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**E1F FLR**

(56) Documents cited  
**US 4805697 A US 4766957 A US 4746423 A**

(58) Field of search  
**UK CL (Edition K) E1F FLR  
INT CL<sup>5</sup> E21B**

(54) Producing oil from a subsurface oil-containing formation layer

(57) Apparatus (1) for producing oil from a subsurface oil-containing formation layer (2) which is traversed by a cased borehole extending upwards to surface, comprises a tubing (5), an annular seal (7), a liquid collecting space (9) below the annular seal (7) which is in fluid communication with the oil-containing formation layer (2), a water disposal space (14) which is in fluid communication with an aquifer, means (17) for limiting fluid flow out of the water disposal space (14), an open-ended pump housing (18) provided with apertures (19) arranged at the lower end of the tubing (5), an oil pump (22) arranged at the upper end of the pump housing (18) for pumping oil to surface, and a water pump (30) arranged at the lower end of the pump housing (18) for discharging water into the water disposal space (14), wherein the oil pump (22) and the water pump (30) each comprise a stator (40) fixed inside the pump housing (18) and a rotor (41) which is connected to a common rotatable shaft (38) extending to surface through the tubing (5).

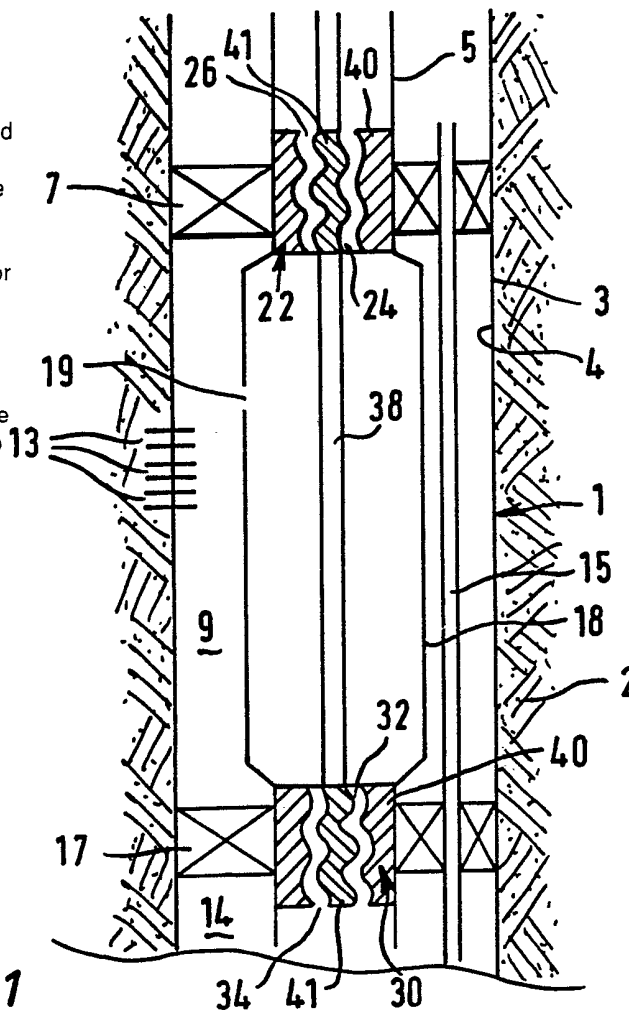


FIG.1

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FIG. 1

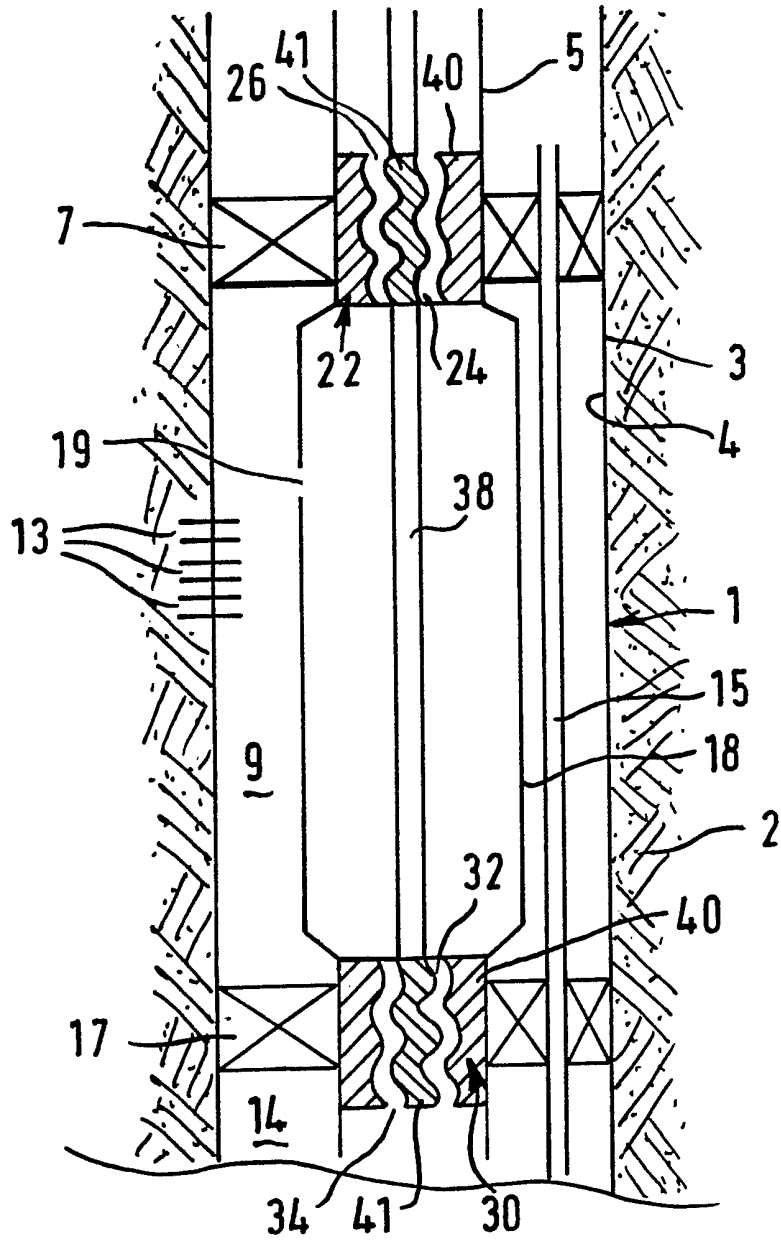
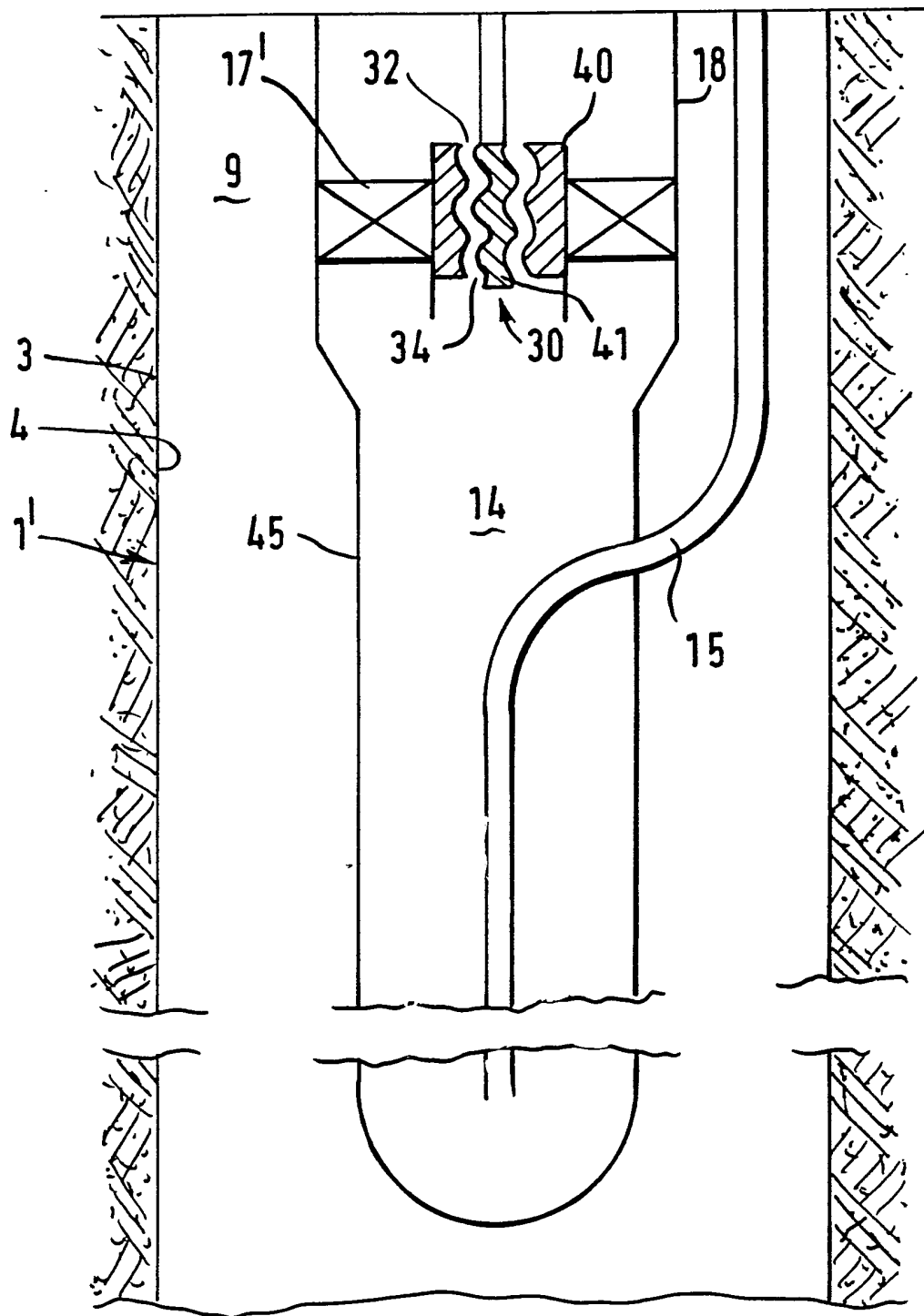


