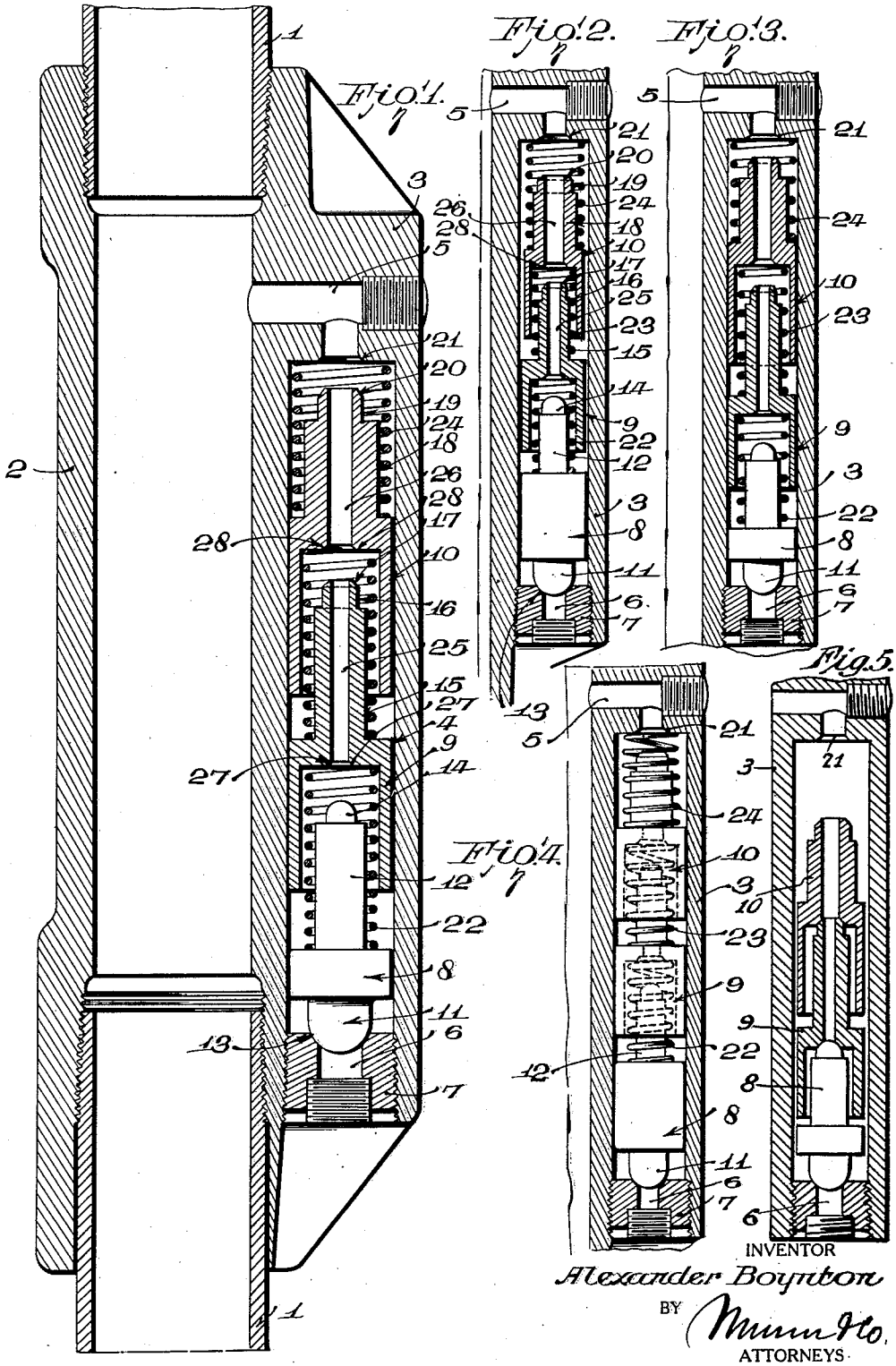
Oct. 25, 1932. A. BOYNTON 1,884,548

AUTOMATIC STAGE LIFT FLOWING APPARATUS FOR WELLS

Filed May 25, 1927



INVENTOR
Alexander Boynton
BY
ATTORNEYS

Patented Oct. 25, 1932 1,884,548

UNITED STATES PATENT OFFICE

ALEXANDER BOYNTON, OF SAN ANTONIO, TEXAS

AUTOMATIC STAGE LIFT FLOWING APPARATUS FOR WELLS

Application filed May 25, 1927. Serial No. 194,122.

