Feb. 9, 1954 J. H. HOWARD ET AL 2,668,553

FLOW VALVE

Filed Sept. 20, 1948 4 Sheets-Sheet 1

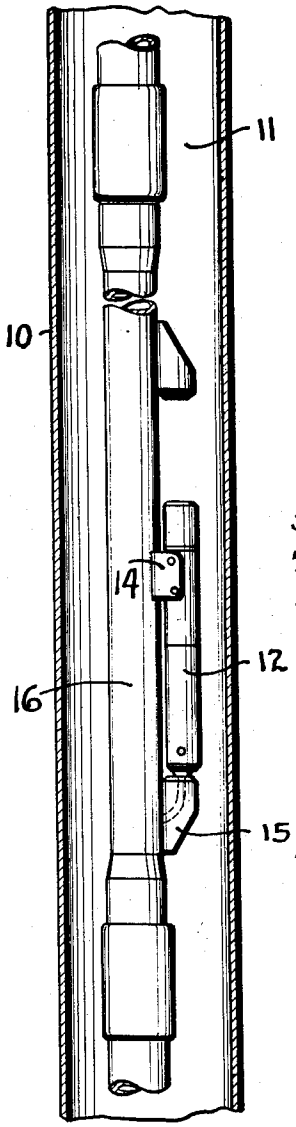


Fig. 1

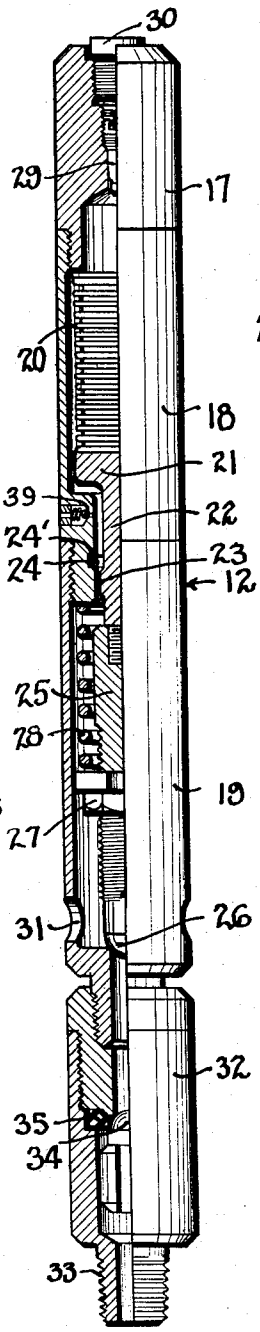


Fig. 2

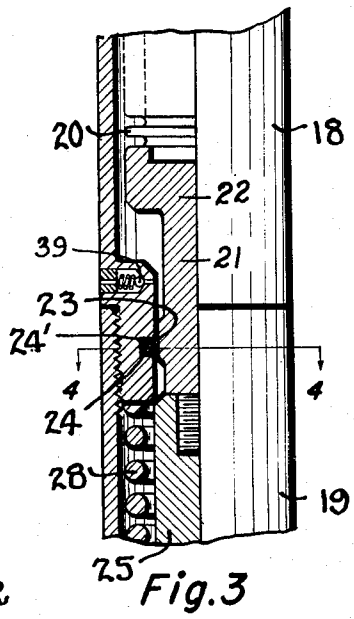


Fig. 3

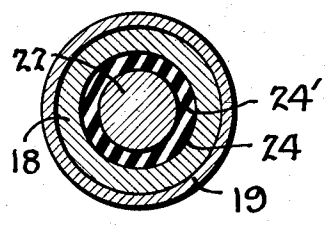


Fig. 4

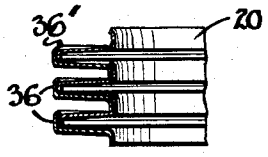


Fig. 5

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FLOW VALVE

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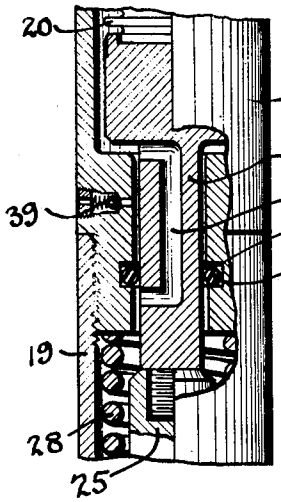


