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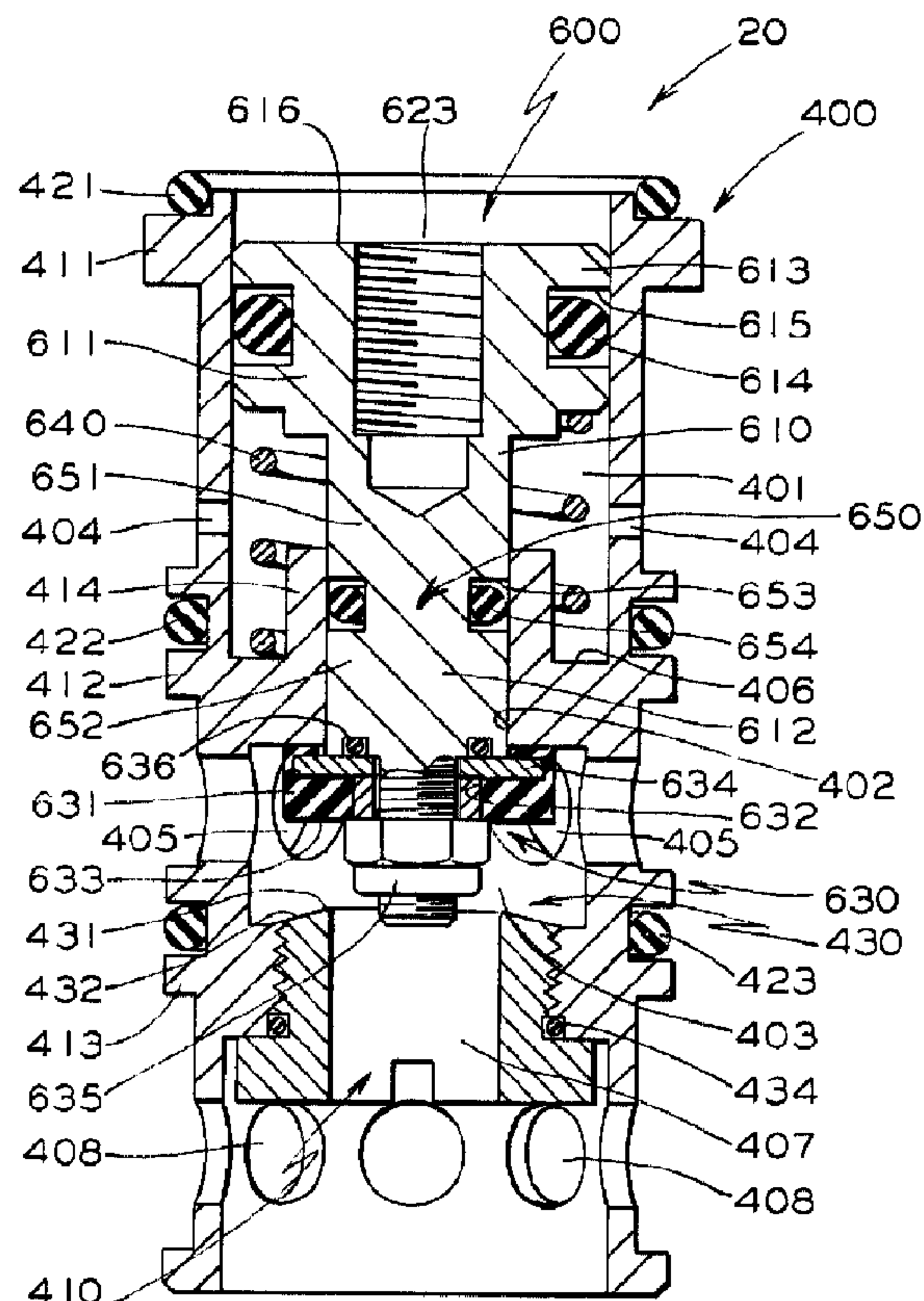
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(57) Abrégé/Abstract:

A valve insert comprises a bushing assembly, a piston assembly and a spring. Its design prevents non-longitudinal movement of the piston assembly as it is moved within the longitudinal bore of the bushing assembly. This virtually eliminates the bell clapper effect commonly suffered by many of the valve inserts currently used in the industry. The design of the valve insert also avoids the pressure imbalances inherent to the prior art valve inserts. The valve insert is designed to fit snugly and sealingly within a suitable borehole, such as the fill and cut-out boreholes of an ECP manifold assembly.



ABSTRACT

A valve insert comprises a bushing assembly, a piston assembly and a spring. Its design prevents non-longitudinal movement of the piston assembly as it is moved within the longitudinal bore of the bushing assembly. This virtually eliminates the bell clapper effect commonly suffered by many of the valve inserts currently used in the industry. The design of the valve insert also avoids the pressure imbalances inherent to the prior art valve inserts. The valve insert is designed to fit snugly and sealingly within a suitable borehole, such as the fill and cut-out boreholes of an ECP manifold assembly.

ECP MANIFOLD VALVE INSERTS**CROSS REFERENCE TO RELATED DOCUMENTS**

The invention is related to U.S. Patent 6,416,034 entitled *ECP Manifold Vent Valve Insert* that has the same assignee and filing date as this document.

FIELD OF THE INVENTION

The invention generally relates to valve assemblies (also referred to as "valve inserts") of the type deployed within a manifold to control the flow of fluid(s) within a system in which the manifold is incorporated. More particularly, the invention pertains to valve inserts designed to be deployed within a manifold of a freight railcar equipped with electrically controlled pneumatic (ECP) brake equipment.

BACKGROUND OF THE INVENTION

The following background information is provided to assist the reader to understand just one of the many environments in which the invention could be used. The terms used herein are not intended to be limited to any particular

narrow interpretation unless expressly stated otherwise in this document.

A freight train typically includes one or more locomotives, a plurality of railcars and several trainlines. For a freight train headed by a locomotive equipped with an ECP brake control system, the trainlines include both pneumatic and electrical lines some of which run from the lead locomotive all the way to the last rail vehicle in the train. A pneumatic trainline known as the brake pipe is one such trainline. It extends the length of the freight train, as does a two-wire electrical trainline known as the ECP trainline. Each locomotive also features a multi-wire electrical trainline known as the multiple unit (MU) line cable. The MU line cable consists of 27 different electrical lines. As is well known in the railroad industry, the MU line cable contains 74V dc power and return lines on which battery power from the locomotive is supplied to the various power consuming devices on the train.

The brake pipe consists of a series of pipe lengths, with one pipe length secured to the underside of each railcar. Each pipe length has, at each of its ends, a flexible hose with a coupler commonly referred to as a glad hand. As the locomotive(s) and other rail vehicles are

coupled in sequence to form the freight train, the brake pipe is formed by connecting the glad hand at the end of each pipe length to the glad hand of another such pipe length on an adjacent railcar. Similar to the brake pipe, the conduit in which the ECP trainline is housed actually constitutes a series of individual conduits. One such conduit secured to the underside of each vehicle interconnects to another such conduit via a connector between each rail vehicle. Supplied from the 74V dc power line of the MU line cable in the locomotive, the ECP trainline typically operates at a nominal 230V dc to power the ECP brake equipment on each railcar of the freight train.

The ECP brake control system in the locomotive includes a cab station unit and a master controller from which the brakes on the train are ultimately controlled. The cab station unit features one or two handle(s) and/or push buttons that the train operator uses to direct control of the brakes. One such handle, known as the automatic brake handle, can be moved to and between the following positions: release, minimum service, full service, suppression, continuous service, and emergency. Between the minimum and full service positions lies the service zone wherein each incremental movement of the handle toward the full service

position causes an even stronger service application of the brakes. The force with which the service brakes will apply depends on how far towards the full service position the automatic brake handle is moved.

Inputs from the handle(s) and/or push buttons are processed by the cab station unit and then passed to the master controller. Operating according to instructions contained within its programming code, and in response to the inputs from the handle(s) and other sources, the master controller formulates a brake command appropriate to current conditions and transmits it along the ECP trainline to each railcar in the freight train. As specified by the American Association of Railroads (AAR), the brake commands and other ECP messages are transmitted from the locomotive using a powerline communications system such as the Echelon LonWorks System. Along the ECP trainline, the brake command(s) are then conveyed to the ECP brake equipment on each railcar via branch wiring. Similarly, in a manner known in the railroad industry, the brake pipe connects to the ECP brake equipment on each railcar via a branch pipe.

The master controller can thus order, through the brake command, any action from a release of brakes to an emergency application of brakes or any degree of brake

application in between those two extremes. The brake equipment may also be designed to provide graduated release of the brakes. The degree of brake application ordered by the master controller is typically conveyed in terms of a percentage of the pressure required for full service brake application. For example, zero percent (0%) is typically designated for a release of brakes, 15% for a minimum service brake application, 100% for a full service brake application and 120% for an emergency brake application.

The ECP brake equipment on each rail vehicle typically includes a car control unit (CCU), several pressure transducers, various pneumatic and/or electropneumatic valves, an auxiliary reservoir, an emergency reservoir, and at least one brake cylinder. Used to monitor the pressures in the brake pipe, the brake cylinder(s) and the two reservoirs, the transducers convey electrical signals indicative of those pressures to the CCU.

Each CCU includes a transceiver and a microprocessor. Controlled by the microprocessor, the transceiver is connected via the branch wiring to the ECP trainline from which it receives the brake commands issued by the master controller. The transceiver converts the electrical brake commands into a form usable by the

microprocessor. Operating according to its programming code and to the dictates of the brake commands and other electrical signals it has received, the microprocessor controls the aforementioned electropneumatic valves in a manner well known in the brake control art. It is through these electropneumatic valves that air can be maintained within, exhausted from, or directed from the reservoir(s) to the brake cylinder(s). By moving the automatic brake handle into service zone, for example, the train operator in the locomotive will cause the ECP brake control system to issue a service brake command along the ECP trainline. In response to the service brake command, the microprocessor on each railcar will then route the appropriate amount of air from the auxiliary reservoir, or, alternatively, the emergency reservoir, through the appropriate electropneumatic valve(s) to the brake cylinder(s).

