Nov. 17, 1931. A. BOYNTON 1,832,088

AUTOMATIC STAGE LIFT FLOWING DEVICE

Filed June 9, 1927

Fig. 3.

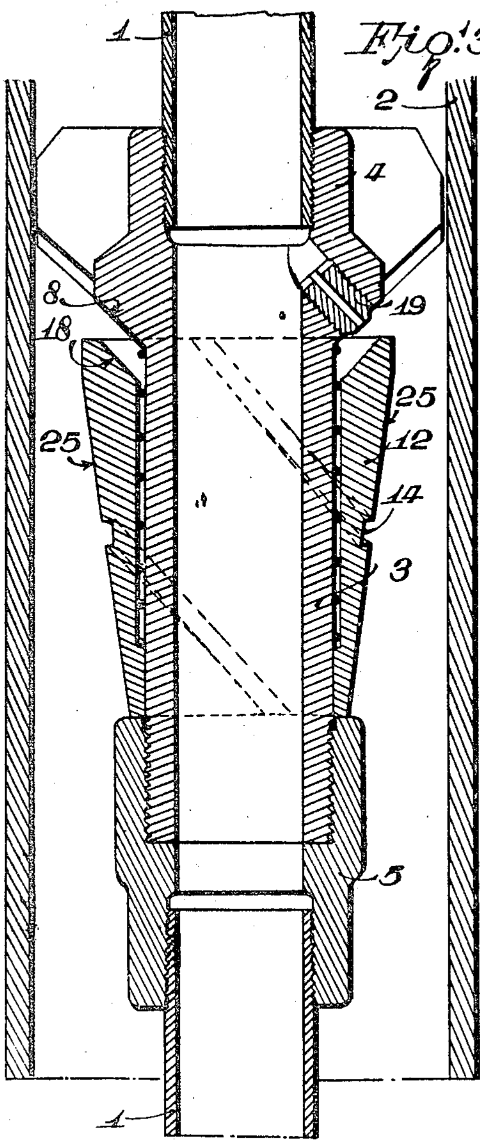


Fig. 1.

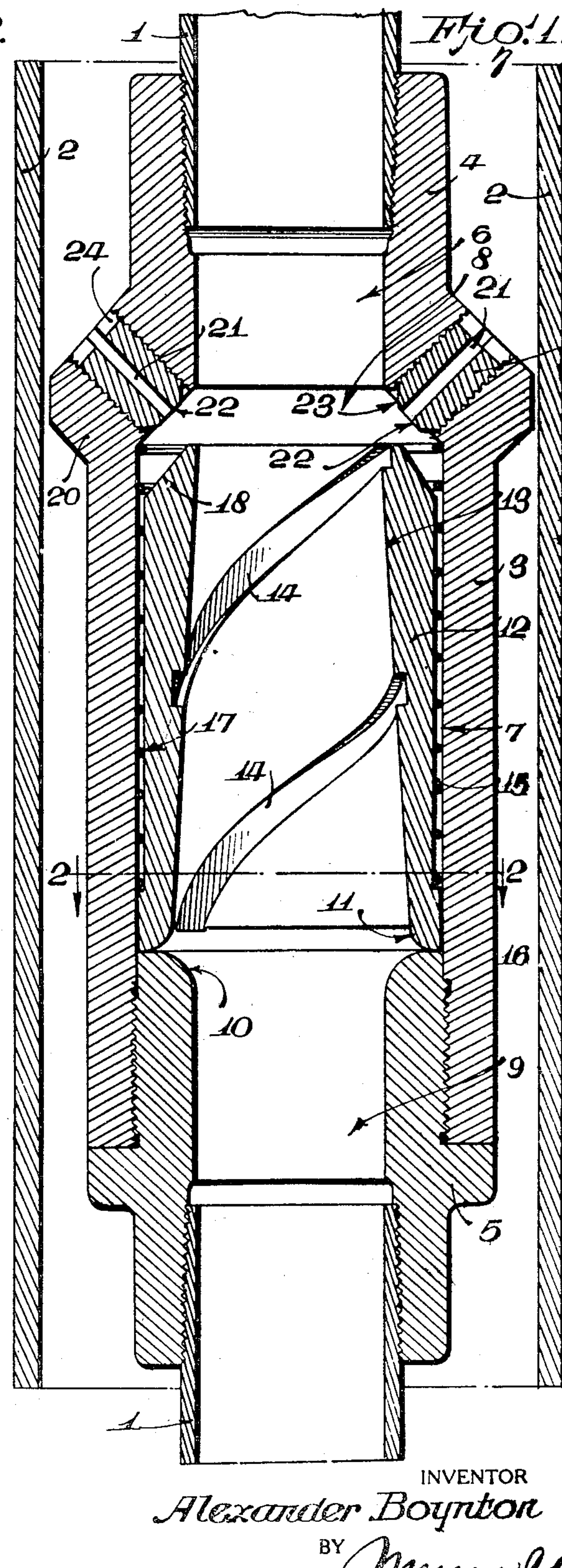
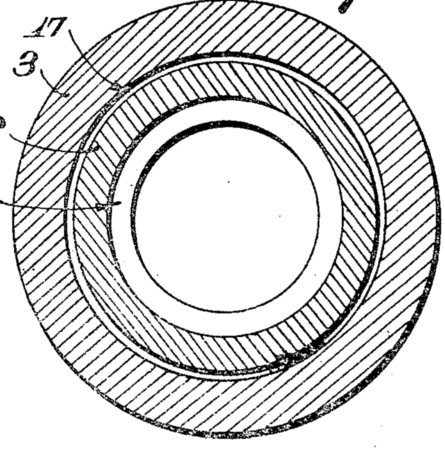


