

March 23, 1954

H. E. MCGOWEN, JR
GAS LIFT VALVE MECHANISM

2,672,827

Filed Nov. 22, 1949

4 Sheets-Sheet 1

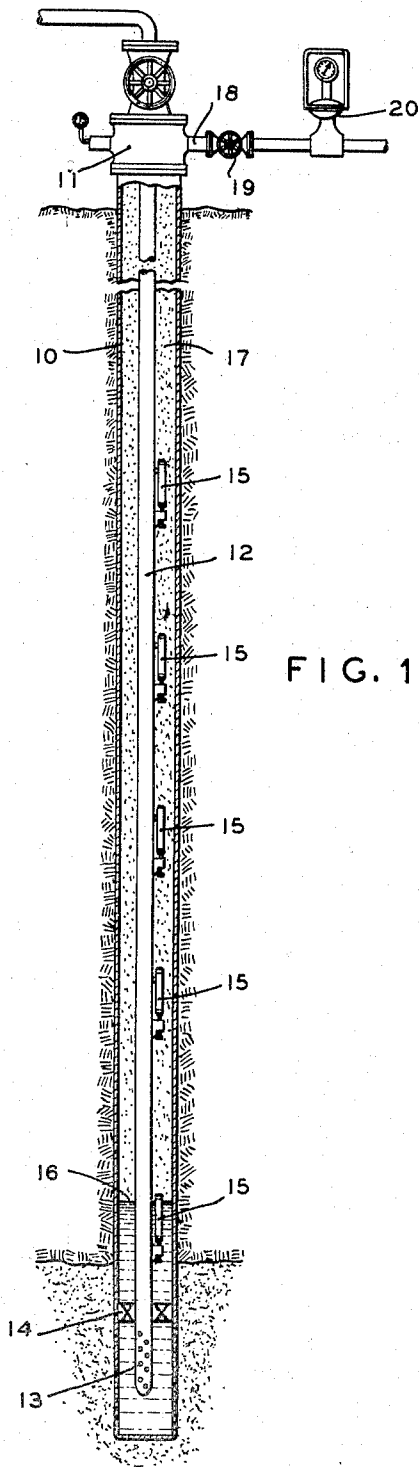
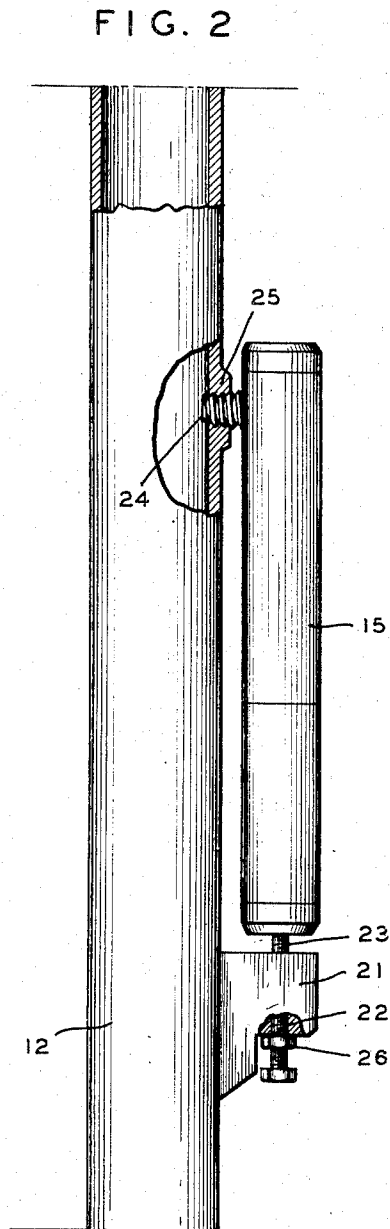