Fig. 6

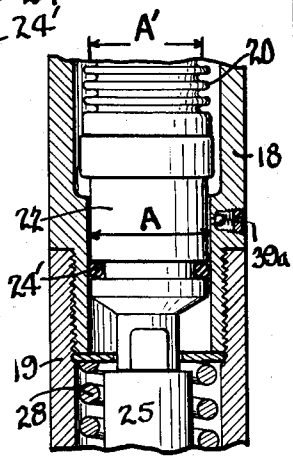


Fig. 7a

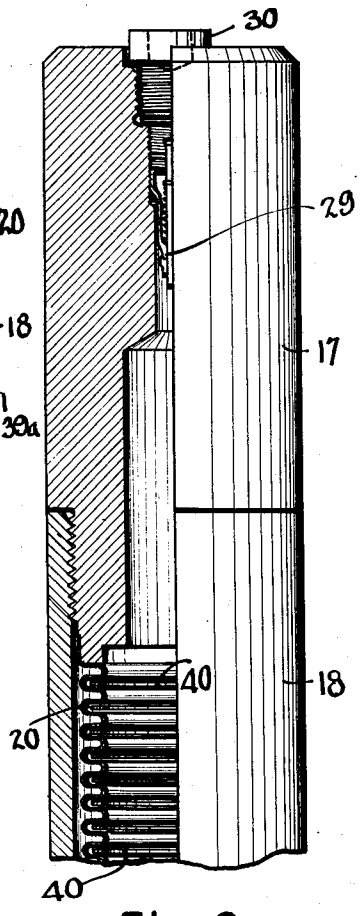


Fig. 9

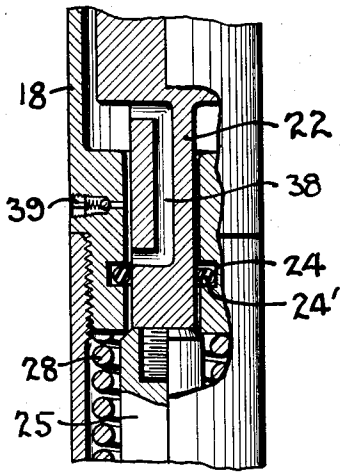


Fig. 7

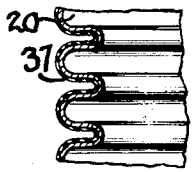


Fig. 8

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FLOW VALVE

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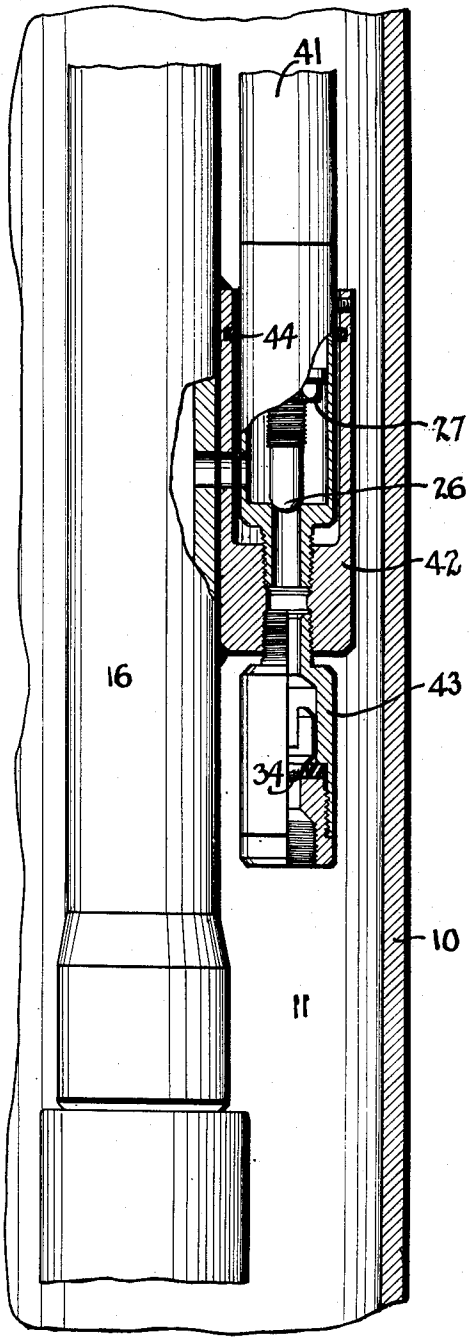