Fig. 2.



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AUTOMATIC STAGE LIFT FLOWING DEVICE

Application filed June 9, 1927. Serial No. 197,693.

This invention relates to improvements in apparatus for causing the flowing of oil or other wells, and it consists of the constructions, combinations and arrangements herein described and claimed.

An object of the invention is to provide a valve for the foregoing purpose of such structural arrangement as renders it capable of utilizing the momentum of a moving column of fluid to close the valve, whether the fluid be liquid or gas, the absence of this momentum establishing a condition under which the valve may open by virtue of its weight.

A further object of the invention is to provide a valve for controlling the admission of the pressure fluid which supplies the moving impulse for a column of liquid, the action of the valve in its opening and closing movement in such control being dependent upon the momentum or lack of sufficient momentum of the liquid column regardless of existing pressure on the inside and outside of the flow line.

A still further object of the invention is to provide a valve for controlling the admission of a pressure fluid by which the well liquid is elevated, said valve being subject to automatic operation by the energy of the moving column.

Other objects and advantages appear in the following specification, reference being had to the accompanying drawings, in which;

Figure 1 is a central vertical section of one of the valves constructed to suit the purposes of a certain tubing method of raising liquid,

Fig. 2 is a horizontal section taken on the line 2—2 of Fig. 1,

Fig. 3 is a central vertical section of a modification illustrating an adaptation of the valve to the purposes of the casing method of lifting the liquid.

A number of co-pending applications deal with the general principle of elevating a liquid from a well by establishing a column of such liquid in what is known as a flow line and applying lifting impulses to such column by injecting a pressure fluid thereinto at intervals. Ordinarily, the liquid is regarded as oil, and the pressure fluid as gas, although the liquid may be other than oil, and the pressure fluid other than gas, as, for example, compressed air.

These applications need hardly be identified more than to say that the apparatuses disclosed thereby operate wholly or in part by the difference in pressure on the exterior and interior of the flow line, one of these applications, notably the one employing what is known as a revamping weight and known as Case #5, filed June 1, 1927, Serial No. 195,739, employing the differential only partially and depending principally on the velocity of the liquid column for the control of the valve in the admission of the pressure fluid.

The present construction is extremely simplified, having been reduced to a single movable part which is made to control the influx (or escape, as the case may be) of the pressure or lifting fluid by the momentum of the moving liquid column. There is thus the situation of the moving column performing an automatic regulation of the pressure fluid which is the cause of its movement.