FIG. 1



INVENTOR.
H. E. MCGOWEN, JR.
BY *Munson H. H. H. H.*
ATTORNEY

March 23, 1954

H. E. MCGOWEN, JR
GAS LIFT VALVE MECHANISM

2,672,827

Filed Nov. 22, 1949

4 Sheets-Sheet 2

FIG. 3

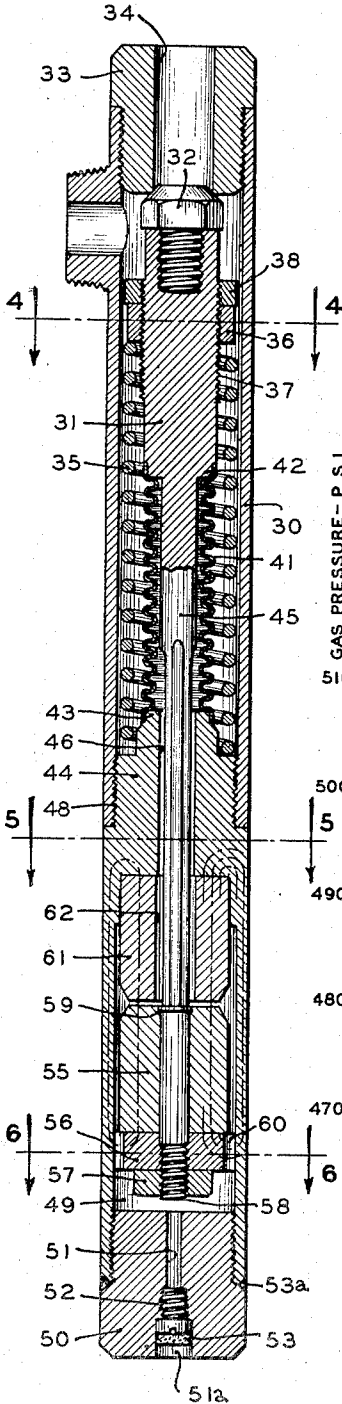


FIG. 4

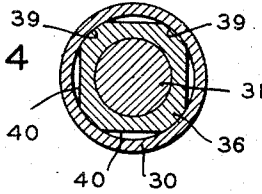


FIG. 5

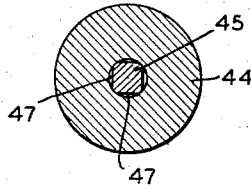


FIG. 6

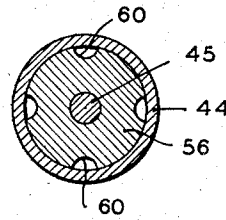
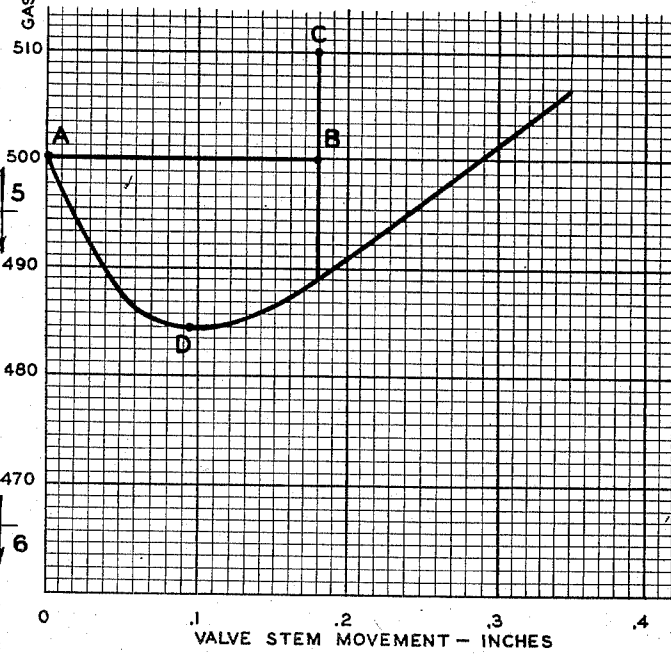


FIG. 7



INVENTOR.
H. E. MCGOWEN, JR.

BY *Munson Hare*

ATTORNEY

March 23, 1954

H. E. MCGOWEN, JR
GAS LIFT VALVE MECHANISM

2,672,827

Filed Nov. 22, 1949

4 Sheets-Sheet 3

FIG. 9

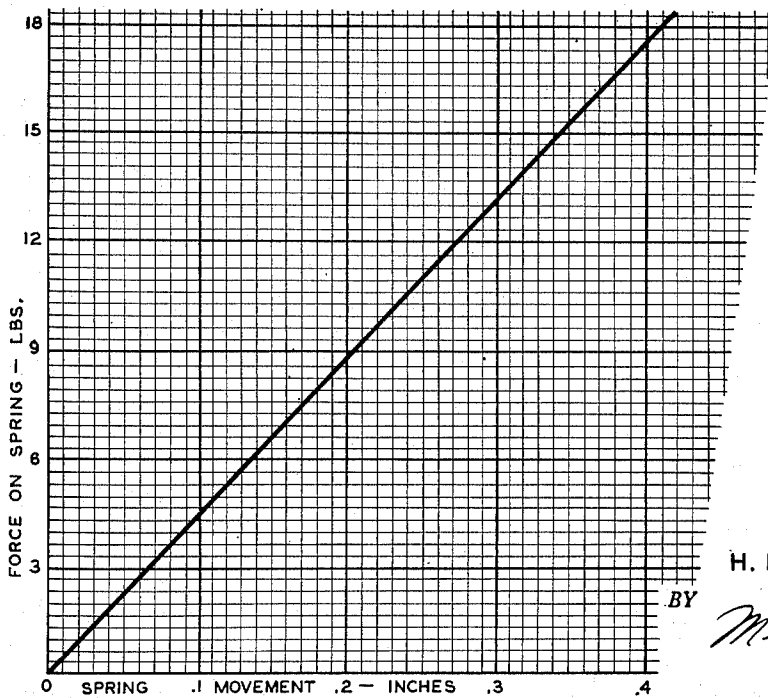
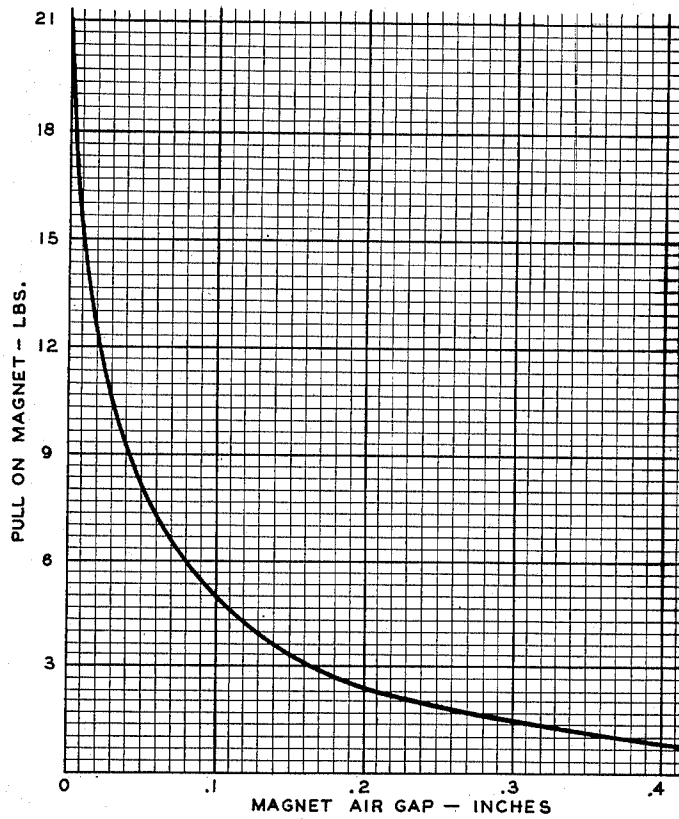