Fig. 10

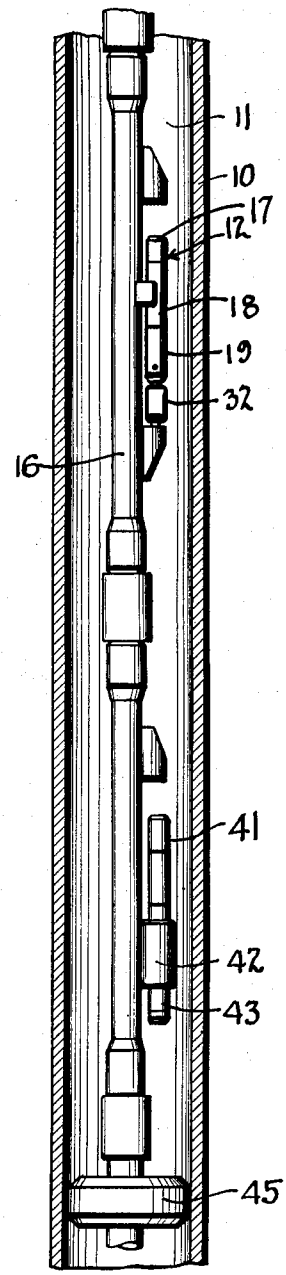


Fig. 11

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FLOW VALVE

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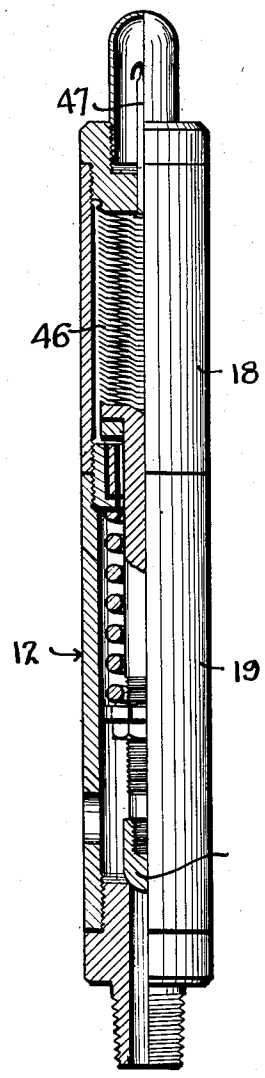


