

Nov. 4, 1958

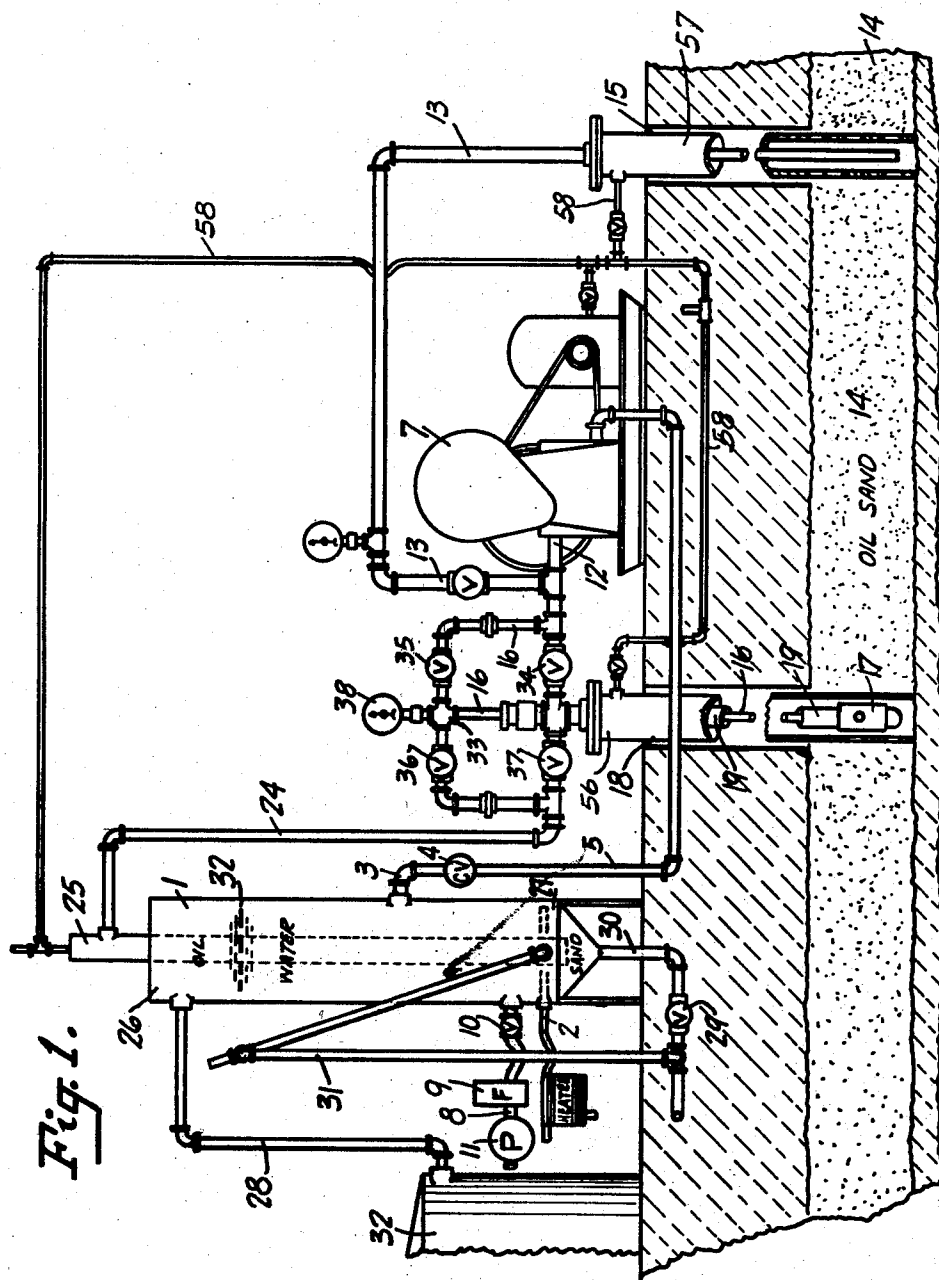
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METHOD FOR SECONDARY OIL RECOVERY

