June 4, 1968 J. O. FAIR 3,386,390

GAS ANCHOR

Filed July 28, 1966 2 Sheets-Sheet 1

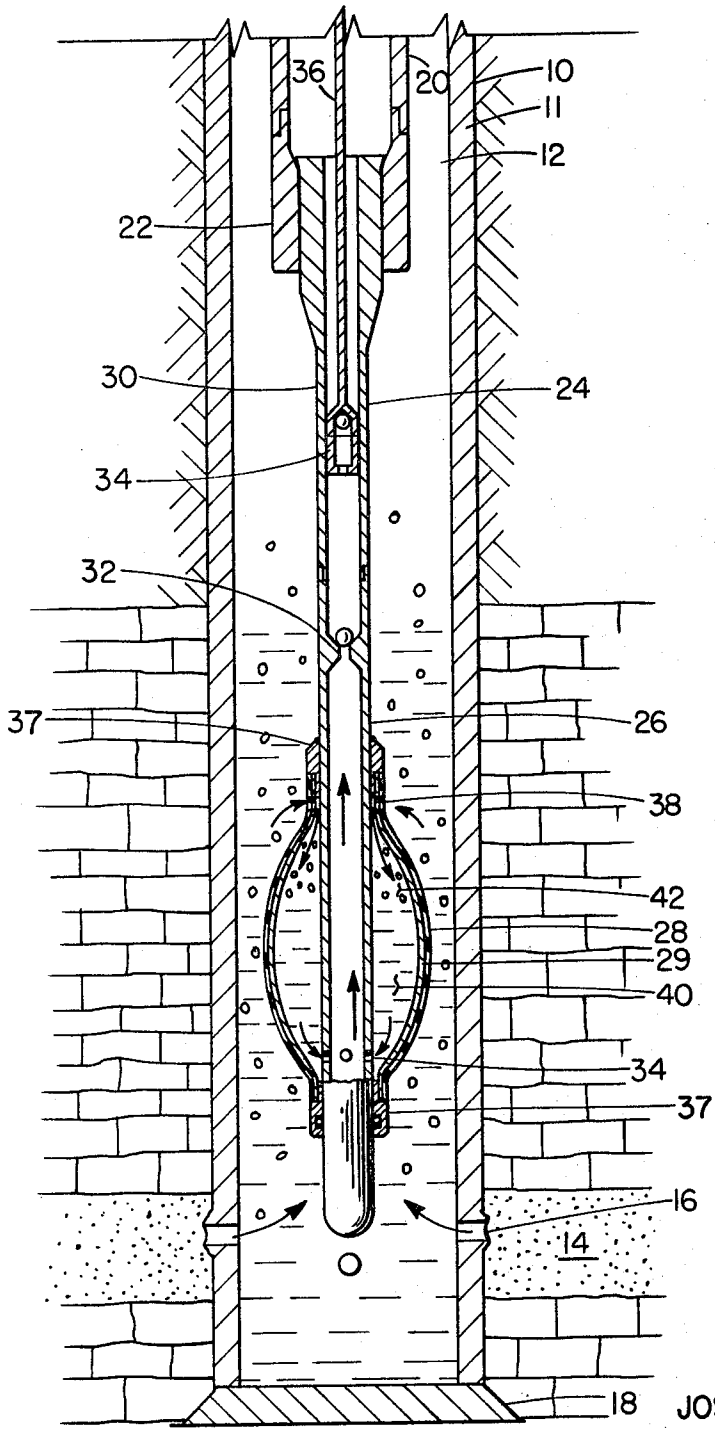


FIG-1

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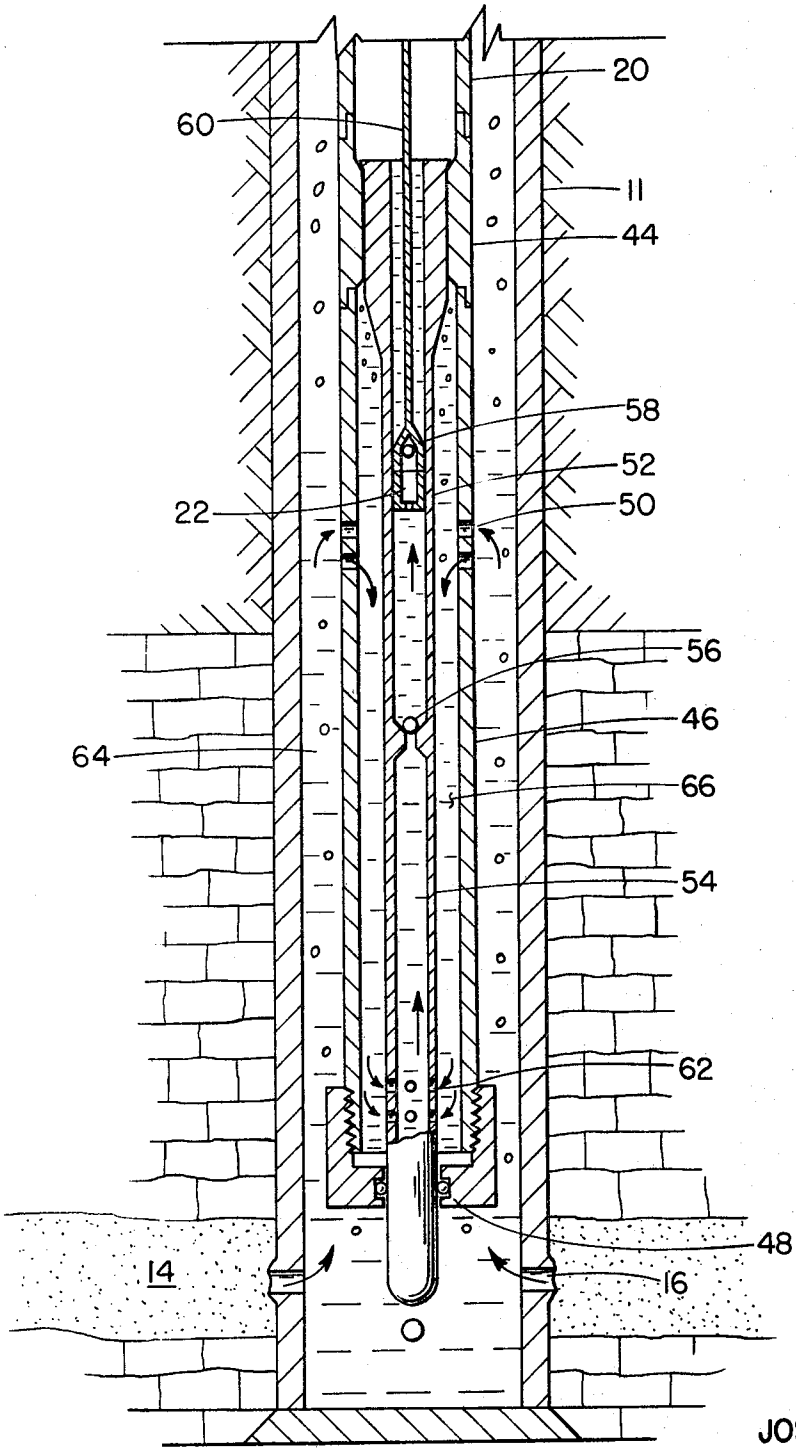


FIG.-2

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GAS ANCHOR

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ABSTRACT OF THE DISCLOSURE

This invention concerns a gas anchor for use in an oil well. When oil can no longer be produced of its own energy, a pumping barrel and gas anchor are lowered down through the string of tubing and extend out the lower end thereof. The upper end of the working barrel of the pump is seated in a landing nipple at the lower end of the string of tubing. A collapsible sleeve surrounds a dip tube which is supported at the lower end of the pump barrel. Bow springs are provided inside the collapsible sleeve and once the sleeve and dip stick leave the lower end of the tubing, the sleeve is expanded out and together with the dip tube forms a gas anchor.

