

Nov. 24, 1953

J. J. JAKOSKY

2,660,249

MEANS FOR HEATING OIL WELLS

Filed Nov. 18, 1949

3 Sheets-Sheet 1

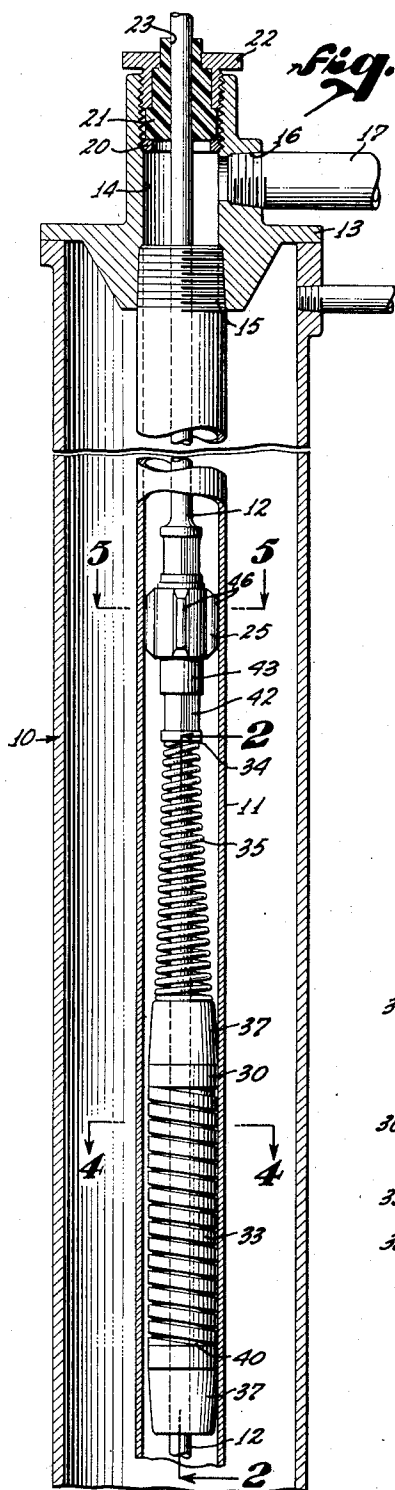


Fig. 2.

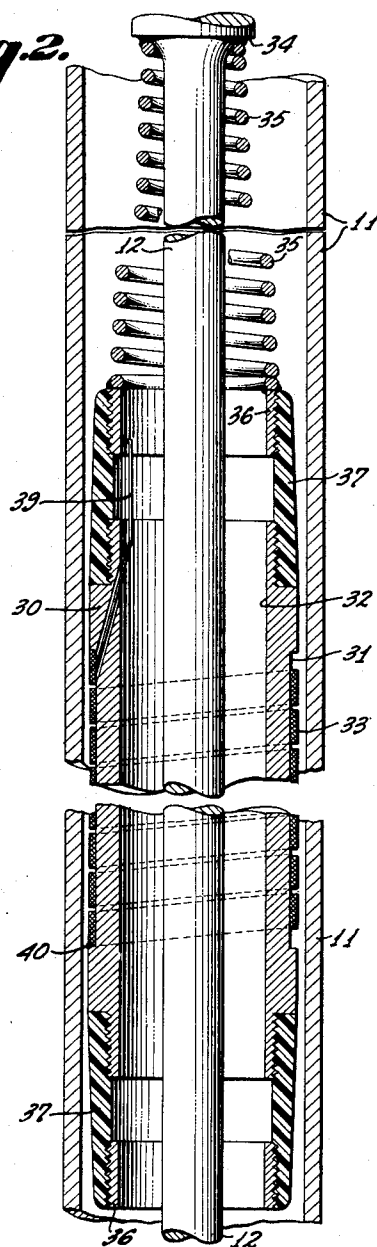
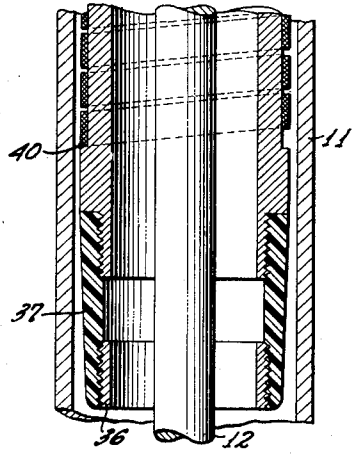
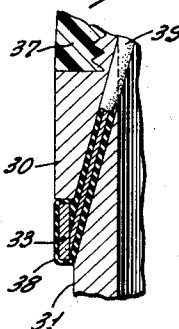


Fig. 3.



