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WELL PUMPING APPARATUS

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This invention relates to the pumping of wells and particularly oil wells of such great depths that conventional apparatus cannot be used therein, due to the stresses in the pump rods.

Heretofore, in wells that would permit of such operation, a pump barrel has been located at the bottom of the well and operated by sucker rods extending downwardly from the walking beam at the surface of the ground. The weight of the rods and the oil lifted thereby is such as to cause stresses on the upward or power stroke that may extend or stretch the rods as much as three feet. The constant reversal of these stresses and the resulting vibrations and whipping set up in the rods causes frequent breakage with damage to the well and attendant loss of production.

In order to overcome these difficulties, it has been proposed to combine such a pump with a conventional gas or air lift, the latter being installed part way down the well, to lighten the upwardly flowing oil from the pump and reduce the load on the latter. A further advantage not generally appreciated is the disproportionate and very advantageous reduction of pressure on the face of the producing strata at the bottom of the well. A concrete example of this will be given later in this specification.

Such an arrangement has been disclosed, as in the Patent No. 1,753,930 issued April 8, 1930 to Charles Jacobsen. The apparatus there proposed and so far used in the industry, however, utilizes a packer to close off the casing below the gas lift foot piece and permit gas to be admitted thereto from the surface. Such a packer or its equivalent has proved to be extremely difficult to remove from a well for cleaning, repairs, etc. and this invention contemplates broadly an improved arrangement, which will permit ready removal of any part of the pump or tubing strings without interference with the well casing or tubing not directly involved.

It is an object of this invention to provide a combination of a pump and a gas lift, the tubing strings being arranged without a packer, and so disposed that the pump or innermost tubing strings may be readily removed for cleaning, replacement, or the like, without disturbing the remaining equipment in the well.

Another object is to provide an improved foot piece for a gas-lift pump arrangement of the type disclosed, which may be inserted inside a string of tubing, and which will permit a pump barrel and valves being withdrawn therethrough without removal of the tubing from the well.

These and other objects and advantages will be more fully apparent from the following description and from the appended drawing, which forms a part of this specification and illustrates a preferred embodiment of this invention. In the drawing:

Figure 1 is a vertical sectional view of the upper portion of a well bore, showing a gas lift foot piece constructed according to this invention and illustrating diagrammatically a possible casing head arrangement.

Figure 2 is a vertical sectional view of the lower section of a well bore, and is a downward continuation of Figure 1, illustrating diagrammatically a pump and valve arrangement at the bottom of the well.

Referring to the drawing, and particularly to Figure 1, the numeral 10 represents a casing which lines the well and which may be perforated at its lower end as at 11 to admit oil into its bore. Casing 10 may be provided at its upper end with a nipple 12 from which well fluid may be withdrawn or which may be closed, as desired. The upper end of casing 10 is fitted with a conventional packed casing head 13 and 25 slips 14, by means of which a string of tubing 15 is supported in the well. Tubing 15 is provided with a nipple 16 which may be connected to a high pressure source of gas or air. Tubing 15 also is fitted with a packed casing head 17 and 30 slips 18, by means of which a second smaller diameter string of tubing 19 is partially supported within tubing 15. Inner tubing string 19 is provided at its upper end with a flow line 20, from which oil and gas may flow to a conventional separator.

The top of inner tubing string 19 is closed by means of the conventional packed polish rod guide 21, through which passes the polish rod 22 at the upper end of a string of sucker rods 23. Polish rod 22 is connected at its upper end to any suitable operating mechanism to give it a reciprocating motion.

At the lower end of the sucker rod string 23 (Figure 2) is a conventional pump of any desired type, consisting generally of a travelling valve 24, working barrel 25 and standing valve 26. The standing valve 26 is preferably connected with the pump barrel 25 by means of a lost motion device 27, so that, by lifting the sucker rods 23 beyond their normal travel, the standing valve body 26 will be lifted off its bevelled seat 28 and taken out of the well together with the sucker rods 23 and pump barrel 25.

Referring again to Figure 1, it will be noted

that the outermost tubing string 15 terminates at its lower end in a collar 29 provided with an inwardly bevelled seat 30. At a corresponding point intermediate the length of the inner tubing string 19 is interposed a foot piece 31, with a correspondingly bevelled shoulder 32. This joint between seat 30 and shoulder 32 is preferably ground or at least accurately machined and of such configuration that a portion of the weight of the inner tubing string 19 will maintain a substantially fluid tight joint, but one which is readily broken, as by lifting out the inner string. The inner diameter of foot piece 31 is such that pump 25 and its attendant valves, etc., may easily be passed therethrough.