Filed March 16, 1955

2 Sheets-Sheet 1



INVENTOR

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2 Sheets-Sheet 2

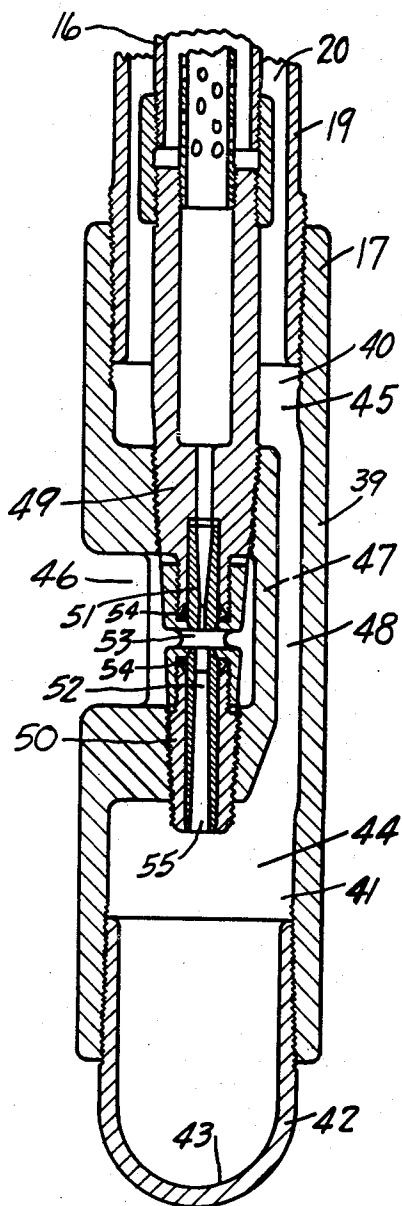


Fig. 2.

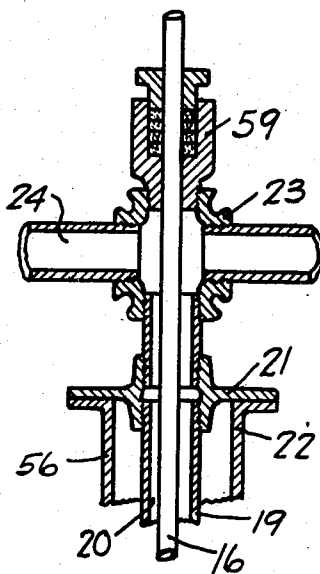


Fig. 3.

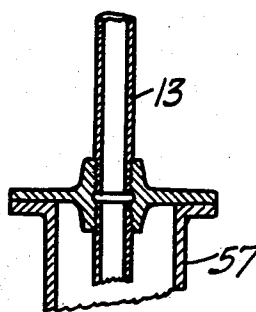


Fig. 4.

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1

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METHOD FOR SECONDARY OIL RECOVERY

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Application March 16, 1955, Serial No. 494,681

8 Claims. (Cl. 166—8)

This invention relates to a method for the production of natural oil from stagnant pools in subsurface formations, especially those formations in which the natural energy has been depleted.

I have in a series of patents, to wit: Patent No. 1,642,121, patented Sept. 13, 1927; Patent No. 1,779,483, patented Oct. 28, 1930; Patent No. 1,801,520, patented Apr. 21, 1931; Patent No. 1,992,436, patented Feb. 26, 1935; Patent No. 2,080,622, patented May 18, 1937; Patent No. 2,080,623, patented May 18, 1937; Patent No. 2,080,624, patented May 18, 1937; Patent No. 2,114,905, patented Apr. 19, 1938; Patent No. 2,291,911, patented Aug. 4, 1942, disclosed means and devices for raising natural oil from oil wells by employing a fluid as a lifting means (hereinafter referred to as the power fluid) under pressure introduced into a tubing located in the oil well, this fluid intermingled with incoming oil from the oil formation in a high velocity zone, under a pressure relatively lower than the formation pressure or less than the submergence head of the oil in the oil well above said zone, such as a venturi-tube, and the intermingled oil and power fluid are circulated to the surface through a tubing passageway separate from the tubing employed for the incoming power fluid.

I have now found that if, as the motive fluid which is employed in the lifting of the oil, I employ it simultaneously to move oil out of stagnant pools into the oil well, I obtain surprisingly high rates of production from subsurface oil formations in which the natural energy has been depleted.

In order to accomplish these results, I circulate the immiscible power liquid, e. g., water, from the surface under pressure of the order of fifteen hundred pounds per square inch, in oil wells of less than fifteen hundred feet deep, through two wells, e. g., an input well and an output well, simultaneously and continuously causing the commingling of the immiscible liquid and oil located in a stagnant pool somewhere in the formation between the two said wells and causing the oil to be moved out of the said pool and into a throat of a venturi-tube submerged in the oil in the output well and returning the commingled oil and water to the surface. In the mentioned output well is located the pumping means described in the aforementioned patents.