This invention relates to the pumping of oil from underground reservoirs penetrated by a well bore. It relates especially to an improved gas anchor for downhole separation of oil and gas.

When a well is first completed in an underground reservoir, i.e., an accumulation of oil and gas within the formation rock, oil from the rocks is usually forced into the well bore and to the surface by the pressure of gas either as a gas cap or gas within the oil. After a well is produced for a considerable period of time, it is normal for the wells to cease to flow naturally because of the decline in pressure. When this occurs, it is necessary to resort to artificial lifting means. Such lifting means normally takes the form of a reciprocating pump which is placed downhole and reciprocally driven by a string of sucker rods suspended in the well bore. The pump itself is normally supported at the lower end of a small string of pipe which is commonly called tubing which is suspended within the well bore. The pumped oil is pumped upwardly through the string of tubing around the string of sucker rods.

For effective operation of such a pumping system, the oil and gas must be separated downhole so that a major portion of the gas escapes up the annulus between the string of tubing and the well bore and essentially only oil is pumped by the pumping unit. Normally the gas separation is effected by use of a device known as a gas anchor. One of the drawbacks of the use of the more conventional gas anchor on wells which have ceased flowing and require pumping is that the tubing string must be pulled, that is, removed from the well bore by removing the tubing from the well by joints and a separation chamber attached to the lower end of the tubing string. Thereafter the tubing string is reinserted in the well bore by reassembling the joints and lowering them to the desired level. The gas anchor is run as a part of the lowermost separation chamber or generally on the rods reciprocating the pump.

In accordance with the present invention, a gas anchor can be effectived without pulling the string of tubing. A preferred embodiment of this invention includes a dip tube which is supported at the lower end of a pump barrel. The dip tube has perforations in its wall adjacent its lower end which is otherwise enclosed. A collapsible sleeve surrounds the dip tube and covers the the perforations. The upper end of the collapsible sleeve means is sealingly attached to the upper end of the dip tube. The other end

of the sleeve means contacts the dip tube in a sealing and sliding relationship. There are part means provided in the sleeve adjacent the end having the sliding contact of the dip tube.

In accordance with this invention, when an oil well is originally completed, a landing nipple is provided at the lower open end of the string of tubing. The barrel of the pump which is to be inserted when the well ceases to flow is adapted to land in such landing nipple and be held firmly in place. The collapsible sleeve and dip tube, supported at the lower end of the pump barrel, are of such size that when the sleeve is collapsed, the sleeve and the dip tube readily pass through the string of tubing and the landing nipple.

After the sleeve means is passed through the landing nipple, it is expanded by suitable means such as by bow spring action. The gas and oil mixture enter the well bore at or below the level of the expanded sleeve. The oil and gas flow together upwardly into the well bore to the level above the ports in the expanded sleeve. The oil and gas tend to separate at this point as the oil flows down the inside of the sleeve and the gas bubbles escape upwardly in the annulus between the sleeve and the well bore. The oil flows downwardly by gravity inside the sleeve and through the ports in the wall of the dip tube. The oil then flows upwardly through the dip tube to the pump.

Various objects and a better understanding of the invention can be had from the following description taken in conjunction with the drawings in which:

FIGURE 1 is one embodiment of an insertable pumping system utilizing a collapsible gas anchor which can be inserted without removal of the string of tubing, and

FIGURE 2 illustrates another embodiment of a downhole pump for effecting a downhole gas anchor without removing the tubing.

Illustrated in FIGURE 1, is an expansible or collapsible type gas anchor. Shown therein is a borehole **10** in which a casing **11** has been set. The casing and hole extend through a producing formation **14** and is in fluid communication therewith through perforations **16**. The casing **11** is set in the borehole with a shoe **18** and cemented in a known manner.

