

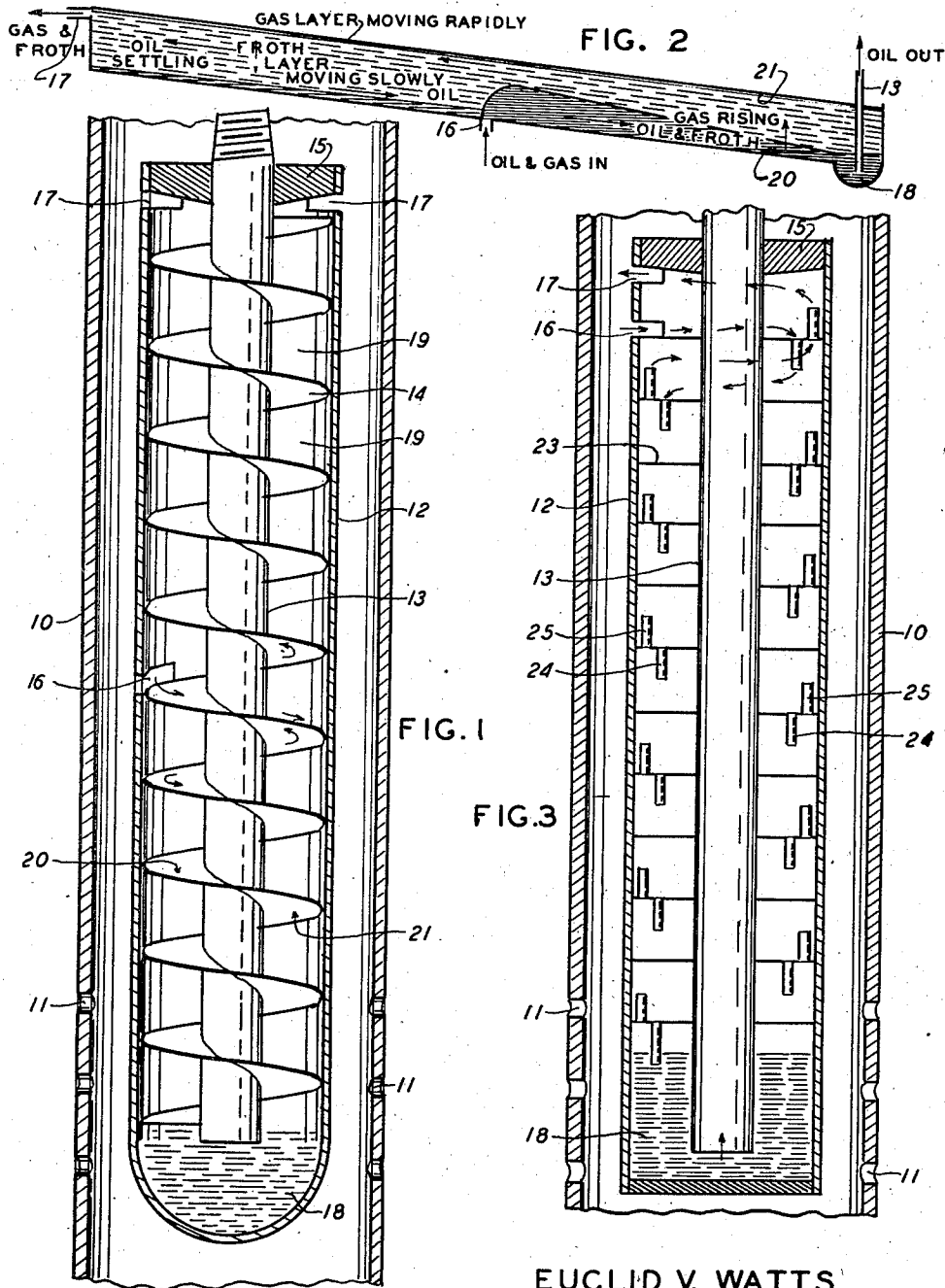
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GAS ANCHOR

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GAS ANCHOR

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1 Claim. (Cl. 103—203)

This invention relates to means for separating entrained gas from a flow of petroleum immediately before its entry into the pump by which it is raised from a subsurface formation to the surface of the earth.

In the production of petroleum, liquid oil and natural gas are frequently intimately associated in the form of a semi-stable froth or foam. This froth is produced when gas is liberated from solution in the oil by decrease in pressure or, occasionally, by turbulent flow of oil and gas through casing perforations or other restrictions.

In the case of a newly tapped reservoir this froth formation may be beneficial in reducing the hydraulic head of the column of oil in the tubing, thus causing a well to flow naturally which would have to be pumped if the froth were excluded and the tubing filled with liquid oil. But when pumping is required, the presence of the froth in the pump barrel materially reduces pumping efficiency. Not only does the froth occupy uselessly a part of the displacement volume of the pump barrel, but if in sufficient quantity, it may expand and contract with the plunger stroke to such extent as to cause gas-lock and total cessation of liquid delivery.

