May 16, 1944. W. E. GILBERT 2,349,164

BOTTOM HOLE INTERMITTER FOR PUMPING WELLS

Filed July 20, 1942

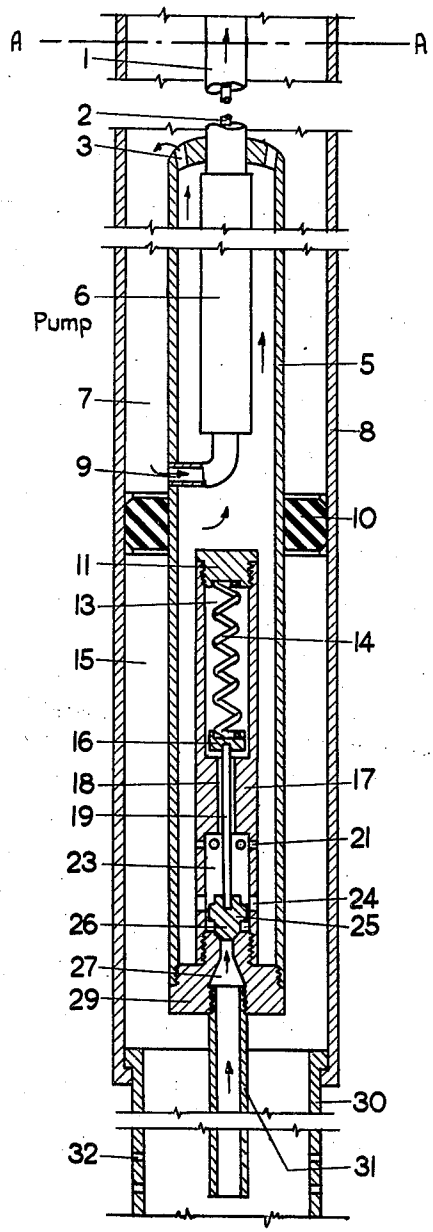


Fig. I

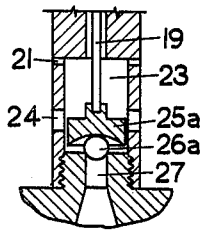


Fig. II

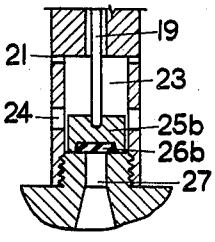


Fig. III

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Patented May 16, 1944 2,349,164

UNITED STATES PATENT OFFICE

2,349,164

BOTTOM HOLE INTERMITTER FOR PUMPING WELLS

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Application July 20, 1942, Serial No. 451,641

2 Claims. (Cl. 103—203)

The present invention relates to apparatus for increasing the output of wells producing oil and gas by pumping, and pertains more particularly to an improved bottom hole intermitter for such wells.

A pumping well normally comprises a string of casing, which may be open or closed at the casing head, and a string of tubing depending within the casing. The tubing string is provided with a pump near its lower end, and the output of said pump is raised to the surface through said tubing string.

In wells producing appreciable amounts of gas together with the oil, it has been customary to vent or withdraw continuously from the annular space between the casing and the tubing the gas produced with the liquid and separated therefrom prior to entrance into the pump, whereby it was expected to reduce the back pressure on the producing sand, and to promote the entry of liquid and gas into the well.

However, difficulty is frequently experienced in securing an adequate separation of the gas from the liquid prior to the entry thereof into the pump, which results in a low liquid volumetric efficiency of the pump operation, and in choking effects due to mist or foam accumulations in the annular space between the casing and the tubing, which in turn cause back pressures against the producing sand and thus limit rates of inflow to the well from producing formations.

It has been found that an improved separation of oil from gas produced therewith may be obtained by periodically interrupting the venting or withdrawal of gas from the annular space between the casing and the tubing. In such cases, an intermitter attached at the surface to the casing outlet, as disclosed in the applicant's co-pending application, Serial No. 375,140, filed January 21, 1942, serves to eliminate or minimize the above undesirable effects and to increase the production of oil for a given pump displacement.

However, such a surface intermitter has a limited effectiveness, since gas continues to bubble through the oil in the well throughout the intermitter cycle, and when the casing is of relatively large diameter, the velocity of the gas is not effectively reduced when the casing outlet at the surface is closed by the intermitter.