A brief discussion will acquaint the reader with the tubing and casing methods alluded to below. The arrangement of a well bore lined with a casing surmounted by a suitable closure at the top from which a tubing string is suspended into the liquid can be visualized without difficulty. In either case, there will be a valve in the tubing string. According to the tubing method, gas under pressure is introduced in the casing, and upon opening of the surface valve in the tubing string the gas intending to escape at a plurality of the valve devices arranged therealong within the well, will perform such operation as to establish a column of liquid within the tubing string and to set such column in motion. The tubing string thus becomes the flow line.

But, according to the casing method, the pressure fluid is admitted by way of the tubing string upon opening of the surface valve when, upon escape of the gas at a plurality of the valve devices connected along the tubing string in the well, the liquid in the casing is caused to rise, the moving impulse being supplied by the escaping gas. Representative of the valve devices for the tubing and casing methods are illustrated in Figs. 1 and 3, respectively, and the description immediately following will make the construction quite clear.

Pipe sections 1 indicate parts of the tubing string suspended in the bore of the well from the casing head at the surface, the well bore being lined with a casing 2. Connected in the tubing string at suitable intervals are the improved valves of which one of each type is illustrated in Figs. 1 and 3.

The valve body 3, reference now being made to that type adapted to the tubing method, has a neck 4 at one end arranged for the connection of one part of the tubing string, and a coupling 5 at the other end arranged for the connection of another part of the tubing string. The arrangement of the valve body provides chambers 6 and 7 of different diameters, these being merged into each other at a beveled annulus 8 to which reference is again made below.

The chambered portion 9 of the coupling 5 is the same in diameter as the chamber 6. The upper edge of the chamber portion 9 is fully rounded at 10 so as to form with the bevel 11 of what is herein known as the revamping weight 12 an expansion chamber in which the fluid is permitted to expand, later to be re-formed or revamped in the tapering or contracted passageway 13 of the revamping weight. The bottom diameter of the passageway 13 is somewhat larger than the diameter of the chambered portion 9, but the top diameter is approximately equal to that of the chamber 6. The arrangement is effective for contracting the previously expanded fluid, the wall of the passageway being formed with a double spiral 14 by which the impact of the fluid causes turning motion of the revamping weight as the latter is lifted by virtue of the force of the re-formed or contracted fluid.

Although gravity is ordinarily relied upon to return the weight 12 to its resting position upon the end of the bushing 5, yet a spring 15 may be employed for the purpose. It must be understood that the use of the spring is optional, and although illustrated in the drawings, ordinarily will not be employed. When employed, the spring rests at one end against a circular shoulder 16 formed by the reduction 17 of the revamping weight and against the face of the beveled annulus 8. The upper and outer edge of the weight 12 is beveled at 18 in agreement with the pitch of the annulus. A plurality of intake plugs 19 are screwed or otherwise adjustably introduced into the somewhat enlarged shoulder 20 of the valve body. These plugs have relatively small or fine ports 21 which in practice should vary from a diameter of $\frac{1}{64}''$ to $\frac{3}{32}''$. These terminate at seats 22 which are reduced to relatively small areas by bevelling the edges of the plugs at 23. The plugs have screw driver slots 24 by which adjustments are readily made.

The devices should be so spaced in the tubing string that the weight of fluid in the tubing between adjacent devices is from one-fourth to one-half as much as the pressure per square inch required to compress the spring and thereby force the plunger to sealing-off engagement upon its upper seat. For illustration, assume the weight of the fluid between any two adjacent devices to be 30 lbs. per square inch, then the pressure per square inch required to compress the spring and seal-off the plunger upon its upper seat should be 60 lbs. to 120 lbs.

The above spacing gives the best results and states the spacing rule correctly, but flow will be initiated and maintained if the weight of the fluid per square inch between the valves is only slightly less than the pressure per square inch required to compress the spring sufficiently to cause the plunger to seal-off upon its upper seat. For illustration, assume the weight of the fluid between any two adjacent devices to be 30 lbs. per square inch, then the pressure per square inch required to compress the spring until the plunger seals-off upon its upper seat must be slightly over 30 lbs. and should, as first stated, be from 60 lbs. to 120 lbs.

