ELECTRICAL OIL WELL HEATER APPARATUS

Filed Aug. 1, 1963

FIG. 1.

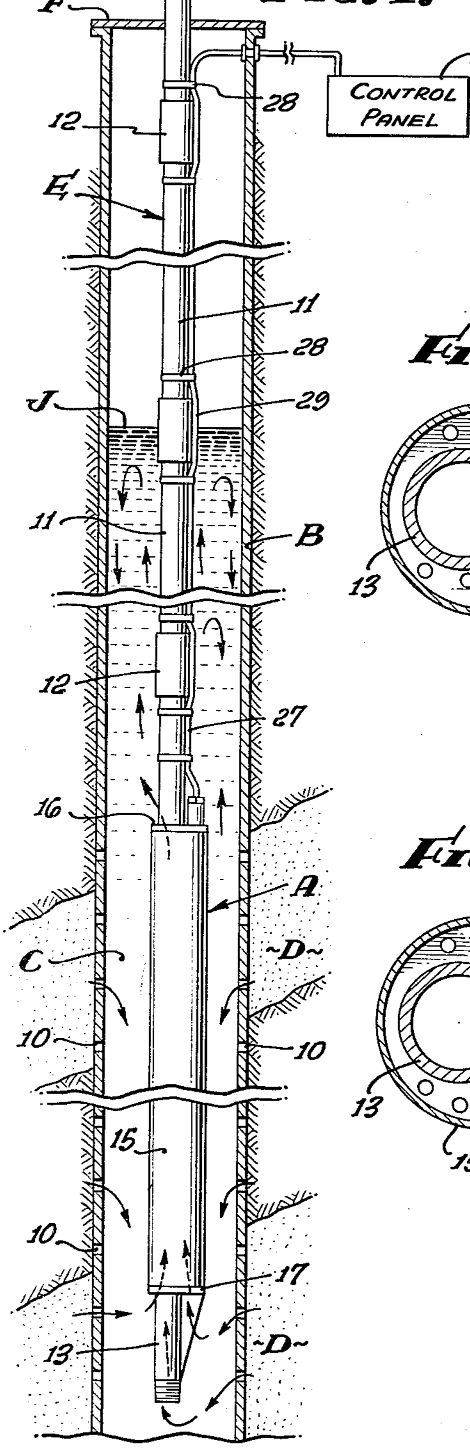


FIG. 2.

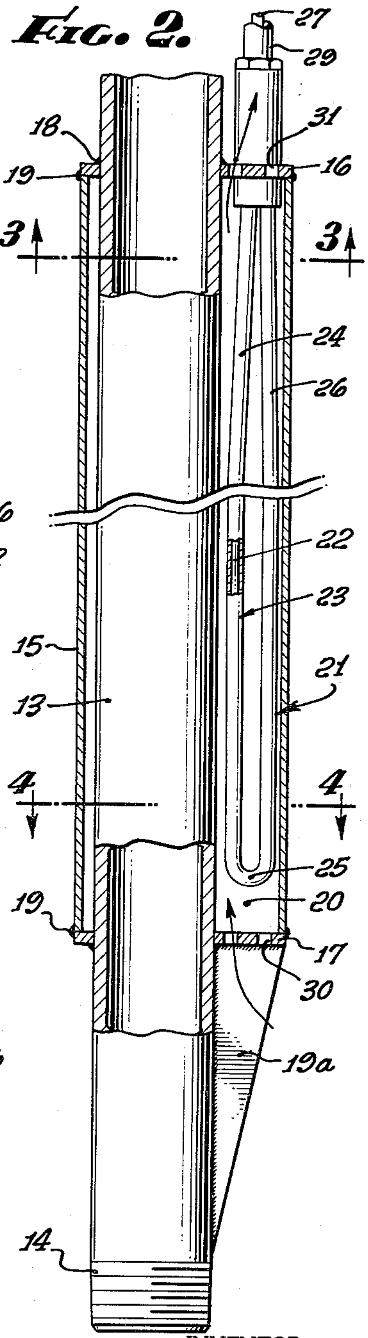


FIG. 3.