Fig. 12

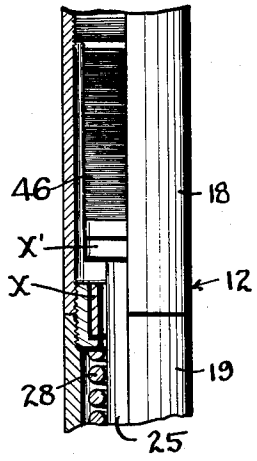


Fig. 13

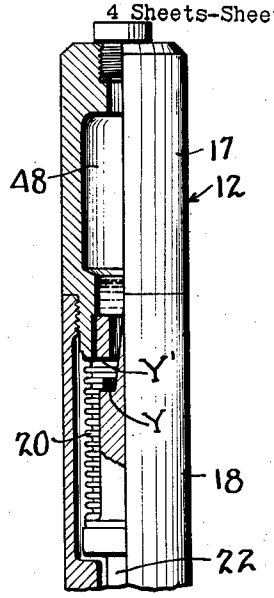


Fig. 14

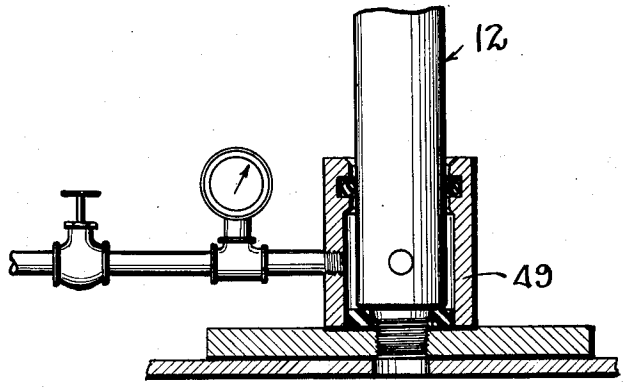


Fig. 15

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2,668,553

UNITED STATES PATENT OFFICE

2,668,553

FLOW VALVE

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Application September 20, 1948, Serial No. 50,038

5 Claims. (Cl. 137—155)

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The invention relates to improvements in gas lift valves and the flowing of wells by the application of fluid under pressure.

Examples of gas lift valves of the type to which the present invention relates are disclosed in Patent No. 2,339,487 issued January 18, 1944 to William R. King; and in the co-pending applications of Carlisle and Mills, Serial No. 658,092 filed March 29, 1946, issued June 12, 1951, as Patent No. 2,556,867 and Serial No. 620,690 filed October 6, 1945, issued March 22, 1949, as Patent No. 2,465,060. These valves embody a pressure loaded bellows type of valve, wherein the bellows thereof is subject to damage by high fluid pressure in the well at the time of installation, and prior to the time when the valves are in the operating stage.

With the foregoing in mind, it is one of the objects of the present invention to provide an improved gas lift valve of the character referred to wherein the bellows is protected against damage by high well fluid pressures in excess of normal operating pressures.

Another object is the provision of an improved lift of the character referred to which has advantages over those proposed heretofore in the way of flexibility in application, efficiency, ease of adjustment and operation satisfactorily over a wide range of conditions.

Other objects and advantages will hereinafter appear, it being understood that well fluids can be either gas, oil, water, mud, or combinations thereof.

For the purpose of illustrating the invention, several embodiments thereof are shown in the drawings wherein:

Fig. 1 is a side elevation of the tubing having applied thereto one of the flow valves of the present invention with the tubing inside a well casing;

Fig. 2 is a longitudinal sectional view of the flow valve in Fig. 1;

Fig. 3 is an enlarged, fragmentary, sectional view illustrative of the operating action of the flow valve in Figs. 1 and 2;

Fig. 4 is a section taken on the line 4—4 in Fig. 3;

Figs. 5 and 8 are detail, fragmentary, sectional views;

Figs. 6, 7, 7A, 9, 13 and 14 are fragmentary, sectional views showing modifications;

Fig. 10 is an elevational view, partly in section, showing a novel way of applying one of the flow valves to the side of the tubing;

Fig. 11 is a view similar to Fig. 1 showing the manner of use of the two types of flow valves known in the art;

Fig. 12 is a view similar to Fig. 2, showing a modification; and

Fig. 15 is a fragmentary view partly in section of a test fitting for the flow valves.

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In Fig. 1 the well casing 10 is positioned in the well and forms a reservoir 11 when the casing is closed in the usual manner at the surface. A flow valve 12, which operates by gas pressure in casing 10, is attached by clamp lugs 14 and a fitting 15 to the string of pipe or flow tubing 16 which is utilized for removing the oil. As shown more clearly in Fig. 2 the flow valve 12 is made up of the sections 17, 18, and 19 screwed together to form a container. A bellows 20 is fixed at its upper end to section 17. To the lower end of the bellows is fixed a cap 21 having a stem 22, the latter being provided with the enlarged portion 23. The valve section 18 is provided at the lower end thereof with an annular groove 24 to receive an O-ring 24' which, when engaged by the enlarged portion 23, seals off the bellows chamber from the relatively high gas pressure in valve section 19.

