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WELL PRODUCTION APPARATUS

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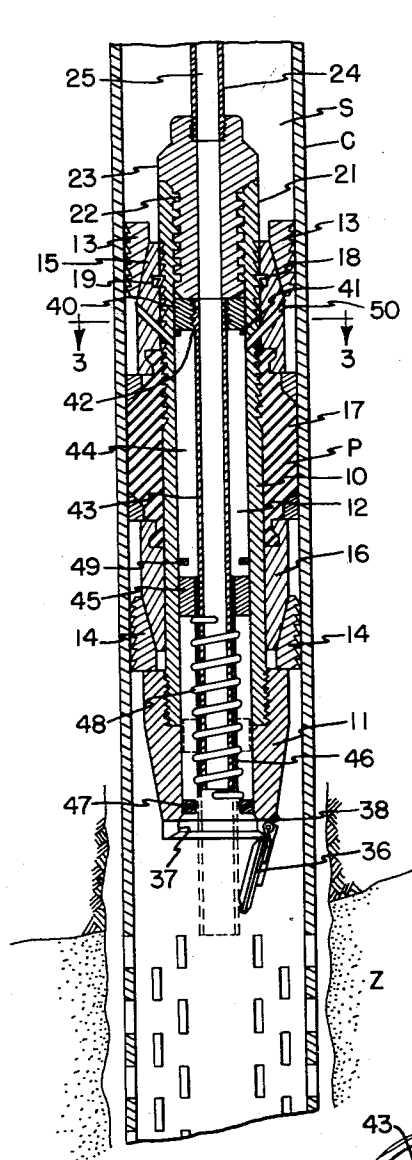


Fig. 1

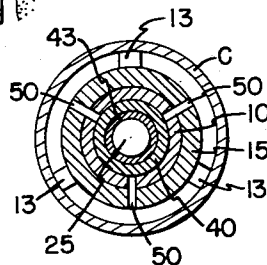


Fig. 3

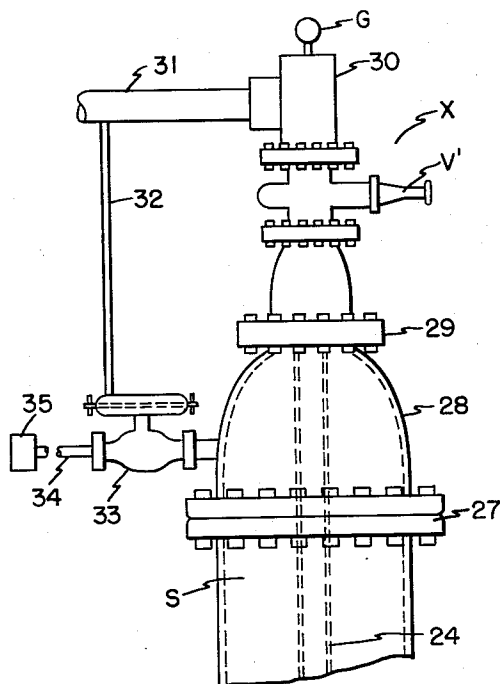


Fig. 2

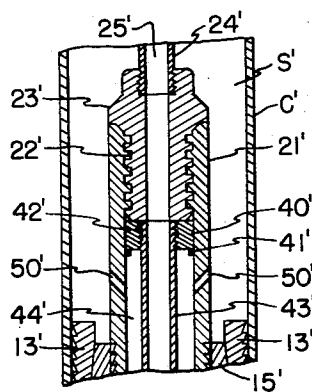


Fig. 4

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WELL PRODUCTION APPARATUS

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This invention relates to production equipment for oil wells and particularly to a well packer of the type incorporating a down hole full opening shut off valve and which incorporates means whereby the opening and closing of the valve may be controlled by liquid pressure regulated at the well surface.

