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HEATING SYSTEM FOR PRESSURE FLUID OF FLUID PRESSURE OPERATED PUMPS

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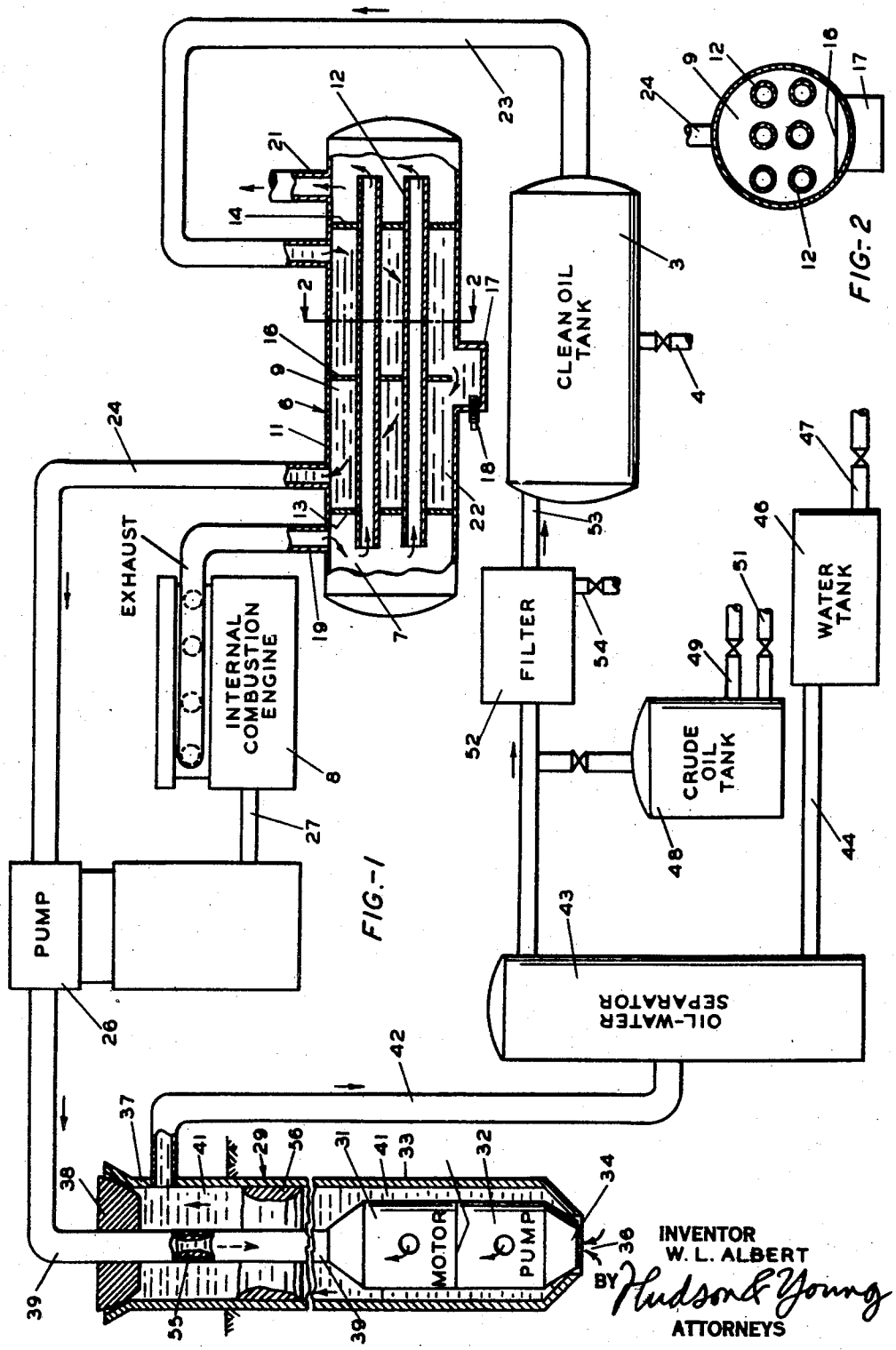


FIG.-1

FIG.-2

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HEATING SYSTEM FOR PRESSURE FLUID OF FLUID PRESSURE OPERATED PUMPS

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1 Claim. (Cl. 103—46)

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This invention relates to a pumping system. In one particular embodiment this invention relates to the removal of well liquids from deep wells. Still more particularly in this aspect this invention relates to an automatic and continuous means for removing meltable materials from well casings and tubings.