The operation is readily understood. The reader may assume a fluid pressure (compressed gas or air) of approximately 200 lbs. as being within the casing 2. Inasmuch as the intake ports 21 afford communication with the interior of the tubing string 1 it follows that there is an equal pressure within the tubing string. The pressure upon the liquid (oil or otherwise) is thus the same on the interior and exterior of the tubing string (presently known as the flow line), and the level of the liquid is thus common.

Next assume an opening of the valve in the flow line 1. The sudden release of pressure will cause an upward movement of the revamping weight 12 in each of the valves, beginning at the uppermost one and continuing in rhythmic downward progression. This upward movement of the revamping weight occurs by virtue of the re-formation or contraction of the fluid in the tapering passageway 13 after the occurrence of the expansion of the pressure fluid in the expansion chamber defined by the rounded portion 10 and bevel 11.

It is assumed that the lift of the revamping weight 12 is sufficient to cause engagement of the bevel 18 with the seats 22 of the intake plugs 19. These plugs having been properly adjusted, the foregoing engagement causes a complete sealing-off of the ports 21 thus stopping the influx of pressure fluid from the casing 2.

This sealing-off engagement is maintained as long as the momentum of the column of moving fluid or liquid in the flow line and in the vicinity of the valve in question is sufficient to keep the revamping weight 12 suspended. A diminution of the momentum of the flowing column will be accompanied by a recession of the revamping weight from the seats 22, so that a volume of pressure fluid will be admitted and injected into the liquid column so as to restore the former momentum thereof. It is thus that the influx or pressure fluid is regulated automatically by the momentum of the moving fluid or liquid column.

The reader will understand from the foregoing description that the entire area of the upper bevel 18 of the revamping weight does not come into contact with the adjacent beveled annulus 8, but that the only upper contact of the bevel 18 is with the very small area of the seats 22 which project slightly below the level of the annulus 8. This fact explains why the sealing-off engagement between the members mentioned may be assumed to be an aggregate area of approximately only 1/4" square.

Every stage lift valve should incorporate means for opening the valve against whatever the weight of the liquid column may be between valves. The principle of this is fully developed in some of the other patent applications mentioned. It may be supposed that all of the valves in the flow line have closed, and that the last or lowermost one of the series likely to be affected by the upward rush of pressure fluid is barely submerged. The consequent lagging of the pressure fluid column will affect the next valve above which will open to such extent as to intake more pressure fluid.

If, as stated before, the combined area of the three seats 22 of that valve is 1/4" square, then the revamping weight would open against the differential of sixteen pounds if the revamping weight weighed 1 lb. The revamping weight would, therefore, have to weigh 3 lbs. in order to open against a differential of 48 lbs., or approximately 2 3/4 lbs. to open against the differential of 42 lbs. This would permit the spacing of the valves 100 ft. apart without the use of the spring illustrated in Fig. 1, but the spacing of the valves in the flow line as well as the particular mode of operation of the revamping weights is a thing readily determinable in practice.

The modification in Figure 3 is designed for the purposes of what has been called the casing method of lifting the well liquid. Such parts of the structure as agree with Fig. 1 are merely identified by corresponding reference numerals without a repetition of the description.

It is now observed that the valve body 3 appears relatively long and slender, and that the revamping weight 12 now rides on the outside of the valve body rather than on the inside as in Fig. 1. This brings about a reversal of parts to the extent that the annulus 8 is now on the outside where it is confronted by the bevel 18 which is formed internally of the revamping weight, rather than externally thereof as in the first form.

The same effect of the tapering passageway 13 (Fig. 1) is got by gradually widening or enlarging the revamping weight as indicated at 25. The enlargement 25 produces a contraction in the passageway of the casing 2 so that fluid rushing upwardly in the casing past the revamping weight 12 will serve to lift the revamping weight in substantially the same manner as already indicated in respect to Fig. 1.

The operation of the modification can be readily understood. The plugs 19, of which a plurality is employed, now extend outwardly, emerging at the annulus 8 whereat they project slightly. Adjustments of the plugs are now made from the inside. Assume that there is fluid (gas or compressed air) in the tubing 1 at a pressure of approximately 200 lbs., and that the valve with which the casing 2 is presumably equipped at the top is opened. It is evident that the rapidly out-rushing pressure fluid will quickly lift all valves or revamping weights 12 which are exposed to the upward movement, and cause them to seal-off upon the seats 22 thereby closing all valves where there is such rapid upward movement.