FIG. 8

INVENTOR.
H. E. MCGOWEN, JR.

BY

Maxwell H. Hare

ATTORNEY

March 23, 1954

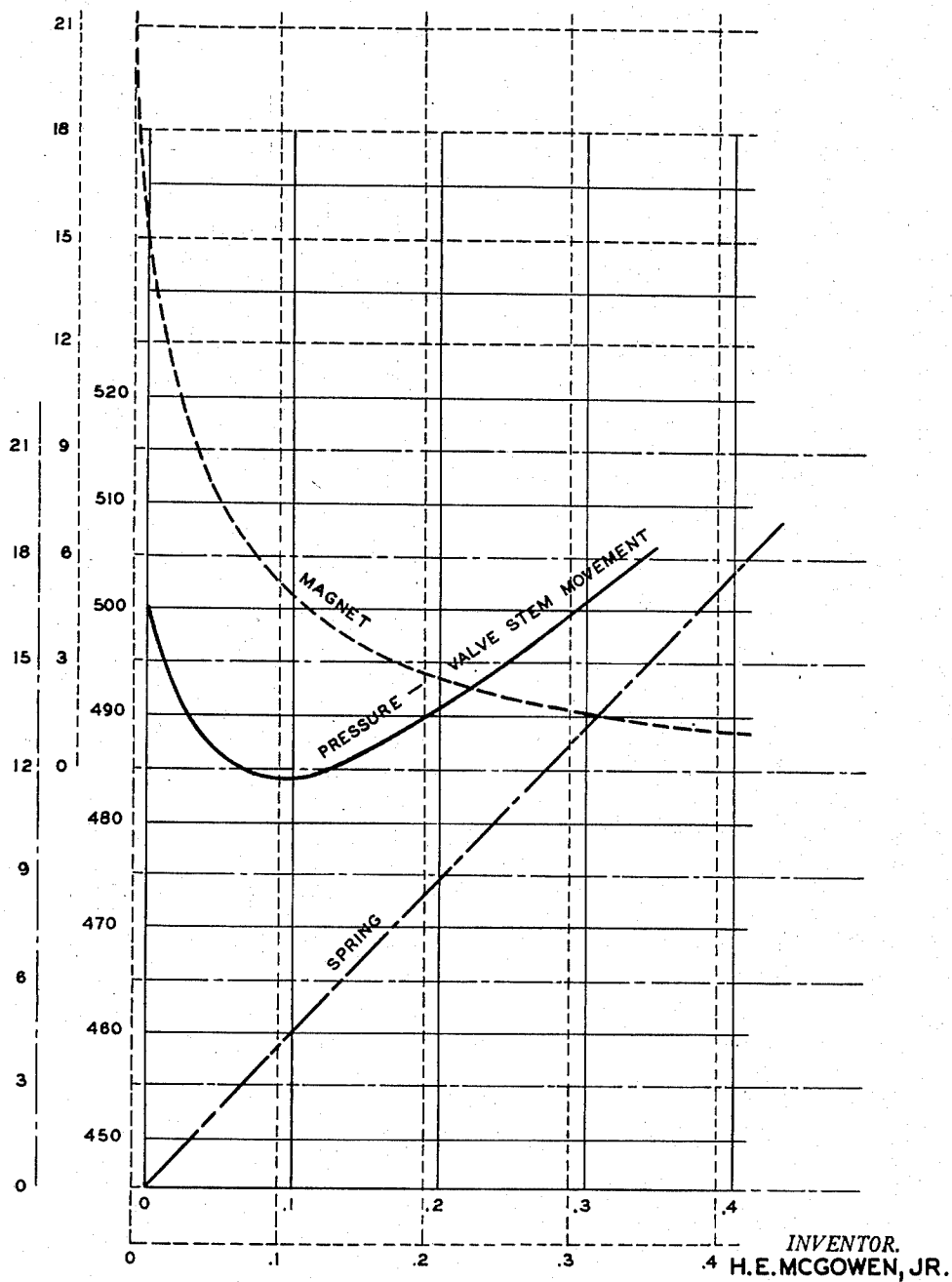
H. E. MCGOWEN, JR
GAS LIFT VALVE MECHANISM

