

[54] APPARATUS FOR CONTROLLING PRESSURE IN A WELL

[72] Inventor: Nestor Sabi, Gretna, La.  
 [73] Assignee: Edwards Engineering Corporation, New Orleans, La.  
 [22] Filed: Oct. 15, 1970  
 [21] Appl. No.: 80,946

3,613,734 10/1971 Elmer .....138/31  
 2,259,019 10/1941 Carr et al.....138/31 X  
 3,470,972 10/1969 Dower.....175/25  
 3,550,696 12/1970 Kenneday.....175/25

Primary Examiner—Stephen J. Novosad  
 Assistant Examiner—Robert A. Hafer  
 Attorney—Philip G. Hilbert

[52] U.S. Cl. ....175/25, 166/91, 175/38  
 [51] Int. Cl. ....E21b 21/00  
 [58] Field of Search .....175/25, 38, 48; 166/91, 75; 138/31

[57] ABSTRACT

This disclosure is directed to a system for controlling pressure in a well bore having a drill string through which a drilling fluid is directed. A balanced piston well choke is disposed in the drilling fluid return line which is automatically responsive to varying flow rates of the return drilling fluid in a manner to maintain a substantially constant back pressure on the return drilling fluid.

[56] References Cited

UNITED STATES PATENTS

R26,220 6/1967 Records.....175/25 X  
 3,362,487 1/1968 Lindsey .....175/38

13 Claims, 2 Drawing Figures

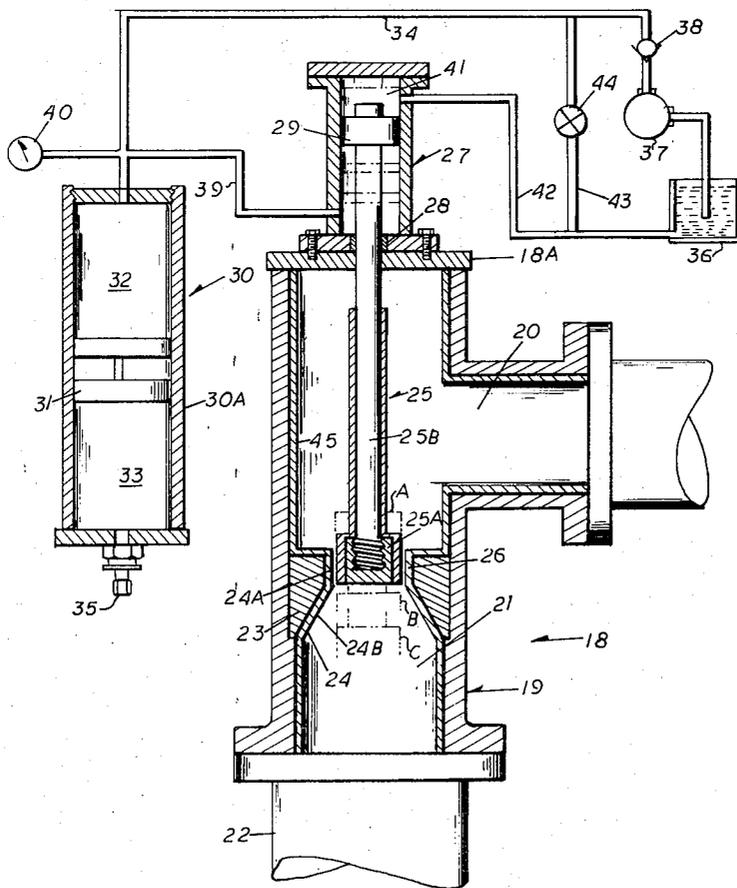
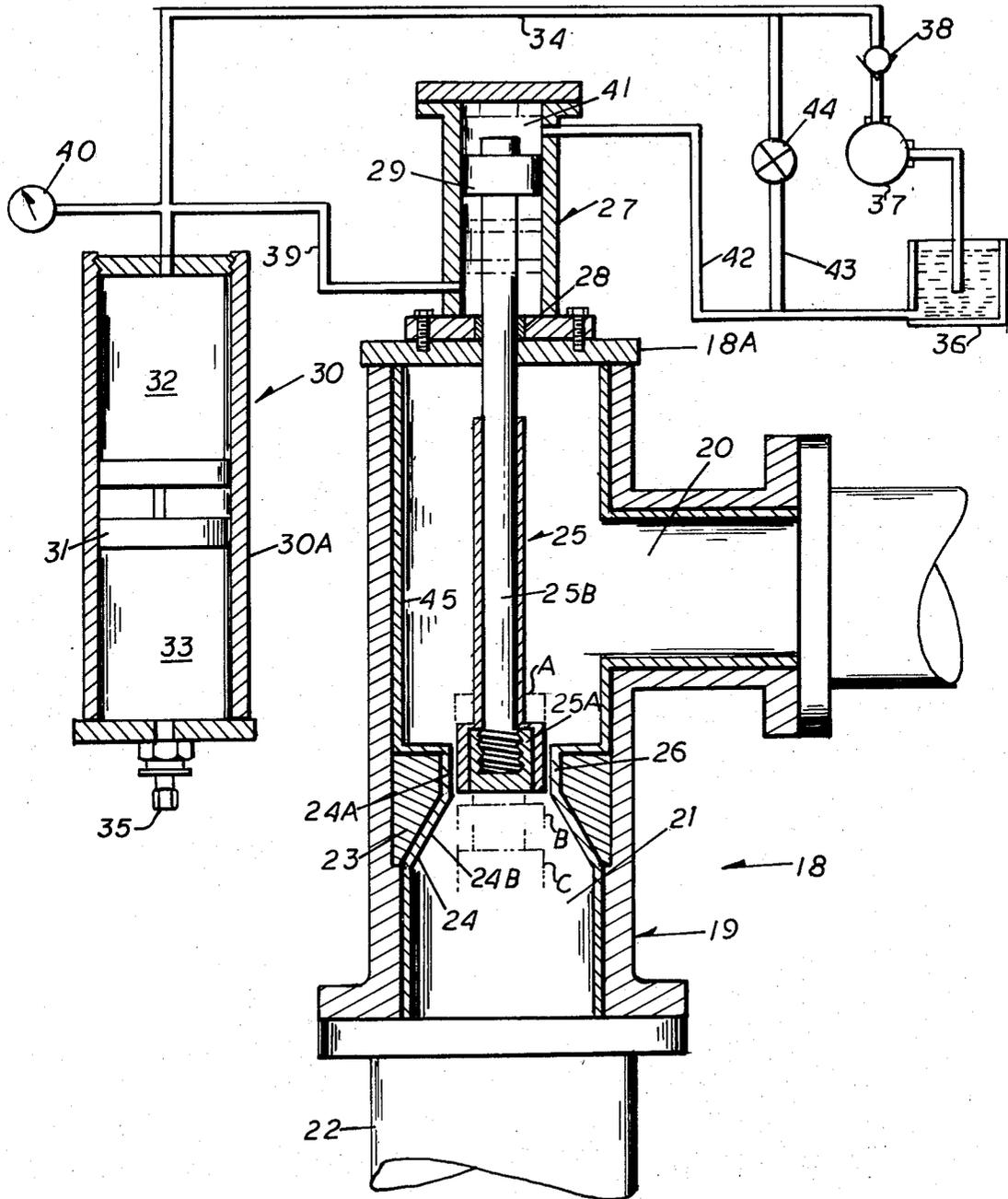




FIG. 2



## APPARATUS FOR CONTROLLING PRESSURE IN A WELL

### PROBLEM

In normal drilling operations, as for example, in drilling oil wells and/or the like, the formation pressures encountered are balanced or slightly over balanced by the hydrostatic pressure of the filling fluid in the well bore. In the event that the drill bit penetrates into a zone in which the formation pressure exceeds the hydrostatic head of the drilling fluid, formation fluid will enter into the well bore. In addition to penetrating zones of abnormally high pressure there may be other reasons why the hydrostatic head could be reduced to a point where it is exceeded by the formation pressure. Therefore it has been recognized that the hydrostatic head can be reduced in a number of ways; and that the net result of permitting the formation fluid into the well bore is the same as having drilled into a zone of abnormally high pressure. When such formation fluid, as for example, contamination-gas, oil or water is allowed to enter into the well bore, the hydrostatic head is further reduced thereby permitting a more rapid entry of the contaminate. If undetected and unchecked contamination or formation fluid will unload the well bore and render the well out of control.