It is therefore an object of the present invention to provide a bottom hole intermitter, whereby the flow of gas is periodically interrupted at a point in the well below the pump, and the bubbling of gas from below the pump through the oil in the annular space between the casing and the tubing is completely stopped during the periods when said intermitter is closed.

It is also an object of this invention to provide an intermitter comprising a packer surrounding the tubing string and completely shutting off the annular space around said string, the intake of the pump opening to said annular space above said packer, and the fluids from the producing formation being admitted to the pump intake through an intermitting valve arranged below said packer.

It is known that gas may be produced with the oil partly in the form of a gas dissolved therein at the pressures and temperatures prevailing in the formation, and partly in the form of free gas present in the oil in the form of bubbles of varying size.

The proportional amount of dissolved gas which will come out of solution due to pressure drops in the pump, with deleterious effect on liquid volumetric efficiencies, may be minimized by means such as disclosed in U. S. Letters Patent No. 2,179,481, to C. J. Coberly, wherein the oil-gas solution is passed through a restricted orifice of a size controlled by a plunger valve responsive to well conditions, and the gas is released from solution by expansion due to a release of pressure.

However, the Coberly system does not depart materially from established practice in its provision for separating free gas from the oil, and specifically cannot perform the function here disclosed, since the Coberly valve is a slow response valve normally adapted to increase or to decrease the degree of aperture of the expanding orifice, but not to open or close said orifice in the periodical manner of an intermitter.

It is, therefore, a further object of this invention to provide the present intermitter arrangement with a snap-action valve inherently adapted to assume a totally closed or a totally open position, thereby contributing to a periodical intermitting action.

These and other objects of this invention will be understood from the following description taken with reference to the attached drawing, where Fig. 1 is a diagrammatic cross-section view of the present bottom hole intermitter, and Figs. 2 and 3 show variants of the valve of Fig. 1.

Referring to Fig. 1, 8 designates a casing string depending into a well from the surface and having a lower portion or liner 30 having perforations 32 through which the fluid from the producing formation flows into the space within the casing.

A tubing string 1 depends within the casing and supports a pump 6, which may be of the reciprocating type actuated from the surface by

means of a sucker rod string 2 within the tubing, although other types such as fluid operated pumps, or centrifugal pumps, may be used with equal advantage for the purposes of this invention.

The tubing string 1 has likewise attached thereto near its lower end a tubing extension 5 surrounding the pump 6. The annular space between the pump 6 and the tubing 5 is in communication with the annular space between the tubing and the casing 8 by means of passages 3.

A packer 10, which may be of the collapsible type, is mounted around the tubing 5, and may be expanded when desired, by means well known in the art, into contact with the casing 8, thus completely separating the annular space between the casing and the tubing into a lower annular space 15 and an upper annular space 7.

The pump 6 is not in communication with the space within the tubing 5, but opens to the upper annular space 7 by means of the intake 9.

The tubing 5 extends to a desired length below the pump 6 and the packer 10, and is closed at its lower end by a plug 29, having a central bore 27 therethrough.

A whicker-bill tubing 31, extending, for example, to a level near the bottom of the perforations 32, is in register with said bore and is supported from the lower side of the plug 29.

The plug 29 supports on its upper side a valve assembly member 17, comprising a cylindrical member having a small diameter central bore 18, and enlarged bores 13 and 23 at its upper and lower ends, respectively.

The lower bore 23 is held in screw-threaded attachment with an upwardly extending projection of the plug 29, thus forming within the valve assembly member 17 a chamber which is in communication with the whicker-bill 31 through the orifice, passage or bore 27, and with the annular space between the valve-assembly member and the tubing 5 through a plurality of openings 21 and 24.

The upper bore 13 is closed by a plug 11, and forms a chamber holding loading means, such, for example, as a spring 14, compressed between said plug 11 and a cup 16 slidably fitting within the chamber. It will be understood that the essential function of the spring is to load the plunger, or, in other words, to augment the gravitational force tending to seat the plunger and that this function may be suitably performed by other means such as replacement of the spring by a weight, or simply by a proper selection of the mass of the slidable plunger parts.