It is therefore customary, in cases in which froth tends to form at the pumping level, to provide the pump with a so-called "gas anchor." This device, in its simplest and most common form, is little more than an elongated cup, open at its upper end except for an attachment to the pump, and provided with an inner tube (the "skeeter bill") which extends from the pump intake to a point adjacent the lower end of the cup.

This device diverts away from the pump suction any large gas bubbles rising through the pool of oil in the bottom of the hole outside the anchor. It also, in theory, permits gas bubbles inducted into or evolved within the cup to rise and escape through the open upper end while a solid (in the sense of unbroken) annular column of oil passes down to the end of the skeeter bill and thus into the pump intake.

This theory is borne out in practice only in instances in which the upward velocity of gas bubbles relative to the oil exceeds the downward velocity of the annular column within the anchor and in which the film properties of the liquid permit the rupture of bubbles as fast as they accumulate at the top of the anchor, thereby completing the separation of the gas phase from the liquid phase.

The downward velocity is, in any given case,

a more or less fixed quantity, being determined by the quantity of oil flowing into the pump intake and the cross-sectional area of the largest column which can be accommodated within the casing. The upward velocity is a function of the viscosity of the oil and also of the size of the bubble, increasing (in an oil of given viscosity) as the square of the diameter of the bubble.

It follows, and is well recognized, that while these simple anchors function to advantage in wells giving small yields of light, low-viscosity crude, their efficiency falls off very rapidly with increasing yield, enhanced velocity and reduced bubble dimensions. For these reasons they are of little if any utility in excluding gas from pumps handling the heavier class of crudes, or large volumes of any viscosity.

The structure described herein is an improvement over the conventional form of gas anchor in two major respects: first in materially increasing the time required for the oil column flowing downwardly within the anchor to travel any given vertical distance; second in reducing the vertical distance through which the gas bubble must rise through the oil body before escaping from it.

The simple structure of the invention and the manner in which it functions are illustrated in the attached drawing, in which

Fig. 1 is a section through a casing and helical gas anchor, showing the pump intake tube in elevation;

Fig. 2 is a diagram used to illustrate the functions of the structure of Fig. 1, and

Fig. 3 is a section through a modified structure which utilizes the same operating principle as that of the first figure.

Referring first to Fig. 1, 10 is a well casing having perforations 11—11 through which oil enters, the oil carrying entrained gas. An anchor shell 12 surrounds the pump suction extension tube 13 and contains a sheet metal helix 14 closely fitting both the tube and the shell. The anchor is suspended from the suction tube by a disc 15 and the upper end of the tube screws into the suction end of a deep well pump not shown. A perforation 16 allows oil to pass from the exterior to the interior of the anchor shell and one or more perforations 17 permit the escape of gas and froth from the upper end of the anchor tube into the casing.

The opening 16 should be located more or less midway the length of the anchor tube 12 and should be in the form of a deep slot situated slightly above the helix—that is to say, the lower edge of the slot should lie far enough above the

upper side of a partial turn of the helix to prevent oil separated at a higher level from returning to the casing. The height of the slit should not exceed half the vertical distance between the turns. The opening or openings 17 should be at the extreme upper end of the anchor tube and immediately beneath the supporting disc 15. The combined areas of openings 17 should at least equal the area of opening 16.

The manner in which this device functions is illustrated diagrammatically in Fig. 2, which represents an extension of the entire length of the helical channel 19 included between the turns of the worm.

Oil with entrained gas enters the channel at 16 and flows downwardly over the upper face 20 of the worm, finally reaching the pool 18 from which oil is drawn by the pump. While so flowing, gas in the forms of free bubbles and of froth, rises to the surface and the liquid volume of the stream diminishes. The free gas bubbles rise through the froth layer until they encounter the lower face 21 of the worm, which they follow upwardly to the point of escape 17, either as large individual bubbles or as a rapidly moving thin stream.

The froth which rises to the surface of the oil stream consists of the smaller gas bubbles separated by a greater or lesser thickness of oil. So long as the proportion of oil in the mass is sufficient to permit the bubbles to retain their globular form, the froth has approximately the same fluidity as the oil, but as the oil drains out from between the globules they become closer together and the fluency diminishes. The final stage in oil drainage is that at which the bubbles are separated only by extremely thin oil films and the bubbles are distorted by mutual contact.

At this stage the froth will not flow of its own volition, but is forced upwardly between the turns of the worm by the superior weight of the entering oil, occupying whatever space is left between the upflowing gas layer and the downflowing oil stream.