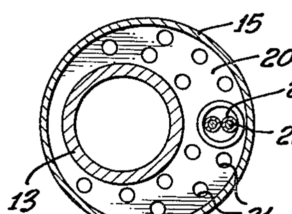
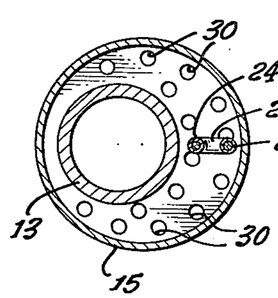


FIG. 4.



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ELECTRICAL OIL WELL HEATER APPARATUS

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2 Claims. (Cl. 166—60)

This application is a continuation-in-part of appplication Serial No. 134,798, filed August 14, 1961, for "Electric Oil Well Heater Apparatus," now U.S. Patent No. 3,114,417, which is a continuation of application Serial No. 719,020, filed March 4, 1958, for "Electric Oil Well Heater Apparatus," now abandoned.

The present invention relates to subsurface well apparatus, and more particularly to subsurface heaters adapted to be located in a well bore to elevate the temperature of the well production therewithin and in the surrounding formation.

An object of the invention is to provide a subsurface heater to be disposed in a well bore that causes heat to be transmitted to the production in the well bore for a substantial distance above the heater itself, such heated production surrounding the tubing string above the heater and minimizing heat loss from the oil that is moving upwardly through the tubing string. In fact, to some extent, the heated production above the heater surrounding the tubing string may actually transfer heat through the tubing string to the oil therewithin.

Another object of the invention is to provide a subsurface heater to be disposed in a well bore, in which the well production is caused to rise thermally through the heater around the production tubing, discharging thermally from the upper portion of the heater, and rising around the production tubing to a substantial distance, then descending for entry into the production tubing and also into the lower portion of the heater externally of the production tubing for recirculation through the heater and around the production tubing thereabove.

A further object of the invention is to provide a subsurface heater to be disposed in a well bore that causes the production in the well bore to circulate thermally through the heater and around the production tubing thereabove, preventing the trapping of any portion of the production in the heater and its potential overheating, that might otherwise cause its coking, or its caking on surfaces of apparatus in the well bore.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGURE 1 is a longitudinal section through a well bore, with an electric oil well heater disposed therewithin;

FIG. 2 is an enlarged view of the heater apparatus, disclosed partially in longitudinal section and partially in side elevation;

FIG. 3 is a cross-section taken along the line 3—3 on FIG. 2;

FIG. 4 is a cross-section taken along the line 4—4 on FIG. 2.

A heater apparatus A is disclosed in the drawings within a well casing B in a body of oil C, or other well production, that flows from a producing zone or zones D through casing perforations 10 to its interior, the well

production being elevated by a suitable pump (not shown) in a string of production tubing E extending from the heater to a casing head F at the top of the well bore. As is well known in the art, the pump is located at a desirable point in the tubing E and is reciprocated by a string of sucker rods G extending through the production tubing to the top of the well bore for actuation by a suitable pump operating mechanism, such as a walking beam (not shown) or a hydraulically operating mechanism (not shown).

The production tubing E is ordinarily made of tubing sections 11 threadedly secured to intervening couplings 12, the lower coupling being threadedly attached to an inner imperforate production tube 13 constituting part of the electric heater apparatus A. The lower end of such tube 13 may be constituted as a threaded pin 14, in the event it is desired to threadedly attach some other member (not shown) thereto.

In addition to the inner imperforate tubing 13, the heater apparatus includes an outer housing or tubular member 15 which is preferably eccentrically disposed with respect to the inner tubular member. This outer member is held in such eccentric relation by upper and lower end plates 16, 17 surrounding the inner member 13 and suitably secured thereto, as by use of welding material 18. The peripheral portions of the end plates 16, 17 are secured, by welding material 19, or the like, to the outer tubular member or housing 15, which is also preferably imperforate. The structure can be reinforced by welding a brace 19*a* to the inner tube 13 and to the lower plate 17. Disposed within the elongate space or chamber 20 between the inner and outer tubular members 13, 15 is an electric heating device 21, which, as disclosed, includes a tube 23 preferably made of stainless steel to avoid corrosion and electrolytic action in the well bore. The tube 23 has one leg 24 extending downwardly within the heating chamber 20 from the upper plate 16 to a location adjacent to the lower plate 17, this leg merging into an intermediate portion 25 which merges into another leg 26 extending upwardly toward the upper plate 16.