In addition, as a safety measure, emergency brake commands are conveyed to the railcars not only electrically along the ECP trainline but also pneumatically along the brake pipe. By moving the handle into the emergency position, the train operator in the locomotive causes the pressure in the brake pipe to drop at an emergency rate. This drop in pressure then quickly propagates along the brake

pipe to each railcar in the train. Should the ECP equipment lose power or otherwise fail electrically, it will still respond pneumatically to the telltale reduction in pressure that occurs in the brake pipe during an emergency. The ECP brake equipment is designed to respond to the emergency pressure drop by supplying pressurized air from both the auxiliary and emergency reservoirs to the brake cylinder(s) and thereby cause an emergency application of the brakes. Absent a command to apply the brakes and under conditions known in the brake control art, the railcar brake equipment through one of its pneumatic valves charges these two reservoirs with pressurized air obtained from the brake pipe.

However pressurized, the brake cylinder(s) convert the pressurized air that they receive to mechanical force. This mechanical force is transmitted by mechanical linkage to the brake shoes. Forced against the wheels and/or disc brakes, the brake shoes are used to slow or stop the rotation of the wheels. The magnitude of the braking force applied to the wheels is directly proportional to the pressure built up in the brake cylinder(s).

As is well known in the railroad industry, an ECP brake control system is typically employed on a freight train only as an overlay for or an adjunct of the conventional

pneumatic or electropneumatic (EP) brake control system. Unlike the ECP brake control system, the conventional EP brake control system in the locomotive uses the brake pipe to convey pneumatically to every railcar in the train all of the brake commands, not just the emergency commands.

In addition to the cab station unit, the conventional EP brake control system includes a brake control computer (BCC) and a pneumatic operating unit (POU). The BCC responds to the signals output by the cab station unit, i.e., by the handle(s) and/or push buttons. Based on these and other signals and on the software that dictates its operation, the BCC controls the operation of various pneumatically and electropneumatically operated devices that comprise the POU. Comprised mainly of pneumatic logic circuitry and solenoid operated valves, these devices are commonly referred to as operating portions. It is through these operating portions that the BCC actually controls the pressure in the brake pipe (and in various other pneumatic trainlines and reservoirs).

The conventional pneumatic brake equipment on each railcar includes a pneumatic brake control valve such as an ABD, ABDX or ABDW type valve made by the Westinghouse Air Brake Technologies Corporation (WABTEC). The brake control

valve (BCV) has a service portion and an emergency portion, both mounted to a pipe bracket. The pipe bracket features a number of internal passages and several ports. Each port connects to one of the interconnecting pipes from the railcar such as those leading to the brake pipe, the brake cylinder(s) and the two reservoirs. It is through the ports and internal passages of the pipe bracket that the service and emergency portions of the BCV communicate fluidly with the pneumatic piping on the railcar.

By moving the automatic brake handle, the train operator in the locomotive can control the pressure level in the brake pipe and thereby direct whether, and to what extent, the brakes are applied. By changing its pressure level using the automatic brake handle, the brake pipe is used to convey release, service and emergency brake commands to the pneumatic brake equipment on every railcar. In response to a release brake command (i.e., when brake pipe pressure is restored to its normal operating pressure), the service portion of the BCV not only charges the two reservoirs with the pressurized air it receives from the brake pipe but also vents the brake cylinder(s) to atmosphere thereby causing the brakes on the railcar to release. In response to a service brake command (i.e., when brake pipe

pressure is reduced at a service rate), the service portion supplies air from only the auxiliary reservoir to the brake cylinder(s) to apply the brakes. How much the brake pipe pressure is reduced, and thus the magnitude of the service brake application, depends on how far the automatic brake handle is moved towards the full service position. In response to an emergency brake command (i.e., when the brake pipe is vented to atmosphere at an emergency rate), the service and emergency portions of the BCV supply air from both reservoirs to the brake cylinder(s) to apply the brakes more quickly and forcefully.

Under the control of a conventional EP brake control system, the brake pipe, or more accurately the pressure level contained within it, determines whether a BCV will charge its two reservoirs or deliver pressurized air previously stored in one or both of its reservoirs to the brake cylinder(s).

On a freight train equipped with both types of brake control systems, the train operator in the locomotive can thus select whether the conventional EP brake control system or the ECP brake control system will be used to operate the brakes. When the conventional braking mode is selected, the brake pipe is used to convey the brake commands

pneumatically to the pneumatic brake equipment on each railcar. When the ECP braking mode is selected, the ECP trainline conveys the brake commands electrically to the ECP brake equipment on the railcars, with the brake pipe also being used to convey emergency brake commands as a safety measure.

Mounted to the pipe bracket of the BCV on each railcar is the ECP manifold assembly, generally designated 1 in Figure 1. Shown only in part, the ECP manifold assembly 1 includes a manifold 150 and a cover plate 200. It is within the ECP manifold 150 that at least some of the aforementioned valves are contained. The ECP manifold 150 contains four boreholes: the cut-out borehole 10, the vent borehole 30, the auxiliary borehole 50 and the emergency borehole 70. Boreholes 50 and 70 are often called fill boreholes. Each of these boreholes has multiple bores, each of which being of progressively narrower diameter, as viewed in succession from top to bottom, to accommodate the contour of the particular valve assembly housed within it.

The ECP manifold 150 also defines several internal passages. The emergency passage 2 interconnects the bottom portion 71 of emergency borehole 70 with the emergency reservoir on the railcar. Likewise, the auxiliary passage 3

pneumatically links the bottom portion 51 of auxiliary borehole 50 to the auxiliary reservoir. Branching off the auxiliary passage 3 is the pilot airway 4. The vent passage 5 interconnects the middle portion 33 of vent borehole 30 to atmosphere. The inlet passage 6 interconnects the middle portion 13 of cut-out borehole 10 with the service portion of the BCV. In an ABDX brake control valve, for example, inlet passage 6 is preferably connected to the c1 passage in the service portion. Communicating with the lower portions 12, 32, 52 and 72 of boreholes 10, 30, 50 and 70, respectively, is the common passage 7. The common passage 7 interconnects these lower portions to the brake cylinder(s).

The ECP manifold 150 houses several valve assemblies (i.e., "valve inserts"). Borehole 10 is used to house the cut-out valve insert 100. Borehole 30 is used to house the vent valve insert 300. Borehole 50 is used to house the auxiliary valve insert 500, and borehole 70 the emergency insert 700. Valve inserts 500 and 700 are often called fill inserts. The inserts shown in Figure 1 employ a design that is well known in the art.

The valve inserts are contained within manifold 150 by cover plate 200. Although only one is shown, four pilot passages 8 are defined in cover plate 200, one atop each

borehole. Above cut-out insert 100, for example, pilot passage 8 communicates with the top portion 17 of borehole 10. Above valve inserts 300, 500 and 700, the other pilot passages communicate with the top portions 37, 57 and 77 of boreholes 30, 50 and 70, respectively.

As best shown in Figures 2 and 3, each valve insert includes a primary bushing 800 and a piston assembly 900. The bushing 800 defines a central bore comprised of upper, middle, and lower cavities 801, 802 and 803. Upper cavity 801 has a larger diameter than middle cavity 802. Consequently, there is an annular ledge at the bottom of upper cavity 801 where the central bore narrows to the middle cavity 802. Likewise, there is an annular ledge at the top of lower cavity 803. The primary bushing 800 also features two annular valve seats within the central bore. The first valve seat 810 is formed on the annular ledge at the bottom of upper cavity 801, and the second valve seat 830 is formed on the annular ledge at the top of lower cavity 803. Each valve seat is flat and formed at an angle with respect to the longitudinal axis of the central bore. If viewed 3-dimensionally, each valve seat would appear as a conic ring-shaped surface.

The primary bushing 800 also has three annular flanges formed around its periphery. Annular flange 811 is situated around the top of bushing 800. Annular flanges 812 and 813 are situated around the middle and bottom, respectively, of bushing 800. The outside diameter of each flange is identical, and each flange defines a groove in which an o-ring is secured. Equipped with its o-rings, the primary bushing 800 is designed to fit snugly within any of the boreholes in the ECP manifold 150. The o-rings prevent leakage between the various portions of the borehole in which a valve insert is housed.

The piston assembly 900 is designed to fit within the central bore of the primary bushing 800. The piston assembly 900 includes an insert piston 910 and sealing elements 920 and 930. From the head 911 of the piston extends a shaft 912. The head 911 has an annular collar 913 formed around its periphery. This collar defines a groove in which an o-ring 914 is secured. This o-ring 914 prevents air from leaking around the head 911. The head 911 at its top also has a knob 915.

The shaft 912 has three rims formed around its periphery. Sealing element 920 is secured around shaft 912 between rim 921 and the underside of head 911, and sealing

element 930 is affixed about shaft 912 between rims 922 and 923. The bottom outside edge of sealing element 920 is designed to seal flush against first valve seat 810. Likewise, the top outside edge of sealing element 930 is designed to seal flush against second valve seat 830. Sealing element 920 and first valve seat 810 together serve as an upper valve, and sealing element 930 and second valve seat 830 together serve as a lower valve.

As best shown in Figure 3, a spring 940 is disposed around insert piston 910 in compression between the underside of collar 913 and the ledge at the bottom of upper cavity 801. This spring biases the insert piston 910 upward so that the lower valve is normally closed and the upper valve is normally open.

The valve inserts shown in Figure 1 are essentially identical, except that valve insert 300 is not equipped with a secondary insert often referred to as a booster. Figure 2 shows a valve insert with a booster, and Figure 3 shows one without. The booster, generally designated 950, has a secondary piston 960 housed within a secondary bushing 970. At its top, bushing 970 has an annular lip 971 that limits upward movement of piston 960.

The secondary piston 960 has an annular flange 961 formed around its periphery. This flange defines a groove in which an o-ring 962 is secured. This o-ring prevents air from leaking around piston 960. The underside of piston 960 contains a hollow shaft 964. This hollow shaft is designed to cooperate with the knob 915 of insert piston 910, as shown in Figure 2.