FIG. 2



PRODUCING OIL FROM A SUBSURFACE OIL-CONTAINING  
FORMATION LAYER

The present invention relates to producing oil from a subsurface oil-containing zone, wherein a reservoir fluid in the form of a mixture of oil and a large amount (up to about 50-99% by volume) of water is produced from the subsurface oil-containing zone. In the specification and in the claims the word oil will be used to refer to hydrocarbon oil.

When such a reservoir fluid is to be produced it is desirable to separate a greater part of the water from the mixture down-hole before oil is transported to surface.

An apparatus for producing oil from a subsurface oil-containing zone which is traversed by a cased borehole extending upwards to surface is disclosed in U.S.A. patent specification No. 4 766 957. The known apparatus comprises a tubing arranged in the borehole, an annular seal arranged in the annular space between the casing and the tubing, a liquid collecting space below the annular seal which is in fluid communication with the oil-containing formation layer, a water disposal space which is in fluid communication with an aquifer, means for limiting fluid flow out of the water disposal space, an open-ended pump housing provided with apertures in its wall arranged at the lower end of the tubing in the liquid collecting space, an oil pump of which the inlet is in fluid communication with the upper end of the interior of the pump housing and of which the outlet is in fluid communication with surface, and a water pump arranged at the lower end of the pump housing of which the inlet is in fluid communication with the liquid collecting space and the outlet is in fluid communication with the water disposal space.

During normal operation, the mixture produced from the oil-containing zone is separated into a water-rich liquid which is pumped into the water disposal space, and an oil-rich liquid which

is passed to surface where it can be further treated before it can be employed.

It is an object of the present invention to improve the known apparatus.

5 To this end the apparatus for producing oil from a subsurface oil-containing formation layer which is traversed by a cased borehole extending upwards to surface, which apparatus comprises a tubing arranged in the borehole, an annular seal arranged in the annular space between the casing and the tubing, a liquid collect-  
10 ing space below the annular seal which is in fluid communication with the oil-containing formation layer, a water disposal space which is in fluid communication with an aquifer, means for limiting fluid flow out of the water disposal space, an open-ended pump housing provided with apertures in its wall arranged at the lower  
15 end of the tubing in the liquid collecting space, an oil pump of which the inlet is in fluid communication with the upper end of the interior of the pump housing and of which the outlet is in fluid communication with surface, and a water pump arranged at the lower end of the pump housing of which the inlet is in fluid communica-  
20 tion with the liquid collecting space and the outlet is in fluid communication with the water disposal space, wherein the oil pump is located near the upper end of the pump housing and the water pump near the lower end, and wherein the oil pump and the water pump each comprise a stator fixed inside the pump housing and a  
25 rotor which is connected to a common rotatable shaft extending to surface through the tubing.