Foot piece 31 is also provided with a plurality of passages 33 through its wall, so that gas or air passing downwardly through the annular space between outer tubing string 15 and inner tubing string 19 will be admitted into the bore of the latter, to act as a gas or air-lift and thus relieve the burden on the pump barrel 25 and sucker rod string 23. Another and more important advantage, however, is the material reduction in pressure upon the face of the oil producing formation, as will be seen from the following illustration.

Assume a well 7000 feet deep producing 25° A. P. I. oil containing 100 cu. ft. of gas per barrel in solution. With a 2" inner tubing string 19 and a 3½" or 4" outer tubing string 15, and a foot piece 31 at 4000 feet, the pump 25 would lift the oil 3000 feet to the foot piece, at which point about 200 cu. ft. per barrel of additional gas would be added, at a pressure of about 600 lbs. per sq. inch, which would lift the oil to the surface. Back pressure at the surface in the separator is assumed at 35 lbs. per sq. inch. The following table shows the disproportionate improvement in the well pressures:

Pressure at—		With gas-lift	Without gas-lift
45	4000 ft.-----	540#	1270#
	7000 ft.-----	1730#	2460#

In operation, as outlined above, the pump 25 and sucker rods 23, together with the standing valve body 26, can be removed without disturbing the tubing strings 15 and 19. In case the pump becomes stuck so that it cannot be removed, the inner tubing string 19 containing the pump and its rods may be removed without disturbing the outer string 15, the bevelled shoulder 32 readily lifting off its seat in collar 29. There are no packers to become stuck or frozen to the casing and all of the pump and gas lift equipment may readily be pulled out of the well without the possibility of a fishing job or damage to the casing.

It will be appreciated that this invention is adapted to wells with several strings of casings, and that other details of construction or modes of operation may be substituted for those here described and illustrated, such as, for example, other modes of making a fluid tight and yet easily separable joint between the foot piece and the surrounding tubing strings. In consequence the invention is to be limited in scope only as may be expressed in the appended claims.

I claim:

1. In a well pumping apparatus utilizing a gas-lift at an intermediate point therein, the combination of an outer tubing, means at the lower end of said tubing forming a seat, an inner tubing extending through and below said outer tubing and provided with means to co-act with said seat to form a fluid-tight joint whereby said inner tubing may be removable from said well independently of said outer tubing, said inner tubing provided with passages above said last named means through which gas may be passed from the space between said outer and inner tubings into the bore of said inner tubing.

2. In a well pumping apparatus utilizing a pump in the bottom of a well and a gas-lift at an intermediate point therein, said pump acting to lift fluid to a point where said gas lift will operate to urge the fluid toward the surface, the combination of an outer tubing, means at the lower end of said tubing forming an inwardly directed seat, an inner tubing extending through and below said outer tubing and provided with a shoulder to rest on said seat and form a fluid-tight joint therewith whereby said inner tubing may be removable from said well independently of said outer tubing, said inner tubing provided with passages above said shoulder through which gas may be passed from the space between said outer and inner tubings into the bore of said inner tubing.

3. In a well pumping apparatus utilizing a pump in the bottom of a well and a gas-lift at an intermediate point therein, said pump acting to lift fluid to a point where said gas lift will operate to urge the fluid toward the surface, the combination of an outer tubing, means at the lower end of said tubing forming an inwardly directed seat, an inner tubing extending through and below said outer tubing, a foot-piece in said inner tubing provided with a shoulder adapted to rest on said seat, the bore of said foot-piece being of such size as to permit the withdrawal of said pump from said well independently of said tubing.

4. A well pumping apparatus according to claim 3 in which said inner tubing is of such size as to permit its withdrawal independently of said outer tubing.

5. In a well pumping apparatus utilizing a pump in the bottom of a well and a gas-lift at an intermediate point therein, said pump acting to lift fluid to a point where said gas lift will operate to urge the fluid toward the surface, the combination of an outer tubing, an inwardly directed seat at the lower end of said tubing, an inner tubing extending through and below said outer tubing, means in said inner tubing adapted to rest on said seat, and a pump in said inner tubing below said means, the diameter of said pump and said inner tubing below said means being such that they may be withdrawn together from said well through said seat.

6. A well pumping apparatus according to claim 5 in which the said means in the inner tubing which rests on the said seat comprises a perforated foot piece.

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