Screwed to the stem 22 is a member 25 having its lower end formed to provide a valve 26. Threaded on member 25 is a nut 27 to hold in compression a spring 28. Initially the bellows is charged with gas at a predetermined pressure for which purpose a suitable valve 29 is provided. The plug 30 and an associated gasket insure against leakage of the gas from the bellows. Inlet openings 31 provide that the pressure in valve section 19 is equal to the gas lift pressure in casing 10, at the flow valve unit 12. This same pressure exists in valve section 18 when valve 26 is closed, as shown in Fig. 2. This is because at such time the enlarged portion 23 is below ring 24', and its diameter is less than the inside diameter of the lower end of valve section 18.

The adjustment of nut 27, and the gas pressure in bellows 20 are such that the combined effect of this pressure and the spring 28 holds valve 26 closed only up to a certain point. In other words, when the gas lift pressure acting on bellows 20 to urge valve 26 upward and off its seat exceeds a predetermined maximum, this valve opens and the bellows contracts. Such upward opening movement of valve 26 is limited by engagement of the upper end of member 25 with the lower end of valve section 18, as shown in Fig. 3. An important aspect of the invention resides in the fact that in this position of the parts, the enlarged portion 23 is in engagement with ring 24 to seal off the valve section 18 from higher well pressure. The charge that is normally in the bellows may approximate 400 to 500 pounds per square inch. Thus it is seen that a hydrostatic pressure in the well of about 5,000 to 6,000 pounds might cause damage to the bellows, if permitted to leak into the space above the seal. This high hydrostatic pressure can be encountered in wells 10,000 or more feet deep at the time when the valves are installed and prior to

the time when drilling fluids are expelled from reservoir 11 to actually start gas lift operations.

The flow valve 12 may be provided with a check valve unit 32 to prevent flow of well fluids from the tubing to the casing reservoir 11 during times when the pressure in the tubing is greater than in the casing and valve 26 is open. This back flow is very undesirable in well operation. The check valve unit 32 has a threaded lower end 33 which screws into the fitting 15. The ball end valve 34 opens downwardly when the pressure above the valve is greater than that below the valve and stays open by gravity until closed by back flow velocity pressure. A ring or disk 35 of suitable flexible material such as Hycar is used to provide a positive seal in addition to the metal-to-metal contact of valve 34 on its seat.

There are usually several of the flow valves 12 in a tubing string, any one of which is set to open at a higher gas lift pressure than the flow valve directly below it.

As shown in Fig. 5 the edges 36 of the bellows discs may be rolled over at 36' to lock them mechanically together prior to the soldering operation. As another expedient, the bellows 20 may be provided with an outside coating 37 of plastic or synthetic rubber as shown in Fig. 8. Such a coating seals up any microscopic pore leaks which would affect the operation of the flow valve. This type of bellows has particular use in cases where instead of having a definite air-pressure charge in the bellows a vacuum is used, or the bellows sealed with atmospheric pressure. Use of a vacuum is possible since there is also a spring adjustment, as shown in Fig. 2. It is, of course, seen that if desired a plastic coating can be applied to the inside of the bellows.

In the modification shown in Figs. 6 and 7 the stem 22 is provided with a fluid passage 38 to conduct the fluid past the O-ring 24' when valve 26 is closed. Also, a relief check valve 39 may be employed. This valve would serve the purpose of bleeding off any trapped fluid which might leak past the O-ring 24' into valve section 18, and otherwise cause a liquid-lock which would prevent, or at least hamper, the normal functioning of bellows 20. Tests and field experience has proven that valves using a bellows seal such as shown in the King Patent No. 2,339,487 can become fluid locked open and be made inoperative. The relief valve 39 will relieve the pressure of this trapped fluid to permit proper operation of the valve.