An advantage of the apparatus according to the invention is that the bulk of the separation takes place inside the pump housing so that the separated water-rich phase is not in contact with the  
30 inner wall of the casing.

In the specification and in the claims the word 'aquifer' is used to denote any formation layer into which the water-rich phase can be pumped.

The invention will now be described by way of example in more  
35 detail with reference to the accompanying drawings, wherein

Figure 1 shows schematically a cross-sectional view of the lower end of a borehole provided with the apparatus of the present invention; and

5 Figure 2 shows schematically a cross-sectional view of the lower part of an alternative embodiment of the present invention.

Reference is now made to Figure 1. The apparatus according to the invention for producing oil from a subsurface oil-containing formation layer is designated with reference numeral 1, and the subsurface oil-containing formation layer is designated with reference numeral 2. The oil-containing formation layer 2 is 10 traversed by a borehole 3 which is cased with a casing 4. Casing 4 extends upwards to surface (not shown).

The apparatus 1 includes a tubing 5 arranged in the borehole 3 and an annular seal 7 arranged in the annular space between the casing 4 and the tubing 5. The apparatus 1 further includes a 15 liquid collecting space 9 below the annular seal 7 which is in fluid communication with the oil-containing formation layer 2 through openings 13 in the wall of the casing 3, a water disposal space 14, and means for limiting fluid flow out of the water disposal space 14 to the liquid collecting space 9 in the form of 20 annular seal 17. The water disposal space 14 is in fluid communication with a aquifer (not shown) which can be located below the annular seal 17. Alternatively the aquifer can be located above annular seal 7, in which case the water disposal space 14 communicates with the aquifer through conduit 15. 25

An open-ended pump housing 18 provided with apertures 19 in its wall is arranged in the liquid collecting space 9. The pump housing 18 is joined to the lower end of the tubing 5. In the upper end of the pump housing 18 is arranged an oil pump in the form of Moineau pump 22 of which the inlet 24 is in fluid communication with the 30 upper end of the interior of the pump housing 18 and of which the outlet 26 is in fluid communication with surface (not shown) through tubing 5, and at the lower end of the pump housing 18 is arranged a water pump in the form of Moineau pump 30 of which the inlet 32 is in fluid communication with the liquid collecting space 35

9 and of which the outlet 34 is in fluid communication with the water disposal space 14.

The oil pump 22 and the water pump 30 each comprise a stator fixed inside the pump housing 18 and a rotor which is connected to a common rotatable shaft 38 extending to surface through the tubing 5. For the sake of clarity the stators and the rotors are referred to with reference numerals 40 and 41 respectively.

During normal operation, reservoir fluid, which is a mixture of oil and water, is allowed to enter into the liquid collecting space 9 through openings 13 in the wall of the casing 4. The mixture enters into the interior of the pump housing 18 through opening 19. A water-rich liquid is removed from the pump housing 18 by means of the water pump 30 and supplied to the water disposal space 14 which communicates with the aquifer. An oil-rich liquid is removed from the pump housing 18 by means of the oil pump 22 and supplied through the tubing 5 to surface.

The two pumps can be so selected that the volumetric flow rate of water and oil is close to the water/oil ratio of the reservoir fluid. The Moineau pump is a progressing cavity pump. Thus for a Moineau pump the volumetric flow rate of the pumped liquid is proportional to the number of revolutions per unit time and thus the volumetric flow rate is hardly affected by the pump rate. Thus having selected a water pump and an oil pump so that the ratio of the volumetric flow rates is substantially equal to the water/oil ratio of the reservoir fluid increasing the pump rates hardly affects the ratio of the volumetric flow rates. Therefore application of the Moineau pump is very suitable. A further advantage of using a Moineau pump is that such a pump exerts only little shear on the liquid to be pumped, when compared to a turbine pump. Thus as the separated liquids are treated gently there will only be a small tendency to form an emulsion containing oil and water.

