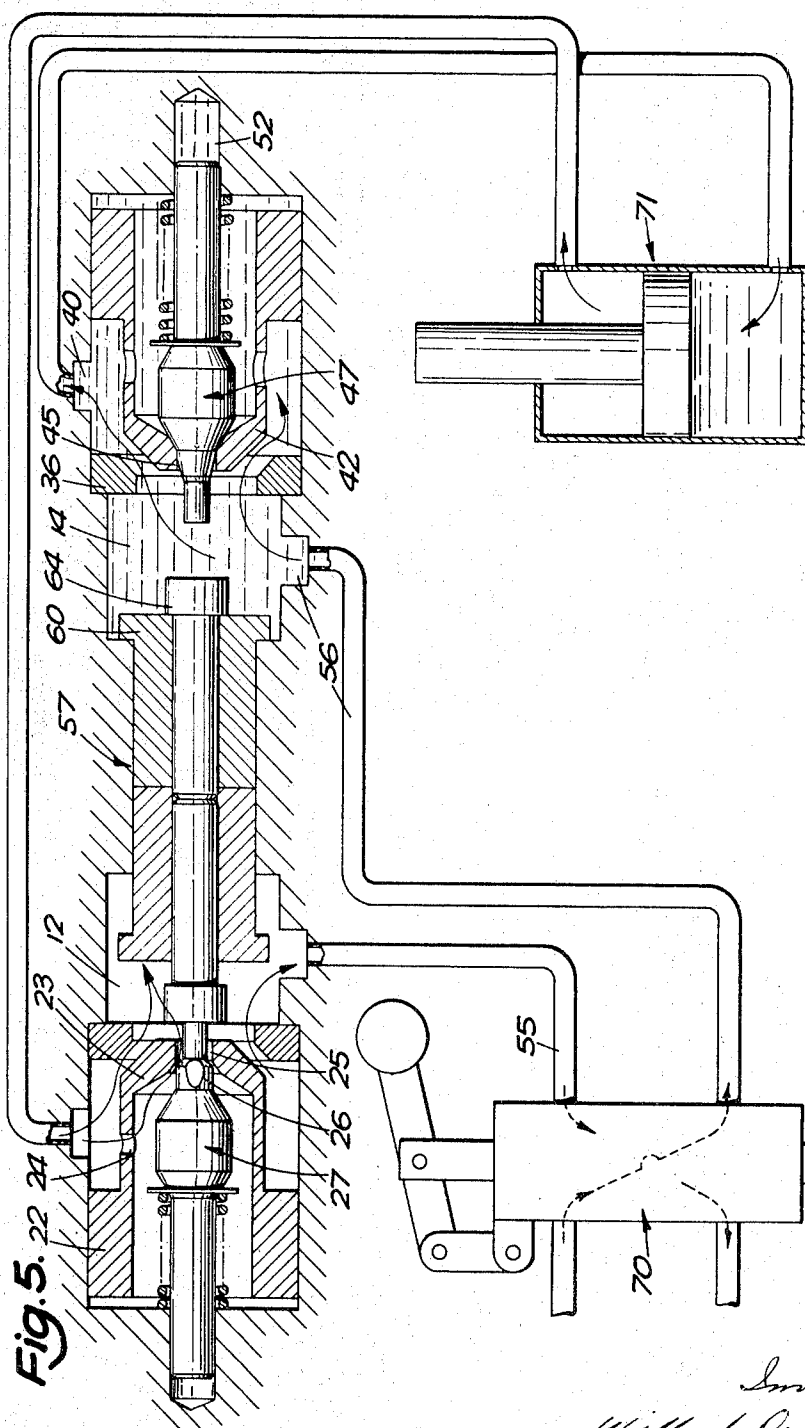
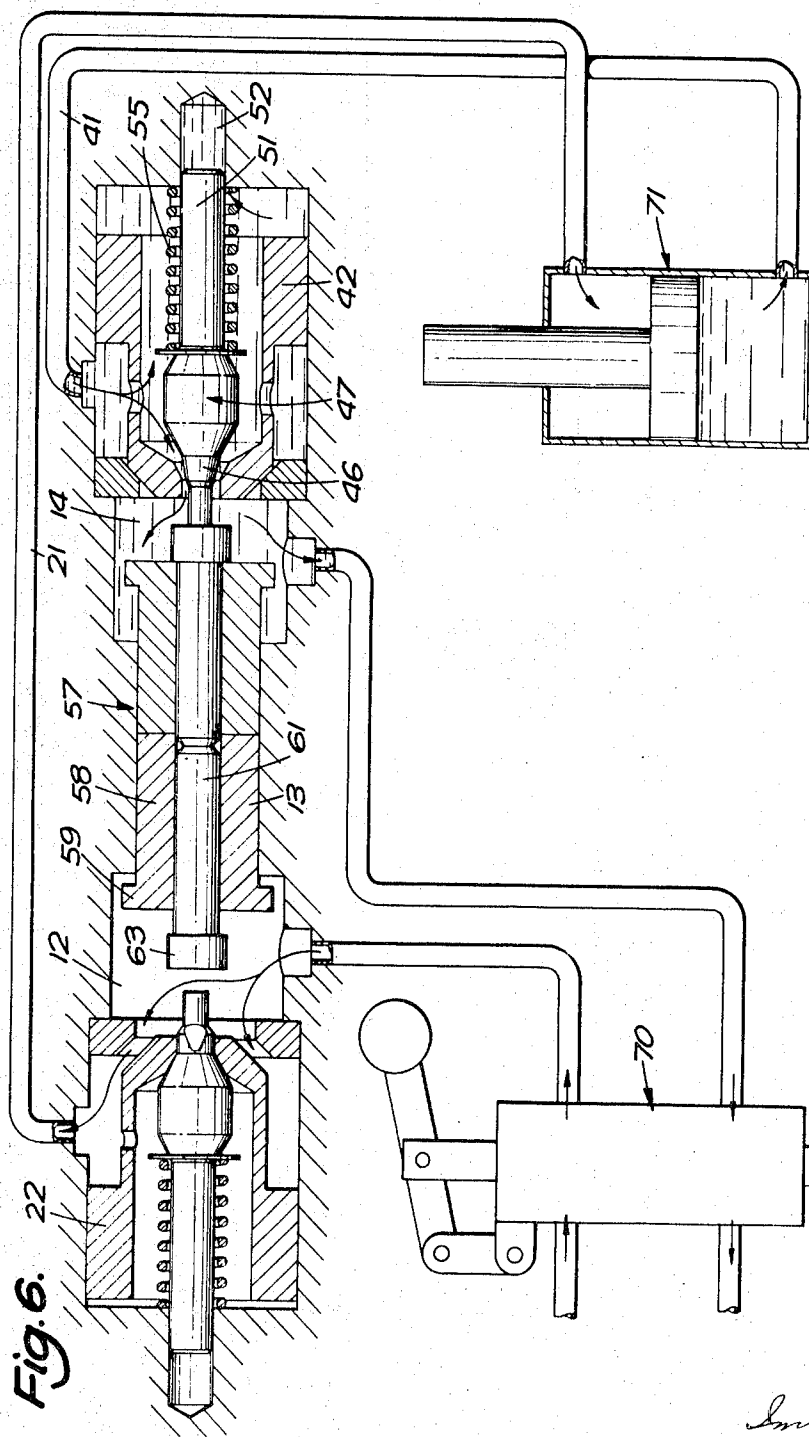