In connection with all off shore wells in particular, during production there is inserted in the bore a packer and regulations require that the oil or gas production flow through production tubing, generally inserted within the packer after it has been set in a casing. Typical and commercially available well production apparatus of this type are shown in the U.S. patents to Burt et al., No. 2,189,703, and McGivern No. 2,507,262, and generally such apparatuses have been very successful. However, it will be noted by referring to these patents that after the packer is set, production tubing is lowered within the bore to open the normally closed valve positioned at the end of the packer and, of course, this valve (which must be of the full opening type so that perforation and survey procedures may be preformed without removing the packer) is the shut off control for the production. In order to shut down production once it has started, it is necessary to remove or elevate the tubing so that the valve will become closed and obviously this requires a substantial operation. For example, during off shore producing, if there is any damage to the apparatus such as by a hurricane or barges running into the equipment or any other break down, then it is necessary in order to shut down production to elevate the tubing and with a plurality of these operations running simultaneously, such is quite a chore. The present invention is designed to overcome this difficulty and provides means for automatically controlling the flapper or shut off valve by merely controlling the pressure of liquid in the annular space between the tubing and the casing. In other words, there is automatic surface control for the valve and since this type of apparatus is generally used in multiples which are connected to a common separator, the present invention permits controlling the liquid pressure within the annular space of each such apparatus by a common control at the separator, there being a packer in each such apparatus with all packers being controlled as a group. Although the instant invention is primarily designed for use in apparatus employed in off shore set-ups and/or marine operations, it is to be understood that it is equally usable anywhere that there is danger of production interruption due to the elements or break down of apparatus generally, such as in gas and oil wells or gas distillate wells.

Bearing the above in mind, it is the primary object of this invention to provide well production apparatus wherein the flow of production through the tubing may be controlled automatically at the surface of the well by merely varying the pressure of liquid contained between the casing and tubing whereby the production valve may be readily opened and closed without interfering with the main tubing.

A further object of the invention is to provide in appa-

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ratus of the type described in the preceding paragraph an improved packer wherein the production valve forming part of the packer may be controlled by a piston element operated within the packer by liquid under predetermined pressure maintained in the annular space between the casing and tubing and controlled automatically at the surface of the well.

Yet another object of the invention is to provide well production apparatus that may be easily incorporated in the commercially available equipment of the said patents without substantial modifications and without substantial increase in cost.

The construction designed to carry out the invention will be hereinafter described, together with other features thereof, and will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof wherein an example of the invention is shown and wherein:

Figure 1 is a longitudinal sectional view of the bottom portion of well production apparatus including a production packer incorporating the teachings of this invention and showing the packer set within the casing and illustrating an oil production zone;

Figure 2 is a longitudinal view of the top of the well production apparatus;

Figure 3 is a sectional view taken along the lines 3—3 of Figure 1; and

Figure 4 is a view similar to a part of Figure 1 but illustrating a modification.

The production packer P shown in the drawings has been modified to incorporate the teachings of this invention. However, the actual parts that do the packing and cause actuation of the packing sleeve may be of any suitable type, although for purposes of illustration a packer similar to the said Burt et al. patent or Baker et al., U.S. Patent 2,637,402 has been disclosed. Packer P may be set in the position shown in Figure 1 to seal the walls of the casing C by various means well known in the art. Packer P, as disclosed, includes essentially body member 10 and a guide 11 threadedly attached to its lower terminus with the guide and body member 10 having formed therethrough a combined passageway 12. Individual slips 13 and 14 of upper and lower segmental slips are provided for anchoring the packer to the casing C, these slips being moved radially into engagement with the casing by and cooperable with expander cones 15 and 16. The slips 13 and 14 are initially held in retracted position and the cones 15 and 16 in ineffective position by anchoring them together and to the packer body by suitable shear pins or screws, not shown, it should be obvious how the packer P is operated to cause the expanding sleeve of rubber 17 to engage in sealed relationship and the slips to become set against the walls of the casing. For example, the principles of the setting tool C of Patent 2,637,402 may be applied. If this were done stud 12 of Patent 2,637,402 would be located to seat at 37 of the instant apparatus and until the packer was set stud 12 would function to hold valve 36 open. Referring to columns 9 to 11 of Patent 2,637,402 it should be apparent how the setting tool C could operate and after setting, tool C would be removed and thus would not interfere with ports 41 nor the operation of the instant apparatus as stud 12 would drop from guide 11. Numeral 18 merely represents a pawl ring engageable in a groove 19 for maintaining the sleeve 17 in its set or compressed condition.

