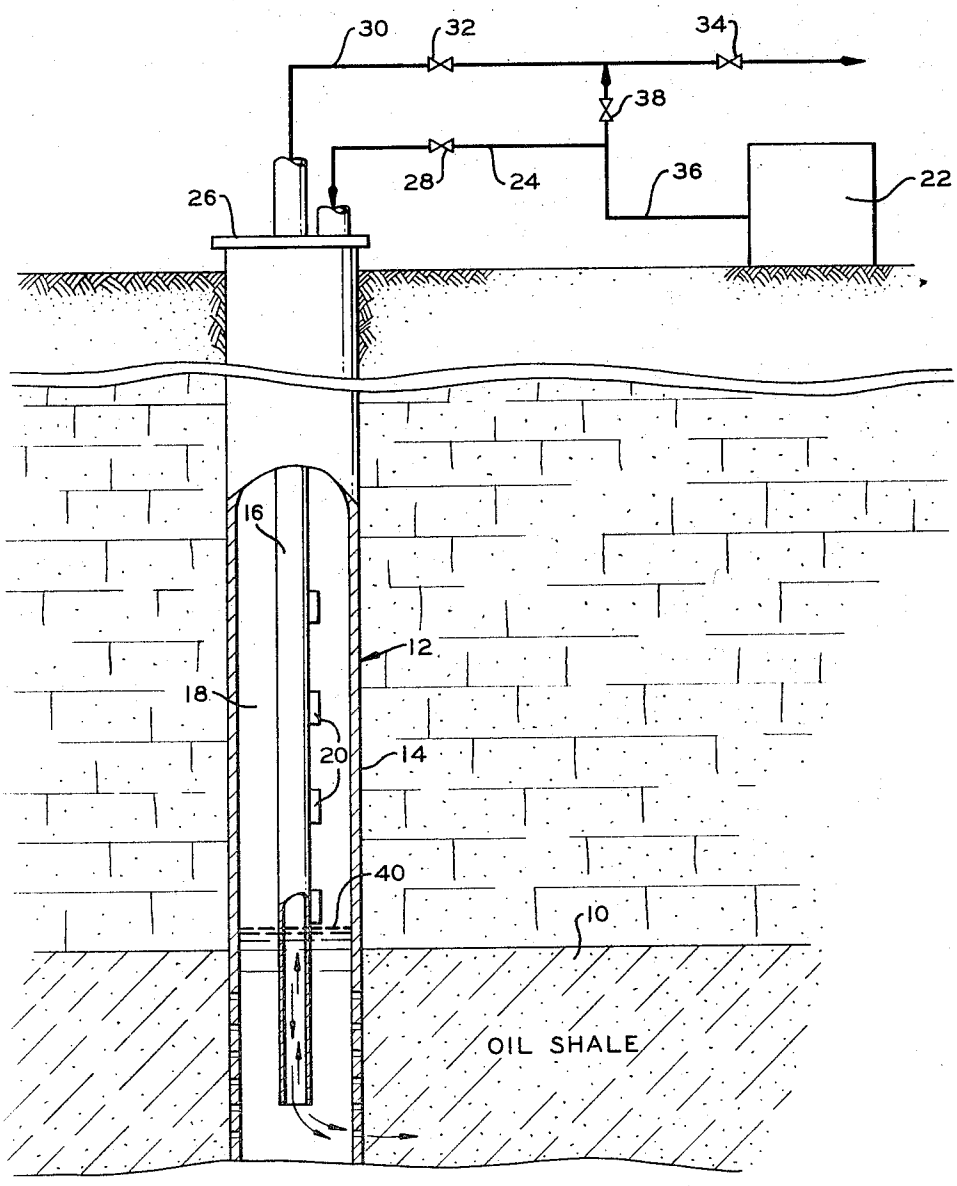
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OIL PRODUCTION WITH STEAM

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OIL PRODUCTION WITH STEAM

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This invention relates to a process and apparatus for producing oil from a subterranean oil-bearing stratum using steam.

Heavy crude oil has been produced by the so-called "huff and puff" method in certain areas of the United States. This method comprises injecting steam into the oil-bearing stratum thru a well tubing in a single drill hole for a substantial period such as 10 to 30 days or more, to cause oil to flow into the well, then terminating steam injection, inserting a pump and pumping rod into the tubing and pumping the oil from the well which has flowed thereinto during the steaming period. After producing the available oil from the bottom of the well, the steaming and pumping steps are repeated. The removal and reinsertion of the rod string and pump is time consuming and expensive. In my copending application, S.N. 350,254, a method and apparatus are disclosed for avoiding withdrawal and reinsertion of the rod string and pump from the tubing string for the steam injection phase of the "huff and puff" process.