In the removal of crude oil from subsurface deposits, hydraulic pumping systems are often used. The crude oil is pumped from the subsurface deposits to the surface through a well drilled to the location of the oil deposits. The typical hydraulic pumping system used is a continuous liquid power circuit comprising two parts; the surface or hydraulic power unit; and the subsurface or production unit. The hydraulic power unit, located on the surface near the oil well, pumps clean power oil under elevated pressure through pipes into the well head, from which point it is conducted to the production unit at the bottom of the well, usually through the tubing. This production unit at the bottom of the well comprises a hydraulic engine integral with a deep well pump. The hydraulic engine drives the deep well pump which draws oil from the formation and forces the oil drawn from the formation and the power oil to the surface of the well. The clean, crude oil or power liquid, therefore, after actuating the production unit engine below the surface of the well is discharged and mixes with the crude oil being pumped from the bottom of the well and returns to the surface usually through the annular space between the tubing and the well casing. In completing the power circuit a portion of the recovered crude oil is recycled as the power liquid to the production unit and back to the well. Obviously, the oil could go down the annular space and up the tubing if desired.

During continuous pumping of some types of crude oil from the well, deposits of wax and paraffin accumulate on the tubing and walls of the well which tend to obstruct the flow of oil being pumped. In order to alleviate this interference to the flow of oil through the tubing by the deposition of paraffin, mechanical and chemical means are required to remove the paraffin deposits. Such mechanical and chemical means for removing the paraffin require extra labor, time and expense. A self-contained circuit providing for the continuous and automatic removal of the paraffin deposits from the well tubing and the pumping of crude oil from the well is much to be desired.

I have found that paraffin deposits formed in the tubings and casing of oil wells, when employing a hydraulic pumping system for the removal of crude oil, can be removed automatically and continuously by using an internal combustion engine as the power unit of said pumping system in combination with a heat exchanger for transferring the sensible heat of the exhaust gases from the internal combustion engine to the power oil or liquid.

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The primary object of this invention lies in the provision for a continuous and automatic means for the removal of meltable material from the tubing and walls of deep wells.

Another object of this invention is to provide a means for continuous removal of well liquids from deep wells by a hydraulic power circuit.

Still another object is to provide a self-contained power system for the removal of crude oil from subsurface deposits wherein paraffin and wax deposits are removed from the tubing and walls of the wells to eliminate the use of high pressures and extra equipment.

Another object is to provide a means for a continuous and constant volume pumping system.

Still another object is to provide a heat exchange means between exhaust gases of an internal combustion engine and power liquid of a hydraulic pumping circuit.

Other objects and advantages will be apparent to those skilled in the art from the following description of the invention and from the accompanying drawings and claim.

Figure 1 is an elevational view with parts in cross section of a continuous hydraulic pumping system embodying the present invention.

Figure 2 is a cross-sectional view taken along line 2—2 in the direction indicated of the element 6 of Figure 1.

Figure 1 shows the continuous hydraulic pumping system described aforesaid wherein a tank 3 is provided for the storage of clean oil to be used as the hydraulic power liquid. Outlet 4 is for the removal of bottom sediment from storage tank 3.

Heat exchanger 6 is provided for the heat exchanging of exhaust gases 7 of internal combustion engine 8 and said power liquid 22. Heat exchanger 6 comprises a cylindrical vessel or casing 11 with tubes 12 longitudinally disposed therein and held in place by separator plates 13 and 14. It is desirable to have the ends of tubes 12 project a short distance from separator plates 13 and 14. Element 16 acts as both a separator plate and baffle to direct the flow of oil. Both separator plates 13 and 14 and baffle 16 are perforated so that tubes 12 can be inserted in them and held

stationary in the vessel 6. A sump 17 is provided for the flow of fluid around baffle 16, said sump having plug 18 for the removal of sludge and other deposits within the heat exchanger 6. Heat exchanger 6 contains an exhaust gas inlet 19 in one end and an outlet 21 in the other.

The tubes 12 inserted in the separator plates are sealed thereto and the separator plates 13, 14 and 16 are sealed to the outer casing of the heat exchanger to prevent leakage of fluids between the gas inlet or outlet sections and the oil section 9 surrounding the tubes between the separator plates. The heat exchanger can be designed for any number of tubes in the cylindrical shell or casing. The casing of the heat exchanger may rest on any suitable base (not shown) which may comprise steel I beams or a cement foundation. The fluid inlets and outlets are preferably so arranged, as shown, that countercurrent flow of power oil and exhaust gases is achieved. However, the direction of flow of either fluid may be reversed in the heat exchanger without departing from my invention, but countercurrent flow gives better heat exchange.