Mounted to the top of cover plate 200 are four solenoids, only solenoid 110 of which is shown in Figure 1. Above each valve insert, one solenoid communicates with the pilot airway 4 and the pilot passage 8 for its corresponding borehole. Each solenoid has an armature stem around which lies an energizable coil. At its head end, the armature stem has a seal. When the coil is deenergized, the armature stem has its head end biased against the top of cover plate 200 above the valve insert. This seals off the pilot passage 8 from the pilot airway 4 and the auxiliary reservoir connected thereto, and thereby prevents pressurized air from acting against the top of the valve insert.

In selecting which brake control system will direct control of the brakes, the train operator in the locomotive ultimately determines the state of the cut-out valve insert 100 in ECP manifold 150. When the conventional EP braking

mode is selected, the CCU on each railcar is not commanded via the ECP trainline to energize the solenoid 110 for cut-out valve insert 100. This leaves cut-out valve insert 100 in its cut-out state, i.e., its lower valve closed and its upper valve open. (As is clear from Figure 1, the lower valve is not used.) Consequently, whenever the conventional brake control system conveys a brake application command along the brake pipe, the cut-out valve insert 100 will allow pressurized air to flow through its upper valve and into the brake cylinder(s). Specifically, air from the c1 passage in the service portion of the BCV will be allowed to flow into inlet passage 6 and through the middle and lower portions 13 and 12 of borehole 10. The pressurized air will then flow past valve seat 810 and through common passage 7 into the brake cylinder(s), and thereby cause the brakes on the railcar to apply.

When the ECP braking mode is selected, the CCU on each railcar receives a signal via the ECP trainline to energize the solenoid 110. When energized, solenoid 110 electromagnetically compels its armature stem upward, and thereby interconnects the pilot passage 8 of valve insert 100 to the pilot airway 4. Pilot air from the auxiliary reservoir then acts against the top of secondary piston 960.

As the pilot pressure builds, the hollow shaft 964 encompasses the knob 915 and soon pushes insert piston 910 downward against the bias of spring 940. This forces cut-out valve insert 100 into its cut-in state, i.e., its upper valve closes. In this state, the cut-out valve insert 100 cuts off inlet passage 6 from common passage 7, and thereby disconnects the brake cylinder(s) from the C1 passage in the service portion of the BCV.

Furthermore, in the ECP braking mode, the brakes are released or applied only by exhausting or pressurizing the brake cylinder(s) through the vent, auxiliary and emergency valve inserts 300, 500 and 700. The CCU on each railcar receives the brake release and application commands via the ECP trainline and energizes the solenoid(s) above the appropriate valve insert(s).

Whenever the ECP brake control system conveys a brake application command along the ECP trainline, for example, the CCU will energize the solenoid above either auxiliary valve insert 500 or emergency valve insert 700 or both. (In practice, it is the emergency valve insert that is typically activated in response to a service brake command.) Pilot air from the auxiliary reservoir then acts against the top of secondary piston 960. As the pilot pressure builds,

the hollow shaft 964 encompasses the knob 915 and soon pushes insert piston 910 downward against the bias of spring 940. This forces the emergency valve insert 700 into its energized state, i.e., its upper valve closed and its lower valve opened. (As is clear from Figure 1, the upper valve is not used.) In this state, the emergency insert 700 allows pressurized air to flow from the emergency reservoir through its lower valve and into the brake cylinder(s). Specifically, air flows from the emergency passage 2 into the bottom portion 71 of borehole 70. The pressurized air then flows past valve seat 830 through common passage 7 and into the brake cylinder(s), and thereby causes the brakes to apply.

Whenever the ECP brake control system conveys a brake release command along the ECP trainline, the CCU will energize the solenoid above vent valve insert 300. Pilot air from the auxiliary reservoir then acts against the top of insert piston 910. As the pilot pressure builds, the insert piston 910 moves downward against the bias of spring 940. This forces the vent valve insert 300 into its energized state, i.e., its upper valve closed and its lower valve opened. (As is clear from Figure 1, the upper valve is not used.) In this state, the vent insert 300 allows the

pressurized air previously developed within the brake cylinder(s) to flow through its lower valve to atmosphere. Specifically, air flows from the brake cylinders(s) through common passage 7 into the bottom portion 31 of borehole 30. The pressurized air then flows past valve seat 830 through vent passage 5 to atmosphere, and thereby causes the brakes to release.

The cut-out and fill valve inserts 100, 500 and 700 were initially designed without boosters 950. This led to problems with the operation of the ECP manifold assembly 1. For example, when a fill valve 500 or 700 was returned to its deenergized state (i.e., lower valve closed) after the brake cylinder was charged, pressurized air from the brake cylinder was free to flow through common passage 7 past the opened upper valve and work against seal 914 surrounding the underside of head 911. Unfortunately, the build up of pressure under the head 911 served to resist downward movement of the insert piston 910. Consequently, to move the fill valve insert to its energized state (i.e., lower valve opened), this meant that more pilot pressure was needed to move the piston insert 911 downward against the combined forces of spring 940 and the brake cylinder pressure acting on the underside of head 911.

It was soon learned, however, that pressure in the auxiliary reservoir can, under certain conditions, be too low relative to the brake cylinder pressure to operate the fill valve properly. Under those conditions, the pilot pressure (from the reservoir via passage 3, pilot airway 4 and pilot passage 8) acting on the top of head 911 was insufficient to move the piston assembly 900 downward to the open position. This meant that no more pressurized air could be delivered to the brake cylinder when the brakes were being operated in the ECP braking mode. For this reason, a booster was added to both the fill and cut-out valves.

The booster 950 allowed better operation of the piston assemblies 900 during those times when pressure in the auxiliary reservoir fell low relative to the brake cylinder pressure. Specifically, as best shown in Figure 2, the seal 962 around piston 960 of the booster has a larger surface area than the seal 914 around the head 911 of insert piston 910. The pilot pressure acting against the larger effective area atop the secondary piston 960 allows more downward force to be generated against the piston assembly 900. (Multiplying the effective area of a side of a piston by the pressure impinging on it gives the force acting on that side of the piston.) This enabled the pilot pressure to more

easily overcome the opposing force caused by the build up of pressure on the underside of the head 911 of insert piston 910.

Despite the improvement in performance it offered, the booster did not address all of the problems associated with the prior art valve inserts. One problem lies with the pressure imbalance inherent to the design of the cut-out and fill valve inserts 100, 500 and 700. The o-ring seal 914 around the head 911 of insert piston 910 has a relatively large effective area. It is larger than that of the sealing element 930 used with the second valve seat 830 to form the lower valve. This difference in effective area has the effect of making the piston assembly 900 self-energizing towards the closed position. As the brake cylinder pressure increases, the force on underside of piston head 911 increases accordingly, and tends to force the lower valve towards the closed position. Consequently, to increase the brake cylinder pressure as is needed to apply the brakes more forcefully, pilot pressure of greater intensity must be applied atop the secondary piston 960 to open the valve insert.

Another problem lies with the unguided movement of the insert piston 910 within the primary bushing 800 for all

of the prior art valve inserts. Rims 921 and 922 each have a surface angled to comport with its associated seat 810 and 830, respectively, to help guide the movement of insert piston 910 within the central bore of bushing 800. These rims, however, do little to prevent the lower end of the shaft 912 from moving to and fro or left or right, as best viewed in Figure 2. This is often referred to as the bell clapper effect. Consequently, when pilot pressure is removed, rims 921 and 922 may not always be aligned with the longitudinal axis of the central bore as spring 940 retracts the insert piston 910 upward. The piston assembly 900 can then get stuck in the open position.

OBJECTIVES OF THE INVENTION

It is, therefore, an objective of the invention to provide a valve insert whose design prevents non-longitudinal movement of the piston assembly as it is moved longitudinally within the bushing assembly and thereby prevents the bell clapper effect suffered by the prior art valve inserts.

Another objective is to provide a valve insert that is designed to avoid the pressure imbalances inherent to the piston and bushing assemblies of the prior art valve inserts.

A further objective is to provide a valve insert that exhibits a spring load and a valve seat design that

together provide a much more reliable seal than the prior art valve inserts, especially at low pressures and low temperatures.

Yet another objective is to provide a reliable cut-out valve insert endowed with the foregoing advantages.

Still another objective is to provide a reliable fill valve insert endowed with the foregoing advantages.

In addition to the objectives and advantages listed above, various other objectives and advantages of the invention will become more readily apparent to persons skilled in the relevant art from a reading of the detailed description section of this document. The other objectives and advantages will become particularly apparent when the detailed description is considered along with the drawings and claims presented herein.

SUMMARY OF THE INVENTION

The foregoing objectives and advantages are attained by an innovative valve insert. In its various embodiments, the valve insert comprises a bushing assembly, a piston assembly and a spring. Formed around the bushing assembly is a plurality of annular flanges. Each annular flange defines a groove in which an o-ring is secured. The o-rings allow the bushing assembly to fit snugly and

sealingly within a suitable borehole, such as the fill and cut-out boreholes of an ECP manifold assembly. The bushing assembly defines a longitudinal bore having an upper cavity, an intermediate cavity and a lower cavity. It also defines a vent port hole connected to the upper cavity and a first port hole connected to the lower cavity. The bushing assembly also has a lower spring seat formed circumferentially at a bottom of the upper cavity and an annular valve seat formed circumferentially about the lower cavity. The annular valve seat features a raised inner portion tapering off at a predetermined angle to a sloped outer portion. Reciprocatable within the longitudinal bore between open and closed positions, the piston assembly comprises an insert piston and an annular sealing member. The insert piston has its head disposed in the upper cavity, with its stem extending downwardly therefrom through the intermediate cavity. The head has an annular collar. A groove defined around the collar accommodates a first annular seal to prevent leakage around the head. The stem is deployed with a means for preventing non-longitudinal movement of the piston assembly as it is moved longitudinally within the longitudinal bore. This means also prevents leakage around the intermediate cavity. Secured to a bottom portion of the

stem, the annular sealing member has a flat surface for sealingly engaging the raised inner portion of the annular valve seat when the piston assembly occupies the closed position. Disposed around the insert piston, the spring lies in compression between an underside of the annular collar and the lower spring seat. The spring biases the piston assembly in the longitudinal bore to either the closed position or the open position depending upon the configuration of the valve insert (i.e., cut-in or fill insert). In the closed position, the piston assembly cuts off the lower cavity from a bottom area subjacent to the lower cavity. In the open position, the piston assembly allows communication between the lower cavity and the bottom area.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a cross-sectional view of an ECP manifold assembly containing four prior art valve inserts, deployed from left to right as a cut-out valve insert, a vent valve insert and two fill valve inserts.

