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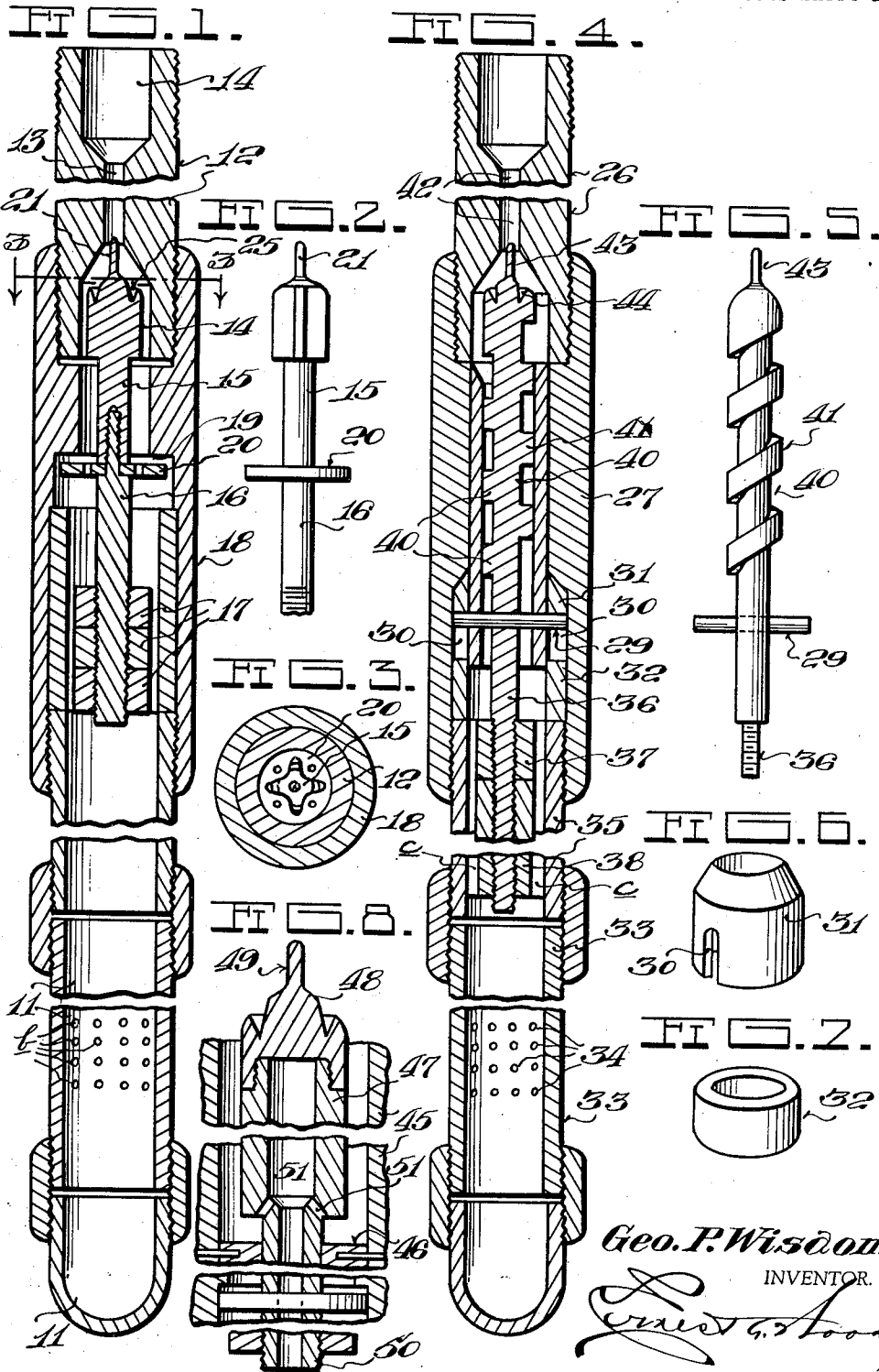
G. P. WISDOM