A stem 19 is attached to the cup 16 and passes through the central small bore 18 into the lower bore 23, being attached at its other end to a plunger or piston 25, slidably fitting within said bore, a certain amount of leakage being permitted between the outer periphery of the plunger 25 and the walls of the bore 23.

The plunger 25 has on its lower face a reduced portion 26 adapted to seat against the valve seat formed by the orifice 27 and to shut off communication between chamber 23 and the fluid tending to enter tubing 5 through the whicker-bill 31, said plunger being actuated into closing position by the spring 14.

The particular form of the plunger 25—26 has been shown in Fig. 1 as effective in giving a fluid-tight seal between the member 26 and the seat formed by the orifice 27. It is, however, clear that other valve arrangements, such as shown in Figs. 2 and 3, can be equally well used. Thus, Fig. 2 shows a valve having a ball member 26*a* and a separate ball-urging plunger member 25*a*. Fig. 3 shows a single-diameter plunger member 25*a*, wherein a fluid-tight seal may be achieved either by precise machining or by using a fluid-tight gasket 26*b*. In all cases, the only operatively essential feature is that the plunger 25 have a diameter considerably larger than that of the orifice 27, through which the pressure differential is applied to the valve, as will be fully explained below.

In operation, the present apparatus is lowered into a well on the tubing 1, and the packer 10 is expanded, thus separating the fluid standing in the well into a portion extending from the bottom of the well up to the packer, and a portion extending from the packer up to the surface of the fluid, such, for example, as a level A—A.

At the outset, static conditions usually prevail in the well, and there is no differential pressure acting either across the packer 10 or the valve assembly 17. The plunger projection 26 shuts the passage 27 by the downward-acting force of the spring 14, which is applied through the stem 19, since the upward-acting bottom hole or well pressure at the level of the valve, acting against the plunger over an effective area equal to the cross-section of passage 27, is balanced by the equal downward-acting hydrostatic head of the fluid standing up to the level A—A, said head being applied, due to the leakage around the portion 25 of the plunger, to an area equal to that against which the upward pressure is applied.

However, when the pump 6 is started, liquid from the upper annular space 7 is drawn through the pump intake 9 and forced upward through the tubing string 1 to the surface.

This reduces both the fluid pressure acting at the pump intake 9, and the pressure or head acting downwardly on the seating area of projection 26.

Since static conditions still prevail in the lower annular space 15, a differential pressure develops which finally becomes sufficient to overcome the force of the spring 13, thus lifting the plunger 25.

As soon as the projection 26 of the plunger 25 is unseated, the differential pressure, due to the small value of the leakage permitted around the plunger 25, begins to act on the whole lower face of the plunger 25, which has a much greater area than the projection 26, with the result that the plunger 25 is instantly snapped back to its uppermost or fully open position, driving the fluid above the piston out through the ports 21, and opening ports 24 to communication with the bore 27.

The differential pressure then causes an upward flow of liquid and gas from the space below the packer through the whicker-bill 31, bore 27, ports 24, the space within the tubing 5, ports 3, and into the upper annular space 7.

Throughout this portion of the intermitter cycle, the pressure differential maintaining the valve in its open position is the difference between the pressure within the chamber 23, which acts against the lower face of plunger 25, and the pressure within chamber 5, which acts against its upper face through the ports 21, said difference of pressures being due to the pressure drop caused by the fluid flow through ports 24.

Since this upward flow reaches a peak capacity and then diminishes, this pressure differential becomes, after a period of time, less than the downward acting force of the spring 14. The valve then closes, and remains closed until the accumulation of pressure in the space below the

packer and the reduction of pressure due to pumping from the upper annular space 7 result in a differential pressure sufficient to unseat again the projection 26.

As an illustrative example, assuming the initial hydrostatic head at the valve of the fluid standing up to the level A—A to be 400 lbs. per sq. inch acting equally upward and downward on the seated valve, the force of the spring 14 to be 32 pounds when fully extended and 52 pounds when fully compressed, the area of the lower face of plunger 25 to be 4 sq. inches, and the cross-section of passage 27 and projection 26 to be 1 sq. inch, the valve will not open initially until the fluid pressure acting downward on the seating area of projection 26 has been reduced below 368 lbs. per sq. inch. When, however, the projection 26 is unseated, the plunger will be snapped back to its open position by the application of the 32 pounds per sq. inch differential pressure to the total lower face of plunger 25, and will remain open, with intercommunication between the throat 27 and the ports 24 until the total upwardly acting differential fluid pressure on the plunger 25 becomes less than (32/4=) 8 lbs. per sq. inch, at which time the valve will close again.