Figure 2 is an enlarged, cross-sectional view of the prior art valve insert of Figure 1 equipped with a booster.

Figure 3 is an enlarged, cross-sectional view of the prior art valve insert of Figure 1 not equipped with a booster.

Figure 4 is a cross-sectional view of a cut-out valve insert according to the invention.

Figure 5 is a cross-sectional view of a fill valve insert according to the invention.

Figure 6 is a cross-sectional view of an ECP manifold assembly showing at left the cut-out valve insert of Figure 4 and at right two fill valve inserts of the type shown in Figure 5.

DETAILED DESCRIPTION OF THE INVENTION

Before describing the invention in detail, the reader is advised that identical components having identical functions have been marked, where possible, with the same reference numerals in each of the Figures provided in this document. This has been done for the sake of clarity and to improve understanding of the invention. The invention is an improved valve insert.

Figures 4 and 5 illustrate two presently preferred embodiments of the invention, namely, a cut-out valve insert and a fill valve insert. The invention is described below as if intended for the environment set out in the background

section of this document. Despite being described in the context of an ECP manifold assembly, it should be apparent from a reading of this document that the invention may be implemented in a variety of fluid control systems, even ones unrelated to the railroad industry. The invention is presented in this context not to limit the scope of the claims set forth below but merely to simplify the description, and thus the understanding, of the invention.

The features generic to both preferred embodiments of the invention are illustrated in Figures 4 and 5 and are described below. In particular, in each of its preferred embodiments, the innovative valve insert comprises a bushing assembly, a piston assembly and a spring. Formed around the bushing assembly, generally designated 400, is a plurality of annular flanges 411, 412 and 413. Flange 411 is situated around the top of the bushing assembly. Flanges 412 and 413 are situated near the middle and bottom, respectively, of bushing assembly 400. Each flange defines a groove around its periphery in which an o-ring is secured. The flanges and o-rings allow the bushing assembly to fit snugly and sealingly within a suitable borehole, such as the cut-out borehole 10 or the fill boreholes 50 and 70 of the ECP manifold assembly 1 depicted in Figure 6. The o-rings 421,

422 and 423 prevent leakage between the various portions of the borehole in which the valve insert is to be housed. The top o-ring 421, for example, provides the seal between the bushing assembly 400 and the cover plate 200 that covers it.

Bushing assembly 400 defines a longitudinal bore, generally designated 410, within which to house the piston assembly. The longitudinal bore 410 has an upper cavity 401, an intermediate cavity 402 and a lower cavity 403. Bushing assembly 400 also defines at least one vent port hole 404 in direct communication with upper cavity 401. It also defines one or more first port holes 405 in communication with lower cavity 403.

The bushing assembly 400 also has a lower spring seat 406 formed circumferentially at a bottom of upper cavity 401. It also features an annular valve seat, generally designated 430, formed circumferentially about lower cavity 403. Annular valve seat 430 features a raised inner portion 431 tapering off at a predetermined angle to a sloped outer portion 432. Depending on the embodiment of the invention, the predetermined angle is preferably 15 or 30 degrees, although it can be adjusted according to the environment in which the invention is to be used.

The piston assembly, generally designated 600, is designed to fit, and be reciprocated longitudinally, within the longitudinal bore 410 of bushing assembly 400. Piston assembly 600 includes an insert piston 610 and an annular sealing member, generally designated 630. Insert piston 610 has its head 611 disposed in upper cavity 401, with its stem 612 extending downwardly therefrom through intermediate cavity 402. The head 611 has an annular collar 613 around its periphery and defines a chamber 623 within its top. A groove 615 defined around the annular collar 613 accommodates a first annular seal 614 to prevent leakage around the head 611 of insert piston 610.

The stem 612 is deployed with a means, generally designated 650, for preventing non-longitudinal movement of piston assembly 600 as it is moved longitudinally within longitudinal bore 410. It 650 also prevents leakage around the intermediate cavity 402. This means is described in greater detail below.

Secured to a bottom portion of stem 612, the annular sealing member 630 comprises an annular disk 631. The annular disk 631 defines a throughhole 632 through which the bottom portion of stem 612 extends. Comprised of a resilient material, the disk 631 has a flat surface 633 for

sealingly engaging the raised inner portion 431 of valve seat 430 when piston assembly 600 occupies the closed position within the longitudinal bore 410.

Disposed around insert piston 610, the spring 640 lies in compression between an underside of the annular collar 613 and the lower spring seat 406. It preferably conveys a load of 3 lb., as compared to the 2 lb. load offered by the springs used with the prior art valve inserts. Spring 640 biases the piston assembly 600 in the longitudinal bore 410 to either the closed position or the open position. The position to which the piston assembly is biased depends upon the particular embodiment that the invention takes. In the closed position, piston assembly 600 cuts off lower cavity 403 from a bottom area 407 subjacent to the lower cavity. In the open position, the piston assembly allows communication between the lower cavity 403 and the bottom area 407.

Referring again to the bushing assembly 400, the vent port hole(s) 404 are designed to align with the vent passage 5 when the valve insert is installed within its appropriate borehole in ECP manifold 150. The vent port hole(s) 404 thus allow the upper cavity 401 on the underside of piston head 611 to vent to atmosphere, and thereby prevent

pressure from building there. If not vented to atmosphere, any pressure that develops there could otherwise resist downward movement of the piston assembly 600 when pilot pressure from the auxiliary reservoir is applied against and acts upon the top surface 616 of insert piston 610.

In the preferred embodiment in which the invention is manifested as the cut-out valve insert shown in Figure 4, the first port hole(s) 405 are designed to align with the inlet passage 6 in ECP manifold 150. This is best illustrated in Figure 6, at left. The cut-out valve insert, generally designated 20, is shown housed within the cut-out borehole 10, with its first port hole(s) 405 in communication with inlet passage 6. At the top of head 611 of insert piston 610, the chamber 623 is aligned with the pilot airway 4 in cover plate 200.

As manifested in the cut-out valve insert 20, the means 650 comprises the stem 612 and a second annular seal 654. More specifically, the stem features an upper land 651 and a lower land 652 between which an annular groove 653 is defined around the stem 612 in intermediate cavity 402. The second annular seal 654 has an effective area roughly equal to that of annular sealing member 630. Secured within groove 653 between the upper and lower lands, the second annular

seal 654 prevents leakage past the intermediate cavity 402. Having equal outer diameters, the upper and lower lands 651 and 652 are dimensioned to fit flush and slide smoothly within the internal cylindrical sleeve 414 of bushing assembly 400 that defines the intermediate cavity. Due to their precise fit within intermediate cavity 402, the lands 651 and 652 prevent the bottom end of stem 612 from jostling to and fro or left or right, as viewed in Figure 4. This design not only guides the movement of insert piston 610 within bushing assembly 400 but also prevents the bell clapper effect suffered by the prior art valve inserts.

Referring still to the preferred embodiment shown in Figure 4, the cut-out valve insert 20 has its annular valve seat 430 facing upward and away from bottom area 407. Moreover, the bottom area is manifested as a bottom cavity 407. This cavity is defined in bushing assembly 400 contiguous with and subjacent to lower cavity 403. The bushing assembly also defines one or more second port holes 408 in communication with bottom cavity 407.

In the cut-out valve insert 20, spring 640 biases piston assembly 600 upward and away from the annular valve seat 430 and thus to the open position. Absent pilot pressure acting against the top surface 616 of insert piston

610, the spring 640 acts to force the piston assembly upward within the longitudinal bore 410. The upward movement of insert piston 610 is limited by the contact that the top surface of annular sealing member 630 makes against the bottom surface of sleeve 414. Secured to the bottom portion of stem 612, the annular sealing member 630 is thus moved by spring 640 upward and away from valve seat 430. This places the lower and bottom cavities 403 and 407 in communication, and thereby interconnects the first and second port holes 405 and 408.

Cut-out valve insert 20 is thus normally biased to the cut-out state, as used in the ECP manifold 150 shown in Figure 6. Consequently, whenever the conventional brake control system conveys a brake application command along the brake pipe, the cut-out valve insert 20 will allow pressurized air to flow into the brake cylinder(s). Specifically, air from the c1 passage in the service portion of the BCV will be allowed to flow into inlet passage 6 and through the first and second port holes 405 and 408. The pressurized air will then flow past the valve seat 430 and through common passage 7 into the brake cylinder(s), and thereby cause the brakes on the railcar to apply.

When pilot pressure from pilot airway 4 acts against the top surface 616 of insert piston 610 and into chamber 223 defined therein, the piston assembly is forced downward against the opposing force of spring 640, soon reaching the closed position. The downward movement of insert piston 610 ends when the flat surface 633 of annular sealing member 630 seats sealingly against the raised inner portion 431 of valve seat 430. The cut-out valve insert 20 has then assumed the cut-in state wherein the lower and bottom cavities 403 and 407 are cut off from each other, as are the first and second port holes 405 and 408. Viewed in the context of Figure 6, with the cut-out valve insert 20 in the cut-in state, the brakes can be released or applied only by exhausting or pressurizing the brake cylinder(s) through the vent and fill valve inserts 80 and 40, respectively.