2,122,080

AUTOMATIC WELL FLOW CONTROL

Filed July 9, 1936

2 Sheets-Sheet 1



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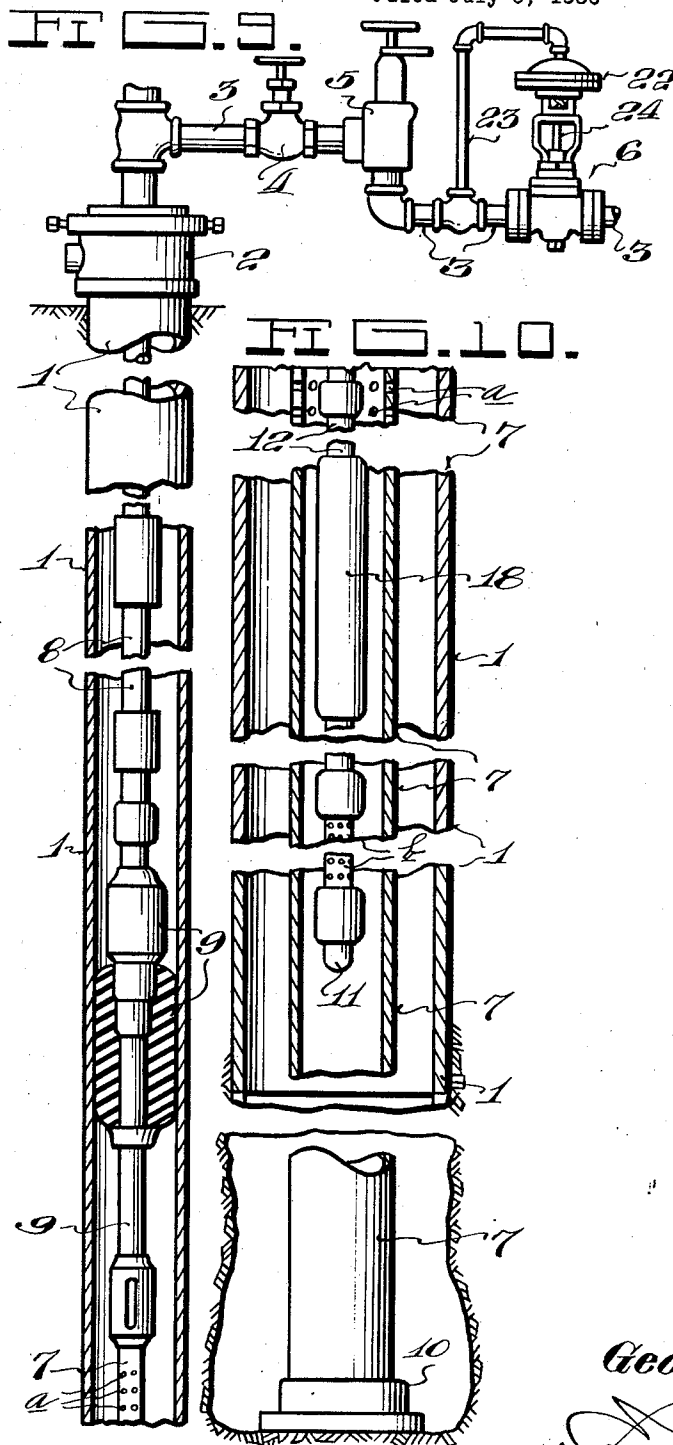
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## UNITED STATES PATENT OFFICE

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## AUTOMATIC WELL FLOW CONTROL

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4 Claims. (Cl. 166—2)

This invention relates to well pumping and flowing equipment and it has particular reference to an automatic well flow control, primarily designed to increase the production of oil from wells normally producing exceptional quantities of salt water.

The principal object of the invention is to provide novel apparatus for controlling the bottom hole pressure, thereby to regulate the production of oil from the well in accordance with the production rate of the oil bearing formation. By thus controlling the bottom hole pressure, wells normally making considerable salt water are put back into condition where they will produce only pipe line oil.