When a well kicks and before it is out of control it must be immediately shut-in. Usually such wells are provided with a blow-out preventor which is closed so that the mud that is in the hole can be recirculated out and replaced with a heavier mud that would balance or slightly over-balance the formation pressure. To attain this, it has been customary to provide a surface choke. Such surface chokes, where not manual, were required to include a feed-back loop system in which a pressure sensing device transmitted a signal to a comparator, with the difference between the input and the feed-back being then translated and converted into a suitable signal to readjust the setting of the choke tending to achieve conditions of equilibrium wherein the input and feed-back are maintained substantially identical. Consequently the chokes heretofore utilized constituted relatively complex and complicated devices.

### OBJECTS

It is an object of this invention to provide an improved balanced choke device in which the feed-back controls heretofore required are eliminated.

Another object of this invention is to provide a balanced piston well choke which is relatively simple in construction, can be inexpensively fabricated, and which is rendered positive in operation.

Another object of this invention is to provide an improved well choke wherein a substantially constant pressure is maintained at varying flow rates of the returning drilling fluid.

### BRIEF SUMMARY OF THE INVENTION

The foregoing objects of this invention are obtained in a system for controlling pressure in a well bore having a drill string through which a drilling fluid is directed by providing a well choke in the return line receiving the drilling fluid from the well bore. The well choke comprises a choke housing having an inlet and outlet wherein the inlet is connected to the return line

of the drill fluid, and the outlet is adapted to connect in communication with the source of mud supply to return the drilling fluid thereto. A valving means is disposed in the outlet end of the choke housing which is rendered responsive to the flow rate of the returning drilling fluid. A piston and cylinder assembly is operatively associated with the valving means for maintaining a back pressure on the valve as the valving means adjusts to the flow rate. This is attained by connecting the piston of the cylinder assembly to the valve stem of the valve means.

The outlet of the choke housing is provided with an annular sleeve to define an orifice having wall surfaces diverging toward the outlet of the choke housing. The valve means includes a valve head arranged to valve the orifice opening in accordance to flow. To maintain a back pressure on the piston and the associated valve substantially constant for changes in rates of flow an accumulator is operatively connected to the piston and cylinder assembly. A floating piston is disposed in the accumulator to partition it into two expansible chambers. A hydraulic fluid from a suitable source is pumped into one of the expansible chambers to a predetermined pressure, and a compressible gas is introduced into the other expansible chamber for maintaining a resilient force on the pressurized hydraulic fluid. Suitable conduit means connect the hydraulic fluid chamber to the cylinder assembly so that a pressure of the hydraulic fluid is brought to bear on the piston connected to the valve means. Suitable relief means and shut-off valves are operatively associated with the piston cylinder assembly to complete the pressure fluid system and which can be operated to release the pressure on the system when desired.

### FEATURES

A feature of this invention resides in the provision of a well choke in which there is a direct relationship between an input signal and the desired operating results, wherein operating changes do not materially affect the relationship so that a feed-back loop can be eliminated.

Other features and advantages will become more readily apparent when considered in view of the drawings and specification in which:

FIG. 1 is a diagrammatic side elevation view illustrating the invention as applied to a drilling rig for drilling a well.

FIG. 2 is an enlarged sectional view illustrating the balanced choke construction of the present invention somewhat schemmatically.

### DETAILED SPECIFICATION

Referring to the drawings, and more specifically to FIG. 1, there is shown a well bore 10 having a drill string 11 suspended therein which is adapted for rotation, and for directing a stream of drilling fluid or mud downwardly therethrough as indicated by the arrows A. The drill string 11 is usually supported and rotated by a conventionally constructed rotary table having blow-out preventors mounted therebelow as indicated by number 12. Pressurized drilling fluid for passage down through the drill string 11 is supplied by a pump 13. An inlet to the pump 13 is connected to a suction line 14 which communicates with a source of supply, as for ex-

ample, a mud tank 15. The output end of the pump 13 is connected in communication with a mud line 16 connecting with the drill string 11.