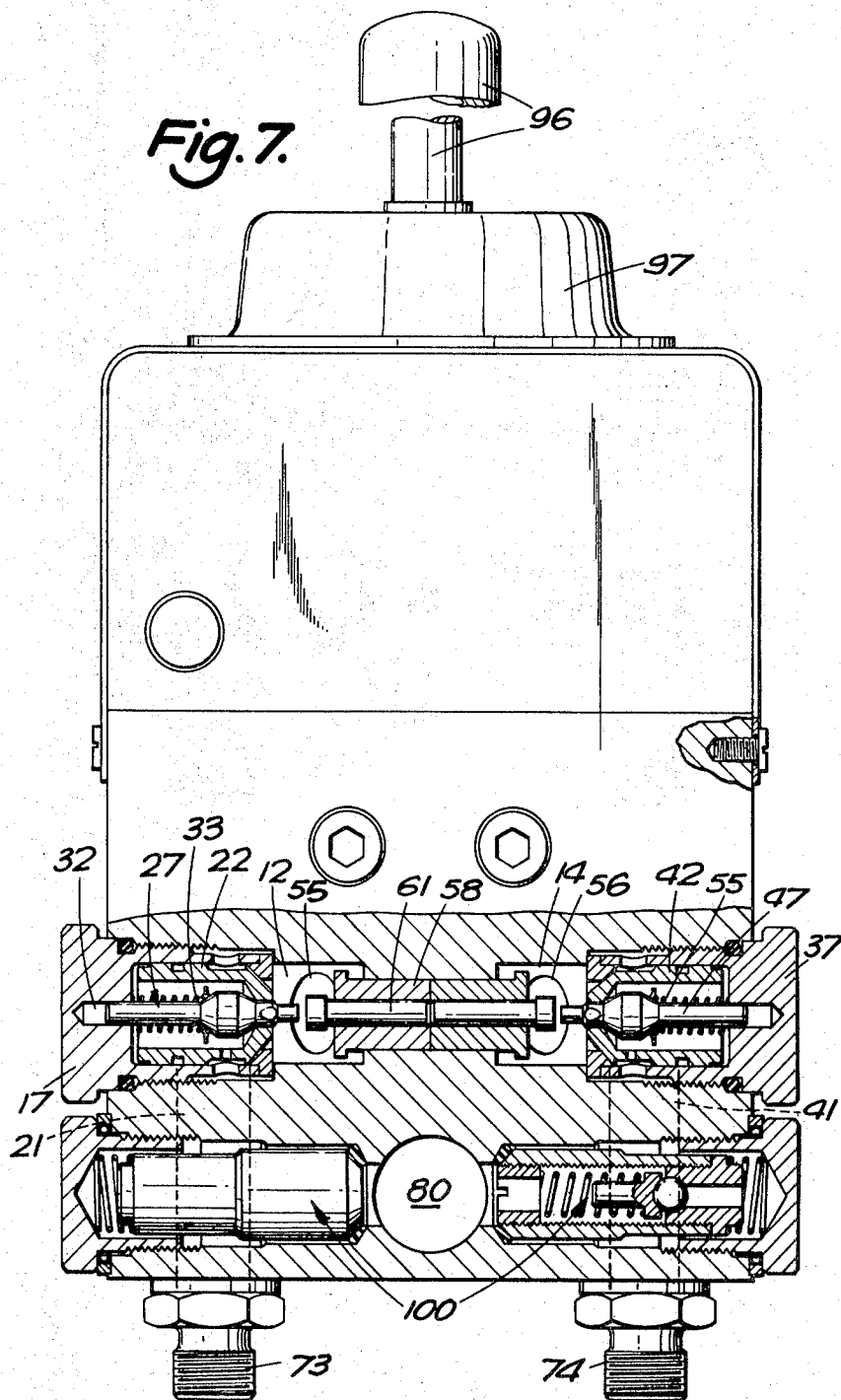