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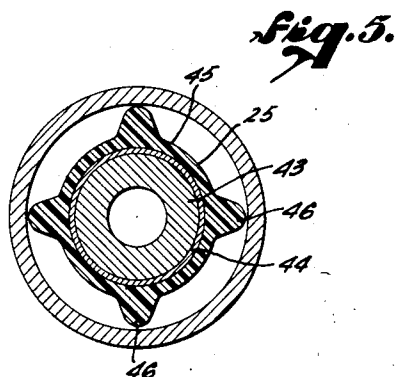
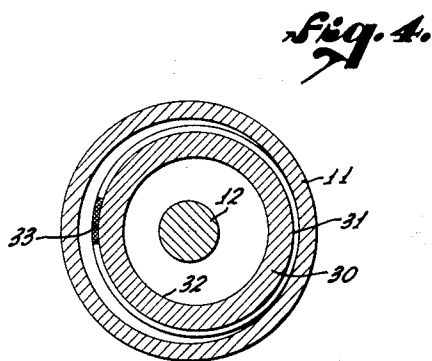
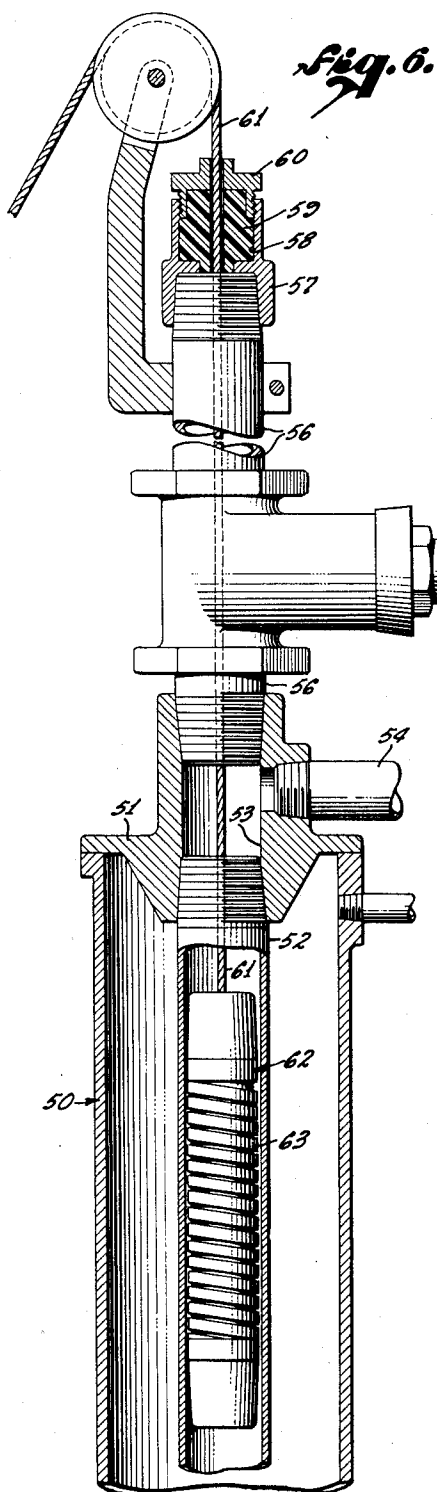
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Fig. 7.