This invention relates to improvements in well flowing apparatus, and it consists of the constructions, combinations and arrangements herein described and claimed.

An object of the invention is to provide a valve device for use in connection with stage lift flowing apparatus for wells, which device embodies instrumentalities for automatically and progressively regulating the volume of pressure fluid in accordance with varying pressure differentials inside and outside the tubing string in which the valve device is located.

Another object of the invention is to provide a valve device in which an arrangement of co-acting plungers is made to perform the foregoing function automatically, the action of the plungers being dependent upon the foregoing pressure differentials.

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

Figure 1 is a vertical section of one of the valve devices herein known as the vertical series plunger type,

Figure 2 is a detail section of a modification employing plungers of the same length but of different diameters,

Figure 3 is a detail vertical section of a further modification employing plungers of different lengths and of the same diameters,

Figure 4 is a detail vertical section of a still further modification employing plungers of the same lengths and same diameters but using springs of different tensions to permit progressive action under the influence of fluid pressure,

Figure 5 is a view similar to Figure 3 illustrating a modification wherein the plungers are of different weights and the springs are omitted.

This application is one of a number of companion applications dealing with apparatus for flowing oil and other wells. The fundamental principle is announced in a co-pending application known as Case #1, filed April 5, 1927, Serial Number 181,144, upon recourse to which it will be understood that the lifting of the liquid in the well is accomplished by imparting pressure-fluid impulses thereto at stages situated determined distances apart.

It is brought out in this, as well as other co-pending applications, that the value of the lifting impulse can be accurately regulated or controlled by a valve device which is subject to wide variation as to form. The valve device is operated, first of all, by the pressure fluid itself, and when so operated, at once becomes the medium by which the flow of the pressure fluid is controlled. The reader will understand from this that the action of the valve device is entirely automatic.

The herein disclosed type of valve device constitutes a controlling means for governing the volume of applied energy at various pressure differentials. This type is designed to admit the greatest volume of pressure fluid, whether that be gas or air, into the tubing string or into the well casing (depending on whether it is used in connection with the tubing or casing methods of raising the well liquid) at a relatively low differential, and cause a decreasing volume of the pressure fluid to be admitted as the differential increases.

Arrangements for governing the volume of applied energy are not so numerous as other arrangements operable in accordance with the velocity of the moving column of liquid. The valve device herein disclosed is one of the foregoing arrangements, and comprises a series of plungers that are capable of progressive action in throttling the volume of by-passing pressure fluid as the pressure differential rises.

Reference is made to Figure 1 in which 1 indicates part of a string of tubing in which numerous valve devices are connected in practice, one of these valve devices being shown in section. The body 2 of the valve device has a lateral enlargement 3 with a chamber 4 communicating at its extremities with the interior and exterior of the valve body. The first avenue of communication is afforded by passages 5, the latter avenue of communication occurring through the port 6 of a chamber-closing sleeve or plug 7 when the lowermost plunger 8 is unseated.

The foregoing lowermost plunger is one of a series, the number of which is obviously subject to variation. The other plungers of the series are designated 9 and 10, these being herein known as the intermediate and uppermost plungers for purposes of distinction. The plungers 9 and 10 are best termed tubular plungers by virtue of having openings extending through from end to end. The large body of the lowermost plunger has projections 11 and 12 at opposite ends, the first sealing-off the port 6 at the seat 13, the second terminating in a valve end 14 performing a sealing-off function in respect to the intermediate plunger.

An arrangement somewhat similar to that described occurs in the case of intermediate plunger 9. The plunger body is made hollow, thus resembling a piston. Extending from the body is a projection 15 terminating in a valve end 16 which is beveled at 17 to more properly engage the seat of the plunger next above. The arrangement of this plunger is the same as that of the plunger 9; the body carries the projection 18 which terminates in the valve end 19 having a beveled end 20 for readily engaging the seat 21 of the vertical one of the passages 5.