This invention is concerned with another method and means for operating the "huff and puff" process without the necessity of removing and replacing the downhole pump and rod string.

Accordingly, an object of the invention is to provide a process and apparatus for producing oil from an oil-bearing subterranean stratum with steam which avoids the use of a downhole pump. Another object is to provide a process and apparatus for producing oil from such a stratum which eliminates pumping and utilizes steam for lifting the oil thru the tubing string. Other objects of the invention will become apparent to one skilled in the art upon consideration of the accompanying disclosure.

A broad aspect of the invention comprises injecting steam from a steam generator at ground level thru a tubing string into an oil-bearing subterranean stratum so as to render the oil less viscous and cause same to flow into the well; terminating the injection of steam thru the tubing string and opening same to the production of oil; injecting steam into the annulus from the steam generator between the tubing string and the casing and admitting steam from the annulus to the tubing string so as to cause oil to rise in the tubing, aerate same, and gas-lift the oil thru the tubing string to a production line connected therewith. Preferably, a series of gas-lift valves are placed in special tubing collars as the tubing is run. These gas-lift valves are positioned several hundred feet apart toward the lower end of the tubing string below the static fluid level. The tubing string functions as an eduction tube. Instead of having to depress the unaerated fluid to the level of the bottom of the tubing before gas may enter and aerate the fluid in the eduction tube, gas enters the tubing at each valve, in turn, aerating the fluid thereabove and starting fluid flow thru the tubing before the fluid in the annulus is depressed to the lower end of the tubing. This results in correspondingly lower starting pressures. After flow has been established throughout the full length of the eductor tube, the pressure conditions within the downward and ascending streams of gas are such that the valves remain closed and all steam flows to the bottom of the eductor tube before mixing with the ascending streams of liquid and vaporous oil.

Various types of gas-lift valves are available commercially. Some admit gas from the annulus into the tubing while others admit gas from the tubing into the annulus

where production is to be effected thru the annulus. In the instant process production thru the tubing is preferred.

In operation without gas-lift valves, the steam pressure in the annulus forces the liquid oil up the tubing until the liquid level in the annulus is depressed to the bottom of the tubing at which stage steam enters the lower end of the tubing and aerates the liquid in the tubing to effect gas lifting thereof.

The invention utilizes a steam boiler or generator at ground level adjacent the well head which is connected by a conduit with the well annulus. A production line or conduit connecting with the tubing string also connects by means of a cross-over conduit with the conduit leading from the steam generator to the annulus. A valve in this cross-over conduit directs the steam either into the annulus or into the tubing string as desired. Other control valves in the connecting conduits permit alternate steam injection and steam lifting of the produced oil into the production line.

A more complete understanding of the invention may be had by reference to the schematic drawing which is an elevation of a preferred arrangement of apparatus for performing the invention.

Referring to the drawing, a viscous oil-bearing stratum **10** is penetrated by a well **12** which is provided with a casing **14** and a tubing string **16** forming an annulus **18** with the casing. Tubing string **16** is provided with a series of gas-lift valves **20** positioned at levels several hundred feet apart in the lower section of the tubing string below the static fluid level. These valves selectively admit steam to the tubing string from the well annulus.

Valves **20** are adapted for high temperature service since the steam temperature may reach temperatures as high as 700–800° F.

A steam boiler or generator **22** is connected by means of a conduit **24** with annulus **18** thru well head **26** and is provided with a cut-off valve **28**. A production line or conduit **30** connects with tubing string **16** at or above the well head and is provided with a pair of spaced-apart cut-off valves **32** and **34**. A cross-over conduit **36** containing valve **38** connects conduit **24** upstream of valve **28** with production line **30** intermediate valves **32** and **34**. This arrangement permits injection of steam into the formation thru tubing **16** by closing valves **28** and **34** and opening valves **32** and **38** so that steam passes thru a portion of conduit **24**, conduit **36**, and production line **30** into the well tubing. The valve arrangement also permits injection of steam thru the well annulus so as to educt oil from the bottom of the well into production line **30** thru tubing string **16** by positioning valves **32** and **34** in the open position, closing valve **38**, and opening valve **28**.

The injection of steam thru annulus **18** is commenced after sufficient steaming of the stratum has been effected to produce a substantial amount of oil in the bottom of the well such as is illustrated by oil level **40**. The steam pressure applied in the annulus on the surface of the oil, with conduit or line **30** open to flow, depresses the oil level and causes oil to rise in tubing **16** so that it passes the lower-most gas-lift valve and actuates the valve so as to admit steam at this level, thereby aerating the oil above the valve with steam and producing a lifting action on the column of fluid within tubing **16**. As oil successively passes the upper gas-lift valves, these valves function in a similar manner and the oil is lifted thru the tubing string with substantially less pressure than would be required without the use of the gas-lift valves.