The upper end of the body member 10 is provided with a head 21, the interior surface of which is threaded at 22 to receive a coupling unit 23 for coupling to the packer P, production tubing 24 and, of course, the coupling unit 23 has a passageway 25 in communication

with and of substantially the same size as the interior diameter of tubing 24. It is to be understood that the tubing 24 and coupling 23 are secured to the head 21 only after the packer is set and the well is in condition to produce and referring to Figure 2, the tubing 24 extends within the casing to the top thereof as illustrated and there is formed between the tubing and coupling and the casing the annular space S extending from above the packing sleeve 17 to the surface or top of the well.

Considering Figure 2 in detail, the letter X generally represents a simplified Christmas tree unit and the essential parts thereof would appear as shown after production is started. A conventional Braden head 27 rests on the well surface and supports the tubing 24, the top of the latter being connected to a tubing head 29 and there being provided a hollow hood 28 surrounding the tubing 24 between its connection with the heads 27 and 29. G is the usual type of gauge, V¹ a gate valve for closing in the tubing 24 and a standard cross T is showing at 30 with line 31 representing the production flow line to the main separator (not shown), it being understood that T 30 includes a choke in the nature of a reduced orifice whereby the pressure downstream from the choke, namely within line 31, is much less than the upstream pressure. Unit X is modified to include flow line 32 connecting flow line 31 to a suitable liquid pressure responsive valve 33 which preferably takes the form of what is known in the trade as a Fisher governor diaphragm valve and which is interposed in a fluid line 34 connected with annular space S. Prior to installing valve 33 (various types of liquid pressure responsive valves may be used, such as a Mercoid valve) liquid under a predetermined pressure is supplied through line 34 to space S and after production is started and the well balanced, valve 33 is connected in circuit, as shown, after having first been adjusted to an extent that it closes line 34 and maintains the liquid under pressure within space S. Of course, the source mentioned is now disconnected from line 34 and the adjustment of valve 33 is such that pressure within space S will not be released through line 34 until the production pressure within line 32 falls a predetermined amount which would be the case in the event of a break down or damage to the well production apparatus.

Now referring to Figures 1 and 3 in particular, the packer P includes at end 11 a one way valve 36 to shut off production from a lower zone Z wherein the casing has been perforated to allow oil or other production to flow from the sands in the manner shown by the arrows of Figure 1. The valve 36 is of the flapper type and is pivotally mounted at the lower end of terminus 11 and is urged toward engagement with the valve seat 37 by a spring 38 and thus this valve 36 is normally maintained closed so that production cannot flow through space 12.

To incorporate the teachings of this invention in packer P there is a modification to the following extent. A ring-like member 40 is sealed by any suitable means 41 to the interior wall of body member 10 and this ring has an opening therethrough substantially the same size as the inside diameter of tubing 24 and is also threaded at 42 for receiving fixed tubing 43 which depends therefrom to a point slightly above seat 37 or, in other words, near the bottom of member 11. Similarly, the fixed tubing 43 has a hollow interior of a diameter substantially comparable to that of tubing 24 and passageway 25 and forms with the interior surface of body member 10 an annular passage 44. The exterior wall of fixed tubing 43 and the inside surface of body 10 function as a cylinder for piston 45, said piston having depending therefrom a second tube 46 which telescopes relative to tubing 43 from the retracted position shown in full lines to the extended position shown in dotted lines. As stated, movable tubing 46 telescopes relative to tubing 43 and is shown as surrounding the tubing 43 and the tubing 46 should also have an interior diameter substantially the same and at least as great as fixed tubing 43. The piston 45 is nor-

mally biased upwardly to the position shown in Figure 1 by means of a coil spring 48 interposed between the lower extremity of the piston and ring-like stop means 47 which is welded or suitably attached to the interior surface of body 10 and, of course, the ring has an opening of a size to permit passage therethrough of tubing 46. Stop means 47 also functions to limit the downward movement of piston 45 and if desired there may be provided stop means 49 to limit the upward movement thereof. Of course it is to be understood that bias means 48 could assume other forms as, for example, the piston 45 could be gas loaded instead of spring loaded.