Another object of the invention is to provide means for use in connection with a tubing string, or a tubing string having a pump at its lower end in an oil well, for controlling the flow of fluid to the tubing string or pump in accordance with a desired production rate irrespective of any variations of pressure existing in the tubing string or in the bottom of the well.

Broadly, the invention seeks to provide apparatus of the character specified, which in some cases successfully displaces surface pumping equipment, holding the pressure under control at all times, eliminating the turbulent condition caused by successive heads in the bottom of the hole and in the tubing, resulting in a steady, uniform flow of fluid to the surface. By thus eliminating these objectional heads, practically all of the salt water is left in the well while only pipe line oil passes through the tubing to the surface for delivery to storage.

With the foregoing objects as paramount, the invention has other and lesser objects and certain novel features of construction and operation of parts, to become manifest as the description proceeds, taken in connection with the accompanying drawings wherein:

Figure 1 is a vertical section of one form of automatic flow valve constructed according to the invention.

Figure 2 is a detail view of the valve proper for controlling the passage of fluid into the tubing.

Figure 3 is the transverse section on lines 3—3 on Figure 1.

Figure 4 is a vertical section through a modified form of the device from that shown in Figure 1.

Figure 5 is a detail elevation of the form of valve proper employed in the device shown in Figure 4.

Figure 6 is a detail perspective view of the valve bushing.

Figure 7 is a detail perspective view of an end bushing complementary to the valve bushing shown in Figure 6.

Figure 8 is a detail view in vertical section fragmentarily showing a modified form of valve, capable of replacing either of the valves shown in Figures 1 and 4.

Figure 9 is an elevation, partly in section showing the upper assembly of the invention, and

Figure 10 is an enlarged view in vertical section of the lower portion of the assembly shown in Figure 9.

Continuing with a more detailed description of the drawings, reference is primarily made to Figure 9 in which 1 designates the well casing, having the conventional casing head 2. A flow line 3 is connected to the head, as shown, and is provided with a stop valve 4 and a flow "bean" 5. From the latter unit, the flow line 3 continues to the excess pressure relief valve 6, to which reference will be later made.

Depending within the casing 1 is the tubing string 7, in the length of which is provided a pump, 8, preferably of the full plunger type. Below the pump 8 is disposed a packer 9, suitably of the character known as the multiple step mandrel type. This packer, upon the setting of the shoe 10 (Figure 10) on the bottom of the hole, is expanded against the walls of the casing 1 to seal off bottom hole fluid, forcing the latter to enter the perforations *a*, in and spaced above the bottom of the tubing 7. Being thus received in the tubing, the liquid enters the strainer 11 of the invention, through its apertures *b*, thence upward through the tubing to the surface in the manner to be presently described.

Referring now to Figure 1, the choke 12, which is, as shown in Figure 10, suspended in the tubing 7 below the packer 9, is constructed to provide a restricted fluid passage 13. This choke is composed of a material such as manganese steel or its equivalent, which will resist frictional wear imposed thereupon by sand bearing oil. The ends of the choke are provided with cavities 14 connected by the said passage 13, and in the lower cavity is disposed the head of the longitudinally displaceable valve 15. This valve controls the hydrostatic pressure in the well and prevents undue turbulence in the tubing 7, caused by surges or heads which occasionally rise from bottom hole pressure and cause excessive amounts of salt water to flow into the tubing.

When frequent heads are permitted to rise in

the tubing, which is a common occurrence in the absence of some restriction, as provided by the invention, not only is salt water produced in abundance which, with its entrained sand, cuts out the valves, but to deprive the oil bearing regions of salt water is to reduce the medium by which oil itself is produced. Hence, the invention is instrumental both in minimizing destructive effects upon the equipment, and in separating the oil and water in the hole, producing only pipe line oil and dispenses with much of the surface equipment necessary for separation of emulsions.

It will be observed in Figure 1 that the valve 15 is provided with a depending stem 16 which has a threaded lower end to receive a series of weight blocks 17, the number of weights required being varied according to the bottom hole pressure.