Springs 22, 23 and 24 tend to move the plunger series in one direction, this accomplishing the seating of the lowermost plunger 8 when unrestricted. These springs, in practice, are each slightly longer than the other in the order given, to illustrate, spring 22 is slightly longer than spring 23 and spring 23 is slightly longer than spring 24. As a variation of this arrangement the springs may be either progressively longer from the top downward, or may be progressively stronger from the top downward without increasing lengths. In any event, the plunger 10 will be first to close, due to the fact that the total amount of energy expended in by-passing all plungers will act to compress spring 24, as later appears. Openings 25 and 26 through the plungers 9 and 10 become progressively larger, the vertical passage 5 with which these openings are communicable being larger in size than opening 26. The lower ends of the openings have seats 27 and 28 for engagement by the valve ends 14 and 16.

It will be observed that the body or skirt of the plunger 9 is somewhat shorter than the body or skirt of the plunger 10 and that the body of the plunger 8 is shortest of all. It is assumed that the diameters of the bodies of all of the plungers are the same, although both the lengths and diameters may be varied as described in connection with the modifications in Figs. 2, 3 and 4.

The operation is readily understood. With an understanding of the apparatus in application #181,144, the reader will be able to differentiate between what is therein known as the tubing and casing methods of lifting the liquid. To anticipate a possible lack of familiarity with these methods, it may be stated that according to the first, the liquid is forced to the surface through the tubing string 1 by means of fluid pressure imposed upon the liquid in the well casing (not shown) surrounding the tubing string. According to the casing method, the column of liquid is forced to the surface in the casing around the tubing string by fluid pressure imposed upon the liquid in the tubing string. The arrangement disclosed in Fig. 1 is primarily intended for use according to the tubing method, but by slight mechanical modification, may be used to serve the purpose of the casing method.

It is assumed that the upwardly moving column of liquid in the tubing string 1 extends well past the location of the valve 2, and that the intake port 6 has become uncovered by the surrounding liquid. The column of liquid in the tubing will impose a back pressure upon the plunger series, tending to keep the lowermost plunger 8 seated as long as the pressure inside of the tubing string predominates over the pressure on the outside to a sufficient extent. A period will be approached when the internal and external pressures will approximate each other thus establishing what may be known as a relatively low differential of pressures.

Upon such occurrence the lowermost plunger 8 will become unseated from the intake port 6 and admit a relatively large volume of pressure fluid whether that be gas or air. Inasmuch as all of the plungers are in disengaged or separated positions, this volume of pressure fluid immediately finds its way into the column of liquid in the tubing string, giving an impetus thereto and increasing the velocity of its movement.

It is now essential to keep the liquid column moving at the proper velocity, the reader detecting at once the fact that the differential must increase to a given and determined point where no additional energy or lifting fluid is required. The shutting off of the energy or lifting fluid occurs in this way:

The uppermost plunger 10, being largest, offers the greatest resistance to the by-passing fluid, less resistance being offered by the intermediate plunger 9 and still less by the lowermost plunger 8. Consequently, plunger 10 will be the first to engage with the seat 21 and thus effect a partial closure of the vertical passage 5, the reader bearing in mind that the opening 26 is still in communication with the interior of the chamber 4 and the pressure fluid.

This opening 26 continues to admit the pressure fluid by-passing plungers 8 and 9 until the foregoing increasing differential causes the plunger 9 to seat at 28 also and so further partially close the opening 26. As the differential further increases, the plunger

8 completes the seal-off by seating at 27 at the base of the opening 25 in the plunger 9. It is thus seen that the valve device causes an automatic diminution of pressure fluid volume while the differential becomes increasingly higher.

It is unnecessary that all springs be of the same tension, or that all of the plungers be of the same diameters as disclosed in Fig. 1. Nor is it necessary that the plungers are of equal weights; in fact the plungers may be of varying weights to respond to different degrees of actuating force imposed thereupon. This modification is illustrated in Figure 5 in which the weight variations are denoted by variations in the sizes of the plungers, it being observed that the springs are here omitted. The larger the plunger and consequently the less by-passing area, the stiffer may be the spring that acts against the particular plunger. Furthermore, the larger the passage through the plunger the weaker must be the spring to produce seal-off at any differential. Some structural variations are disclosed in Figs. 2, 3 and 4, and inasmuch as all parts are identical with those described in Fig. 1 (excepting for proportions), it is deemed needless to repeat the description, the use of similar reference characters being sufficient to convey an understanding of the following conclusion.

In Fig. 2, the plungers 8, 9 and 10 are of the same length (or approximately so) but of different diameters. In Fig. 3 these plungers are of different lengths (as in Fig. 1), but of the same diameter. In Fig. 4, the plungers are the same length and the same in diameter, but the various springs 22, 23 and 24 are intended to be of different tensions to cause progressive seating of the plungers in the manner already understood.