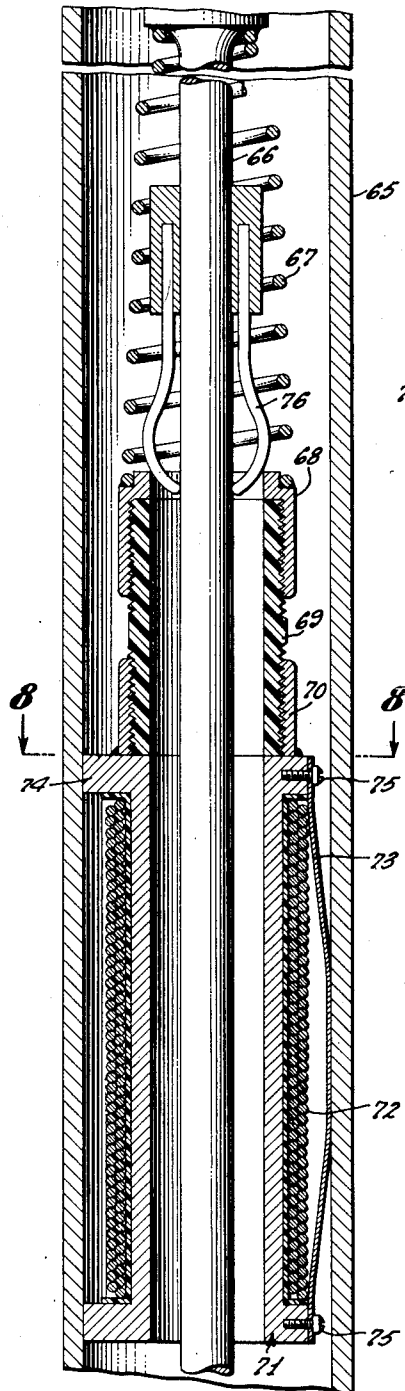


Fig. 9.

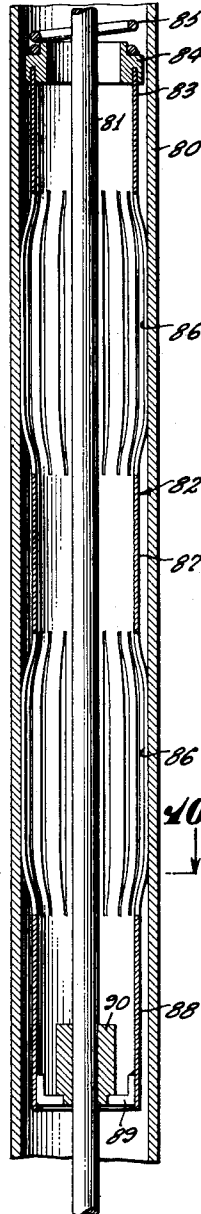


Fig. 8.

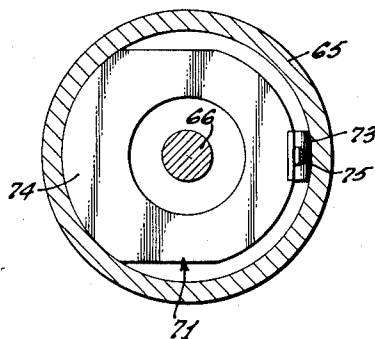
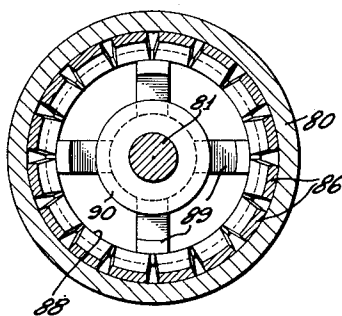


Fig. 10.



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UNITED STATES PATENT OFFICE

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MEANS FOR HEATING OIL WELLS

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5 Claims. (Cl. 166—17)

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My invention relates to a means and method for heating the fluid contained in the tubing of a flowing or pumping oil well.

In a great majority of oil wells a certain amount of gas is produced with the oil, the gas being usually methane and other light hydrocarbons. In some wells the ratio of gas to oil is excessively high; under these conditions difficulty occurs due to the cooling action of the methane and light hydrocarbons which are released from the oil with a decrease in hydrostatic pressure.

As the oil with its dissolved gas flows up the tubing, the hydrostatic pressure is gradually decreased; the release resulting therefrom of this gas lowers the temperature of the oil by an accumulative cooling action and freezes any moisture which may happen to be present in the gas to form hydrate.

In other cases the oil may contain a high paraffin content, and the cooling action will cause the paraffin to solidify and separate from the oil. The paraffin is deposited upon the walls of the tubing, eventually closes the opening, and may completely stop the fluid.

In other wells having a low gas-oil ratio, the oil is often of heavy gravity with a relatively high solidifying point; such oils are usually of such viscosity as to make their pumping an expensive and difficult operation. To efficiently produce the viscous oil from such wells, it is desirable to heat the oil in order to reduce its viscosity. Most heavy oils have a very steep temperature viscosity gradient and a rise of 20° to 30° Fahrenheit will often cut viscosity to one third its initial value. By heating the fluid flowing through the tubing, it is possible to prevent the formation of hydrates and paraffins and to lower viscosity to facilitate the production either by pumping or flowing.