2,672,827

Filed Nov. 22, 1949

4 Sheets-Sheet 4

FIG. 10



BY

M. H. K. R.

ATTORNEY

UNITED STATES PATENT OFFICE

2,672,827

GAS LIFT VALVE MECHANISM

Harold E. McGowen, Jr., Bunkie, La., assignor to
Sid W. Richardson, Inc., a corporation of Texas

Application November 22, 1949, Serial No. 128,719

20 Claims. (Cl. 103-232)

1 This invention relates to gas lift valves for oil wells and the like.

In accordance with the invention, the gas lift valve employs spring power, bellows power, or a combination of spring and bellows power, together with a novel arrangement of permanent magnets to insure a wholly new snap action of the lift valve, obtaining a wide open port so as to admit high pressure gas without pressure losses.

The invention will be fully understood from the following detailed description of one of the many physical forms the invention may assume, taken in connection with the accompanying drawings forming a part of this specification.

In said drawings:

Fig. 1 is a sectional elevation of a well casing and well with gas lift valves at intervals, and an intermitter and other operating mechanism at the top of the well;

Fig. 2 is an enlarged sectional elevation of part of the well tubing with a gas lift valve;

Fig. 3 is an enlarged longitudinal section through the improved gas lift valve;

Fig. 4 is a section on line 4-4 of Fig. 3;

Fig. 5 is a section on line 5-5 of Fig. 3;

Fig. 6 is section on line 6-6 of Fig. 3;

Fig. 7 is a diagram of the valve stem movement in relation to the gas pressure;

Fig. 8 is a diagram of the movement of a coil spring, such as is suitable in the improved gas lift valve, responsive to compression thereon;

Fig. 9 is a diagram of the magnetic pull of a magnet suitable for the described gas lift valve, plotted against the air gap; and

Fig. 10 is a diagram combining the curves of Figs. 7, 8 and 9 to show graphically the advantageous effect of using a magnet with the spring and bellows of the gas lift valve.

Referring first to Fig. 1, 11 denotes a well casing of conventional form; 12 the usual casing head; 13 the tubing depending from the casing head and having a strainer 14 at the bottom thereof, while 15 denotes the conventional packer. Arranged at spaced intervals along the string of tubing are a series of gas lift valves 16 which are adapted to operate at predetermined pressures to admit gas under pressure to the interior of the tubing for the purpose of raising oil or other liquid from a normal level 17 within the well to the surface of the ground. For this purpose high pressure gas is admitted to the space 18 between the casing 10 and the tubing 12 through a lateral pipe 19 communicating with the interior of the

2 casing head 11 and with the space 17. The flow of gas may be controlled by any suitable valve 19 in pipe 18 and by the use of an intermitter 20 which serves to inject high pressure gas into the casing intermittently within any desired time cycle and at predetermined pressure, as is known in the art. The parts so far mentioned, being known and in use, are shown diagrammatically and will not be further described.

Referring to Fig. 2, the tubing 12 has a shoulder member or arm 21 rigidly secured thereto and having a tapped bore 22 for receiving a stud 23 whose upper end engages a bore (to be described) at the lower end of the gas lift valve 15. Near its upper end the gas lift valve has a screw-threaded nipple 24 by which it is screwed through a boss 25 in tubing 12 thereby to communicate with the interior of said tubing. After the gas lift valve is secured to the tubing by nipple 24 it is locked against movement by engagement of stud 23, and a lock nut 26 which is tightened against the underside of arm 21 secures the stud against displacement. Each of the gas lift valves shown in Fig. 1 is thus removably attached to tubing 12 and is in communication with the interior of said tubing but only at its upper end.