Reference is now made to Figure 2 showing schematically a cross-sectional view of the lower part of an alternative embodiment of the present invention. Parts shown in Figure 2 which are also shown in Figure 1 have got the same reference numerals. In Figure 2

the water disposal space 14 is the interior of a tail pipe 45 which is joined at its upper end to the lower end of the pump housing 18. The bottom end of the tail pipe 45 is closed. Annular seal 17' prevents liquid flowing out of the water disposal space 14 to the interior of the pump housing 18. The operation of the apparatus is similar to the operation of the apparatus of Figure 1.

Suitably the volume of the water disposal space is large as compared to the interior volume of the pump housing, more suitably the volumetric ratio is between 5 and 10.

The annular seals 17 and 17' can be provided with a bleeder valve (not shown) which allows the top layer in the water disposal space, which is between 1 to 5% of the water-rich phase, to leave the water disposal space. An advantage is that any oil entrained in the water-rich phase will accumulate in the top layer, and in this way the oil is allowed to leave the water disposal layer and will therefore not be passed on to the aquifer.

In an alternative embodiment the rotor 41 of the water pump is releasably connected to the common driving shaft 38 to allow pumping of oil only. The common driving shaft 38 can be designed as a hollow shaft provided with an aperture debouching into the interior of the pump housing 18 so that demulsifiers can be supplied to the interior of the pump housing 18 where to emulsion of oil and water has to break.

The inner surface of the wall of the perforated section of the tubing can be provided with an inverted gutter spiralling upwardly to improve separation.

The apparatus according to the present invention has been described with reference to Figures 1 and 2 in which the apparatus was shown vertically, the apparatus can as well be applied in a deviated borehole and in a horizontal borehole. When used in a horizontal borehole a first location is said to be above a second location when the first location is nearer to the surface (measured along the borehole) than the second location, in this case the second location is below the first one, or the first location is the upper one and the second location is the lower one.



C L A I M S

1. Apparatus for producing oil from a subsurface oil-containing formation layer which is traversed by a cased borehole extending upwards to surface, which apparatus comprises a tubing arranged in the borehole, an annular seal arranged in the annular space between  
5 the casing and the tubing, a liquid collecting space below the annular seal which is in fluid communication with the oil-containing formation layer, a water disposal space which is in fluid communication with an aquifer, means for limiting fluid flow out of the water disposal space, an open-ended pump housing provided with  
10 apertures in its wall arranged at the lower end of the tubing in the liquid collecting space, an oil pump of which the inlet is in fluid communication with the upper end of the interior of the pump housing and of which the outlet is in fluid communication with surface, and a water pump arranged at the lower end of the pump  
15 housing of which the inlet is in fluid communication with the liquid collecting space and the outlet is in fluid communication with the water disposal space, wherein the oil pump is located near the upper end of the pump housing and the water pump near the lower end, and wherein the oil pump and the water pump each comprise a  
20 stator fixed inside the pump housing and a rotor which is connected to a common rotatable shaft extending to surface through the tubing.
2. Apparatus as claimed in claim 1, wherein the rotor of the water pump is releasably connected to the common driving shaft.
- 25 3. Apparatus as claimed in claim 1, wherein the common driving shaft is a hollow shaft provided with an aperture debouching into the interior of the pump housing.
4. Apparatus as claimed in any one of the claims 1-3, wherein the pump is a progressing cavity pump such as a Moineau pump.

**Patents Act 1977**  
**Examiner's report to the Comptroller under**  
**Section 17 (The Search Report)**

Application number

9021582.3

**Relevant Technical fields**

(i) UK Cl (Edition K ) E1F (FLR)

(ii) Int Cl (Edition 5 ) E21B

**Databases (see over)**

(i) UK Patent Office

(ii)

Search Examiner

D J HARRISON

Date of Search

27 NOVEMBER 1991

Documents considered relevant following a search in respect of claims 1-4

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	US 4805697 A (FOUILLOUT)	1
A	US 4766957 A (MCINTYRE)	1
A	US 4746423 A (MOYER)	1



Category	Identity of document and relevant passages	Relevant to claim(s)

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