To effect this desired heating, I employ a current of electricity conveyed down the well to the desired depth. The current is of a magnitude that its I^2R losses in flowing through the conductor will give the desired heating effect. The dissipation of heat, however, is to be confined chiefly to a portion of the conductive path while the remainder of the path is to dissipate a minimum amount of heat, as will be apparent later from the detailed description of my invention.

One conductor for conveying the current is the tubing itself. The other conductor may be either the pump or sucker rods which are inside the tubing if the well is pumping, or an insulated

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cable suspended in the tubing if the well is free flowing.

I am aware that a great many prior attempts have been made to heat the oil in the tubing by means of electricity wherein the tubing has been used as one of the conductors; however, in most of the prior attempts the casing surrounding the tubing has been used as the other conductor. In these prior endeavors the tubing is insulated from the casing by a spacer disposed along the tubing to keep it centrally located within the casing. The tubing is also insulated where it passes through the casing head. The sucker rod must be insulated from the pumping mechanism and the casing head.

As will become apparent later from a discussion of the power involved, such method is costly and for various practical reasons not satisfactory.

One of the principal problems involved in using the sucker rod as one of the electrical conductors is to provide means for electrically connecting the sucker rod to the tubing at the desired point in the well.

One of the objects of my invention is to provide means for making a satisfactory electrical contact at the lower end of the heating circuit which is capable of carrying relatively large currents and which will freely drop of its own weight into the tubing.

In the devices known to the art for heating substances in oil wells, wherein the casing and tubing comprise the two sides of the electric circuit, serious problems of electrolysis arise. The casing which carries the electrical current is in contact with the ground and other current-carrying material, such as water; therefore, electrolytic action tends to destroy the casing, which results in expensive replacements and shut-down time.

A further object of my invention is to provide a system for heating the systems in oil wells, which does not present any problem of electrolysis. The electrical circuit is confined to the sucker rod and tubing, which are not in contact with the ground, and, therefore, no electrolytic action takes place.

Other and further objects and advantages will become apparent from the drawings and the specifications relative thereto.

In the drawings:

Figure 1 is a fragmentary sectional view of an oil well installation having the heating apparatus embodying the principles of my invention.

Figure 2 is an enlarged sectional elevation of the electrical coupling for connecting the sucker rod to the well tubing.

Figure 3 is an enlarged fragmentary view of the electrical coupling shown in Figure 2.

Figure 4 is a sectional view taken on line 4—4 of Figure 1.

Figure 5 is an enlarged sectional view taken on line 5—5 of Figure 1.

Figure 6 is a fragmentary sectional elevation showing a modification of my invention.

Figure 7 is a fragmentary sectional elevational view showing a modified form of my invention.

Figure 8 is a section taken on line 8—8 of Figure 7.

Figure 9 is a fragmentary sectional elevation of a further modification embodying the principles of my invention.

Figure 10 is a sectional view taken on line 10—10 of Figure 9.

Experimental work has shown that a much greater efficiency of operation may be obtained by employing a heating system utilizing the tubing as one conductor and having the other conductor within the tubing. When the tubing and casing are employed as the conductors, as revealed in the prior art, the current requirement is excessive due to the low resistance of the tubing. An example of the requirement is given in United States Letters Patent No. 2,244,255, which gives the following data regarding the current requirement to heat a two-inch tubing and casing combination. The specifications therein recite:

"To illustrate, with the adapter set at 1500 feet in two-inch tubing, the tubing may be heated to around 120° Fahrenheit by using a current of 50 volts and 750 amperes, or 37,500 watts for a period of 35 to 40 minutes."

Experimental work has indicated that such requirements are correct. My experimental work has indicated that when using the tubing and an internal conductor, the current may be much less than that required in the tubing-casing system; and in addition the heat is more efficiently utilized.

The relative operating efficiencies may be illustrated as follows: assuming that it is desired to raise the temperature 100° Fahrenheit, simple calculations will show the following typical relations:

(a) The conductive area of 8 $\frac{5}{8}$ inch O. D. casing is 8.85 square inches.

(b) The conductive area of 3 inch O. D. tubing is 1.90 square inches.

(c) The conductive area of a $\frac{3}{4}$ inch diameter sucker rod is .443 square inch.