Care must be taken that the several plungers in series must have proper clearance between them and the chamber in which they work. The difference in diameter between the various plungers and the chamber may vary from .005″ to .030″. The last plunger to close, and which produces the complete seal-off, must work against a spring tension to conform to the following rule:

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.

It is the purpose of the foregoing modifications to illustrate how the actuating force may be made to variously operate upon the plungers in order to seat and open them in series. The foregoing description makes it evident that the principle of the invention is not limited to any definite system or coordination of plungers and springs.

I claim:—

1. A device of the character described comprising a valve body affording a passageway, and a plurality of telescoping valve elements of which one is solid and another hollow and open from end to end situated in the passageway being subject to relative shifting movement under the influence of fluid flowing through the passageway and through said hollow valve element thereby to perform a throttling action upon the fluid volume.

2. A device of the character described comprising a valve body having a passageway, a solid plunger tending to close one end of the passageway, and a hollow plunger engageable with the other end of the passageway and coacting with the solid plunger in throttling the volume of by-passing fluid upon unseating of the solid plunger.

3. A device of the character described comprising a valve body having a passageway, a solid plunger situated in the passageway tending to close one end thereof, and a plurality of coacting tubular plungers forming part of the passageway of which one is engageable with the opposite end of the passageway and another is mutually engageable both with said one plunger and said solid plunger to regulate the volume and control the flow of fluid occurring in the valve body and plunger passageways upon unseating of the solid plunger.

4. A device of the character described comprising a valve body having a passageway, a solid plunger situated in the passageway tending to close one end thereof, a plurality of coacting hollow plungers of which one is engageable with the opposite end of the passageway and another is mutually engageable both with said one plunger and said solid plunger to regulate the volume and control the flow of fluid occurring in the passageway upon unseating of the solid plunger, and re-

silient means located between the plungers tending to keep them separated.

5. A device of the character described comprising a valve body having a passageway, a plunger situated in the passageway being capable of seating upon one end of the passageway and having an opening for the flow of fluid when said plunger is seated, and a coacting plunger capable of seating upon an end of the opening and in turn having an opening restricting the flow of fluid through said seated plungers.

6. A device of the character described comprising a valve body having a passageway, a plunger situated in the passageway being capable of seating upon one end of the passageway and having an opening for the flow of fluid when said plunger is seated, a coacting plunger capable of seating upon an end of the opening and in turn having an opening restricting the flow of fluid through said seated plungers, and a solid plunger capable of seating upon and closing said last named opening to stop the flow of fluid through said seated plungers.

7. A device of the class described comprising a valve body having a passageway, and a plurality of successively larger tubular plungers forming part of the passageway being progressively and cumulatively engageable with each other and with an end of the passageway to vary the available area in the plunger passageway for the flow therethrough of fluid.

8. A device of the class described comprising a valve body having a passageway, a plurality of successively larger plungers being progressively and cumulatively engageable with each other and with an end of the passageway to vary the available area in the passageway for the flow therethrough of fluid, and springs between the plungers tending to keep them separated, said springs being of sizes varying with the sizes of the plungers.

9. A device of the character described comprising a valve body having a passageway, a plurality of plungers having openings therethrough terminating in seats for mutual engagement and for engagement of one of the plungers with an end of said passageway, and a plunger coacting with another of the foregoing plungers being arranged to engage the seat of the respective plunger opening and the opposite end of the passageway.

10. A device of the character described comprising a valve body having a passage therethrough, a plurality of plungers located in the passageway each including skirt portions and projections terminating in valve ends through which projections and valve ends there are openings, said valve ends being arranged for seating against adjacent plunger and passageway parts, a solid plunger including a projection and valve ends at opposite extremities for seating against adjacent plunger parts and upon the opposite end of the passageway, and resilient means in engagement with the plungers tending to move them into separate positions.

11. A device of the character described comprising a valve body having a passageway, and a series of gravity operable plungers of which one is solid and the rest tubular to form part of the passageway through the tubular plungers, all of said plungers being of varying weights to respond to different degrees of actuating force imposed thereon by fluid flowing through the passageway thereby to seat the plungers upon each other or separate them in succession for a control of the fluid volume.

ALEXANDER BOYNTON.