It will therefore be seen that the valve will remain closed until the differential pressure acting upwardly on the valve exceeds 32 lbs. per sq. inch, and will remain open until this differential drops below 8 lbs. per sq. inch, thus giving the desired intermitter action. The above values, of course, are given only by way of example, and the present apparatus may be adjusted to meet any specific well conditions or pressure ranges, for example, by inserting in each case a pre-set spring of the proper compressive force into the chamber 13, and by selecting proper sizes for the plunger 25—26 and the ports 21 and 24 of the valve assembly.

When the valve is open, and the fluid comprising oil and free gas emerges through the ports 3, the gas tends to flow upwards, and the upper annular space 7 below the ports 3 and above the packer 10 serves as a downpass of a gas anchor permitting the gas to separate from the oil before the latter is drawn into the pump intake 9. When the valve is open, therefore, the present intermitter and pump combination operates in the conventional manner of a pump equipped with packer-type gas anchor. Under these conditions, the initial percentage of free gas in the liquid and the flow velocities in the downpass often prevent a satisfactory degree of oil-gas separation.

However, during that portion of the intermitter cycle when the valve is closed, the supply of gas through the ports 3 is cut off, and the free gas still remaining in the fluid present in the upper annular space 7, both above and below ports 3, tends to ascend through the fluid in said annular space, whereby the amount of free gas entering the pump intake 9 is effectively minimized. Also, during this portion of the intermitter cycle, the reduced gas flow will help to dissipate any accumulations of mist or foam above restrictions, such as tubing catchers, in the annular space between the casing and the tubing, which accumulations tend to create unnecessary back pressures against the producing formations, and thus to limit rates of fluid entry to the well.

It will be seen from the above that the present invention provides a system for intermittent natural fluid flow through a snap-action valve from a lower space underlying a packer to an upper annular space above said packer, and for production by pumping from said upper annular space, which system increases the efficiency of the pump, decreases the back-pressure on the producing formation, and frequently makes it practicable to pump from shallower pump settings than those required when conventional equipment is used.

I claim as my invention:

1. A bottom hole pressure intermitter system comprising a packer adapted to be set in a well, means comprising a pump for continuously withdrawing well fluid from the space above the packer, a conduit extending through the packer and adapted to deliver the fluid from the space below the packer to the space above the packer, a cylindrical valve chamber within said conduit, ports in communication between said chamber and said conduit, means comprising an orifice forming a valve seat for admitting fluid from the space below the packer into said chamber the diameter of said orifice being substantially smaller than that of said chamber, a valve plunger comprising an enlarged diameter member adapted for loose sliding reciprocation within said chamber and a reduced diameter member adapted to close said valve seat, and adjustably pre-set loading means adapted to urge the reduced member of said plunger into closure with said valve seat against fluid pressure differentials acting across the valve, whereby the ratio of the pressure differentials at which said valve opens and closes is substantially equal to the ratio of the diameters of the enlarged member of said plunger and of said orifice, respectively.

2. A bottom-hole pressure intermitter system comprising a packer adapted to be set in a well, means comprising a pump for continuously withdrawing well fluid from the space above the packer, a conduit extending through the packer and adapted to deliver the fluid from the space below the packer to the space above the packer, a cylindrical valve chamber within said conduit, means comprising an orifice for admitting fluid from the space below said packer to said chamber, the diameter of said orifice being substantially smaller than that of said chamber, port means in the walls of said chamber in communication between said chamber and said conduit, valve means comprising a plunger adapted for reciprocation within said chamber between a plunger position below said port means closing said orifice and a plunger position above said port means opening said orifice, said plunger being adapted for a loose sliding fit within said cylindrical chamber, and adjustably pre-set loading means independent of fluid pressures adapted to urge said plunger valve means to close said orifice against pressure differentials acting on said plunger, whereby the ratio of the pressure differentials at which said orifice is opened and closed by said plunger valve is substantially equal to the ratio of the respective diameters of said plunger and said orifice.

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