For a given current flow the tubing and casing combination will have 17.7% of the heat generated in the casing, all of which will be lost as far as heating the oil in the tubing is concerned, and experimental work shows that about 5% of the heat generated in the tubing will be lost. Since the tubing is dissipating 82.3% of the total heat, the tubing loss is 5% of 82.3, or 4.1%. This means that approximately 21.8% of the total energy is lost.

For the combination using the tubing and a $\frac{3}{4}$ inch sucker rod conductor in the tubing, there is no loss from the casing since it carries no current. There is no loss from the conductor within the tubing, and there is a 5% loss of the energy in the tubing; but since the tubing is carrying only 18.6% of the total energy, the loss would be 5% of 18.6, or .93%. This

means that for the same power input, the tubing casing combination wastes 23.5 times as much energy as the tubing sucker rod combination.

Experimental work has shown actually that the tubing sucker rod combination will require only

.443
1.90

or 23.3% of the current for the same heating effect per foot of conductor. The smaller current leads directly to a smaller I²R loss in the conductors leading to the rod and tubing. It can thus be seen that the efficiency of the tubing sucker rod combination is much greater; furthermore, since the tubing sucker rod combination requires a current only 23.3% of that of the casing-tubing combination, all electrical equipment becomes correspondingly smaller and less expensive.

Referring to the drawings for specific details of one embodiment of my invention, I have illustrated in Figure 1 an oil well having a casing 10, a tubing 11 substantially concentrically disposed through the casing and a sucker rod 12.

The casing 10 is provided with a casing head 13 in the usual customary manner. The casing head 13 is formed with a bore 14 into which the tube 11 is threaded as at 15.

The casing head is formed with a lateral bore 16 threaded to receive a discharge pipe 17.

I have provided a packing of sucker-rod stuffing box in the upper end of the casing head which comprises a locking ring 20, an insulated packing or bushing 21, and a lock nut or packing nut 22. The packing 22 is formed with a bore 23 through which the sucker rod 12 is permitted to reciprocate.

A plurality of dielectric spacers 25 are secured at spaced intervals preferably at each joint length along the sucker rod to prevent the sucker rod from engaging or touching the tubing 11.

Although it is not shown, it will be understood that the tubing 11 is electrically connected to one side of an electrical circuit, and the sucker rod 12 is connected electrically to the other side to complete the circuit when the desired contact is made between the sucker rod and the tubing.

I have provided means for making the contact desired; such means are illustrated more clearly in Figures 2 and 3.

The connector means comprises an iron core 30 having a recessed central portion 31. The core 30 is formed with a bore 32 which is sufficiently large to permit free reciprocating movement of the sucker rod 12 without interfering with the pumping action or the flow of oil upwardly through the core 30.

The sucker rod 12 is formed with a shoulder 34 and a coil compression spring 35 is securely fastened thereto by welding or other suitable means. The spring 35 also abuts against the electrical connector means and is welded securely to the metal ring 36. A dielectric sleeve 37 is threadedly connected to the core 30 and to the ring 36 so that the core 30 is not electrically connected to the sucker rod except as herein-after explained.

A conductor 33 preferably of the flat ribbon type having an insulating layer 38 of any suitable type encasing said conductor is wound in a spiral coil about the core 30 in the recess 31. The conductor is connected to the ring 36 by means of any suitable connector means 39. The lower end of the coil 36 is electrically connect-

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ed to the core 30 as at 40 so that the core 30 becomes a part of the electrical system after the current has passed through the coil 33.

It will, therefore, readily be seen that upon passage of current down through the sucker rod through the spring 35, ring 36, conductor 39, coil 33, into the core 30 that upon contact of the core 30 with the tubing 11 a powerful electro-magnet is created which tends to tightly hold the core 30 against the side of the tubing 11 as is seen in Figure 4. As best seen in Figure 1, the spring 35 is given an initial bend or bow, thereby tending to press the core 30 to the right (Figure 1) against the inner surface of the tubing 11. This effects an initial contact which permits current to flow from the source of potential at the top of the well through the tubing and sucker rod. Once initiated, current flow in the coil 33 instantly induces a strong magnetic field which presses the core 30 tightly against the wall of the tubing 11, thereby fortifying the contact initially established by the bow in the spring 35.

As is well known, sucker rods come in relatively short lengths and must be coupled together. Such coupling is accomplished by forming the sucker rods with a square end section 42 and a threaded end which is in threaded engagement with a coupling 43.