It should be noted that annular valve seat 430 can be formed on a separate cylindrical part, as shown in Figure 4. This would require the separate valve seat 430 to be secured within the longitudinal bore 410 between the lower and bottom cavities 403 and 407. An o-ring or like annular resilient element 434, such as that shown in Figure 4, would be used to make an airtight seal between the lower and bottom cavities 403 and 407.

In the preferred embodiment in which the invention is manifested as the fill valve insert shown in Figure 5, the first port hole(s) 405 are designed to align with the common passage 7 in ECP manifold 150. This is best illustrated in Figure 6, at right. Two fill valve inserts, generally designated 40, are shown. One is housed within the auxiliary borehole 50, and the other is housed within the emergency borehole 70. For each fill valve insert 40, the first port hole(s) 405 communicate with the common passage 7 and therethrough with the brake cylinder(s) of the railcar on which the invention is installed. At the top of head 611 of insert piston 610, the chamber 623 is aligned with the pilot airway 4 in cover plate 200.

As manifested in the fill valve insert 40, the means 650 comprises the stem 612 and a second annular seal 664. More specifically, the stem features an upper land 661 and a lower land 662 between which an annular groove 663 is defined around the stem 612 in intermediate cavity 402. The second annular seal 664 has an effective area roughly equal to that of annular sealing member 630. Secured within groove 663 between the upper and lower lands, the second annular seal 664 prevents leakage past the intermediate cavity. Having equal outer diameters, the upper and lower lands 661

and 662 are dimensioned to fit flush and slide smoothly within the interior cylindrical wall 424 of bushing assembly 400 that defines intermediate cavity 402. Due to their precise fit within intermediate cavity 402, the lands 661 and 662 prevent the bottom end of stem 612 from jostling to and fro or left or right, as viewed in Figure 5. This design not only guides the movement of insert piston 610 within bushing assembly 400 but also prevents the bell clapper effect suffered by the prior art valve inserts.

Referring still to the preferred embodiment shown in Figure 5, the fill valve insert 40 has its annular valve seat 430 facing downward towards bottom area 407. As viewed in Figure 6, the bottom area 407 will be the bottom portion 51 of borehole 50 when the fill valve insert 40 is used as an auxiliary valve. Similarly, the bottom area 407 will be the bottom portion 71 of borehole 70 when the valve insert is used as an emergency valve.

In the fill valve insert 40, spring 640 biases the piston assembly 600 upward and thus to the closed position. Absent pilot pressure acting against the top surface 616 of insert piston 610, the spring 640 acts to force the piston assembly upward within the longitudinal bore 410. Secured to the bottom portion of stem 612, the annular sealing member

630 is thus moved upward by spring 640 so that its flat surface 633 sealingly seats against the raised inner portion 431 of annular valve seat 430. The fill valve insert 40 is thus normally biased to the closed position wherein the lower cavity 403 and the first port hole(s) 405 therewith are cut off from bottom area 407.

When pilot pressure from pilot airway 4 acts against the top surface 616 of insert piston 610 and into chamber 223 defined therein, the piston assembly 600 is forced downward against the opposing force of spring 640. The downward movement of insert piston 610 causes the flat surface 633 of annular sealing member 630 to unseat from the raised inner portion 431 of annular valve seat 430. Moved to the open position by the pilot pressure, the piston assembly 600 allows the lower cavity 403 and the first port hole(s) 405 in communication therewith to communicate with the bottom area 407.

Figure 5 also illustrates a backup annular cushion 475. It also shows an annular recess 617 defined around stem 612 at the base of the head 611 of insert piston 610. Secured within this recess 617 is the inner portion of the backup annular cushion 475. When the piston assembly 600 is moved to the open position, the bottom surface of backup

cushion 475 engages an annular inner portion of the bottom of upper cavity 401.

In both preferred embodiments of the valve insert, the annular sealing member 630 has an internal washer 634 around which the annular resilient disk 631 is formed. In the cut-out valve insert 20, the sealing member 630 is secured to the bottom of stem 612 by a nut or like means 635. An o-ring or similar resilient element 636 is used to make an airtight seal between the base of the stem 612 and the top of the sealing member 630. In the fill valve insert 40, the stem 612 has a rim 618 formed around its periphery near the bottom portion of insert piston 610. With the bottom of stem 612 inserted through its throughhole 632, the sealing member 630 is secured by a nut or like means 635 to the underside of this rim 618. The outer surface of rim 618 is angled downward. This further aids in guiding the piston assembly 600 as it is moved longitudinally within the longitudinal bore 410.

Both preferred embodiments of the invention are designed to avoid the pressure imbalance inherent to the prior art valve inserts. As noted earlier, in both the cut-out and fill valve inserts 20 and 40, the second annular seal 654/664 has an effective area roughly equal to that of the

annular sealing member 630 of piston assembly 600. This equivalence in effective area has the effect of balancing the piston assembly 600 within the longitudinal bore 410 of bushing assembly 400.

First consider the fill valve insert 40 in the context of Figures 5 and 6. When the fill valve insert is returned to its closed position after the brake cylinder is charged, pressurized air from the brake cylinder is free to flow through common passage 7 and work against the underside of second annular seal 664 surrounding stem 612. Likewise, this same pressure works against the flat surface 633 atop annular sealing member 630. Because the second annular seal 664 and the annular sealing member 630 have essentially equal effective areas, the opposing upward and downward forces developed against those two surfaces are balanced. Consequently, to move the fill valve insert 40 to its open position as is needed to apply the brakes more forcefully, the pilot pressure required to re-open the valve will be essentially the same as the pilot pressure that was required to open the fill valve when the brake cylinder(s) were depressurized.

Second consider the cut-out valve insert 20 in the context of Figures 4 and 6. When pilot pressure is acting

against the top surface 616 of insert piston 610, the piston assembly 600 is kept in the cut-in state (i.e., closed position). In a subsequent transition to the conventional EP braking mode, pressurized air from the c1 passage in the service portion of the BCV may be allowed to flow into inlet passage 6 and then into lower cavity 403 before the pilot pressure is removed. The pressurized air from the BCV would then be able to work against the top surface of annular sealing member 630, as the cut-out valve 20 may still not have been moved out of the cut-in state. Likewise, this same pressure would work against the underside of second annular seal 654 surrounding stem 612. Because the annular sealing member 630 and the second annular seal 654 have essentially equal effective areas, the opposing upward and downward forces developed against those two surfaces are balanced. Consequently, the cut-out valve 20 will not be prevented from reassuming the cut-out state when so commanded.

The presently preferred embodiments for carrying out the invention have been set forth in detail according to the Patent Act. Persons of ordinary skill in the art to which this invention pertains may nevertheless recognize various alternative ways of practicing the invention without departing from the spirit and scope of the following claims.

Persons who possess such skill will also recognize that the foregoing description is merely illustrative and not intended to limit any of the ensuing claims to any particular narrow interpretation.

CLAIMS

I claim:

1. A valve insert comprising:

(a) a bushing assembly around which a plurality of annular flanges are formed with each of said annular flanges defining a groove in which an o-ring is secured and which allow said bushing assembly to fit snugly and sealingly within a suitable borehole, said bushing assembly defining (i) a longitudinal bore having an upper cavity, an intermediate cavity and a lower cavity, (ii) a vent port hole connected to said upper cavity and (iii) a first port hole connected to said lower cavity, said bushing assembly also having (iv) a lower spring seat formed circumferentially at a bottom of said upper cavity and (v) an annular valve seat formed circumferentially about said lower cavity, said annular valve seat featuring a raised inner portion tapering off at a predetermined angle to a sloped outer portion;

(b) a piston assembly reciprocatable within said longitudinal bore between an open position and a closed position, said piston assembly comprising an insert piston and an annular sealing member, said insert piston having a head disposed in said upper cavity and a stem extending downwardly therefrom through said intermediate cavity, said head having an annular collar defining a groove in which a first annular seal is disposed to prevent leakage around said

head, said stem deployed with a means for preventing non-longitudinal movement of said piston assembly as said piston assembly is moved longitudinally within said longitudinal bore and for preventing leakage around said intermediate cavity, said annular sealing member being secured to a bottom portion of said stem and having a flat surface for sealingly engaging said raised inner portion of said annular valve seat when said piston assembly occupies said closed position; and

(c) a spring disposed around said insert piston and in compression between an underside of said annular collar and said lower spring seat, said spring for biasing said piston assembly in said longitudinal bore to one of (i) said closed position wherein said lower cavity is cutoff from a bottom area subjacent to said lower cavity and (ii) said open position wherein communication is established between said lower cavity and said bottom area.

2. The valve insert claimed in claim 1 wherein said means comprises:

(a) said stem having an upper land and a lower land between which a groove is defined around a middle portion of said stem in said intermediate cavity; and

(b) a second annular seal disposed in said groove between said upper and said lower lands, said second annular

seal having an effective area equal to that of said annular sealing member of said piston assembly.

3. The valve insert claimed in claim 2 wherein:

(a) said annular valve seat faces upward;

(b) said bottom area is manifested as a bottom cavity defined in said bushing assembly contiguous with and subjacent to said lower cavity of said longitudinal bore;

(c) said bushing assembly further defines a second port hole connected to said bottom cavity; and

(d) said spring biases said piston assembly upward to said open position in which said annular sealing member is held off of said annular valve seat to allow communication between said lower and said bottom cavities and between said first and said second port holes connected respectively thereto.

4. The valve insert claimed in claim 3 wherein said annular valve seat is formed on a separate cylindrical part that is sealingly secured within said longitudinal bore between said lower and said bottom cavities of said bushing assembly.

5. The valve insert claimed in claim 4 wherein said predetermined angle is approximately 15 degrees.

6. The valve insert claimed in claim 5 wherein said suitable borehole is a cut-out borehole of a manifold assembly, and said valve insert fits within said cut-out borehole such that said vent port hole communicates with a vent passage in said manifold assembly, said first port hole communicates with an inlet passage in said manifold assembly, and said second port hole communicates with a common passage in said manifold assembly.