Fig. 5.

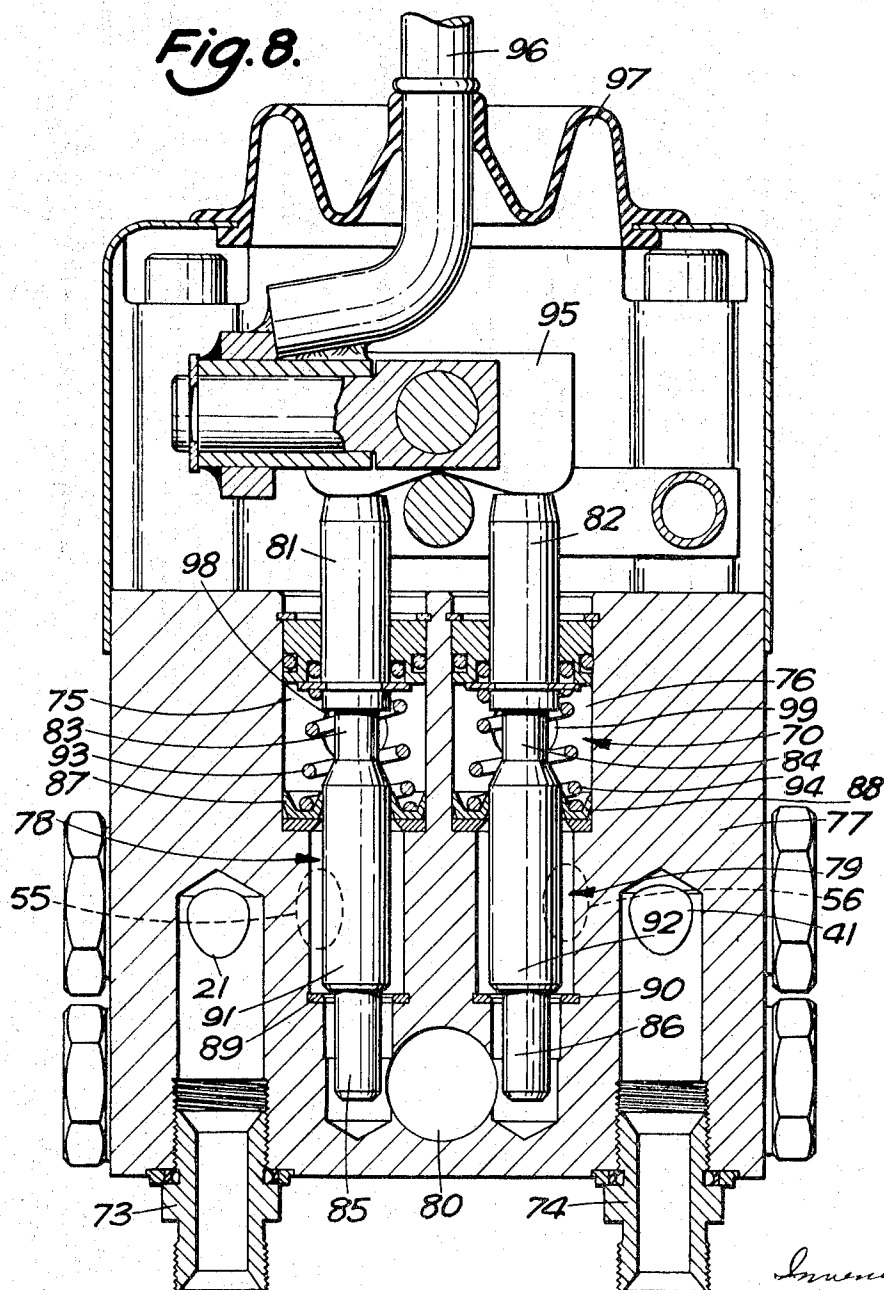
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LOCK-OUT VALVE ASSEMBLIES FOR HYDRAULIC CONTROL SYSTEMS