The tubular member 18, housing the valve assembly is threaded upon the lower end of the choke 12 and has an interior and annular shoulder 19, serving as a movement limiting means for the valve 15, since the perforated disc 20 engages this shoulder when the fluid pressure is such as to lift the valve to its extreme raised position.

The head of the valve 15 has a projection 21 thereon which, when the valve is raised, enters the passage 13 of the choke, but at no time is this passage entirely closed thereby. As the hydrostatic pressure gradually increases, the valve is urged toward the passage 13, reducing the velocity of the fluid in the passage. There is, of course, a variance in the pressure of the fluid in the tubing 7 and in order to establish a pressure equilibrium therein, the flow "bean" 5 and excess pressure or relief valve 6 are provided on the surface, the latter being responsive to changes in tubing pressure. By thus controlling the pressure at the bottom of the hole and at the top with cooperating valve means, the fluid pressure in the tubing is held within bounds and a natural flow of oil results.

The relief valve 6 is of conventional construction and is provided with a diaphragm and spring 22, which is actuated only when the pressure in the line is excessive. When this occurs, fluid passes through the bypass 23, and bears upon the diaphragm, urging the valve stem 24 downward, to move the valve to closed or partially closed position. Thus the flow of fluid through the tubing string is in accordance with a natural or desired production rate, irrespective of any variation of pressure existing in the tubing string on bottom of the well.

In order to prevent sanding up, that is, the accumulation of microscopic particles of grit about the valve 15 to possibly hinder its performance, an annular trap 25 surrounds the top of the head of the valve as shown in Figure 1.

With reference now to the modified form of the invention shown in Figure 4, the choke 26 is not unlike that shown in Figure 1 and suspends a body 27 similar to the tubular body 18, shown in Figure 1. Unlike Figure 1, the valve 40, shown in detail in Figure 5, is held against rotation, being provided with a lateral pin 29, passing through the valve stem and entering slots 30 in the bushing 31, the latter reposing in an annular recess made interiorly in the body 27. An end bushing 32, Figure 7, is disposed beneath the bushing 31 for convenience in assembling. As in Figure 1, the screen or strainer 33, with perforations 34 is suspended below the body 27 and

within the intermediate tubular joint 35, between the body 27 and screen 33 depends the valve stem 36. This stem is threaded, as shown, and carries a series of weights 37, but the lowermost weight 38 is fluted at c, to permit passage of fluid, yet affords a guide for the valve, inasmuch as portions thereof slidably engage the walls of the tubular joint 35 as the valve is longitudinally actuated by fluid pressure in the well.

The valve 40 is constructed with a spiral rib 41, the latter affording the maximum friction surface for fluid rising under influence of hydrostatic pressure, in the apparatus, and which insures positive movement of the valve toward the opening of the passage 42 in the choke 26. As in the case of the structure shown in Figure 1, the valve 40 has a protuberance 43 which enters the restricted passage 42 but does not, at any time, entirely close the passage. This valve also has an annular sand trap 44 about its upper end, to entrap sand likely to hinder the performance of the valve.

The pin 29 also extends through holes in a slidable sleeve 28, which sleeve partakes of any movement of the valve 40. The sleeve 28 is preferably made of bronze or other bearing metal, so as to reduce the friction between it and the body 27. By this means the sharp edges of the spiral ribs 41 cannot cut into the body 27, and if there should be any grit, scale, or other abrasive substance on the ribs 41 the same would not scar the inner surface of the body 27.

With reference to the modified form of valve shown in Figure 8, only a fragmentary part of the body or valve housing 45 is shown but in this fragmentary representation, an interior annular shoulder 46 is depicted. The valve is comprised of the hollow head 47 and removable cap 48, the latter having a protuberance 49 thereon capable of entering the restricted passage in a choke similar to chokes 12 and 26. The stem 50 of this valve is hollow, as shown, to admit fluid from the well to the hollow head 47. From this point, fluid under pressure is constrained to pass from the head through the restricted apertures 51 to impinge against the shoulder 46. Thus, this valve provides for both, an impulse and reactance turbine effect.