7. The valve insert claimed in claim 1 wherein said predetermined angle is approximately 15 degrees.

8. The valve insert claimed in claim 2 wherein said predetermined angle is approximately 15 degrees.

9. The valve insert claimed in claim 2 wherein:

(a) said annular valve seat faces downward towards said bottom area at a bottom of said bushing assembly; and

(b) said spring biases said piston assembly upward to said closed position in which said annular sealing member is held against said annular valve seat to prevent communication between said lower cavity and said bottom area.

10. The valve insert claimed in claim 9 further including a backup annular cushion disposed around said stem at a base of said head, said backup annular cushion for engaging an annular inner portion of said bottom of said upper cavity when pilot pressure acting on a control surface atop said head forces said annular sealing member downward off of said annular valve seat thus moving said piston assembly to said open position wherein communication is established between said lower cavity and said bottom area.

11. The valve insert claimed in claim 10 wherein said predetermined angle is approximately 30 degrees.

12. The valve insert claimed in claim 11 wherein said suitable borehole is a fill borehole of a manifold assembly, and said valve insert fits within said fill borehole such that said vent port hole communicates with a vent passage in said manifold assembly, said first port hole communicates with a common passage in said manifold assembly, and said bottom area communicates with a reservoir passage in said manifold assembly.

13. The valve insert claimed in claim 9 wherein said predetermined angle is approximately 30 degrees.

14. A cut-out valve insert comprising:

(a) a bushing assembly around which a plurality of annular flanges are formed with each of said annular flanges defining a groove in which an o-ring is secured and which allow said bushing assembly to be incorporated within a suitable borehole, said bushing assembly defining (i) a longitudinal bore having an upper cavity, an intermediate cavity, a lower cavity and a bottom cavity, (ii) a vent port hole connected to said upper cavity, (iii) a first port hole connected to said lower cavity and (iv) a second port hole connected to said bottom cavity, said bushing assembly also having (v) a lower spring seat formed circumferentially at a bottom of said upper cavity and (vi) an upwardly facing annular valve seat formed about said longitudinal bore between said lower and said bottom cavities, said annular valve seat featuring a raised inner portion tapering off at a predetermined angle to a sloped outer portion;

(b) a piston assembly reciprocatable within said longitudinal bore between an open position and a closed position, said piston assembly comprising an insert piston having a head disposed in said upper cavity and a stem extending downwardly therefrom through said intermediate cavity, said head having an annular collar defining a groove in which a first annular seal is disposed to prevent leakage around said head, said stem having (i) a pair of lands

between which a second annular seal is disposed for preventing non-longitudinal movement of said piston assembly as said piston assembly is moved longitudinally within said longitudinal bore and for preventing leakage around said intermediate cavity and (ii) a bottom portion to which an annular sealing member is secured, said annular sealing member having a flat surface for sealingly engaging said raised inner portion of said annular valve seat when said piston assembly occupies said closed position, said second annular seal having an effective area essentially equal to that of said annular sealing member; and

(c) a spring disposed around said insert piston and in compression between an underside of said annular collar and said lower spring seat, said spring for biasing said piston assembly away from (i) said closed position wherein pilot pressure acting on a control surface atop said head overcomes said spring and forces said annular sealing member downward against said annular valve seat to cut off communication between said lower and said bottom cavities to (ii) said open position wherein said annular sealing member is held off of said annular valve seat to allow communication between said lower and said bottom cavities and said first and said second port holes connected respectively thereto.

15. The cut-out valve insert claimed in claim 14 wherein said annular valve seat is formed on a separate cylindrical part that is sealingly secured within said longitudinal bore between said lower and said bottom cavities of said bushing assembly.

16. The cut-out valve insert claimed in claim 14 wherein said predetermined angle is in the range of 10 to 20 degrees.

17. The cut-out valve insert claimed in claim 14 wherein said suitable borehole is a cut-out borehole of a manifold assembly, and said cut-out valve insert fits within said cut-out borehole such that said vent port hole communicates with a vent passage in said manifold assembly, said first port hole communicates with an inlet passage in said manifold assembly, and said second port hole communicates with a common passage in said manifold assembly.

18. A fill valve insert comprising:

(a) a bushing assembly around which a plurality of annular flanges are formed with each of said annular flanges defining a groove in which an o-ring is secured and which allow said bushing assembly to be incorporated within a suitable borehole, said bushing assembly defining (i) a

longitudinal bore having an upper cavity, an intermediate cavity and a lower cavity, (ii) a vent port hole connected to said upper cavity and (iii) a first port hole connected to said lower cavity, said bushing assembly also having (iv) a lower spring seat formed circumferentially at a bottom of said upper cavity and (v) an annular valve seat formed about said longitudinal bore that faces downward to a bottom area subjacent to said lower cavity, said annular valve seat featuring a raised inner portion tapering off at a predetermined angle to a sloped outer portion;

(b) a piston assembly reciprocatable within said longitudinal bore between an open position and a closed position, said piston assembly comprising an insert piston having a head disposed in said upper cavity and a stem extending downwardly therefrom through said lower cavity, said head having an annular collar defining a groove in which a first annular seal is disposed to prevent leakage around said head, said stem having (i) a pair of lands between which a second annular seal is disposed for preventing non-longitudinal movement of said piston assembly as said piston assembly is moved longitudinally within said longitudinal bore and for preventing leakage around said intermediate cavity and (ii) a bottom portion to which an annular sealing member is secured, said annular sealing member having a flat surface for sealingly engaging said raised inner portion of

said annular valve seat when said piston assembly occupies said closed position, said second annular seal having an effective area essentially equal to that of said annular sealing member; and

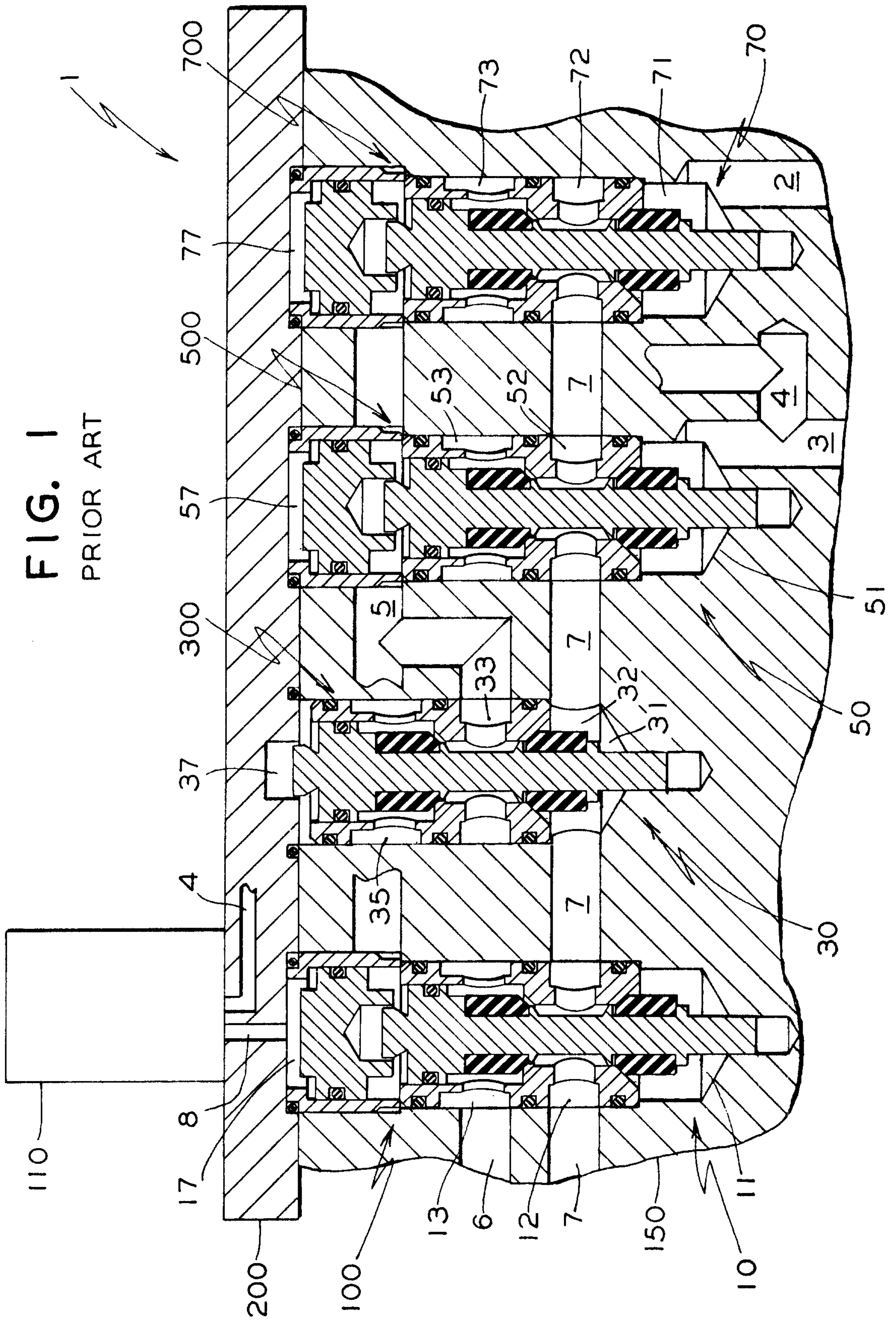
(c) a spring disposed around said insert piston and in compression between an underside of said annular collar and said lower spring seat, said spring for biasing said piston assembly to (i) said closed position wherein said annular sealing member is pulled upward against said annular valve seat to cut off communication between said lower cavity and said bottom area and away from (ii) said open position wherein pilot pressure acting on a control surface atop said head overcomes said spring and forces said annular sealing member downward off of said annular valve seat to establish communication between said lower cavity and said bottom area.

19. The fill valve insert claimed in claim 18 wherein said predetermined angle is in the range of 25 to 35 degrees.

20. The fill valve insert claimed in claim 18 further including a backup annular cushion disposed around said stem at a base of said head, said backup annular cushion for engaging an annular inner portion of said bottom of said upper cavity when pilot pressure acting on said control surface of said head forces said piston assembly downward to said open position.