Liquid communication is made between space S and annular passage 44 and this may take the form as illustrated in Figures 1 and 3 by providing ports 50 through the cone 15 and the body member 10. These ports should be of a size so there will be no clogging therein and may comprise any number, although it is believed that one between each pair of slips 13 will be satisfactory. It can be appreciated that liquid may then flow from space S through the ports 50 into the annular passage 44 and if the pressure of this liquid is sufficient to overcome the upward bias effect of spring 48 in addition to the bottom hole pressure below the packer, then it will cause the tubing 46 to move downwardly into the dotted line position and in so traveling the valve 36 will be opened and in such condition any production flowing from zone Z may flow upwardly through tubing 46, tubing 43 and tubing 24 into the flow line 31 and into the separator, not shown. It is to be understood that once the valve 36 is opened, if the pressure of the fluid within space 44 is released, then the bottom hole pressure below the packer is the major factor in forcing the piston 45 upward, although spring 48 has an effect in causing such movement.

In describing the operation of the embodiment of Figures 1, 2 and 3, it must be kept in mind that the sequence of operations may be varied and will be dictated by the crew and equipment, such as the casing perforating step prior or following setting of the packer. Also, only the important operational procedures will be mentioned. Assuming a pay zone Z is located, then of course the normal mud circulation fluid will maintain or hold the production in until the mud is displaced or, in other words, the mud weight is maintained higher than the bottom hole pressure of the production. The casing C is now put in the well and perforated at the zone Z in a well known manner. Next, the packer is run down the well and set as shown in Figure 1 and, of course, some mud will remain beneath the packer P, but in any event the production will, in conjunction with spring 38, maintain the valve 36 closed. Following this, by well known means the mud above the packer P is displaced with other fluid such as oil or oil distillate which results in a high pressure differentials below and above the packer. Now the coupling unit 23 is connected to the head 21, the tubing 24 connected all the way to the surface and the Christmas tree X is assembled substantially as shown, except for the installation of the safety valve 33 and line 31. To equalize the pressure below and above the valve 36, fluid must be pumped into tubing 24 and 43 or, in other words, into the production line tubing above the valve 36 and this is done in a well recognized manner. In addition to these preparatory steps many others take place in readying the apparatus for production, such as the usual procedures of acidizing, sand-fracing and swabbing.

Preferably liquid under sufficient pressure is now supplied to annular space S from a source 35 and through line 34. Any hydraulic fluid is satisfactory and of course the source 35 is readily available at the well surface, as well as suitable gauges for determining the pressure thereof. The chosen pressure of the liquid is such as to cause the liquid to flow from space S through ports 50 into passage 44 and move piston 45 to the dotted line

position, whereupon the valve 36 will be fully opened and production will flow through tubing 46 and the rest of the tubing to line 31 and to the main separator not shown.

After the well has become balanced and production has been flowing for a desired interval, then safety valve 33 is connected as shown in Figure 2 and adjusted for a predetermined setting whereby in the event the pressure of flow within line 31 drops a predetermined amount, the pressure within annulus S may be released through the valve 33 and the piston 45 raised to close the valve 36 automatically. In other words, once the well is balanced, source 35 may be disconnected and the valve 33 is set to close the line 34 until production pressure in line 31 drops, whereupon the hydraulic pressure within space S is released through line 34 an amount sufficient to result in closing of valve 36. Thus it can be seen that regardless of the cause, such as equipment breakdown or hurricane damage, production is automatically shut off by means 33 controlled at the surface. Furthermore, if the separator (not shown) pressure is varied this could be sufficient to open line 34 and result in upward movement of the piston 45.

Preferably the ports 50 and passage 44 between the top of piston 45 when in an upward position and the ring 40 are packed prior to packer installation with grease or a heavy viscous fluid to maintain the mud from invading the ports and cylinder and thus particles normally included in the usual circulation fluid will not interfere with later operation of the piston. It has been mentioned that quite often, especially in off shore production, a multiplicity of production lines 31 are connected to a common separator station. In such a case mechanical or electronic control means may be provided at the station for varying the pressure within lines 31 sufficiently to release the liquid pressure within spaces S and shut down quickly all wells simultaneously or individually as the situation dictates.