In the modification shown in Fig. 7A the effective cross-section area A of stem 22 and ring 24' is equal to the effective cross-section area A' of the bellows 20. Thus, normally no pressure acts directly on the bellows but since the area thereof and that of stem 22 are equal the fluid pressure acts on the stem below the ring 24' to compress the bellows so that the same valve operation is obtained without fluid pressure coming in direct contact with the bellows. This is obvious since in this construction, the ring 24' is carried by stem 22, and engages the inside surface of valve section 18 to provide the fluid seal-off. Also a relief check valve 39A may be provided which serves the same purpose as the valve 39 in Fig. 6.

In the modification shown in Fig. 9 the bellows 20 is provided between its convolutions with inside spacers 40 to prevent collapse of the bellows by overload pressure. These spacers may also be placed on the outside as well as the inside if desired.

In the construction shown in Fig. 10 the flow valve 41 is of the type which operates by the hydrostatic pressure of the oil column in the tubing 16, instead of by the gas lift pressure between the tubing and casing 10. There is a fitting 42 secured to the tubing 16, and into which the flow valve is screwed as shown. A check valve unit 43 operates the same as the corresponding unit 32 in Fig. 2 to prevent back flow from tubing to casing. In this case the check valve 43 is reversed in position. In operation when the hydrostatic pressure exceeds a predetermined amount, as determined by the adjustment of nut 27, valve 26 opens, whereupon the lifting gas can enter by way of valve 34 and force the oil column upwardly through the tubing. There is an O-ring seal 44 between the fitting 42 and the flow valve. This construction is simple and positive.

Fig. 11 illustrates use of the two types of flow valves. That is, there is the flow valve 12 which operates by the gas pressure in casing 10, and the flow valve 41 which operates by the hydrostatic pressure of the oil column in the tubing 16. By the use of these two types of valves the well may be flowed either by intermitting gas to the casing and flowing through valve 12, or the well may be flowed with a constant gas pressure in the casing applied to the tubing through the valve 41 which is controlled by the hydrostatic pressure of the oil within the tubing. This dual method of gas lifting gives flexibility of operation which is desirable in certain wells for maximum efficiency. A tubing packer 45 serves the purpose of directing the fluid flow through the tubing 16. The use of the packer is not required in many wells.

In Fig. 12 the bellows 46, which corresponds to and serves the same purpose as the bellows 20 in Fig. 2, is of a type which can be fully collapsed, as shown in Fig. 13 of valve 26. The bellows may be charged through a copper tube 47 which is bent and sealed after the charging. Bellows of this type, when operated to a fully compressed position are capable of withstanding extremely high pressures and require no bellows seal.

In Fig. 13 the additions of ring type permanent magnets at X and X' serve the purpose of giving snap action to the opening and closing of the valve. The other material used in the valve would be non-magnetic in this case.

In the construction shown in Fig. 14 the bellows 20 is filled with water, Prestone, or any other suitable liquid. This liquid forms a positive fluid trap in the bellows when the valve completely opens causing gasket Y to seat on Y' and this trapped fluid will give support to the inside thereof from collapse due to excessive outside pressure. An additional air or gas chamber 48 is provided above the liquid so that proper operation can be obtained even though the space inside the bellows is filled with liquid.

Fig. 15 illustrates a novel form of fitting 49 which may be used for shop testing the opening pressure of flow valves prior to well installation.

It will be understood that various modifications within the conception of those skilled in the art are possible without departing from the spirit of the invention or the scope of the claims.

What is claimed is:

1. A flow valve comprising, a housing, said housing providing a valve seat and a flow passage

in one end thereof extending through said valve seat, a pressurized bellows connected at one end to the other end of the housing, an extension on the other end of said bellows, a valve stem connected at one end to said extension and having a seating element on the other end thereof to seat upon said valve seat to close said flow passage, and means including the pressure of said bellows urging said valve stem to closed position, said housing providing port means in the wall thereof to admit pressure fluid into said housing between said valve seat and said bellows, at least one of said extension and said housing having a sealing means therein of the O-ring type accessible from either end of said housing to establish sealing contact therebetween on the bellows side of said port means, and a fluid pressure check valve disposed in the housing wall on the bellows side of said sealing means and arranged to relieve trapped fluid pressure on the exterior surface of said bellows.