A suitable resistance wire 22 is mounted in the tubing 23 and insulated therefrom, in a known manner. The upper portions of the legs of the resistance wire 22 are suitably connected to electric power conductors (not shown) forming part of a power cable 27 extending along and suitably fastened to the production tubing E, the power cable passing out of the well casing above ground and to a control panel H, to which a power source is connected. The insulated cable 27 is fastened to the production tubing in any suitable manner. As specifically shown, clamps 28 surround the production tubing at opposite ends of each coupling 12, forcing a cable protector 29, extending along the cable 27, inwardly to clamp the latter to the production tubing. One form of clamp device that can be employed is described and claimed in my application for "Electric Cable Clamp and Protector," Serial No. 160, 082, filed December 18, 1961.

The lower plate 17 has a plurality of perforations or openings 30 to permit fluid to flow from the well casing B into the lower portion of the heating chamber 20 surrounding the inner production tube 13. The upper plate 16 also has perforations or openings 31 that permit the heated well production to pass upwardly therethrough into the well casing above the heater A. The well production can also pass into the lower end 14 of the inner production tube 13 to be elevated by the pump in the tubing string E to the top of the well bore. The heater A between the upper and lower end plates 16, 17 may be of any suitable length. For example, the length may vary from about 10 feet to about 25 feet, the resistance heating element 22 being approximately twice such distance. This provides a large extent of heating of the liquid passing upwardly through the lower perforations 30 into the chamber 20.

The heat transferred from the resistance heating element 22 through the tube 23 to the liquid in the chamber 20 is, in turn, conducted from such liquid through the wall of the inner production tube 13 to the well production flowing upwardly through the production tube. The heat of the liquid in the chamber 20 is also transmitted through the wall of the outer housing or tubular member 15 to the production in the well casing surrounding the latter. Thus, a liquid heat exchanger is provided in which the liquid in the chamber 20 contacts the full surface of the inner production tube 13 between the end plates 16, 17 to transfer heat to the oil passing upwardly through the production tube, and which also conducts heat through the full surface of the outer tubular member 15 to the production in the well casing surrounding the latter. The heat of the oil in the well casing B will also be transferred outwardly through the casing itself and its perforations 10 into the formation D for the purpose of heating the oil therewithin and reducing its viscosity, facilitating flow of such oil into the well bore.

The oil, or other liquid, in the heating chamber 20 is not stationary, but moves upwardly therefrom. As the oil is heated in the chamber, it rises thermally therewithin, jetting upwardly through the perforations 31 in the upper end plate 16 and passing upwardly through the well production in the casing above the heater A and along the production tubing E above the heater, such heated production flowing thermally upwardly through the well production in the casing until it reaches to substantially the upper fluid level J of the well production. In passing upwardly in the casing B above the heater A, the liquid discharged from the heater will transmit heat to the production tubing E above the heater, at least to the portion of the production tubing in the vicinity of and above the heater, and will also commingle with and heat the oil in the casing B above the heater and surrounding the tubing string E. Thus, the tubing string E up to the upper fluid level J of the oil will be surrounded by a body of liquid at an elevated temperature, rather than by a body of relatively cold liquid, which will minimize the loss of heat from the oil being pumped upwardly through the tubing string E to the top of the well bore. As the heated oil rising around the tubing E cools, it will tend to descent, in all probability flowing downwardly along the casing to the production zone D, commingling with the oil flowing from the zone D into the well at a lower temperature, this lower temperature production then flowing partially into the lower end 14 of the inner production tube 13 and partially through the lower perforations 30 in the plate 17 back into the heating chamber 20, where the heating element 22 again imparts heat thereto and elevates its temperature. The fluid medium in the heating chamber continues to transmit its heat through the inner production tubing 13 to elevate the temperature of the oil therewithin, and also flows upwardly thermally through the heating chamber 20, discharging through the openings 31 in the upper plate into the well casing thereabove.