I heat the said immiscible power liquid to about two hundred thirty degrees Fahrenheit and circulate about thirty-five gallons per minute through tubing connected with the venturi-tube located in the output well, and thirty-five gallons per minute into the formation through the input well.

With these said rates of circulation of liquid I recover about twelve or more barrels of net oil per hour from the formation.

With the above mentioned temperatures used in the power liquid, the heat transferred to the oil-water stream in the output well containing the jet pump or venturi-tube is seven hundred fifty thousand British thermal units per hour and the heat loss to the formation, and which

2

serves to heat the formation and area surrounding the output well, is four hundred thousand British thermal units per hour.

In output wells of less than two thousand feet deep, I find in heating the power liquid to a temperature of two hundred thirty degrees Fahrenheit and circulating this heated liquid down through the jet pump located deep in the output well that, the temperature of the returning commingling oil and water at the surface is about two hundred degrees Fahrenheit or a differential loss of thirty degrees Fahrenheit.

This said loss of thirty degrees in temperature results in a net loss of three hundred fifty thousand British thermal units per hour in the output well.

When using this heated water flood repressuring drive to cause natural oil to be moved into the output well from stagnated conditions or pools in the formation, I have found that a considerable quantity of fine sand is moved simultaneously with the natural oil into the said output well and I get a surprising increase in the rate of flow of oil to the surface when I cause this fine sand to be simultaneously and continuously removed from the output well with the natural oil, as contrary to an intermittent action in the removal of said sand and oil.

I base this increase in oil production on the fact that unless this fine sand, which has a fineness similar to that of flour, is immediately and continuously removed to the surface together with the oil just as soon as the sand reaches the output well, said sand will build up in the area surrounding the said output well and cause the oil production to be either shut off or considerably reduced. Thus from my discovery it is evident that many oil wells were heretofore abandoned prematurely because of the lack of removal and the accumulation of the said fine flour like sand in the area surrounding the abandoned oil well and caused the oil well bore to be shut off from the formation.

My invention will be further described in connection with the drawings, in which:

Fig. 1 is a schematic elevation view of the recovery system, showing the joint piping system and the union relationship of two oil wells joined together to provide an integral unit utilizing a subterranean channel.

Fig. 2 is a sectional elevation through the jet pump.

Fig. 3 is a fragmentary sectional elevation at the well head of the output well in which is located the jet pump.

Fig. 4 is a fragmentary sectional elevation at the well head of the input well through which water is fed into a subterranean channel.

Fig. 2 illustrates the form of jet pump described in detail in Patent No. 2,114,905, to which reference may be had for more and further particulars of the structure and mechanical operation of the jet pump. I may use the form of jet pump illustrated in any of the other of my patents referred to above.

I employ the form here illustrated as a convenient example of a mechanical structure in which the process of my invention may be carried out, without any intention of limiting the method to said structure, since the method may be carried out in any of the structures disclosed in my listed patents or in any other structure wherein the immiscible liquid and oil may be commingled in the manner to be described below.

On the surface I employ a tank 1 in the bottom of which are provided heating coils 2, through which steam or hot oil or hot water may be circulated by conventional pumping means for reasons to be described below. An outlet 3 is provided near the bottom thereof controlled by a check valve 4 and connected by line 5 to the suction side of pump 7. A main supply line 8 will be connected to tank 1 to furnish a supply of water to the suction side of pump 7 from outside sources such as

3

for example, water wells or rivers or oceans and in this line 8 would be incorporated a filter 9 to eliminate plant life and sea life and oxygen from the water thus used. A suitable check valve 10 is provided in line 8, and also a booster pump 11 will be incorporated in line 8 if needed to raise water from a source well not shown to supply water to the suction side of pump 7.

The discharge from pump 7 passes into a main discharge pipe line 12 and then into discharge pipe line 13 leading into the oil formation 14 through input well 15 and said discharge also passes into discharge pipe line 16 which is connected with the jet pump 17 located in the the output well 18.

The line 16 is jacketed by the tubing 19 which is connected to the jet pump 17 and serves to provide an annulus passageway 20 for fluids entrained from the formation 14 by the jet pump 17. This tubing 19 is suspended in the output well 18 by conventional means 21 forming the casing head 22. From this annulus passageway 20 fluids circulated by the pump 7 plus all fluids entrained from the formation 14 are discharged therefrom at the cross 23 into line 24.