The sucker rod spacers and installers 25 may be of any desired form such as is shown in Figures 1 and 5. The spacer comprises a metal ring 44 having an intumed lip adapted to be engaged between the end of the sucker rod and the coupling 43. A dielectric shield 45 having radial fins 46 is secured to the metal ring 44 and acts as a spacer guide and insulator for the sucker rod.

Whereas, I have illustrated in Figure 1 an electro-magnetic coupler having one spring 35 suspending the coupler from the sucker rod, it is readily apparent that an additional spring can be employed on the bottom of the coupler to thereby suspend the coupler between two shoulders of the sucker rod by means of two springs rather than one.

After the current has been turned on and the circuit completed by the electro-magnetic action of the coupler, the sucker rod is free to reciprocate without disturbing the electrical contact by compressing or extending the spring 35. It is also readily apparent that due to the differential in effective cross sectional area between the sucker rod and the tubing, that the greatest drop in potential will occur in the sucker rod; and in view of the fact that the heating factor is dependent upon and varies directly with the second power of the potential drop, the principal source of heat will be generated in the sucker rod, which is completely surrounded by the oil or other fluids being pumped from the well, and that all heat generated therein will be dissipated directly to the oil and that heat losses therefrom are at a minimum.

In Figure 6 I have illustrated a modified form of my invention for use in connection with the free flowing oil wells where sucker rods are not necessary.

I have illustrated therein only the upper portion of an oil well having a casing 50 enclosed by a casing head 51, a tubing 52 in threaded engagement with the casing head, the casing head, of course, being formed with a bore 53 to permit discharge of the flowing oil through a pipe

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54. A short length of tubing 56 extends upwardly from the casing head 51 and is provided with a cap 57 in threaded engagement therewith. The cap 57 is formed with a bore 58 adapted to engage and to receive an insulating packing 59, and a packing nut 60 is in threaded engagement with the upper end of the bore 58. The packing nut 60 and the packing member 59 are formed with suitable bores to permit the introduction of an insulated electrical cable 61. An electro-magnetic coupler designated generally 62 is suspended from the lower end of the insulated conductor 61. The coupler 62 is provided with a coil conductor 63 in a similar manner as described in connection with Figure 2 so that when current is connected to the cable 61, it passes through the cable 61 into the coil 63, then to the core 62, and back up the casing 52, thereby creating an electro-magnet which makes a strong, effective and efficient contact for the passage of the electrical current.

It will readily be seen that the diameter of the conductor 61 is relatively small with respect to the tubing 52 and that, therefore, the principal heat generated will be in the cable 61, which is immersed in the oil so that the principal heating effect will be directly into the oil and minimum heat loss will occur.

In the modification illustrated in Figures 7 and 8, I have shown the usual oil well tubing 65 having a sucker rod 66 depending therein in the usual manner, to which is secured a coil spring 67 in the manner similar to that shown in Figures 1 and 2.

An upper thread collar 68 is secured to the spring 67 by welding or other suitable means. A collar 68 is internally threaded and is adapted to receive in threaded engagement a tubular insulator 69. A lower threaded collar 70 is also secured to the lower end of the insulator 69 and has a magnetically permeable core body 71 secured thereto by means of welding. The body 71 is formed with a recess into which a coil 72 is disposed. The coil 72 has one end electrically connected to the collar 68 and its other end electrically connected to the core 71.

The core 71 is formed with an eccentric shoulder 74 at each end thereof. As will be seen in Figure 8, the eccentric shoulder 74 has one edge defining an arc of the same radius of curvature as the inner surface of the tubing 65.

A spring 73 is secured to the shoulder 74 and is adapted to engage the inner surface of the tubing 65 to resiliently urge the core 71 against the opposite surface of the tubing 65 as shown in Figure 8, to thereby complete an electrical circuit from the shoulders 74 to the tubing 65.

As was previously explained, one pole of a source of electrical energy is connected to the sucker rod 66, the other pole being connected to the tubing 65 so that upon contact between the shoulders 74 and the tubing 65, an electrical circuit will be completed through the coil 72, thereby setting up a strong magnetic field to more securely attract the shoulders 74 against the side wall of the tubing 65. A pair of bowed fingers 76 are secured to the rod 66, by means of a collar pressed onto the rod 66 within the spring 67. As the core 71 is pushed down through the tubing 65 the fingers 76 come into engagement with the upper edge of the collar 68, thereby preventing further compression of the spring 67 and obviating the possibility of the spring 67 doubling back upon itself, should the frictional resistance encountered by the core 71 be quite high.