It is apparent that the allowing of the well production to flow upwardly through the heating chamber 20 causes a recirculation of the oil through such chamber, the hot oil in the chamber transmitting its heat through the inner production tube 13 to the oil therewithin, and also through the outer tubular member or housing 15 to the oil surrounding the latter. The heated oil in the chamber also discharges from the upper end of the chamber, flowing thermally upwardly through the mass of liquid C in the casing B to elevate the temperature of the latter, causing the production tubing E to be surrounded by a liquid mass at an elevated temperature.

Accordingly, a subsurface oil well heater A has been provided that actually embodies a liquid heat exchanger for transferring heat to the production in the innner production tubing 13, as well as to the liquid in the well casing surrounding the heater. The mass of production C in the well casing B is caused to circulate therewithin by virtue of the thermal action of the oil in the heating chamber 20, its rising upwardly through the production in the casing above the heater, and its subsequent descent. The heated oil commingles with the production within the casing, and, during its descent, with the production flowing into the casing from the producing formation or formations D. Thus, the oil in the heating chamber 20, being in a dynamic state at all times, is less susceptible to overheating in the event the current is allowed to flow through the resistance heating element 22 for too long a period. If, for example, the pump is inoperative, but the current is allowed to flow through the electric heater, a static mass of oil in the heating chamber 20 could readily become overheated, possibly effecting its coking and caking on the surfaces of the inner and outer tubular members 13, 15, as well as on the tube 23 containing the electric resistance element. With the oil allowed to circulate thermally upwardly out of the heater into the relatively large mass of fluid C thereabove, the possibility of any portion of the oil in the well casing reaching too high a temperature is considerably minimized, since the thermal circulation of the oil into and out of the heater A requires the heater to elevate the temperature of a much greater mass of oil than embodied within the chamber 20 itself.

The electric heater A may include a thermally responsive device (not shown) for controlling the passage of current to the heater, and thereby retain the temperature of the well production between desired minimum and maximum limits. Such temperature can be varied by suitable devices in the control mechanism H at the top of the well bore. Such temperature control forms no part of the present invention. One form thereof is described and claimed in the aforesaid continuation applications, Serial Nos. 134,798, now U.S. Patent No. 3,114,417, and 719,020, now abandoned.

What is claimed is:

1. In subsurface well heating apparatus: an inner, imperforate tubular member through which well production is adapted to be conducted; an outer tubular member surrounding said inner member; upper and lower plates mounted eccentrically on said inner member at the upper and lower portions, respectively, of said outer member and secured to said inner and outer members to mount said outer member in spaced and eccentric relation to said inner member to form a heating chamber therewith substantially wider at one side of said inner member than at the diametrically opposite side thereof; heating means disposed lengthwise within said chamber at said wider portion thereof; said upper and lower plates being perforate, whereby well production can enter the chamber through a perforation in said lower plate, flow upwardly through said chamber and along said heating means, and discharge from said chamber through a perforation in said upper plate.

2. In subsurface well heating apparatus: an inner, imperforate tubular member through which well production is adapted to be conducted; an outer tubular member surrounding said inner member; upper and lower plates mounted eccentrically on said inner member at the upper and lower portions, respectively, of said outer member and secured to said inner and outer member to mount said outer member in spaced and eccentric relation to said inner member to form a heating chamber therewith substantially wider at one side of said inner member than at the diametrically opposite side thereof; electric resistance heating means disposed lengthwise in said chamber in the wider portion thereof; said upper and lower plates being perforate, whereby well production can enter the chamber through a perforation in said lower plate, flow

upwardly through said chamber and along said heating means, and discharge from said chamber through a perforation in said upper plate.

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