Accordingly, when the tubing pressure is normal the valve hovers a short distance above the shoulder 46, being held thus by fluid passing through the orifices 51. However, should the pressure increase, the fluid impinges shoulder 46 with greater force, thereby tending to raise the valve. The farther upward the valve travels, the less the reactance effect, although the impulse effect remains the same, and hence an automatic control is provided.

It is sometimes necessary to close down a well for various reasons. After the well has been closed down and the flow suspended, especially in small producing wells, it is difficult to again resume the flow. A swab however may be operated in any suitable manner and serves the dual purpose of cleaning the tubing of paraffin deposits and likewise primes the well to establish or renew production.

It will of course be understood that since the entire valve 40 is exposed at all times to the fluid, the downward pressure thereof would exactly counterbalance the upward pressure. When the oil is flowing and impinges against the valve mechanism, it tends to raise the said valve mechanism, which tendency is resisted by the movable part of the valve mechanism. Let us

assume that the upward flow of oil is  $x$  barrels per hour and that this produces a force tending to lift the movable part of the valve mechanism by  $y$  pounds. If it is further assumed that the weight of the movable part of the valve mechanism is  $y$  pounds, the pin 29 will remain at the lower ends of the slots 30, and the movable part of the valve mechanism will be in equilibrium. If there should now be a tendency for the oil to flow so as to produce more than  $x$  barrels per hour, such as  $x+1$  barrels per hour, the movable part of the valve mechanism would start moving upwardly, but this would instantly decrease the flow and would correspondingly decrease the force imparted to the valve mechanism by the upward flow of liquid tending to move the movable part of the valve mechanism upwardly. It is therefore obvious that the flow will depend upon the size of the opening through which the flowing liquid will pass and its velocity, but the size of this opening is controlled by the amount of liquid impinging against the movable part of the valve mechanism and its velocity will be correspondingly decreased, with a net result that, even through the flow tends to increase beyond  $x$  barrels per hour, the net resultant will be a flow of  $x$  barrels per hour. It is therefore apparent that the valve mechanism shown in the drawings constitutes a balanced valve structure, it being balanced by restricting the velocity and the mass of the flowing oil so that the resultant flow of oil will be constant.

In using the term "balanced valve mechanism" I mean it to be in contra-distinction to a valve which will simply open or close according to the pressure induced by the flowing mass. It should be understood that in the structure shown in this application that the valve 40 does not remain in either its lower or its uppermost position at all times, but when the flow of oil tends to increase beyond the flow desired, the valve mechanism only partially closes and closes by an amount, so that the resultant will be the desired flow.

The valve mechanism is constructed so that the sum total of all the exposed areas on each end of the valve mechanism subject to hydraulic pressure are equal, and these ends are subject to hydraulic pressure under all conditions of operation.

The operating force moving the valve mechanism upwardly is derived from a given mass of fluid moving around the turns of the spiral, which is restrained from rotating. This force is balanced by a mass attached to the valve mechanism so that when the pressure difference around the valve is increased and more fluid mass tends to flow around the spiral, this state of balance is disturbed and the valve mechanism moves upwardly thereby partially shutting off the increased flow, and a new state of balance obtains.

What is claimed is:

1. In combination with a string of tubing, a fluid choke, a valve provided with spiral ribs below said choke, said ribs being exposed to the upward flow of liquid to lift said valve, an extent corresponding to the velocity of said liquid and correspondingly to close partially said choke by the movement of said valve.

2. In combination with a string of tubing, a fluid choke, a valve below said choke, means to prevent said valve from closing entirely, said valve being provided with spiral ribs, said ribs being exposed to the upward flow of the liquid, and means to prevent the valve from turning.

3. In combination with a string of tubing, a fluid choke, a valve below said choke, said valve being provided with spiral ribs, said ribs being exposed to the upward flow of liquid, and a pin and slot connection to prevent said valve from turning.

4. In combination with a string of tubing, a fluid choke, a valve below said choke, a body in which said valve is movable, and a sleeve interposed between said valve and body and movable with said valve to diminish friction.

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