Referring to Figure 3, in the event it is not desired to provide the ports 50 within the cone 15, then it is merely necessary to elongate the body 10 and provide ports 50' above the cone. Of course, some of the other parts will be altered in size and shape as illustrated by the primed references of Figure 4. In any event, in the claims the phraseology "ports in said body member" is meant to include ports 50 or 50'.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. In apparatus for wells, a casing within the well extending from the surface to adjacent a production zone, a packer unit having an elongated body with a passage therethrough adapted to be set in sealed off condition in the well casing adjacent the bottom thereof, a production shut off valve connected to the lower end of said body and normally biased to closed position to close the lower end of said passage, hollow tubing connectable with the upper end of said body and extending to adjacent the surface of said well, said casing and tubing forming an annular passageway from above the packer unit to the well surface, a plurality of ports in said body for providing liquid flow relationship between said passage and passageway, production pipe positioned within said body passage communicating with said tubing and forming with the interior wall of said body an annular space extending from above the points of entry of said ports into said passage to adjacent the lower end of said body, means for sealing the top of said annular space, a piston within said annular space having depending therefrom a second production pipe arranged to telescope relative to said first

pipe from an extended to a retracted position, means for normally biasing said piston upwardly to a retracted position within the space whereupon said second pipe is within said body and above said valve, and means controlled at the surface of the well for applying liquid under sufficient pressure in said annular passageway and through said ports into said space to force said piston downwardly therein and thus cause said second pipe to move to an extended position to thus fully open said shut off valve and communicate with the production zone therebeneath.

2. Apparatus as defined in claim 1 wherein the inside surface of said body beneath said sealing means and the outside of said first production pipe forms a cylinder for said piston and wherein adjacent the bottom of said passage there extends from said body and into said passage stop means for limiting the upward movement of said piston.

3. Apparatus as defined in claim 2 wherein the bias means for said piston is a coiled spring having one end abutting the piston.

4. Apparatus for wells conditioned for production wherein there is provided a casing within the well extending from the surface to adjacent a production zone comprising hollow elongated body means, a production shut off valve carried by said body means at the lower end thereof and normally biased to closed position to close the lower end of said body means and prevent production from passing upwardly therethrough, production tubing connected with said body means in production flow relationship and extending to adjacent the surface of said well, packer means operatively associated with said body means adapted to be set in sealed off condition in the casing, said tubing and body means forming with said casing an annular passageway from above the packer means to the well surface, fluid operated piston means operatively associated with and located within said body means for opening said valve to permit production to flow through said body means and tubing to the well surface, means including at least one opening in said body means above the packer means for providing separate liquid flow relationship between the annular passageway and said piston means, and means for applying at the well surface liquid under sufficient pressure in said annular passageway and through said opening to cause said piston means to move to a position to engage and open said valve.

5. Apparatus as defined in claim 4 wherein there is provided at the surface of the well an adjustable liquid pressure responsive means connected in circuit with production flowing from said tubing and with the liquid maintained within said annular passageway, the pressure responsive means functioning to normally maintain the liquid pressure but having been set whereby, in the event of a predetermined reduction in the pressure of the production, the pressure of said liquid maintained within the said annular passageway will be automatically released and the piston means returned to its normal position and the valve closed.

6. Apparatus as defined in claim 4 wherein said piston means includes a piston and a member depending therefrom for engaging the shut off valve upon movement of the piston under fluid pressure from a retracted to an extended position.

7. Apparatus as defined in claim 6 wherein there is provided means for normally biasing the piston means to a retracted position and wherein there is provided stop means for limiting the extent of the retracted position of the piston means.

8. Apparatus as defined in claim 4 wherein there is positioned within the hollow area of said body means a production pipe communicating with said tubing and and forming with the interior wall of said body means an annular space extending from above the points of entry

of said opening into said hollow area to adjacent the lower end of said body means, means for sealing the top of said annular space, said piston means being movable within said space and comprising a piston having depending therefrom a second production pipe arranged to telescope relative to said first named production pipe.

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