21. The fill valve insert claimed in claim 20 wherein said predetermined angle is approximately 30 degrees.

22. The fill valve insert claimed in claim 18 wherein said suitable borehole is a fill borehole of a manifold assembly, and said fill valve insert fits within said fill borehole such that said vent port hole communicates with a vent passage in said manifold assembly, said first port hole communicates with a common passage in said manifold assembly, and said bottom area communicates with a reservoir passage in said manifold assembly.



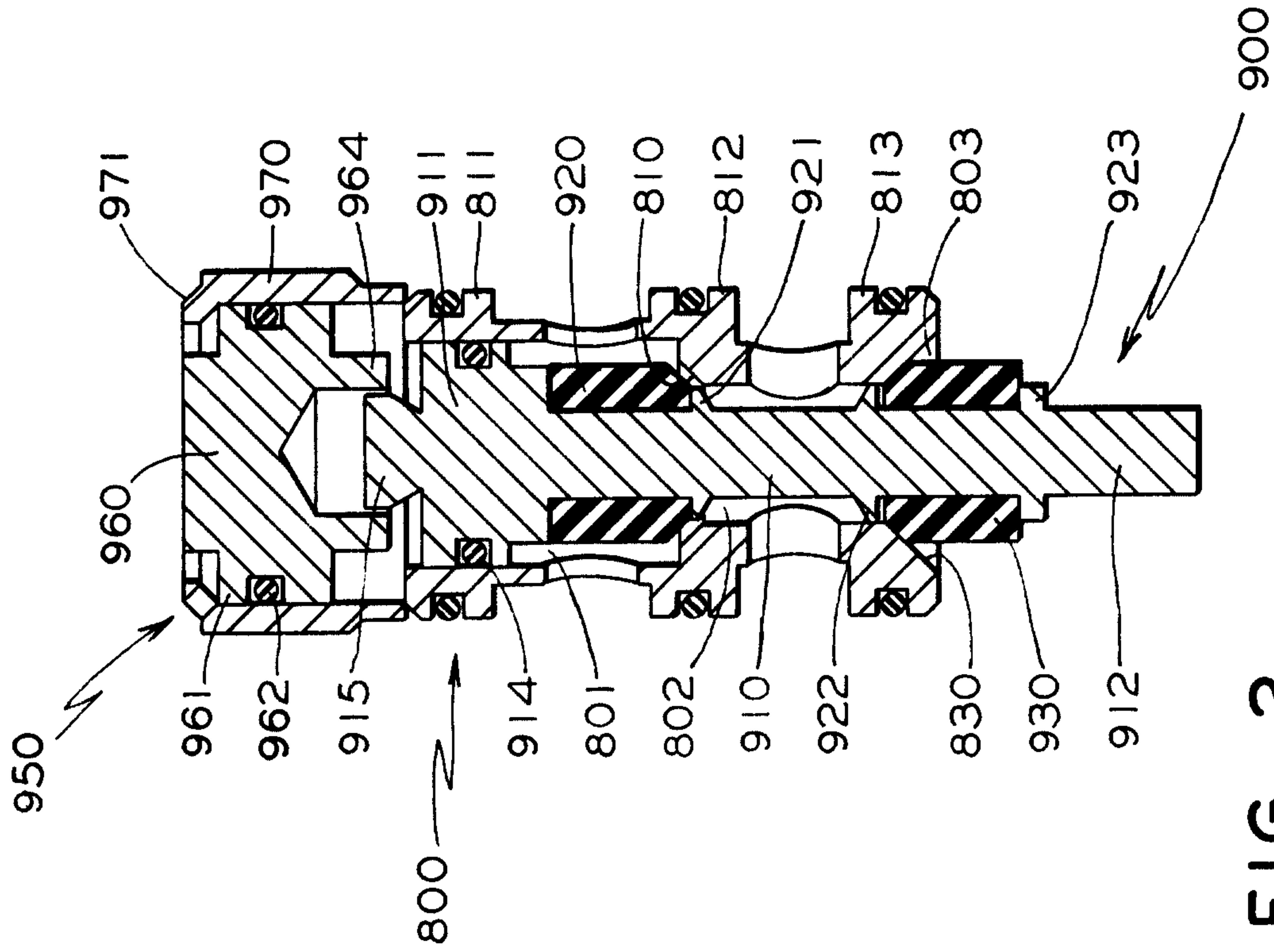


FIG. 2
PRIOR ART

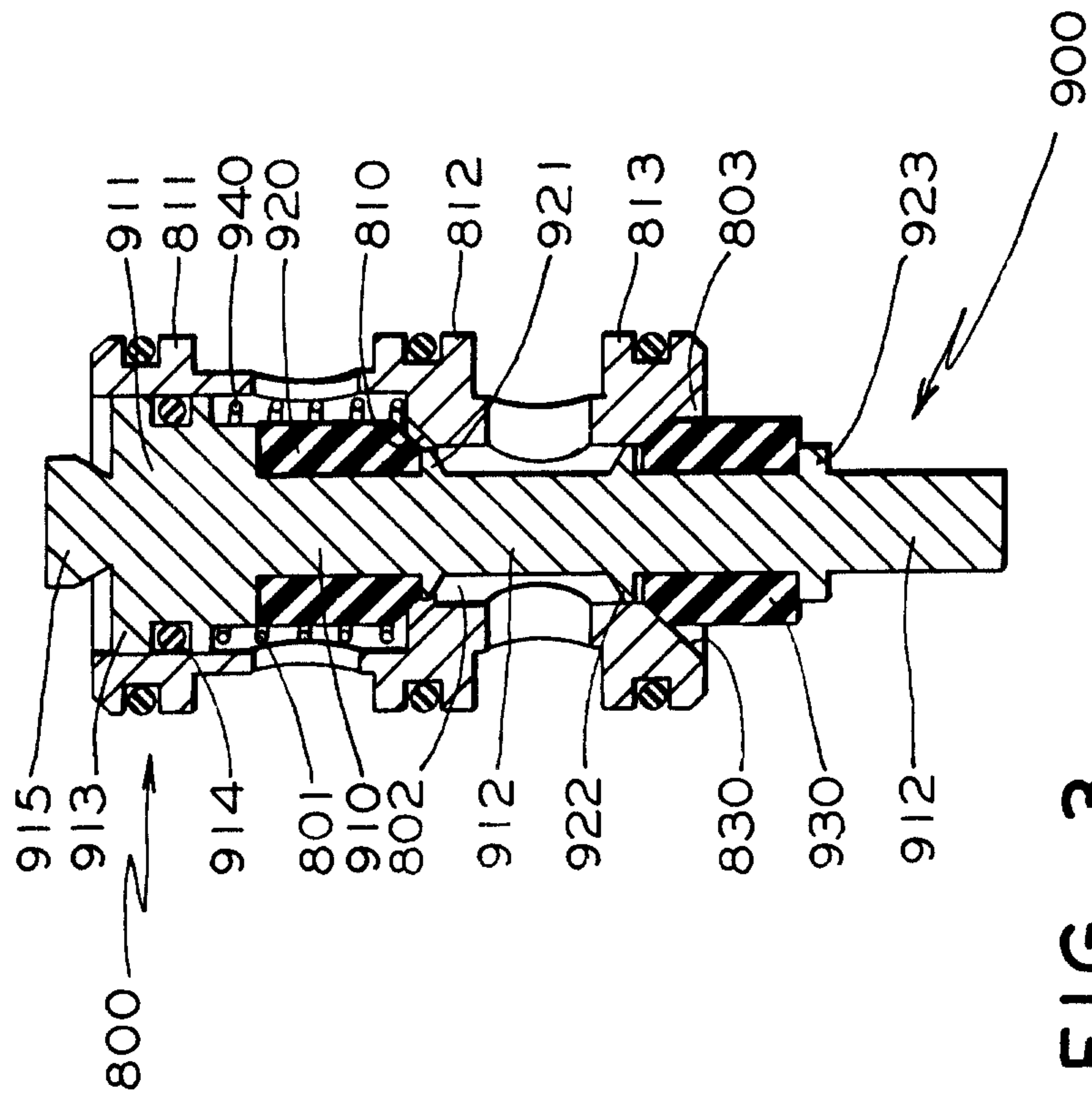


FIG. 3
PRIOR ART

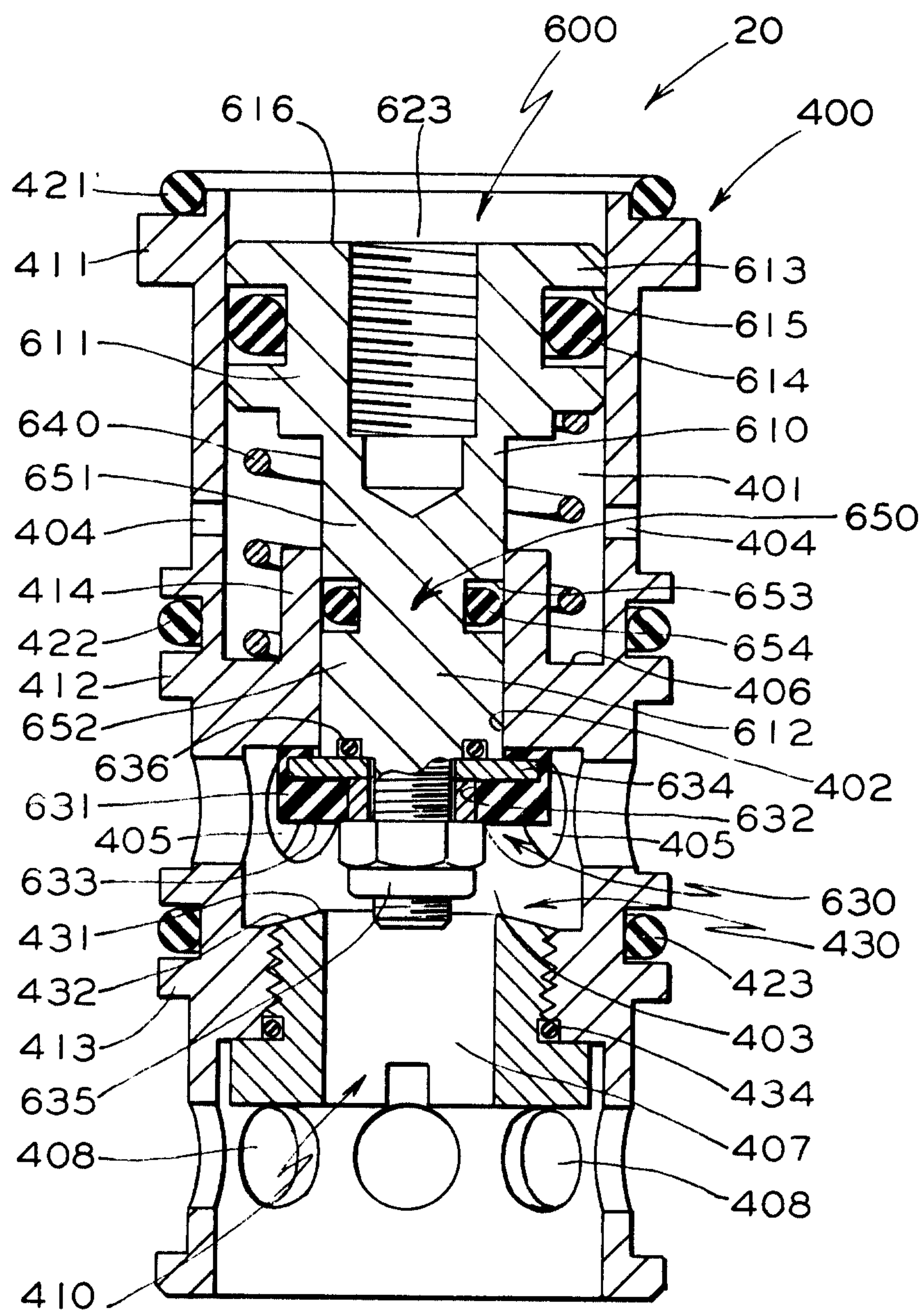


FIG. 4

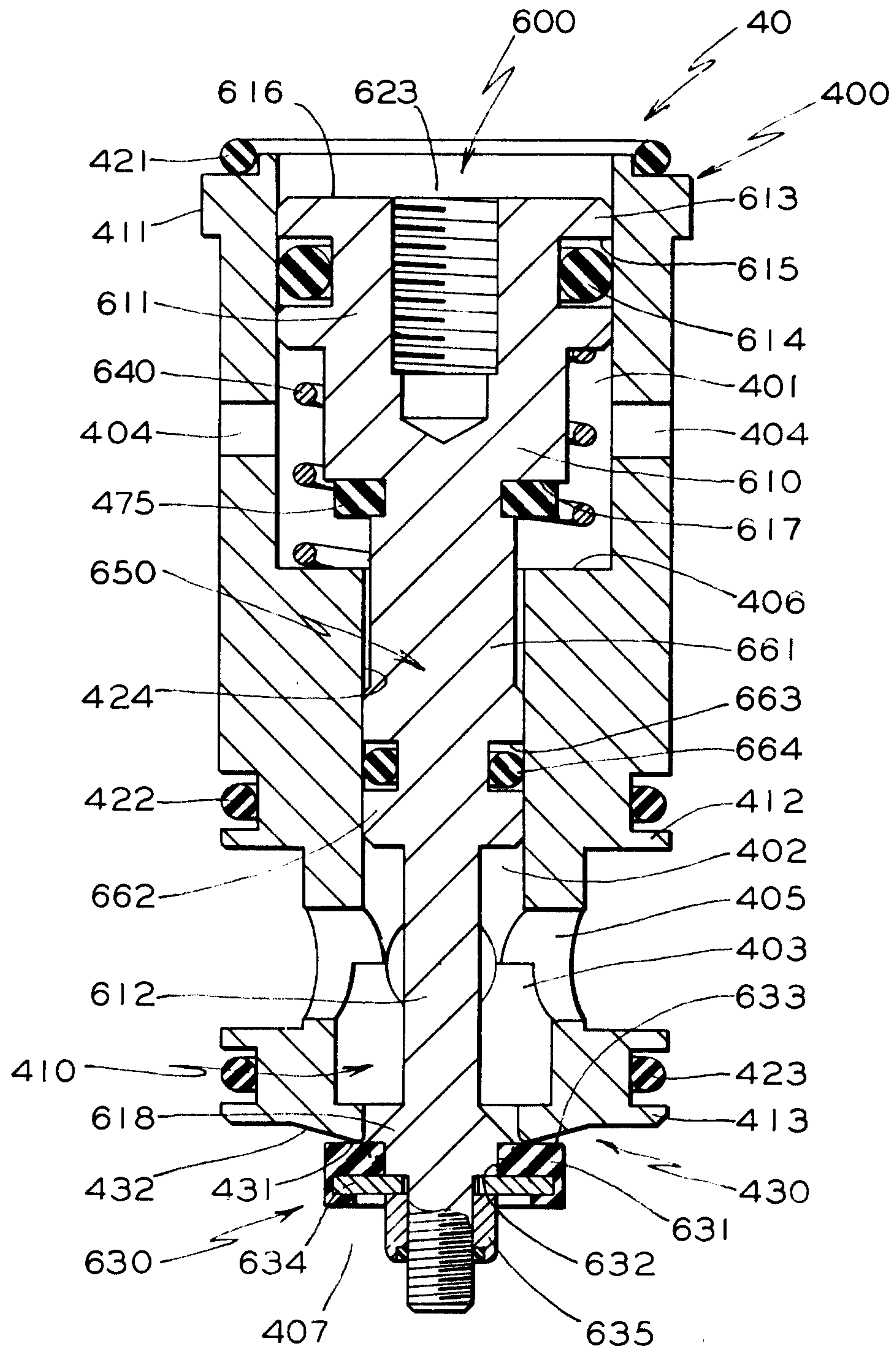


FIG. 5

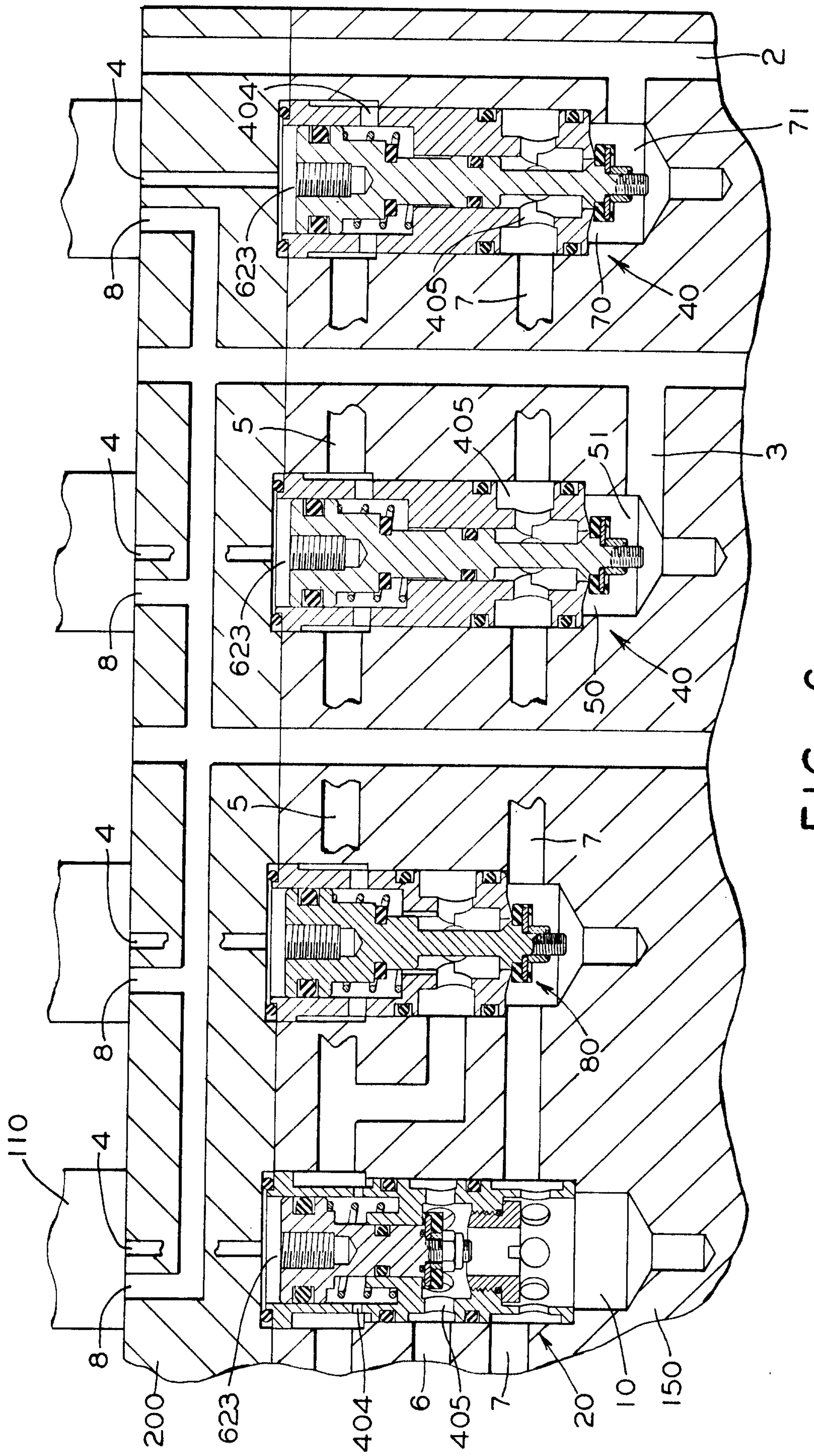


FIG. 6