When the point is reached where there is no rapid upward movement the valves will, of course, be opened and energy will be discharged through ports 21 at such points, thus causing the well to flow by stages through the open valve where energy is needed most. All other vales above remain closed where lifting energy is not needed. Although springs are shown in connection with both forms of the invention, yet it is not believed essential to use a spring in practice.

While spring 15, if used at all, should generally be placed above revamping weight 12 to add to the weight of same, as shown in Fig. 1, it is quite evident that in flowing wells which produce extremely light fluids such as high gravity oil, and oil that is very highly gasified, the action of such very light fluids may be insufficient to exert the proper lifting energy upon revamping weight 12 to seat the same at the proper time to admit the intaking through ports 21 of the exact amount of lifting energy to properly flow the well. In such cases it will be necessary to lighten revamping weight 12, and thereby increase its sensitiveness by placing spring 15 below weight 12, i. e., between weight 12 and bushing 5.

While the construction and arrangement of the improved valve is that of the generally preferred forms herein indicated, obviously other modifications and changes may be made without departing from the spirit of the invention or the scope of the claims.

I claim:—

1. Apparatus of the character described comprising a pair of conduits of which one serves as the flow line, a port in one of the conduits affording communication between the interiors of the conduits, and a valve of hollow construction defining part of the passageway of the flow line and being of such formation that the momentum of the fluid flow in said line tends to move the valve toward a sealing-off position over the port, said valve having a spiral formation causing simultaneous turning movement.

2. A valve comprising a body having a plug with a port affording communication between the interior and exterior of the body, and a valve member riding upon the valve body to coact with the plug to control the passage of fluid through said port, said valve member having a formation exercising a constricting influence upon a fluid stream passing over said formation thereby causing lifting of the valve member in respect to said ports.

3. A valve comprising a body having an annulus and a plug projecting slightly at said annulus to provide a seat, said plug having a port terminating at said seat, and a valve member riding upon the valve body to engage said seat and control the flow of fluid through said port, said member having a tapering formation against which a moving fluid is adapted to act to lift the valve member in the direction of said plug-seat.

4. A valve comprising a body having an annulus defining a merging place between chambers of two diameters within the body, a plug fitted in the body at said annulus defining a seat at which a port in said plug terminates, and a valve member situated in the chamber of largest diameter having a portion engageable with the seat to control the passage of fluid through the port from one side to the other of the valve body and having a tapering passageway defining part of a conduit through the valve body, said passageway serving to contract a column of fluid flowing therethrough which fluid thus tends to move the valve member toward said seat.

5. A valve comprising a body having a beveled annulus defining the merging place of chambers of two diameters, a plug fitted upon the valve body and projecting at the annulus to form a valve seat at which a port in the plug terminates, and a valve member operable in the chamber of largest diameter having a corresponding bevel arranged to engage said valve seat, said valve member having a tapering passageway against which a moving fluid column is adapted to exercise a lifting effect upon the valve member.

6. A valve comprising a body having a beveled annulus defining the merging place between chambers of two diameters, a coupling fitted into the chamber of largest diameter, in turn having a chambered portion with a rounded edge, and a valve member movable within the chamber of largest diameter in the valve body having a bevel coacting with said annulus and a bevel confronting said rounded edge to define an expansion chamber, said valve member having a tapering passageway in which fluid is contracted after expansion in said expansion chamber thus exercising a moving effort upon the valve member in the direction of said valve seats.

7. A valve comprising a body having a somewhat enlarged shoulder serving as centering means for the valve body within a casing, a valve member operable within the valve body having a tapering passageway therethrough against which a flowing fluid column may act to move the member in one direction, and a plurality of plugs adjustably fitted in said shoulder forming seats with which the valve member is engageable, said plugs having ports affording communication between the interior and exterior of the valve body.

8. A valve comprising a body, a plurality of plugs fitted thereupon and projecting to provide valve seats, said plugs having ports affording communication between the interior and exterior of the valve body, and a valve member slidable upon the valve body being of tapering formation and having a bevel at one extremity to coact with the valve seats and effect a control of fluid flowing through said ports.

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