Connected in communication with the well bore 10 is a return line 17 for receiving the returning drilling fluid for return back to the mud tank 15.

In accordance with this invention there is disposed in the return line 17 a balanced choke means 18 for maintaining a substantially constant back pressure on the drilling fluid regardless of any change in the flow rate of the returning drilling fluid.

As illustrated in the drawings, the choke means 18 comprises a choke housing 19 having an inlet end 20 and an outlet end 21 which are suitably connected to the return line 17 and a discharging conduit 22 emptying to the mud tank 15 respectively. Disposed adjacent the outlet end 21 of the choke housing 19 is a partition or sleeve 23 defining an orifice 24 having a central opening 24A provided with a substantially uniform cross section at the inlet end thereof, and which opening tapers or diverges at 24B toward the outlet end of the orifice sleeve 23.

Cooperatively associated with the orifice 24 is a valving means 25 comprising a valve head 25A and a connected valve stem 25B. As best seen in FIG. 2 the valve head 25A is provided with a diameter which is slightly smaller than that of the central opening 24A to define a small annular space 26 between valve head 25A and the central opening 24A in the virtually closed position.

Disposed above the upper end of the choke housing 19 is a cylinder assembly 27. The arrangement is such that the valve stem 25B extends upwardly through the upper end 19A of the choke housing 19 and into the cylinder assembly 27. Suitable sealing means or packing 28 is disposed about the valve stem 25B at the point where the valve stem 25B enters into the cylinder assembly 27. Connected to the extended end of valve stem 25B is a piston 29 which is disposed in sliding engagement with the walls of the cylinder assembly. Preferably the valve head 25A and the piston 29 are sized so that they are substantially equal in diameter.

An accumulator 30 means is operatively connected to the cylinder assembly 27 for exerting a fluid back pressure on piston 29. In the illustrated form of the invention the accumulator 30 comprises an accumulator housing 30A having disposed therein a freely floating piston 31. The arrangement is such that the freely floating piston 31 partitions the accumulator housing 30A into two expansible chambers 32 and 33. A conduit 34 is provided for introducing a hydraulic fluid into chamber 33. The other chamber 33 is provided with an inlet 35 through which compressed gas may be introduced thereinto.

A source 36 of hydraulic fluid is operatively connected to the other end of conduit 34. Connected in circuit in conduit 34 is a pump 37 for pumping the hydraulic fluid from supply 36 to chamber 32 for building up and maintaining the desired pressure on the accumulator. Connected on the outlet side of the pump 37 is a check valve 38.

A branch conduit 39 is interconnected between the accumulator chamber 32 of the piston assembly 27 so that the hydraulic pressure exerts a predetermined back pressure on the piston 29 and connected valve head 25A. A pressure gauge 40 is connected to the

connecting conduit 39 to indicate the pressure of the hydraulic fluid.

The chamber defined in the upper end portion of the cylinder assembly 27 is operatively connected by a vent conduit 42 to the supply 36 of hydraulic fluid.

Interconnected between the conduit 34 and the vent conduit 42 is a branch 43 in which a relief valve 44 is positioned. Thus the branch 43 with relief valve 44 is connected in parallel to pump 37 and check valve 38.

In the construction described it will be noted that the valve head 25A and the connected piston 29 will move in unison depending upon the rate of flow of drilling fluid through the choke housing 19. Also in the illustrated form of the invention it will be noted that the diameter of the free floating piston 31 is made larger than the diameter of the valve head 25A and the connected piston head 29. Also a removable hardened liner 45 may be disposed about the internal surfaces of the choke housing and associated orifice sleeve and cooperating valve head and stem.

To operate, the relief valve 44 is closed and the pump 37 energized or activated until a predetermined hydraulic fluid pressure is attained in the fluid chamber 32 of the accumulator, it being understood that floating piston 31 is properly loaded by a compressed gas or other means, e.g., a spring. When the desired pressure has been reached in chamber 32, the pump 37 is shut off and the system is thus primed for operation, as the hydraulic pressure is exerting a back pressure on piston 29 through conduit 39.