During this upward movement, which carries the froth past the oil inlet and toward or to the upper end of the helical channel, the froth is subjected to forces which tend to rupture the oil films, permitting the gas to escape and the oil to coalesce into globules. These forces consist principally of the internal movements occasioned by relatively rapid movement of the interior of the helical column and retardation of the faces in contact with the walls, and of the agitation of the froth mass by large gas bubbles forcing their way over its upper surface. This froth resolving action continues throughout the length of the helical channel and under favorable circumstances may break down the froth as fast as it is separated from the entering oil. In that event only gas escapes from the upper end of the channel while the small amount of oil separated from the froth returns along the bottom of the channel to rejoin the entering stream. Ordinarily, resolution will be less than perfect and some very light froth, containing only a minute amount of oil, will be returned to the space between the casing and the anchor shell, but at a level materially above the oil inlet.

The advantage of this structure over the conventional form (which would be represented by removing the worm from the form of Fig. 1 and admitting oil at the upper end of the anchor shell) will be evident from the above description. In the prior art form the rising gas has to traverse the entire length of the downflowing oil column

before escaping. The critical velocity of oil flow is that which equals the rate of rise of the smallest gas bubbles which must be removed in order to bring the oil into condition to be pumped, and this critical velocity is not changed by lengthening the distance between the inlet point and the lower end of the shell. In the helical form the gas separates from the oil at an obtuse angle and must rise through an oil layer of less depth than the vertical distance between adjacent turns of the worm in order to escape from the oil flow into the froth mass, moving in the opposite direction and from which it cannot return. Thus in the helical form the critical limitation is not the velocity of the oil stream, but the time of residence of the oil in the channel, and this time may be increased by lengthening the anchor up to such limits as are fixed by the desired location of the pump itself.

The most desirable level for oil inlet 16 will vary with the condition of the oil column in the casing and with the rapidity with which the gas and froth separate from the entering oil. The portion of the anchor below the oil inlet performs the stripping of the oil, and the length of this portion must be sufficient to effect a substantially clean separation before the oil enters the pump suction. On the other hand, the portion of the channel above the inlet performs the greater part of the froth resolution and thus the longer this portion of the channel the less will be the quantity of froth returned to the casing outside the anchor. Also, the greater the distance between the froth outlet and the oil inlet, the smaller will be the chance of froth circulating back to the inlet with the entering oil.

Generally speaking, oils of high viscosity or in which the gas is very finely dispersed will require that the oil inlet be at a relatively high level, while with less viscous oils or those in which the gas is coarsely dispersed it may with advantage be placed lower. The optimum position for the inlet in any given well can be determined only by experiment with shells having inlets at different levels.

A modified form of the device, using a different structure but the same functional principles, is shown in Fig. 3. In this form the worm of Fig. 1 is replaced by a plurality of plates 23 dividing the annular space between shell 12 and pump tube 13 into chambers. These chambers communicate through downwardly directed tubes 24 and upwardly directed tubes 25, each of which should extend at least half way through the depth of the adjacent chamber. The inlet 16 for oil and gas may be placed immediately below the outlet 17 for gas and froth, as in Fig. 3, or at a lower level as in Fig. 1. The two communication tubes 24 and 25 should be on the same side of the plate in which they are located, with the pairs of tubes alternating from side to side in descending from plate to plate.

Oil and entrained gas enter the inlet opening 16 and flow across the plate to the downpipe 24, passing thus to the lower portion of the chamber next below. In this horizontal flow, some gas and froth are separated, rising to the top of the chamber, passing from the top chamber through outlet 17 and from each chamber below it, through the riser pipe 25, into the upper part of the chamber next above. Thus in each chamber the heavier liquid flows toward the downpipe and to the lower part of the chamber next below, while the lighter gas and froth flow over the liquid surface,

in a contrary direction, and into the upper part of the chamber next above.

The gravity difference between the oil flowing downwardly and the gas and froth being displaced upwardly is the sole motivating force available to produce flow and care must be taken not to make the communicating pipes too narrow. This form of the device is highly effective in both stripping and breaking froth but has less capacity for any given set of dimensions than the helical form.

As the pressure drops across the partitioning members in either of the forms described are wholly negligible, either the worm of Fig. 1 or the plates and tubes of Fig. 3 may be of light sheet metal so long as it is capable of resisting corrosion by saline well fluids.

I claim as my invention:

In a gas anchor: an inner tubular member; a

substantially closed shell surrounding and spaced from said tubular member to define a vertical annular space communicating with the interior of said tubular member at its lower end; partitions, at least approximately horizontal, dividing said space into a succession of chambers; means affording communication between the bottom of each chamber and the lower part of the chamber next below; means affording communication between the top of each chamber and the upper part of the chamber next above; means for admitting a stream of gas-containing oil into the lower part of one of said chambers to flow laterally therein and downwardly from chamber to chamber; and means for venting from the uppermost of said chambers a stream of gas separated from said oil stream and flowing countercurrent thereto and thereover.

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