Line 24 discharges into a baffle 25 formed an elongated cylinder extending from the upper portion 26 of tank 1 to the lower portion 27 thereof. This baffle 25 conveys the oil, water and sand from the output well 18 to bottom of tank 1 wherein the water and oil stratifies and water is recirculated to the pump 7 through line 5 and oil is withdrawn through line 28. A suitable valved 29 clean-out or drain line 30 is provided in the bottom of tank 1 to flush out the sand separated from the water and oil in tank 1. The sand flushed out of tank 1 is conveyed by line 30 to a sump pit not shown. An automatic bleeder line 31 maintains a constant water level 32 in tank 1. This bleeder 31 is connected to the bottom of tank 1 and also to the line 30 leading to the sump pit above mentioned.

A storage or shipping tank 32 receives the oil conveyed thereto by line 28.

By referring to Fig. 1 it will be noted that I provide at the output well head 22 what is termed in the industry as a christmas tree 33. This so-called christmas tree 33 comprises a series of four plug valves 34, 35, 36 and 37 arranged to reverse the flow of fluids into the line 16 and tubing 19 and permits, at the operator's will, fluid to be discharged into the formation 14 through the jet pump 17. The regular direction of flow of discharge from pump 7 into line 16 is made by closing plug valve 34 and opening valve 35 and closing valve 36 and having valve 37 opened.

To reverse the flow of the discharge from pump 7 so that the flow is directed into the annulus passageway 20 I arrange the said four plug valves thusly, valve 34 opened, valve 35 closed, valve 36 opened and valve 37 closed. I use this latter valve manipulation when cleaning out the output well from sand and/or discharging water into the formation 14 through output well 18. Should the annulus 20 become plugged with sand at any time I simply reverse the flow of fluid from pump 7 as just described and clean out the said annulus 20.

A pressure gauge 38 connected in the christmas tree 33 serves to show the pressure set up by the pump 7.

Referring now to the jet pump 17 which is located in the output well 18 and to Fig. 2 of the drawings.

At the end of tubing 16 and 19 is positioned a pump body 39, cored or bored at 40 at one end to produce an inlet bore into which the tubing 19 may be threaded or otherwise secured by a fluid-tight connection. The opposite end of the body is likewise bored or cored at 41. The bore 41 is closed by a subjoint or bull plug 42 which makes a fluid-tight seal in the bore 41. The inner face of the plug 42 forms a hemispherical surface 43. There is thus formed a chamber 44. Cored passages 48 connect chamber 44 with upper chamber 45. The pump body 39 is cored to produce a chamber 46 which communicates with the formation 14 through the side

4

wall of pump body 39. The chamber 46 is separated from chamber 44 and chamber 45 by a wall 47.

Connected to tubing 16 is a split venturi-tube formed of two axially aligned venturi cones 49 and 50 whose nozzles 51 and 52 are spaced from each other by a small separation 53 which has direct communication with chamber 46 and formation 14.

Venturi-cones 49 and 50 each have threaded engagement with pump body 39 to make a fluid-tight seal with the body 39.

The nozzles 51 and 52 are cast of tungsten-carbide material to resist abrasion set up by sand being entrained from the formation 14. These nozzles are secured in venturi-cones 49 and 50 by lead seals 54 in a fluid-tight seal construction. These nozzles have direct communication with formation 14 through the medium of chamber 46. The discharge orifice in nozzle 51 is smaller in diameter than the opposing orifice in nozzle 52.

The discharge outlet 55 from cone 50 and nozzle 52 is so positioned that the axis of the cone is coincident with the vertical radius of the semispherical cup 43.

The tubing 19 is of such length that the inlet port 46 is at the desired submergence below the fluid level of the fluid in the bore hole forming the output well 18.

The operation of the unit is as follows: The hot water is pumped by pump 7 at the desired discharged pressure as reported by gage 38 and passes downwardly through tubing 16, enters nozzle 51 and discharges therefrom through chamber 53 into the opposite nozzle 52. The fluids and sand entrained from the formation 14 intermingle with the hot water in this nozzle 52 and are discharged at 55 into the chamber 44 of the pump body 39. From chamber 44 the intermingled fluids flow upward through passage 48 into the chamber 45 thence upward through the annulus passage 20 to the surface of the earth.

As is explained in the aforementioned listed patents, this zone at chamber 53 is the vena contracta of the venturi-tube system and the hot water being circulated by pump 7 is at its highest linear velocity, at this point, of any in the entire system. At this point or chamber 53 the hydrostatic pressure is converted into velocity and consequently, the pressure in chamber 53 is low compared to that at the inlet to the nozzle 51 or at the outlet 55 from nozzle 52. This highest velocity being a function of the dynamic head of the water flowing in line 16 in relation to the pump 7 discharge pressure. As the pump pressure is increased a velocity of hot water is reached in the venturi-tube where the static head of the oil in the bore hole 18 is sufficient to permit the oil, sand and gas to flow through chamber 53 into nozzle 52 as also explained above.