Power oil enters heat exchanger 6 through line 23 passing over and around the tubes 12 and out through line 24. Internal combustion engine 8 drives power liquid drive pump 26 by any suitable drive means such as shaft 27. The internal combustion engine 8 and drive pump 26 comprise the power unit. Conduit 19 conveys exhaust gases from internal combustion engine 8 into heat exchanger 6.

A production unit generally designated as 28 is provided for the removal of well fluids from an oil well generally designated at 29, and said unit 28 comprises a hydraulic engine 31 which drives a deep well hydraulic pump 32 positioned in the well casing 33, preferably adjacent to the bottom of said casing. However, pump 32 may be positioned at a higher point in the casing provided this point is below the point at which pump suction would form vapor from the well fluids present. The position of this high point depends on the pressure naturally on the well fluids from the formation and upon their vapor pressure. The pump 32 has an inlet 34 in communication with an oil formation 36 and otherwise casing 33 is sealed to the pump 32.

The well 29 may be provided with the usual oil string casing 33, a casinghead 37, and a tubing hanger 38 supporting tubing 39. Any type of well head or hookup may obviously be employed. Preferably tubing 39 is connected to the inlet of engine 31 so that power liquid from drive pump 26 will flow down the tubing 39 and the exhaust liquid from motor 31 and well fluid pumped by pump 32 will be forced up annular space 41 and out flow line 42. However, by obvious changes the tubing 39 could conduct the exhaust liquid and well fluids while annular space 41 conducted the power liquid from the drive pump.

An oil and water separator 43 is generally provided for the separation of water from the crude oil whenever the crude oil contains water. Water separates from the oil in separator 43 by gravity and is withdrawn by line 44 into water tank 46 which is provided with outlet 47. Tank 48 is for the storage of excess crude oil from the system and has an outlet line 49 for the removal of the oil and another outlet line 51 for the withdrawal of bottom sediment. A filter 52 may be provided for removing waxes and solid deposits from the portion of the crude oil recycled to the power unit by way of line 53 and clean oil tank 3. Conduit 54 is a means for removing sludges and other deposits collected in the filter 39. The filter 52 may be any type of oil cleaning apparatus, such as settlement tanks.

Figure 2 is a cross sectional view along line 2—2 of heat exchanger 6 in the direction shown showing tubes 12 for the conduction of exhaust gases through the heat exchanger countercurrent to the flow of hydraulic fluid within the annular space 9 outside the tubes. The clearance of baffle 16 over sump 17 is shown.

Paraffin, waxes, or other solid meltable deposits are shown at 55 and 56.

In the operation of such a system as shown in Figure 1, waxes, paraffin or other solid meltable materials often form at such points as 55 in the tubing or 56 in the annular space 41. These are merely shown as the most probable examples as the point of paraffin deposition may vary and may be on any point in the power circuit 24, 26, 39, 31, 41, 42, 43, 52, 3, 23 although its accumulation at such a point as heat exchanger 6 is highly unlikely.

The passage of the oil in the power circuit is believed obvious so a very short description of this operation is given. Oil from tank 3 flows by gravity, or is pumped, through pipe 23 and heat exchanger 6 to pump 26 which pumps it down pipe 39 into motor 31 which exhausts the oil to space 41 and motor 31 drives pump 32 pumping well fluids from formation 36 into space 41. The exhaust oil from motor 31 and exhaust well fluids from pump 32 pass up space 41 and pipe 42 to water separator 43. If there is gas present in any quantities water separator 43 may be supplemented in the usual manner (not shown) by a gas separator but generally in a pumped well there is too little gas to need any separate treatment as tanks 43, 48, 52 and 3 may be provided in practice with gas relief valves (not shown). Water is taken out in separator 43 and removed to tank 46, and the excess crude oil produced placed in tank 48, while the remainer of the oil completes the power oil circuit by passing through filter 52 into tank 3.