During a drilling operation, the return drilling fluid enters the choke housing 19 through inlet 20 and it is directed toward the orifice 24 and the valve head 25A valving the orifice, and against the back pressure of the hydraulic fluid operating on the piston 29. Thus in a no flow condition the valve head 25A is disposed in position A with the valve head 25A virtually closing the central opening 24A of the orifice 24, except for the small annular space 26 between the vertical surface of the valve head 25A and the central opening 24A. As the flow of return drilling fluid is increased the valve head tends to move downwardly through the flared portion 24B of the orifice 24 whereby a larger annular space is defined to permit fluid flow therethrough as indicated by positions B and C of the valve head as viewed in FIG. 2. As increased flow is accompanied by a larger annular space, the pressure drop remains virtually constant. However, as the piston is subjected to a substantially constant back pressure under the influence of the hydraulic fluid operating thereon, the rate of flow of drilling fluid may vary without disturbing the system pressure. The position which the valve head 25A assumes is thus dependent upon the flow, and it will thereby automatically adjust to variations in flow, but the back pressure will remain substantially constant as it is balanced by the hydraulic pressure which is being exerted against the piston 29. Since the valve head 25A and piston 29 are formed with substantially equal diameters, the reading of the pressure gauge will correspond to the desired back pressure in the main flow system, and a balance is obtained with equal pressure being exerted on both sides of the seal so as to minimize any risk of leakage of hydraulic fluid into the drilling fluid or conversely of the drilling fluid into the hydraulic fluid.

As flow increases, piston 29 tends to move in the direction of the compression of the compressor means, e.g., gas in chamber 33 of the accumulator 30. Thus while there may be a slight pressure variation with flow, such variation can be rendered insignificant by making the area of the floating piston 31 substantially larger than that of the piston 29. Thus the motion of floating piston 31 relative to the motion of piston 29 is rendered negligible. For this reason there will not be any appreciable pressure change, regardless of the position of the valve head 25A as demanded by the flow rate.

The arrangement is such that the system pressure can be reset at the will of the operator by either pumping up the hydraulic system by means of operating pump 37 or by releasing the pressure by means of the relief valve 44, independently of the rates of flow of the drilling fluid through the choke housing.

Thus with the system set to maintain a predetermined back pressure, the rate of flow may be varied without disturbing the system pressure. As the back pressure is determined by the pressure drop across the annular space between the plug and the orifice opening, increased flow being accompanied by a larger annular opening, the pressure drop remains the same.

In the illustrated embodiment a piston type accumulator 30 is described in which a compressed gas is acting on one side of the piston 31. However, it will be understood that a spring (not shown) may be employed to load the piston 31 instead of compressed gas as described. Another type of accumulator which may be utilized (and not shown) is one which employs an elastomer bag filled with compressed gas as one expandable chamber. However the piston type accumulator herein illustrated is preferred as it can be operated over a much wider range of pressure. The bag type accumulator is generally not recommended over a 2:1 range, while in practice a choke may be required to operate at 300 p.s.i. in one case and at 2,000 p.s.i. in another.

While the instant invention has been described with respect to a particular embodiment thereof it will therefore be readily understood and appreciated that variations and modifications may be made without departing from the spirit or scope of the invention.

What is claimed is:

1. In a system for controlling pressure in a well bore having a drill string through which a drilling fluid is directed, the combination comprising:

- means for circulating a drilling fluid through said drill string,
- a return line connected in communication with said well bore for receiving the return drilling fluid from said well bore,
- a valve means disposed in said return line which is automatically responsive to variations in flow of said return drilling fluid through said return line, and means for maintaining a substantially constant back pressure on said valve means,
- said valve means including a valve housing having an inlet and an outlet,
- said inlet being connected to said return line, and said outlet adapted to connect to a mud tank,
- means defining an orifice in said outlet,
- a valving member for valving said orifice which is rendered responsive to the rate of flow of said returning drill fluid,

and means operatively associated with said valving member for maintaining a predetermined back pressure thereon,

said back pressure producing means including a fluid pressure-cylinder connected to the valve housing, a piston disposed within said cylinder, said piston being directly connected to said valving member so as to be rendered responsive to the movement of said valving member, and means for imposing a substantially constant back pressure on said piston.