It will be observed that the commingled fluids in the annulus passage 20 flow in a closed system into pipe 24 and out of pipe 5 to and from tank 1. A stuffing box 59 is provided to seal off the tubing 16 in relation to tubing 19 to cap the annulus passage 20.

A conventional casing 56 is used in output well 18 and a conventional casing 57 is likewise used in input well 15. Both of these casings will be perforated at the place where the casing contacts the formation 14. One or more input wells 15 may be used to supply the output well 18. The input well 15 and output well 18 will be spaced from one hundred feet to three hundred feet apart.

Pump 7 will be a triplex pump construction capable of discharging about seventy gallons per minute up to twenty-five hundred pounds per square inch pressure and the average pressure used will be about seventeen hundred fifty pounds per square inch pressure. Therefore operating under seventy gallons per minute discharged into line 12 at seventeen hundred fifty pounds per square inch pressure I will use a ninety horsepower internal combustion engine to drive the pump 7.

In the average oil well there may be found enough gas

5

to run this engine and if so I will use pipe line 58 having connections with the engine, not shown, and the casings 56 and 57 and also with the tank 1 at the uppermost portions thereof in each case. Otherwise I will use butane to run this prime mover, or an electric motor may be used in oil fields where electricity is available.

The said seventy gallons per minute of water discharged by pump 7 will be used to feed the input well pipe 13 to discharge about thirty five gallons per minute into the formation 14 through this input well 15 and the remaining thirty-five gallons per minute will be used as a power fluid or motivating medium in output well 18 to operate the jet pump 17 located therein. I have above described the piping means or system to distribute this said seventy gallons per minute of water, heated in tank 1 to about two hundred degrees Fahrenheit, to input well 15 and output well 18.

One of the important discoveries I have made to increase the production of oil is to overcome the present conventional oil field practice of providing means such as gravel pack or the like to hold out sand from entering into the output well in order that the conventional reciprocating rod pumps would not become sanded up. I overcome this erroneous practice by removing the sand as fast as it comes into the oil well, and I let the sand come freely into the oil well rather than to hold the sand out from coming into the oil well. By so doing I prevent the fines or fine sand from building up in the area in the formation 14 surrounding the well 18 and shutting off the oil from entering the well 18. Thusly I welcome all the sand to now come into the output well 18 and by so doing I provide a free flow of oil and sand into the output well 18 and I cause the oil and sand to be removed to the surface simultaneously and continuously as fast as the sand comes into the output well 18, and by so doing I get a surprisingly increase in oil production over that of the conventional methods.

But in order to efficiently remove this sand and oil, which is in a commingled state, I have discovered that I have to provide a certain specific velocity of fluid in the jet pump 17, or I should say in the venturi-tube located in the jet pump 17, or the jet pump will not work satisfactory. The velocities which must be used are as follows:

In a 500' well the velocity of the power fluid is about 19,560 feet per minute; and in a 1,000 foot oil well, the velocity of the power fluid is about 27,350 feet per minute; and in a 2,000 foot oil well for example, the velocity of the power fluid will be 33,900 feet per minute; and in a 3,000 foot oil well, for example, the velocity of the power fluid will be about 42,000 feet per minute.

I have used these said fluid speeds in actual oil field tests and find them practical as applied to raising oil, water, and sand from deep deposits in the earth.

An essential function in removing sand from deposits in the earth is to keep the sand moving continuously from the formation 14, as contrary to an intermittent action such as is found in a conventional reciprocating rod oil well pump.

This continuous sand entraining action serves to prevent quantities of fine sand from building up as a barrier surrounding the output well 18 and thusly shutting off the inward flow of oil thereto.

To lessen the abrasive action of the sand entrained into the jet pump 17 and upon nozzle 52 thereof, I circulate four to five volumes of clear hot water as a motivating fluid to intermingle with one volume of fluid entrained from the formation 14 and containing a large percentage of fine sand.

For example, the area of the orifices of nozzles 51 and 52 will be made such so that when thirty-five gallons of fluid is being circulated through the jet pump there will be seven to nine gallons per minute entrained from the formation 14 into the annulus passage 20 of the system.