The details of construction of each gas lift valve are shown in Figs. 3, 4, 5 and 6. A tubular casing 30 of non-magnetic material carries the nipple 24 already described and encloses a reciprocating valve stem 31 also of non-magnetic material. At its upper end the valve stem carries a replaceable Stellite-faced valve 32 which seats against a valve seat member 33 which is screwed into the top of casing 30 and has a large central gas port 34. When valve 32 is off its seat gas is free to flow from space 17 through the port 34 and out through nipple 24 into the well tubing 12. A coil spring 35 surrounds the valve stem and presses valve 32 on the valve seat by its end engagement with a spring-adjusting nut 36 screwed by threads 37 on the valve stem near its upper end. A lock nut 38 holds the spring-adjusting nut 36 in adjustment. Obviously nut 36 adjusts the cycle of valve 32, since the valve-unseating pressure is greater if nut 36 compresses spring 32 to a greater extent. As shown in Fig. 4, the adjusting nut 36 has four arcuate portions 39 which slidably engage the interior of casing 30 and four straight sides 40 which permit the gas to flow past the adjusting nut to establish desired pressure conditions in the lower part of casing 30, where a pressure-re-

sponsive bellows 41 is located. Bellows 41 is sealed and contains non-compressible fluid such as oil under partial vacuum and has its upper end secured and sealed upon a shoulder 42 on valve stem 31 while its lower end is secured and sealed to a boss 43 on the upper end of a magnet housing 44. The outside diameter of bellows 41 is the same as the diameter of the valve stem at its upper end. The valve stem 31 has a reduced extension 45 which extends axially through the bellows and through a bore 48 in magnet housing 44, said bore being larger than the valve stem extension 45, which has flats 47, best shown in Fig. 5. At its lower end casing 30 is closed and sealed by the magnet housing, which is screwed into the casing as indicated at 48 and provides an abutment for the lower end of spring 35.

Magnet housing 44 is hollow on the inside to provide a chamber 49 and is closed and sealed at its lower end by a screw-threaded non-magnetic plug 50, said plug having a central bore 51 closed by a plug screw 52 and sealed by sealing silver solder 53 or the like. Solder 53 may similarly seal the screw joint between plug 50 and the magnet housing. The central bore 51 is enlarged as indicated at 51^a to receive the plug screw and to provide a recess for receiving the upper end of locking stud 23 (Fig. 2) as previously described. The bores 51^a, 51 provide an inlet facilitating initial introduction of fluid into the chamber 49 and hence into the bellows 41, since the interior of the bellows communicates through bore 46 in the magnet housing with chamber 49.

At the lower end of valve stem 31 a permanent magnet 55 is secured, or if desired several permanent magnets may be employed. A washer 56 of magnetic material is held by a nut 57 against the magnet or magnets 55, said nut being secured on the extreme end of the valve stem by screw threads 58. A small washer 59, secured against upward movement on the valve stem, provides the necessary fixed abutment for the upper end of the magnet, so that by merely tightening nut 57 the magnet is fixed to the valve stem. As shown in Fig. 6, the periphery of magnetic washer 56 has several grooves 60 permitting oil or other fluid to flow past washer 56 to chamber 49, or from that chamber past the washer and magnet to bore 46 and the interior of the bellows. Another magnet 61, which is annular, with a central fluid passage-way 62, is secured in the magnet housing 44 and hence is fixed relative to magnet 55 which moves with the valve stem. Magnet 61 is always 0.01 in. from the adjacent end of magnet 55 when the valve 32 is seated, so that in case the valve and seat wear the magnets will not hold the valve off its seat, causing a continuous gas leak. As will be understood, the opposite poles of the magnets 55, 61 are arranged to attract each other. The magnet flux circuit (indicated in dotted lines) includes both magnets, the magnetic washer 56 whose periphery is in contact with the magnet housing, and the lower end of the permeable magnet housing.

As the area of the bellows and of valve port 34 is the same, the valve is balanced to any changing fluid level in well tubing 12. Thus the fluid in the tubing has no effect on the operation of the valve. The fluid and partial vacuum in the bellows are such that when the valve stem moves 0.17 in. (in the preferred construction) the vacuum is lost and the bellows has a solid or non-compressible fluid support within it, which prevents injury to the bellows in the event of excessive pressures. It is preferred that a change of

25 p. s. i. pressure will deflect the spring 0.17 in., which gives a full opening of the valve of 0.307 sq. in. for a $\frac{5}{8}$ in. valve port. This is believed to be a larger valve port and opening than any other automatic lift valve on the market. A large open port is desirable because it allows the gas to enter the tubing 12 with no choking effect and allows the gas to expend a greater amount of its potential energy in lifting the well fluid, in turn cutting down on the amount of gas required to operate a given well, or alternately, allowing more fluid to be lifted with a given quantity of gas.

Now referring to Fig. 7, study of the pressure-valve movement curve shows that once the valve opens and the gas bleeds through the valve to its closing pressure of 484 p. s. i., gas at 500 p. s. i. must be admitted before the valve will be open again. This will not happen until gas is admitted automatically to the system through the intermitter 20 in a predetermined time cycle. Thus the valve is pressing on its seat with a differential pressure of 16 p. s. i. which will tend to cause a good "seal-off" at the seat. Other valves on the market "float" at or near their opening pressure, which tends to cause constant gas leakage.

The operating cycle is as follows:

- (1) Below 484 p. s. i. the valve is shut tight, as just explained (position A).
- (2) At 500 p. s. i. the valve snaps open (A to B).
- (3) At 510 p. s. i. the valve stem is stationary (B to C).
- (4) At 484 p. s. i. the pressure bleeds down (C to D).
- (5) At 483 p. s. i. the valve snaps shut (D to A).