Suspended within the casing **11** is a string of tubing **20** which is provided with a landing shoe **22** at the lower end thereof. An annular space **12** is formed between the string of tubing and casing **11**. A suitable landing shoe is commercially available and for example is provided by the Pacific Pumps, Inc. and designated as their Product 82–2528–2225 Seating Nipple Cup-type 2½"–8RT–EUE+45. When the well is first completed the landing seat **22** is provided at the lower end of the tubing string. A packer, not shown, is placed about the string of tubing closing the annulus in a conventional manner. Then oil flows inwardly through perforations **16** into the interior of the casing and upwardly through tubing **20**. As mentioned above when the pressure in the reservoir **14** declines to a certain point, the oil will no longer flow to the surface and must be lifted artificially. At this point of production depletion there is normally an excess of gas which would interfere with pumping if it is not separated from the oil. This problem is conveniently met in applicant's disclosed device without removing the tubing string **20**. As described above, pump **24** and the gas anchor comprising dip tube **26** and sleeve **28** as shown in FIGURE 1 are conveniently made so that they can be lowered downwardly through tubing **20**. Pump **24** includes barrel **30**, standing valve **32**, and traveling valve **34** which is reciprocated by a string of sucker rods **36** which extend to the surface.

The gas anchor mechanism includes dip tube 26 and sleeve 28. Dip tube 26 is connected to or made an integral part of the lower end of the working barrel 30 and the interior of dip tube 26 is in fluid communication with the lower end of standing valve 32. The lower end of dip tube 26 is enclosed; however, there are perforations 34 in the wall of the dip tube adjacent the lower end thereof. A collapsible sleeve 28 surrounds the lower portion of dip tube 26 including the perforations 34. Bow springs 29 urge sleeve 28 outwardly into a position such as shown in FIGURE 1. The upper end of sleeve 28 has sealing contact with the periphery of dip tube 26. This can be accomplished as shown by molding the upper end of sleeve 28 to ring 37 which is sealed to dip tube 26 by welding. This fixes the position of the upper end of the sleeve 28 with dip tube 26. The lower end of sleeve 28 is slidingly and sealingly attached to the outer periphery of the lower end of dip tube 26. This can be accomplished in any conventional way and is shown here as being accomplished by having the lower ends of sleeve 28 molded about the exterior of sliding ring 37. The bore of ring 37 may have a sealing fit about dip tube 26 by use of any suitable sealing means. The upper end of sleeve 28 is provided with port means 38 fluidly communicating the interior of the sleeve with the interior of the well bore.

In operation then, when the reservoir pressure declines to a level where pumping is required, pump 24 and the gas anchor, including dip tube 26 and sleeve 28, are lowered downwardly through tubing 20 until barrel 30 is firmly seated in landing seat 22. A suitable barrel 30 for landing seat 22 is commercially available from Pacific Pumps, Inc. and is identified as a Rod Insert Stationary Barrel Bottom Cup Holddown Pump. After sleeve 28 is passed through landing seat 22, bow springs 29 expands it to the position shown in FIGURE 1. When pumping comences by reciprocating rods 36, oil and gas flow inwardly through perforations 16 from formation 14. The fluid flowing in is a mixture of oil and bubbles of gas. The oil and gas bubbles flow upwardly until they pass port means 38. At this point the oil and a part of the gas bubbles start to flow downwardly inside sleeve 28. Separation of the gas and the fluid is primarily by gravity. To separate the gas from the oil then, it is necessary to cause the oil to flow downwardly at a rate less than the rate of the rise of the bubbles of gas. Thus it is desired that the downpass area within sleeve 28 be as large as space limitations permit. However, sleeve 28, when expanded, cannot be large enough to block the upward flow of oil and gas exterior of the sleeve. Typically sleeve 28 can be made to expand to about 4¼ inches in diameter for 5½ O.D. inch casing 11. The vertical or longitudinal dimension of sleeve 28 will depend upon the quantity of oil and gas to be separated; typically this can be about 8 feet. The oil and gas are separated in the sleeve 28 so that the fluid 40 in the lower part of the sleeve is primarily oil alone whereas the fluid 42 in the upper part of the sleeve contains some gas bubbles which have not yet escaped. The oil flowing inwardly through perforations 34 into dip tube 26 is then relatively free of gas bubbles. Freed gas to the annulus is liberated from the annulus at the surface.