The invention relates to lockout valve assemblies for hydraulic control systems. Such valve assemblies are applicable to hydraulic control systems in which a double acting hydraulically operated device, such as an hydraulic ram, is controlled by an hydraulic control valve which, in one position, supplies hydraulic fluid under pressure to one side of the device and places the other side of the device in communication with exhaust, and, in another position, places said one side of the device in communication with exhaust and supplies hydraulic fluid under pressure to the other side.

Such hydraulic control valves suffer from the disadvantage that, firstly, a high degree of precision in construction is required to obtain adequate sealing of the service ports which are in communication with opposite sides of the device, and, secondly, when the device is being operated against a heavy load, and that load is suddenly reversed, (such as when a crane or excavator boom passes over a dead center position) the load is able to "runaway" before the operator can operate the hydraulic control valve to meet the changed condition.

To overcome these disadvantages the above-mentioned "lockout" valve assembly may be incorporated between the hydraulic control valve and the hydraulically operated device.

One known kind of lockout valve assembly (known hereinafter as "the kind referred to") comprises first and second nonreturn valves adapted to permit flow from the hydraulic control valve to the two sides respectively of the double-acting device, each valve comprising a chamber for communication with a service port of the hydraulic control valve and a movable main valve member engageable with a valve seat surrounding an outlet from the chamber, and a pilot valve member engageable with a pilot port in the main valve member, there being provided between the first and second valves a reciprocable plunger assembly having one end thereof projecting into each valve chamber and adapted, when moved further into the chamber, to engage and move the pilot valve member in a manner to permit flow of hydraulic fluid through the pilot port.

In operation of the assembly: when the hydraulic control valve is operated to supply hydraulic fluid under pressure to one side of the device the fluid under pressure passes through the first nonreturn valve thereby increasing the pressure in the valve chamber of that valve. This causes the plunger assembly to move so that its opposite end projects further into the valve chamber of the second nonreturn valve so as to move the pilot valve member of the second valve in a manner to permit flow of hydraulic fluid through the pilot port in the main valve member. The main valve member can then move away from its seat permitting hydraulic fluid to pass from the other side of the hydraulically operated device back to the other service port of the hydraulic control valve and thence to exhaust.

Should the load suddenly be removed or reversed, as happens for example when a crane or excavator boom passes over a dead center position, as soon as the device begins to "runaway" there is a drop in pressure on the high pressure side of the device and hence a drop in pressure in the chamber of the first nonreturn valve. This causes the plunger assembly to move in the opposite direction to that described above so that its end projects further into the first valve chamber and its opposite end is withdrawn from the valve chamber of the second valve. The pilot port of the second valve therefore closes and consequently the main valve closes so as to lock the device.

In conventional lockout valve assemblies this locking of the device causes pressure to build up again in the first valve chamber so that the plunger assembly moves once again to project into the second valve chamber to open the pilot port and hence the main valve to permit hydraulic fluid once again to escape from the device. "Runaway" therefore begins again and the lockout valve operates again as described above to lock the device. Consequently the implement being operated by the hydraulic device tends to move in a series of jerks which may often be violent.

The invention provides a lockout valve assembly having features to reduce or eliminate this disadvantage.

According to the invention there is provided a lockout valve assembly comprising first and second nonreturn valves, adapted to permit flow from a hydraulic control valve to the two sides respectively of a double-acting device, each nonreturn valve comprising a chamber for communication with a service port of the hydraulic control valve, a movable main valve member engageable with a valve seat surrounding an outlet for communication with one side of the double-acting device, and a pilot valve member engageable with a pilot port in the main valve member, there being provided between the first and second nonreturn valves a reciprocable plunger assembly having one end thereof projecting into each valve chamber and adapted, when moved further into the chamber, to engage and move the pilot valve member in a manner to permit flow of hydraulic fluid through the pilot port, characterized in that means are provided to restrict the speed of movement of the pilot valve member in the direction to arrest flow of hydraulic fluid through the pilot port. The provision of the speed control means, controls the rate at which the pilot valve closes should the load begin to "runaway" so that the jerky operation referred to earlier is reduced.