In more detail: (1) A timed cycle of gas injection into the casing at the ground surface starts at 483 p. s. i. This is the point at which the system rests from the last injection period. During this rest period fluid moves into the well tubing and rises above the operating valve. (2) When the casing pressure rises to 500 p. s. i., due to the injection of gas at the ground surface, the valve opens. (3) At about 510 p. s. i. the timing cycle at the surface stops admitting gas into the well. (4) Gas enters the tubing 12 through the open lift valve and lifts the fluid in the tubing until the pressure drops to 484 p. s. i., the valve meanwhile closing slowly. (5) At 483 p. s. i. the valve snaps shut and the system rests until the fluid can rise in the well again.

An advantageous feature of the described valve is the fact that temperature will not adversely affect it. The bellows is not pressure loaded. The effect of changes in temperature on the fluid in the bellows, on the spring that actuates the valve stem, and on the permanent magnet, is negligible.

The bellows is smaller in diameter than a conventional bellows and therefore will resist greater pressure. And as stated, it is protected by the non-compressible fluid within it which stops collapse beyond a predetermined point, as the space occupied by the partial vacuum is taken up by the partial collapsing of the bellows, and the fluid is incompressible. Due to the balanced set-up of bellows and valve, the rising fluid level in the well tubing will not affect the opening and closing pressures of the valve. The only pressure affecting the valve action is that applied against the end of the valve stem. This area is contacted only by the compressed gas in the casing, which is the control medium for opening and closing the valve. Inside the bellows the flats

47 on the valve stem act as small fluid ports, so that any opening or closing action will be cushioned and there will be no jarring or vibration of the permanent magnets.

The valve stem is of non-magnetic material so that there is no flux leakage through the core of the magnets. On the other hand the magnet housing is of a permeable material which will readily conduct the flux from the magnets and make a complete circuit as indicated in the dotted lines.

The primary use of the magnets is to obtain a wide open port so as to admit high pressure gas without pressure losses due to choking. So far as I know, this can not be done with only a bellows under pressure for power, or with a spring alone used for power, or combined with a bellows, as such designs result in a choking of the valve as the opening pressure is attained and this choking action continues until nearly the top injection pressure is obtained in the casing. The diagram, Fig. 8, shows comparative actions of spring-powered valves. To obtain the same opening as the described magnetic valve the casing pressure would have to be raised 25 p. s. i. beyond its opening pressure, which would waste gas and also cause other valves to open, adding to the gas waste.

The described magnets for snap action and a wide opening of the valve port are useful with (1) a spring for power, (2) a bellows under pressure for power, (3) a combination of a spring and a pressured bellows for power, (4) well-fluid-controlled and operated automatic valves, (5) a surface controlled and operated valve, and (6) any combination of the above named valves.

All the valves in a series or string will be set to open at the same gage pressure because when they are placed in a well the static head of the gas will cause the lower valves to open first as the gas is injected into the casing and the pressure begins to rise. Initially there is fluid in the casing as well as in the tubing and as gas pressure is applied to the casing this fluid passes through the valve ports and rises up in the tubing in a U-tube effect. Valves immersed in fluid in the casing will not be contacted by gas, and thus the lowest exposed valve will open first (as explained above) and any fluid which rises due to the U-tube effect above this lowest available valve will be lifted out of the well. As lower valves are in turn exposed by removal of the fluid, they will open in turn and gas flowing through them into the tubing will lift fluid above the level of each valve to the surface. Ultimately a level of operation is reached where new fluid comes into the tubing from the well as fast as it is lifted to the surface. This is the "static operating point" in the well and is determined by the amount of fluid the well will make, the type of lift valve, and the available gas pressure.

It is to be understood that the apparatus will work if the fluids are reversed, that is, if fluid is in the casing and gas is in the tubing. Therefore the foregoing description and descriptive terms in certain of the claims are to be taken as merely explanatory and illustrative and not as limitations.

Obviously many changes may be made in the construction and arrangement of the parts of the lift valve; also some omissions and additions may be made; hence I do not wish to be limited to the particular embodiment at present preferred by me and described above, but only as required by

the appended claims interpreted in the light of the prior art.

What I claim is:

1. A gas lift valve comprising a valve body having a gas port and a valve seat; a valve adapted when seated to close said port; a spring within the body resisting unseating of the valve, and permanent magnet means wholly within the body connected and arranged to oppose by magnetic flux movement of the valve toward open position; said permanent magnet means comprising a hollow magnet housing which is magnetically permeable; a permanent magnet secured to and wholly enclosed by the magnet housing; a second permanent magnet placed pole-to-pole to the first magnet; means connecting the second magnet with the valve so that the valve when unseated moves the second magnet away from the first; said connecting means consisting of a valve stem of non-magnetic material; a washer of magnetic material on the valve stem and in contact with the second magnet and also in contact with the inner walls of the hollow magnet housing, and a nut securing the washer and second magnet upon the valve stem; the magnet housing, the two magnets and the washer together forming a closed path for lines of magnetic flux.