A gas-lift valve is actuated by a predetermined fluid pressure or head at the valve level so as to open when said pressure is reached and admit steam to the tubing to aerate the liquid oil therein. This aeration reduces the pressure head in the tubing at the valve level and causes the valve to close until the head is again built up to the

required opening pressure. Small holes in the tubing collars at selected levels also function as gas-lift valves, but are not the full equivalent of such valves as the holes are enlarged by corrosion and/or erosion and eventually render the tubing string inoperative.

By proper use of packers, dual production zones may be produced by steaming and gas lift from steam injected thru a common annulus.

After the flow of oil thru production line **30** reaches a selected minimum, the valves in the conduit system connected with steam generator **22** are reversed and steam is again injected thru tubing **16** into the stratum so as to further heat and produce oil therefrom. The steaming and steam-lift steps are repeated as long as oil production from the stratum around the well is profitable.

In producing viscous oil from a sand formation at a depth of about 3200', steam at a temperature in the range of 600 to 700° F. is injected at a pressure in the range of 1500 to 2500 p.s.i.g. for an extended period of at least 15 and up to 100 hours or more so as to produce a substantial amount of liquid oil in the bottom of the well. The injection of the steam thru the tubing from the steam generator is then terminated and steam at reduced pressure is injected into the annulus with the tubing string open to the production line. The steam pressure on the oil in the annulus causes the oil to rise in the tubing string so that the oil in the annulus falls to a level below the upper-most steam-lift valve resulting in a pressure differential between the steam in the annulus and the oil in the tubing which causes steam to be injected thru said valve thereby steam aerating the oil in the tubing and producing an eduction effect on the fluid column in this tubing. At this time, the steam injection and gas-lift steps are repeated in the same order.

A packer can be installed packing off the well bore annulus below all gas-lift valves in which case oil in the annulus when packer is installed is produced into tubing through the lowermost valve. Steam enters the tubing at successively lower valves as previously described when no packer is used.

Certain modifications of the invention will become apparent to those skilled in the art and the illustrative details disclosed are not to be construed as imposing unnecessary limitations on the invention.

I claim:

1. Apparatus for producing oil from an oil-bearing subterranean stratum which comprises in combination:

(a) a casing communicating with said stratum from a well head;

(b) a tubing string within said casing forming an annulus therewith extending from said well head at least to the level of said stratum, said tubing string being free of a pump;

(c) a series of gas lift valves in said tubing string below the static fluid level, each being positioned at a substantially different level for injecting steam to said tubing string from said annulus;

(d) a steam generator at ground level near said well head;

(e) a first conduit connecting with said tubing string at the well head;

(f) a second conduit connecting with said annulus adjacent the well head and with said steam generator;

(g) a pair of spaced-apart flow control valves in said first conduit;

(h) a flow control valve in said second conduit;

(i) a third conduit connecting said second conduit at a point intermediate the valve of (h) and said generator with said first conduit at a point intermediate the valves of (g); and

(j) a flow control valve in said third conduit.

2. Apparatus for alternately injecting steam thru a well into an oil-bearing subterranean stratum and steam lifting oil produced by the steam injection comprising in combination:

(a) concentric casing and tubing strings connecting a well head with said stratum providing an annulus therebetween;

(b) a gas lift valve positioned at each of several levels in said tubing string for injecting steam into said tubing from said annulus;

(c) a steam generator at ground level adjacent said well head;

(d) conduit means for passing steam from said generator to said tubing string and to said annulus;

(e) valve means in said conduit means for alternately separately passing steam to said annulus and to said tubing string; and

(f) means for passing produced oil from said tubing string to a production line when steam is being injected into said annulus.

3. A process for producing oil from an oil-bearing stratum thru a well therein provided with a casing and a tubing string, which comprises the steps of:

(a) providing said tubing string with gas lift valves at selected spaced-apart levels beginning near the level of said stratum and injecting superheated steam at high pressure from a steam generator into said stratum thru said tubing string for an extended period so as to cause hot oil to flow into said well from the surrounding stratum;

(b) thereafter, terminating the injection of steam thru said tubing string and injecting steam from said generator into the annulus formed by said tubing and casing;

(c) injecting steam at substantially less pressure than in step (a) from said annulus thru said gas lift valves into said tubing string progressively at a series of different levels therein beginning at the lowermost as the liquid oil passes each level so as to lift said oil thru said tubing while maintaining said tubing open to flow to a production line; and

(d) repeating steps (a), (b), and (c).

4. The process of claim **3** wherein said stratum bears a low gravity viscous crude oil.

5. The process of claim **3** wherein said stratum is a tar sand.

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