The present device operates upon the theory that the paraffin 55, 56 which accumulates in the tubing 39 and casing 33 of the well 29 constricts the passage of the oil through this tubing or casing increasing the power or work requirements of the power unit 26, 8 necessary to supply a constant volume of oil to the production unit 28. The increase in power requirements increases the amount of work required from the internal combustion engine 8 operating the pump 26. Since an increase in the work requirements of the internal combustion engine 8 results in a direct increase in the temperature of the exhaust gases 7, the heat from the exhaust gases 7 is transferred to the power oil 22 used in driving the production unit 28. The warmed oil 24 when conveyed to the well 29 melts the paraffin wax accumulated at 55, 56 and thus relieves the constriction in the tubing 39 and casing 33 of the well. When the constriction is relieved the power requirements of the power unit correspondingly decrease which results in a decrease in temperature of the exhaust gases 7. A decrease in temperature of the exhaust gases 7 decreases the temperature of the power oil 22.

Thermodynamically, the greater the work requirements of the internal combustion engine 8, the greater the pressure within the combustion chamber (not shown) and the higher the temperature of combustion. This high temperature of

combustion accounts for the high temperature of the exhaust gases 7. Thus, when the temperature of combustion within the combustion chamber increases, the temperature of the exhaust gases and the power oil also increases.

Clean crude oil should preferably be used as the hydraulic power fluid 22. Such oil may be already available in the vicinity of the well and can be supplied from the crude oil as it is produced from the well. Water from tank 46 could be used if pipes 47 and 23 were connected, but this is not preferred. The power oil 22 is easily cleaned since practically no emulsion is formed by hydraulic pumping. Tanks of the continuous flow type (not shown) are therefore very satisfactory and economical for cleaning the power oil where no source of clean oil is available. An advantage of this method of cleaning the oil is that all of the production is delivered to the oil lines as dehydrated oil.

The present range of the equipment of the pumping system described includes the removal of oil from depths as great as 15,000 feet and the production of volumes as large as 4,500 barrels of oil per day. In the normal application, the power oil ratio to crude oil produced may be about 1 to 1.

In many cases the filter 52 and clean oil storage tank 3 may be eliminated. In other cases where very little water is normally obtained in the crude oil, the oil water separator 43 and water tank 46 may also be eliminated. Under such circumstances, a portion of the oil from the well is passed directly to the heat exchanger.

The heat exchanger 6 used in this system is not limited to the type described but may be any of the horizontal or vertical heat exchangers (not shown) commonly used for the heat exchange of fluids. Double pipe heat exchangers in which one fluid flows through a pipe inserted in another pipe in which another fluid is flowing, may be conveniently adapted to the present invention. Heat exchangers may also be multiple pass heat exchangers as well as single pass heat exchangers and may have any number of baffles within the heat exchanger casing for directing the flow of fluids. However, the heat exchanger illustrated is preferred, and because of this preference is regarded as a subcombination useful per se in such systems.

The drawing showing the relative position of the different apparatus is only illustrative, and the position of the apparatus may be interchanged to suit the circumstances and conveniences. Thus, heat exchanger 6 may often be placed after pump 26 rather than before. Other units may obviously be transposed without departing from my invention.

This invention may apply to any type of deep well from which fluids are being pumped by a power liquid and in which solid meltable material may deposit in the pumping circuit or system. The constriction in the pumping circuit of the deep well will be relieved by the application of the present invention in an automatic and continuous manner.

Having described a preferred form of my invention and having pointed out the principal considerations to be observed in the construction and operation of equivalent pumping systems, it is obvious that various other changes can be made without departing from the scope of the invention and it is to be understood that the invention is to be limited only by the scope of the appended claim.

Having described my invention I claim:

In a deep well pumping system comprising a power liquid circuit including as component parts well tubing and casing, surface piping connecting the upper ends of said casing and tubing, a hydraulic engine in the well casing driven by said power liquid, a deep well pump in said casing driven by said engine for pumping well liquids into said circuit, and a driving pump in fluid communication with said surface piping for driving said power liquid in said circuit, and an internal combustion engine driving said driving pump, and wherein solid meltable material may deposit in the well tubing and casing of said power circuit, the improvement comprising a heat exchange means connected in said surface piping and adapted for indirect heat exchange between exhaust from said internal combustion engine and power liquid in said surface piping whereby upon substantial constriction of a portion of the power liquid circuit within the well tubing or casing by deposition of said meltable material therein resulting in increased work requirements of said internal combustion engine, the increased temperature of the exhaust in said heat exchange means will increase the temperature of said power liquid so that a substantial portion of said meltable material will melt and substantially relieve said constriction.

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