2. A flow valve comprising, a housing, said housing providing a valve seat and a flow passage in one end thereof extending through said valve seat, a pressurized bellows connected at one end to the other end of the housing, an extension on the other end of said bellows, a valve stem connected at one end to said extension and having a seating element on the other end thereof to seat upon said valve seat to close said flow passage, and means including the pressure of said bellows urging said valve stem to closed position, said housing providing port means in the wall thereof to admit pressure fluid into said housing between said valve seat and said bellows, at least one of said extension and said housing having a sealing means therein of the O-ring type accessible from either end of said housing to establish sealing contact therebetween on the bellows side of said port means, and a fluid pressure check valve disposed in the housing wall on the bellows side of said sealing means and arranged to relieve trapped fluid pressure on the exterior surface of said bellows, said extension being of substantially the same cross-sectional area of said bellows.

3. A flow valve comprising, a housing, said housing providing a valve seat and a flow passage in one end thereof extending through said valve seat, a pressurized bellows connected at one end to the other end of the housing, an extension on the other end of said bellows, a valve stem connected at one end to said extension and having a seating element on the other end thereof to seat upon said valve seat to close said flow passage, and means including the pressure of said bellows urging said valve stem to closed position, said housing providing port means in the wall thereof to admit pressure fluid into said housing between said valve seat and said bellows, an enlarged portion on said stem spaced from its connection to said extension a sealing member in said housing between said bellows and said port means, a shoulder in said housing between said sealing member and said valve seat, a radially extending enlargement on said extension positioned in slidably sealing contact with said sealing member when said stem is moved to compress said bellows and to bring said portion in abutment with said shoulder, at least one of said extension and said housing having a sealing means therein of the O-ring type accessible from either end of said housing to establish sealing contact therebetween on the bellows side of said port means, and a fluid pressure check valve disposed in the housing wall on the bellows side of said sealing means and arranged to relieve trapped fluid pressure on the exterior surface of said bellows, said sealing member being of the O-ring type and being accessible from either end of said housing.

4. A flow valve comprising, a housing, said housing providing a valve seat and a flow passage in one end thereof extending through said valve seat, a pressurized bellows connected at one end to the other end of the housing, an extension on the other end of said bellows, a valve stem connected at one end to said extension and having a seating element on the other end thereof to seat upon said valve seat to close said flow passage, and means including the pressure of said bellows urging said valve stem to closed position, said housing providing port means in the wall thereof to admit pressure fluid into said housing between said valve seat and said bellows, a reduced inner diameter portion of said housing between said bellows and said port means, a sealing member in said portion, said extension having a reduced outer diameter section extending into said portion in slidably sealing contact with said sealing member, said extension also providing passage means therein opening outwardly at one end on the bellows side of said portion and opening outwardly at the other end so that such opening is positioned on the valve seat side of said sealing member when said stem moves toward valve closed position and on the bellows side of said sealing member when said valve stem moves toward valve opened position, and a fluid pressure check valve disposed in the housing wall on the bellows side of said sealing means and arranged to relieve trapped fluid pressure on the exterior surface of said bellows, said sealing member being of the O-ring type and being accessible from either end of said housing.

5. A flow valve comprising, a housing, said housing providing a valve seat and a flow passage in one end thereof extending through said valve seat, a pressurized bellows connected at one end to the other end of the housing, a valve stem connected at one end to said bellows and having a seating element on the other end thereof to seat upon said valve seat to close said flow passage, and means including the pressure of said bellows urging said valve stem to closed position, said housing providing port means in the wall thereof to admit pressure fluid into said housing between said valve seat and said bellows, a sealing means between said valve stem and said housing on the bellows side of said port means, an exit for pressure fluid trapped by said sealing means in the housing space surrounding said bellows and acting on the exterior of said bellows, and a pressure relief valve to control said exit.

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PAUL R. MILLS.

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