FIGURE 2 illustrates another embodiment whereby a gas anchor can also be effected downhole without removing a string of tubing. The embodiment of FIGURE 2 like that of FIGURE 1, requires preliminary modifications of the lower end of the conventional string of tubing so that such gas anchor can be effected when desired. The embodiment in FIGURE 2, like FIGURE 1, includes a string of tubing 20 suspended within casing 11 which has been set through producing formation 14. The lower end of tubing 20, when it is first run, is provided with a landing nipple 44, a tubular extension 46 secured to the lower end of landing nipple 44, and a landing shoe 48 on

the lower end of extension 46. Typically nipple 44 must have, for example, .060 inch less diameter than landing shoe 48. The tubular extension 46 has a series of perforations 50 in the upper end immediately below landing nipple 44 and considerably above landing shoe 48. The lower end of tubular extension 46 is in open communication through landing shoe 48 with the interior of casing 11 to have the benefits of open tubing completion. Thus when the well is flowing, fluid flows inwardly from the formation 14 through perforations 16, up through the lower end of landing shoe 48, tubular extension 46, or perforations 50, and into tubing string 20 where it is conducted to the surface.

When the well ceases to flow, it is necessary to use an artificial lift system. The artificial lift system of FIGURE 2 takes the form of a reciprocating pump 52 having dip tube 54. Pump 52 is similar to pump 24 of FIGURE 1. It includes a standing valve 56 and a traveling valve 58 which is connected to, and reciprocated by, sucker rods 60. The lower end of dip tube 54 is provided with perforations 62. The gas anchor then includes tubular extension 46 and dip tube 54. After insertion of the pump 52 and dip tube 54 (which are lowered by rods 60 and the barrel of the pump forced into landing nipple 44 and dip tube 54 into landing shoe 48) the embodiment takes on the form shown in FIGURE 2. As the gas and oil mixture flows upwardly in annulus 64 between the string of tubing and the casing, oil and gas will tend to run in perforations 50 when pumping operations start. As the oil and gas are flowing downwardly in the annulus 65 between dip tube 54 and tubular extension 46, oil is separated from the gas by gravitation as the gas still wants to go up. If the velocity of the oil flowing downwardly in annulus 66 is less than the rate of the gas bubbles flowing up through the oil, then fairly complete separation occurs. The gas free oil then enters perforations 62 at the lower end of dip tube 54 and is then pumped upwardly by the pump through tubing string 20.

It is believed clear that by the use of either embodiment shown in FIGURE 1 or FIGURE 2 that a gas anchor can be effected at the lower end of a string of tubing 20 without pulling such string of tubing. This permits the gas anchor installation to be effected without killing the wells, that is, adding heavy fluid to the entire well bore to prevent flow of fluid out of perforation 16. Sufficient fluid of density necessary to stop flow through tubing string 20 is all that is required. This minimizes formation damages which occurs when wells are killed. With my system I also retain the advantage of open end tubing production for repairs during the time the well is flowing.

While the above embodiments of this invention has been described with a certain detail, it is to be understood that various modifications of the device can be made without departing from the scope or spirit of the invention.

I claim:

1. A device for separating oil from gas in a well bore drilled in the earth which comprises:

a pump barrel,

a dip tube supported at the lower end of said pump barrel and enclosed at its lower end, said dip tube having perforations in its wall adjacent the lower end,

a collapsible sleeve means surrounding said perforations of said dip tube, one end of said collapsible sleeve means sealingly attached to the upper end of said dip tube above said perforations, the other end of said collapsible sleeve means contacting said dip tube in a sealing and sliding relationship,

port means in said sleeve adjacent the end sealingly attached to said dip tube.

2. An apparatus as defined in claim 1 in which said collapsible sleeve means includes an elastic sleeve and a plurality of bow springs urging said elastic sleeve outwardly from said dip tube.

3. An apparatus as defined in claim 1 including a standing valve and a traveling valve within said pump barrel.

4. An apparatus as defined in claim 2 including a string of tubing suspended in said well bore and a seating nipple means at the lower end of said string of tubing to receive said pump barrel.

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