2. A gas lift valve comprising a body having a gas inlet port; a gas discharge port; a valve adapted when seated to close the inlet port and when unseated permitting free flow of gas through the inlet port and out the discharge port; means to close the valve automatically, said means yielding to predetermined gas pressure outside the inlet port; bellows means fixed to the valve and acting to yield readily up to a certain point and then positively prevent further valve movement away from its seat; said body having a tubular extension housing fluid communicating with the interior of said bellows means, said housing being composed of material permeable to magnetic lines of force, a stem portion carried by said valve and projecting into the tubular extension, a permanent magnet carried by said stem and closely but slidably fitting said tubular housing, and means providing a passage connecting the tubular extension with the interior of the bellows.

3. A gas lift valve comprising a body having a gas inlet port; a gas discharge port; a valve adapted when seated to close the inlet port; spring means acting to hold the valve seated normally but yielding to predetermined gas pressure outside of the inlet port; a valve stem secured to the valve and being of non-magnetic material; said valve stem having flats and extending axially of the body; a sealed bellows surrounding the valve stem and secured thereto at one end; a magnet housing of material permeable to magnetic lines of force and having a central bore through which passes part of the valve stem with the flats; a permanent magnet secured to the end of the valve stem; the magnet housing having an interior chamber for fluid and said chamber being in communication with the interior of the bellows by way of said central bore; another permanent magnet secured to the magnet housing and in magnetic circuit therewith; the two magnets being constructed and arranged so as to attract each other; the first mentioned magnet being in magnetic circuit with the magnet housing but constructed so as to permit fluid to flow past it into or out of the chamber.

4. The invention defined in claim 3 wherein

the valve stem is screw threaded at the end remote from the valve, a washer of magnetic material is mounted on the valve stem and has its periphery in sliding contact with the interior walls of the magnet housing and provided with grooves permitting fluid to flow past the washer in either direction, and a nut is screwed on the end of the valve stem and is in contact with the washer to hold the washer in contact with the first mentioned magnet, so that the two magnets, the washer and the magnet housing are all in the same magnetic circuit.

5. A gas lift valve comprising a valve body having a gas port and a valve seat, a valve adapted when seated to close said port, a spring within the body resisting unseating of the valve, and permanent magnet means wholly within the body and constructed and arranged to oppose by magnetic flux movement of the valve toward open position, said permanent magnet means including a permanent magnet connected to the valve and slidable within the body, said valve being secured to a sealed bellows mounted within the body and containing an incompressible fluid and a partial vacuum, the bellows mounting and securement being such that opening of the valve effects partial collapse of the bellows, the fluid and partial vacuum in the bellows being so selected that when the valve moves a small fraction of an inch the vacuum disappears and the bellows then has a solid non-compressible fluid support on the inside which prevents damage to the bellows in the event of extreme pressure, the areas of the bellows and of the valve port being substantially the same.

6. A gas lift valve comprising a valve body having a gas port and a valve seat, a valve adapted when seated to close said port, a spring within the body resisting unseating of the valve, and permanent magnet means wholly within the body and constructed and arranged to oppose by magnetic flux movement of the valve toward open position, said permanent magnet means including a permanent magnet connected to the valve and slidable within the body, said valve body being provided with a tubular extension of material permeable to magnetic lines of flux and serving as a magnetic housing, a second permanent magnet fixed to and in magnetic circuit with said magnetic housing, said two magnets having adjacent ends of opposite polarity and being adapted to separate when the valve is unseated.

7. A gas lift valve as defined in claim 6 wherein the two magnets are separated by an air gap on the order of one one-hundredth of an inch when the valve is seated.

8. A gas lift valve comprising an elongated body having a gas passage therein provided with a valve seat, a valve coacting with said seat and adapted when seated to close said passage, resilient means normally acting to hold the valve seated but yielding to predetermined gas pressure to permit the valve to open, a valve stem extending axially of said body, a magnet housing carried by the body, a permanent magnet carried by said stem and closely but slidably fitting said housing, and a second permanent magnet secured to the housing and coacting with the first to produce snap action of the valve.

9. A gas lift valve comprising a body portion having a gas flow passage therethrough and a valve seat therein, a reciprocating valve member adapted when seated to close said passage, resilient means normally acting to hold said valve seated but yielding to predetermined gas

pressure to permit the valve to open, a valve stem extending axially of the body, a sealed bellows surrounding the stem and secured thereto at one end, a magnet housing carried by said body of material permeable to magnetic lines of force and having a central bore through which the valve stem is adapted to pass, a permanent magnet secured to said stem and movable within limits within said housing, said magnet housing having an interior chamber for fluid, and means providing interconnecting fluid passageways between said chamber and the interior of said bellows.

10. A gas lift valve comprising a tubular body having a gas passageway housed therein, a valve seat in said passageway and a reciprocating valve coacting with said seat and controlling flow of gas through said passageway, said valve having a stem extending axially of the body, sealed bellows surrounding said stem and secured thereto at one end, a permanent magnet secured to the end of the stem opposite said valve, said body including a magnet housing surrounding said stem and closing the end of said body, said magnet housing being formed of material permeable to magnetic lines of force and having an interior chamber for fluid, and means providing interconnecting fluid passageways between said chamber and the interior of said bellows.