There may be movable with the valve member a piston part reciprocable within a bore closed at one end there being a restricted passage through which hydraulic fluid can escape as the piston parts moves towards the closed end of the bore.

The restricted passage is preferably in communication with a part of the hydraulic circuit which is on the side of the main valve member nearer the double-acting device.

The restricted passage may be provided by a clearance between the piston part and the walls of the bore.

There may be provided a spring opposing movement of the piston part towards the closed end of the bore.

In any of the above arrangements the reciprocable plunger assembly may comprise a first plunger and a second, longer plunger of smaller cross-sectional area passing through the first plunger and reciprocable relatively thereto to a limited extent, each said pilot valve member and pilot port being so arranged that movement of the plunger assembly as a whole moves said pilot valve member to an extent to permit a restricted flow of hydraulic fluid through the pilot port, and further movement of the second plunger, relatively to the first plunger, moves said pilot member to a further extent permitting a greater flow of hydraulic fluid through the pilot port sufficient to permit the main valve member to move away from its valve seat.

Preferably the pilot valve member and pilot port are so shaped that movement of the valve member by the plunger assembly causes a gradually increasing restricted flow of hydraulic fluid through the pilot port.

The pilot port may comprise a passage of uniform cross-sectional area in the main valve member, and the pilot valve member may comprise a portion movable into and out of the passage, the cross-sectional area of which portion varies along its length. For example, said passage may be of circular cross section and said portion of the pilot valve member may be also of mainly circular cross section so as to be slidable within the passage but which portion has formed on its surface at least one flat plane inclined to the central axis of the portion of the pilot valve member.

The aforesaid second plunger is preferably formed with abutments disposed to engage parts of said first plunger so as to limit movement of the second plunger with respect to the first plunger. The abutments may comprise enlarged heads at opposite ends of the second plunger.

Each plunger may be formed in two abutting but otherwise unconnected parts.

The following is a more detailed description of various embodiments of the invention reference being made to the accompanying drawings in which:

FIG. 1 is a section through a lockout valve assembly, the parts being shown in a neutral position;

FIGS. 2, 3 and 4 are similar views of alternative forms of assembly;

FIG. 5 is a diagrammatic view showing the valve assembly of FIG. 1 in one operative position;

FIG. 6 is a similar view to FIG. 5 showing the valve assembly in another operative position;

FIG. 7 is a section through a control unit for an hydraulic implement, incorporating the valve assembly of FIG. 1; and

FIG. 8 is a further section through the unit of FIG. 7, showing the hydraulic changeover valve.

Referring to FIG. 1: the valve assembly is for connection between the service ports of a hydraulic control valve and opposite sides of a double-acting hydraulically operated device, such as a double-acting hydraulic ram operating an implement such as a loader.

The valve assembly comprises a block 10 in which is formed a transverse stepped bore comprising portions 11, 12, 13, 14 and 15.

Two similar nonreturn valves are provided within opposite ends of the bore. In the first, left-hand valve an annular main valve seat 16 abuts the annular face between the two portions 11 and 12 of the bore and is held in engagement therewith by a hollow plug 17 which is screwed into the portion 11 of the bore, there being provided a resilient sealing ring 18 between the plug and the bore.

The plug 17 is formed with a central bore 19 and an orifice 20 places the bore 19 in communication with a passage 21 which is arranged to be in communication with one end of the double-acting ram.

A hollow main valve member 22 is in close sliding engagement within the bore 19 and the head 23 of the valve member 22 is engageable with the valve seat 16. An aperture 24 in the valve member 22 places the aperture 20 in communication with the interior of the valve member.

The head 23 of the valve member 22 is formed with a central pilot port 25 within which a portion 26 of a movable pilot valve member 27 is a close slidable fit. The portion 26 is formed with a flat 28 the surface of which is inclined with respect to the longitudinal axis of the member 27. The member 27 further comprises a portion 29 of reduced cross-sectional area which projects beyond the part 26, and an enlargement 30 disposed within the main valve member 22. Extending leftwards from the enlargement 30 is a piston part 31 the free end of which is slidable within a closed bore 32 in the end of the plug 17. A helical compression spring 33 encircles the piston part 31 of the valve member 27 between the bottom of the bore 19 and a ring 34 which encircles the valve member 27 adjacent the enlargement 30.