2. The invention as defined in claim 1 wherein said latter means including an accumulator for containing a supply of fluid for exerting said fluid pressure on said piston.

3. The invention as defined in claim 2 and including means for maintaining a pressure on said fluid.

4. The invention as defined in claim 1 wherein said valve head and said piston have substantially equal diameters.

5. The invention as defined in claim 1 and including an abrasive resistant liner disposed within said housing.

6. In a system for controlling pressure in a well bore having a drill string through which a drilling fluid is directed, the combination comprising:

- means for directing drilling fluid through said drill string,
  - a return line connected to said well bore for receiving the return drilling fluid from said bore,
  - a choke means connected to said return line, said choke means including a housing having an inlet for said drilling fluid and an outlet for said drilling fluid,
  - means defining an orifice adjacent said outlet,
  - a valve means responsive to the rate of flow of said drilling fluid for valving said orifice means,
  - said valve means including a valve head and connected valve stem,
  - a cylinder adapted to contain a fluid pressure connected to the end of said choke housing,
  - said valve stem extending into said cylinder,
  - a piston connected to the extended end of said valve stem,
  - an accumulator housing,
  - a floating piston disposed in said accumulator housing dividing said housing into two expandable chambers,
  - means for introducing a hydraulic fluid into one of said chambers,
  - means for introducing a compressible gas into the other of said chambers,
  - means connecting said one chamber in communication with said cylinder for maintaining a fluid pressure on said piston,
  - and means for venting said cylinder.
7. A balanced piston well choke comprising:
- a choke housing having an inlet and outlet,
  - a valve means disposed in alignment with said outlet responsive to varying rates of flow therethrough,
  - means for imposing a back pressure on said valve means for maintaining said back pressure substantially constant for varying rates of flow therethrough,
  - said latter means including a cylinder and associated piston,

said piston being connected to said valve means to move therewith,  
 means for imposing a fluid pressure on said piston to resist the movement thereof for imposing a predetermined back pressure thereon,  
 said valve means including a valve head and connected valve stem,  
 said valve stem being interconnected between said piston and valve head.

8. The invention as defined in claim 7 wherein said means for imposing a fluid pressure on said piston includes:

an accumulator housing,  
 a floating piston disposed in said housing,  
 means for introducing a hydraulic fluid on one side of said floating piston and a compressible gas on the other side of said floating piston,  
 conduit means interconnected between said accumulator and said cylinder for conducting said hydraulic fluid therebetween,  
 pump means for maintaining a predetermined pressure on said hydraulic fluid.

9. The invention as defined in claim 7 wherein said valve head and piston have substantially uniform diameters.

10. The invention as defined in claim 8 wherein the diameter of said floating piston is greater than said piston.

11. In a system for controlling pressure in a well bore having a drill string through which a drilling fluid is directed, the combination comprising:

means for directing drilling fluid through said drill string,  
 a return line connected to said well bore for receiving the return drilling fluid from said bore,

a choke means connected to said return line,  
 said choke means including a housing having an inlet and an outlet for said drilling fluid,  
 means defining an orifice adjacent said outlet,  
 a valve means responsive to the rate of flow of said drilling fluid for valving said orifice means,  
 said valve means including a valve head and a connected valve stem,  
 a cylinder adapted to contain a fluid pressure connected to said choke housing,  
 said valve stem extending into said cylinder,  
 a piston connected to the extended end of said valve stem,  
 and a means connected to said cylinder for introducing a fluid pressure into said cylinder to maintain a substantially constant fluid back pressure on said piston as said connected valve means is rendered responsive to the rate of flow of said drilling fluid.

12. The invention as defined in claim 7 wherein said means for imposing a fluid pressure on said piston includes an accumulator operatively connected to said cylinder for exerting a predetermined pressure on said piston.

13. The invention as defined in claim 11 wherein said latter means includes an accumulator,  
 a floating piston disposed in said accumulator for partitioning said accumulator into two expansible chambers,  
 means for supplying a fluid in one chamber on one side of said floating piston to maintain a fluid pressure on said first mentioned piston,  
 and means for introducing a compressible gas pressure into the other chamber on the other side of said floating piston.

\* \* \* \* \*

40

45

50

55

60

65