The above mentioned thirty-five gallons per minute of

6

fluid is the fluid used in the jet jump 17 as my motivating fluid or water and it is heated so that in addition to its entraining function, it is also utilized for heating the formation 14 and augments the flow of oil and fine sand into the output well 18. The pressure set up by the flow of water out of the input well 15 onto the formation 14 causes oil to be moved in formation 14 toward and into output well 18 and it also causes loose sand to be moved together with the said oil. This heated water also augments the separation of the oil and water in tank 1 in an efficient manner and by this action allows the water to be used over again as the motivating medium to entrain oil, sand and interstitial water from the formation 14 in a continuous and constant method of production, through means of a closed system arranged to automatically function as a whole, as contrary to an intermittent functional method of recovery. An important function of this method is the provision for the continuous and constant removal of sand out of output well 18 on the basis of my findings that it is as equally important to provide for the above described removal of sand in the production of oil as it is to provide for the production of the natural oil. As above stated the present conventional oil field practice is to do everything possible to keep the sand out of the output well, whereas in my new result I provide every means to remove the sand out of the immediate area surrounding the output well.

What I claim is:

1. A process for the secondary recovery of petroleum fluids from a subterranean formation having therein an output well and an input well spaced therefrom comprising: providing a continuous flow of heated liquid into and out of said output well thereby heating the formation adjacent the output well and the petroleum fluids therein, causing said flowing liquid during its passage from said output well to flow at a linear velocity sufficient to entrain therein and convey therewith petroleum fluids and entraining in said flowing fluid and conveying thereby petroleum fluids from said output well, withdrawing liquid mixed with petroleum fluids from said flowing liquid during the passage of the latter from said output well, introducing additional heated liquid into said flowing liquid during passage of the latter into the output well, introducing into said input well heated liquid at a sufficient rate, temperature and pressure to thereby heat said formation between said wells and the petroleum fluids therein and to drive a volume of said petroleum fluids into said output well, said steps of introducing heated liquid into said input and output wells being performed to jointly cause the flow of petroleum fluids from the formation into said output well.

2. A process for the secondary recovery of petroleum fluids from a subterranean formation having therein an output well and an input well spaced therefrom comprising: providing a continuous flow of heated liquid into and out of said output well thereby heating the formation adjacent the output well and the petroleum fluids therein, causing said flowing liquid during its passage from said output well to flow at a linear velocity sufficient to entrain therein and convey therewith petroleum fluids and sand particles and entraining in said flowing liquid and conveying thereby petroleum fluids and sand particles from said output well, withdrawing liquid mixed with petroleum fluids and sand particles from said flowing liquid during the passage of the latter from said output well, introducing additional heated liquid into said flowing liquid during passage of the latter into the output well, introducing into said input well heated liquid at a sufficient rate, temperature and pressure to thereby heat said formation between said wells and the petroleum fluids therein and to drive a volume of said petroleum fluids into said output well, said steps of introducing heated liquid into said input and output wells being performed to jointly cause the flow of petroleum fluids from the formation into said output well.

3. The process of claim 1 wherein the liquid introduced into the input and output wells is at a temperature of at least 230° F. and the flowing liquid and the withdrawn liquid removed from said output well is at a temperature of about 200° F.

4. The process of claim 1 wherein said linear velocity is at least 19,000 feet per minute.

5. The process of claim 1 wherein said linear velocity ranges between 19,000 and 42,000 feet per minute.

6. The process of claim 1 wherein the heated liquid is introduced into said output well at a pressure exceeding the hydrostatic pressure in said output well by from 1500 to 2500 pounds per square inch.

7. The process of claim 1 wherein said continuous flow of liquid in said output well is effected by continuous circulation of liquid in a closed system.

8. A process for recovering petroleum fluids from a subterranean formation having spaced output and input wells therein comprising: introducing into said input well a heated liquid at a rate, temperature and pressure sufficient to heat said formation between said wells and the petroleum fluids therein and to drive the latter into said output well, continuously circulating into and out of the output well in a closed system heated liquid at a pressure in excess of the hydrostatic head of the output well thereby heating the formation adjacent the output well and the petroleum fluids therein, producing in said output

well with a portion of said excess pressure flow of said circulating liquid at an accelerated linear velocity sufficient to thereby entrain and convey therewith petroleum fluids in said output well, removing from said accelerated flow of liquid said entrained fluids, introducing additional heated liquid into said circulating liquid in sufficient quantity and pressure to replace said removed fluids and to maintain said quantity and pressure of fluid circulating in said closed system.

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