The second right-hand nonreturn valve is similar to that just described and the parts 36 to 54 correspond to the parts 16 to 34 respectively.

The portions 12 and 14 of the bore in the block 10 constitute the aforementioned first and second valve chambers and passages 55 and 56 leading from the service ports of an hydraulic control valve are in communication with the chamber 12 and 14 respectively.

A plunger assembly 57 is reciprocable within the portion 13 of the bore and comprises a first plunger 58 which is formed at its opposite ends with flanges 59 and 60 respectively which limit the extent of reciprocable movement of the plunger 58 in the bore portion 13. A second plunger 61 is reciprocable within a central bore 62 in the first plunger 58 and is formed at its ends with heads 63 and 64 which limit the extent of reciprocable movement of the plunger 61 in the plunger 58. Each of the plungers 58 and 61 acts as a single unit although each is formed in two abutting parts, as shown, for assembly purposes.

The lockout valve operates as follows reference being made to FIGS. 5 and 6.

In FIG. 5 the hydraulic control valve 70 controlling the double-acting ram 71 is shown having been operated to place the passage 56 in communication with fluid pressure and the passage 55 in communication with exhaust, for example a

reservoir of hydraulic fluid. Fluid pressure will rise in the chamber 14 and will cause the main valve member 42 of the lower valve to move, together with the pilot valve member 47, away from the valve seat 36 so that fluid under pressure can pass through the aperture 40 and to the passage 41 and thence to the ram 71.

The high pressure in the chamber 14 causes the plunger assembly 57 as a whole to move leftwards to the position shown in FIG. 5 where the flanges 60 and 64 form a seal which prevents pressure fluid escaping to the low pressure chamber 12. In this position the plunger assembly 57 has pushed the pilot valve member 27 leftwards so that the portion 26 is clear of the pilot port 25 in the valve head 23. The pilot port 25 is larger than the aperture 24 so that fluid being displaced from the upper end of the ram 71 can freely move the valve member 22 and pass unrestricted into the chamber 12 and thence to exhaust via the passage 55 and control valve 70.

Assume now that it is wished to use the ram 71 to lower a heavy load. To achieve this it is necessary to release the fluid under pressure in the lower end of the ram in a controlled manner. Under steady conditions the pressure in the lower end of the ram is transmitted into the interior of the valve member 42 and the closed bore 52 thus tending to hold the valve member 42 and pilot valve member 47 on to their respective valve seats. To open the port 45 to permit fluid to escape from the lower end of the ram 71 to the reservoir via the passage 56 it is necessary for the control valve 70 to be operated to place the passage 55 in communication with fluid pressure and the passage 56 in communication with the reservoir. FIG. 6 shows the control valve operated to this position. In that position of the control valve, hydraulic fluid is passed into the chamber 12 past the valve member 22 to the upper end of the ram 71. However since the load has inertia, there will be a finite time lapse before the load has accelerated downwards to a velocity corresponding to the rate of fluid input into the upper end of the ram. During this time, the fluid pressure in the passages leading to the upper end of the ram will rise to a comparatively high value, and will push the plunger assembly 57 to the right to its maximum travel, which in turn will move the valve member 47 to the right to its position of maximum opening against the pressure in the bore 52 and spring 55. This allows unrestricted flow of fluid from the lower end of the ram with the result that the load can accelerate downwards freely. After a given time, the velocity of the load will match the rate of fluid flow into the upper end of the ram, and the pressure of this end of the ram will start to fall rapidly. As this happens, the combined force of the spring 55 and the fluid pressure in the bore 52 will start to close the valve 47. This rate of closure must now be controlled in such a manner as to cause the acceleration of the load to be checked, and the ram to continue travelling at a constant velocity. If the valve 47 were allowed to close freely, it would be slammed shut by pressure rising sharply in the bore 52 and the load would be arrested violently, causing a jerking descent as referred to earlier.

The required control of the rate of closure is achieved by placing the bore 52 into communication with the interior of the valve member 42 through a restricted passage. In the present case, the restricted passage is formed by leaving a clearance between the part 51 and the bore 52 but it could be formed as a separate passage.

The relative diameters of the parts 46 and 51 and the strength of the spring 55 are so designed that the spring is incapable of closing the valve 47 against more than moderate pressures, and closure is brought about only by the build up of pressure in the bore 52. The rate of flow into the bore 52 is controlled by the clearance between the part 51 and the bore so that the valve 47 is caused to move leftwards to the closed position at a predetermined rate. This ensures that any reduction in velocity of the falling load is gradual, but once it is required to hold the load, the needle valve is confirmed closed by static pressure.