11. A gas lift valve as set forth in claim 10 wherein the magnet closely fits said magnet housing and is provided with fluid passageways extending lengthwise therethrough.

12. A magnetic gas lift valve comprising an elongated body having a gas passage therein provided with a valve seat, a reciprocating valve coacting with said seat for controlling the flow through said gas passage, said valve having a stem extending axially of the body, a sealed bellows surrounding the stem and secured thereto at one end, a permanent magnet secured to the stem at a point remote from the valve and beyond the point of attachment of the bellows, and a magnet housing carried by the body and formed of magnetic material, said magnet housing being chambered to enclose fluid, and means providing longitudinal passageways between said chamber portion and the interior of the bellows.

13. A gas lift valve comprising a body having a gas inlet port; a gas discharge port; a valve adapted when seated to close the inlet port; resilient means acting to hold the valve seated normally but yielding to predetermined gas pressure outside of the inlet port; a valve stem secured to the valve and being of non-magnetic material; said valve stem having flats and extending axially of the body; a sealed bellows surrounding the valve stem and secured thereto at one end; a magnet housing of material permeable to magnetic lines of force and having a central bore through which passes part of the valve stem with the flats; a permanent magnet secured to the end of the valve stem; the magnet housing having an interior chamber for fluid and said chamber being in communication with the interior of the bellows by way of said central bore; said magnet being in magnetic circuit with the magnet housing but constructed so as to permit fluid to flow past it into or out of the chamber.

14. A gas lift valve comprising an elongated body having a flow passage therein provided with a valve seat, a reciprocable valve coacting with said seat and adapted when seated to close said passage, resilient means normally acting to hold the valve seated but yielding to predetermined

pressure to permit the valve to open, said valve having a stem extending axially of said body, a plug member carried by said body and having a central bore to permit passage of said stem, a sealed bellows connected at one end to the stem and at the other end to said plug, said body including a tubular portion extending beyond said plug and serving as a fluid chamber, an enlarged member carried by said stem closely fitting and slidable in said housing, and means providing guide passageways through the enlarged stem portion and plug to permit fluid to pass between said fluid chamber and the interior of said bellows.

15. A gas lift valve as set forth in claim 14 wherein the fluid chamber is of material permeable to magnetic lines of force, and the enlarged stem portion slidable therein comprises a permanent magnet.

16. In combination with a well casing, well tubing within the casing and spaced therefrom, a casing head closing the top of said casing, means intermittently supplying pressure fluid to the space between the tubing and casing under gradually increasing pressure, means comprising a valve body forming a pressure fluid passage between the tubing and casing, a valve seat in said passage, and gas lift valve means controlling flow of pressure fluid through the passage, comprising a valve member slidable within said body and coacting with said seat, resilient pressure means within said body urging the valve member against the seat in a direction to oppose the force of pressure fluid in said passage acting to open the valve; the improvement wherein means comprising a permanent magnet connected to the valve member and slidable therewith in said valve body is provided supplementing said resilient yielding pressure means and acting until the pressure of said pressure fluid finally overcomes the combined effect of the resilient pressure means and of the permanent magnet, thereby fully opening the valve and permitting full flow of pressure through the passage without pressure loss to effect lifting action upon liquid within the well.

17. The combination as set forth in claim 16, wherein the resilient pressure means acting on said valve member includes a spring.

18. The combination as set forth in claim 16, wherein the resilient pressure means is fluid actuated.

19. The combination as set forth in claim 16, wherein the resilient pressure means utilizes a combination of spring and bellows power.

20. Well pumping apparatus comprising, in combination with a well casing, well tubing within the casing and spaced therefrom, means comprising a valve body forming a passage connecting the interior of the tubing and casing, a valve seat in said passage, and a gas lift valve slidable in said body and coacting with said seat, means supplying lifting fluid under gradually increasing pressure to said connecting passage in a direction tending to force said valve from its seat, resilient pressure means within said body urging the valve against its seat, and means comprising a permanent magnet connected to said valve and movable therewith in said valve body supplementing the action of said resilient pressure means, until the combined effect of the resilient pressure means and of the permanent magnet is overcome, thereby instantly and fully opening the valve and permitting full flow of pressure fluid through the passage without pressure loss to effect lifting action upon liquid within the well.

HAROLD E. MCGOWEN, JR.

References Cited in the file of this patent UNITED STATES PATENTS

Number	Name	Date
152,444	Westland	June 23, 1874
1,934,548	Kellogg	Nov. 7, 1933
1,981,965	Morgan	Nov. 27, 1934
2,216,809	Derby	Oct. 8, 1940
2,313,564	Manley	Mar. 9, 1943
2,437,187	Eshbaugh	Mar. 2, 1948
2,446,680	Walton	Aug. 10, 1948
2,465,060	Carlisle	Mar. 22, 1949
2,466,515	Van Denberg	Apr. 5, 1949
2,501,755	Bent	Mar. 28, 1950
2,556,867	Carlisle	June 12, 1951

FOREIGN PATENTS

Number	Country	Date
119,381	Sweden	May 29, 1947