The forming of the plunger assembly 57 in two parts further helps the control of jerky operation of a lowering load since it provides for the opening of the valve 47 in two stages. A small pressure in the chamber 12 will result in the assembly being moved as shown, to a maximum when the flange 59 engages the shoulder between the bores 12 and 13. This first movement opens a restricted passage between the part 46 and the port 45 and allows the load to start moving downwards at a moderate speed. Should it be required to move the load faster, and more fluid is passed to the upper end of the ram 71, a higher pressure in the chamber 12 will act on the inner plunger 61 and move that plunger further to a maximum when the head 63 engages the flange 59 causing a larger passage to be opened between the part 46 and port 45 thus allowing the load to fall more rapidly.

The principal value of the two-part plunger assembly is when two or more rams or services require to be operated from the same source of fluid supply. It is normally the case, in such circumstances, that the different rams are subject to different loads, and all the fluid will therefore pass to the ram which requires the lowest pressure to operate, and as the attitude of, say, an excavator, varies and the load distribution shifts, the fluid will first go to one ram, then another, with a consequent jerkiness of motion. Consider a load to be lowering at full speed with the plungers 58 and 61 both at their right hand position. If then a further control lever were operated, say to close or open the grab of an excavator (which only requires low pressure) there would be a sudden drop of pressure in the system, with the result that the plunger assembly 57 would move leftwards to allow the valve 47 to close, and the lowering would be arrested. Due to the two-part construction of the plunger assembly however, the inner plunger 61 will move first, reducing the rate of descent, without stopping it, and a condition of equilibrium is quickly established in which both services are moving smoothly, the fluid from and to each being metered by the first stage of movement of the valve 47 as shown in FIG. 6.

FIGS. 7 and 8 are parallel sections through a control unit for a hydraulic implement. FIG. 7 shows the lockout valve assembly of FIG. 1 incorporated in the unit and shows how the passages 21 and 41 communicate with outlets 73 and 74 to which are connected conduits leading to the opposite end of the ram to be controlled by the unit.

FIG. 8 shows in greater detail the changeover hydraulic control valve 70. The valve 70 comprises two chambers 75 and 76 formed in the main block 77 of the unit. Stepped bores 78 and 79 extend downwardly from the lower ends of the chambers and communicate with a return gallery 80 which is in communication with the source of hydraulic fluid for example a hydraulic reservoir.

Spindles 81 and 82 are reciprocable in the chambers 75, 76 and bores 78, 79. The spindles are formed with portions 83 and 84 respectively of reduced cross section and lower end portions 85 and 86 respectively also of reduced cross section. Glands 87 and 88 surround the spindles at the junctions between the chambers 75, 76 and the bores 78, 79 and form fluid tight seals with the spindles. Valve glands 89, 90 are located on the shoulder between the two parts of each of the stepped bores 78 and 79 and are arranged to be sealably engaged by the parts 91, 92 of the spindles.

The two spindles are urged upwardly by springs 93 and 94 respectively into engagement with a pivoted rocker arm 95 to which is secured the lower end of a control lever 96 which projects through a resilient cover 97 mounted on the upper part of the unit.

Passages 98 and 99 lead from the chambers 75 and 76 respectively to the high pressure source of the hydraulic system. The aforementioned passages 55 and 56 leading into the chambers 12 and 14 of the lockout valve assembly communicate with the upper parts of the stepped bores 78 and 79.

When the lever 96 is in the neutral position shown in FIGS. 7 and 8 the two parts of the stepped bores 78 and 79 and the passages 55 and 56 are isolated from the passages 98 and 99

and hence from the high pressure source, and are in communication with the fluid reservoir via the return gallery 80. The two chambers 12 and 14 of the lockout valve assembly shown in FIG. 7 are therefore both in communication with the fluid reservoir and the device controlled by the valve assembly is hydraulically locked.

If the lever 96 is swung to the left the spindle 81 is depressed so that the part 91 thereof engages the valve gland 89 and cuts the passage 55 off from communication with the return gallery 80. Simultaneously however the reduced cross section portion 83 of the spindle enters the gland 87 placing the passage 55 into communication with the passage 98 leading to the source of fluid pressure. The chamber 12 in the lockout valve assembly is therefore placed into communication with the source of fluid pressure whereas the chamber 14 remains in communication with exhaust and the lockout valve assembly operates as described above. If the lever 96 is swung to the right the spindle 82 is depressed so that, similarly, the passage 56 and chamber 14 are placed in communication with the high pressure source whereas the chamber 12 and passage 55 are in communication with exhaust.

The control valve unit shown in FIGS. 7 and 8 may incorporate a number of assemblies, for example four assemblies, of the kind shown for controlling various implements.

It will be appreciated that in the arrangements described above the pressure at which the pilot valves are completely opened will depend on the cross-sectional area of the inner plunger 61 and FIG. 2 shows an arrangement in which this inner plunger is of greater diameter so that a smaller pressure is required to move the plunger to a sufficient extent to open the pilot valve completely. The arrangement of FIG. 2 is otherwise similar to the arrangement of FIG. 1.

FIG. 3 shows an arrangement in which the plunger assembly comprises only a single plunger 65.

If it is required to restrict permanently the rate of lowering then the arrangement of FIG. 3 may be employed. As shown in that FIG. (and also shown dotted in FIGS. 5 and 6) there are provided in the bores of the valve members 22 and 42 pistons 66 and 67 respectively which surround the valve members 27 and 47 and have heads 68 and 69 formed with tapered apertures which come into sealing engagement with the enlarged portions 30 and 50 of the valve members. The pistons 66 and 67 restrict the rate of opening of the pilot valves, so as to improve fine control of the ram, and at the same time prevent a sudden drop in pressure behind the main valve members 22 or 42 when the pilot valve is completely open, thus limiting the rate of descent to the rate of flow through the pilot ports 25 and 45 alone.

FIG. 4 shows a modification in the arrangement of FIG. 1 in which pistons 66 and 67 are provided.

It will be appreciated that since the restriction of flow of fluid into and out of the bores 32 and 52 depends on the clearance between the piston parts 31 and 51 and those bores it is necessary for the piston parts and bores to be matched comparatively carefully. To avoid the necessity of accurate machining of the bores 32 and 52 therefore these may be of larger diameter than the piston parts 31 and 51 and these piston parts may be a closer sliding fit in annular sealing members abutting the entrances to the bores 32 and 52.

We claim:

1. A lockout valve assembly comprising first and second nonreturn valves, adapted to permit flow from a hydraulic control valve to the two sides respectively of a double-acting device, each nonreturn valve comprising a chamber for communication with a service port of the hydraulic control valve, a movable main valve member engageable with a valve seat surrounding an outlet for communication with one side of the double-acting device, and a pilot valve member engageable with a pilot port in the main valve member, there being provided between the first and second nonreturn valves a reciprocable plunger assembly having one end thereof projecting into each valve chamber and adapted, when moved further into the chamber, to engage and move the pilot valve

member in a manner to permit flow of hydraulic fluid through the pilot port, means being provided to restrict the speed of movement of the pilot valve member in the direction to arrest flow of hydraulic fluid through the pilot port.

2. A lockout valve assembly according to claim 1 wherein there is movable with the valve member a piston part reciprocable within a bore closed at one end there being a restricted passage through which hydraulic fluid can escape as the piston part moves towards the closed end of the bore and through which fluid must pass to enter the bore and cause closure of the pilot valve.

3. A lockout valve assembly according to claim 2, wherein the restricted passage is in communication with a part of the hydraulic circuit which is on the side of the main valve member nearer the double-acting device.

4. A lockout valve assembly according to claim 3, wherein the restricted passage is provided by a clearance between the piston part and the walls of the bore.

5. A lockout valve assembly according to claim 2, wherein there is provided a spring opposing movement of the piston part towards the closed end of the bore.

6. A lockout valve assembly according to claim 1, wherein the reciprocable plunger assembly comprises a first plunger and a second, longer plunger of smaller cross-sectional area passing through the first plunger and reciprocable relatively thereto to a limited extent, each said pilot valve member and pilot port being so arranged that movement of the plunger assembly as a whole moves said pilot valve member to an extent to permit a restricted flow of hydraulic fluid through the pilot port, and further movement of the second plunger, relatively to the first plunger, moves said pilot member to a further extent

tent permitting a greater flow of hydraulic fluid through the pilot port sufficient to permit the main valve member to move away from its valve seat.

7. A lockout valve assembly according to claim 6 wherein the pilot valve member and pilot port are so shaped that movement of the valve member by the plunger assembly causes a gradually increasing restricted flow of hydraulic fluid through the pilot port.

8. A lockout valve assembly according to claim 7 wherein the pilot port comprises a passage of uniform cross-sectional area in the main valve member, and the pilot valve member comprises a portion movable into and out of the passage, the cross-sectional area of which portion varies along its length.

9. A lockout valve assembly according to claim 8, wherein said passage is of circular cross section and said portion of the pilot valve member is also of mainly circular cross section so as to be slidable within the passage but which portion has formed on its surface at least one flat plane inclined to the central axis of the portion of the pilot valve member.

10. A lockout valve assembly according to claim 6, wherein said second plunger is formed with abutments disposed to engage parts of said first plunger so as to limit movement of the second plunger with respect to the first plunger.

11. A lockout valve assembly according to claim 10, wherein said abutments comprise enlarged heads at opposite ends of the second plunger.

12. A lockout valve assembly according to claim 6, wherein each plunger is formed in two abutting but otherwise unconnected parts.

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