Figures 9 and 10 illustrate a modified form of my invention, wherein the electrical connector between the sucker rod and the well tubing comprises a plurality of resilient fingers rather than an electromagnetic core.

In this modification numeral 80 represents a well tubing, and 81, a standard sucker rod. I have provided a sleeve 82 formed of resilient, relatively thin-walled material, having an upper cylindrical section 83, which is secured to a collar 84. The collar 84 is welded to a spring 85. It will be understood that the spring 85 is connected to the sucker rod in a manner similar to that shown in Figures 1 and 7. The sleeve 82 is formed with a plurality of slots axially disposed, thereby defining a plurality of contacting fingers 86. After the sleeve 82 has been slotted, the contacting fingers 86 are expanded so that the external diameter thereof is slightly greater than the internal diameter of the tubing 80, whereby upon insertion into the tubing 80 a resilient contact will result between the contacting members 86 and the inner wall of the tubing 80.

Whereas, I have illustrated a contacting sleeve having upper and lower contacting fingers 86 connected by a central cylindrical section 87 and terminating in a lower cylindrical section 88, it will be understood that the choice of the number of fingers to be used and the number of sections will be a matter of discretion, the only limitation being that each finger press against the tubing wall with sufficient force to carry its share of the current required for heating purposes. By using a large number of contacting fingers, a relatively light pressure can be used and still carry sufficient current in the rod 81 to effectively heat substances in the tubing 80 and yet be easily inserted into the tubing without having to apply excessive axial pressure to overcome the friction between the fingers and the inner wall of the tubing.

The lower end of the contacting sleeve 82 is provided with a spider having radial arms 89 connected to a bushing 90 slidably disposed over the rod 81. The bushing 90, which acts as a guide, should fit loosely enough on the rod 81 that reciprocation thereof does not cause axial movement of the contacting member 82.

While I have herein shown and described my invention in what I have conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of my invention, which is not to be limited to the details disclosed herein, but is to be accorded the full scope of the claims so as to embrace any and all equivalent devices.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In combination with an oil well tubing formed of conductive material and adapted to be positioned in an oil well, and a conductor passing substantially concentrically through said tubing, said conductor being effective to generate heat when a current is passed therethrough, means for insulating said conductor from said tubing, means for connecting the upper end of said tubing and said conductor to opposite sides of a source of electrical current and magnetic means for electrically connecting said conductor to said tubing at a point deep in the oil well whereby heat will be generated in said conductor to thereby heat fluid substances in the oil well.

2. In combination an oil well tubing formed of conductive material and adapted to be positioned in an oil well and a pump rod formed of con-

ductive material and having a substantially higher electrical resistance than said tubing, passing substantially concentrically through said tubing, means for spacing said rod from said tubing, means for connecting the upper end of said tubing and said rod to opposite sides of a source of electrical current and magnetic means for electrically connecting said rod to said tubing at a point deep in the oil well whereby heat will be generated in said rod to thereby heat hydrocarbon substances in the oil well.

3. In combination an oil well tubing formed of conductive material and adapted to be positioned in an oil well and a pump rod formed of conductive material passing substantially concentrically through said tubing, said rod being effective to generate heat when a current is passed therethrough, means for spacing said rod from said tubing, means for connecting the upper end of said tubing and said rod to opposite sides of a source of electrical current and means for electrically connecting said rod to said tubing at a point deep in the oil well whereby heat will be generated in said rod to thereby heat fluid substances in the oil well, said last-mentioned connecting means comprising a core formed of magnetically permeable material having a bore through the center thereof to permit passage of hydrocarbon substances, a magnetic coil wound around said core having one end thereof connected to said pump rod and the other end thereof connected to said core, whereby upon contact between said core and said tubing a magnetic field is created to thereby strengthen the contact therebetween.

4. The combination of claim 5 wherein said pump rod has a substantially higher electrical resistance than said tubing, said combination also including means for spacing said pump rod from said tubing.

5. In an oil well having electrically conductive tubing extending into the well, and an electrically conductive reciprocable pump rod extending into the well within the tubing, said pump rod being effective to generate heat when a current is passed therethrough, the combination of a contact member within said tubing circumjacent said rod and in electrical engagement with said tubing, an elongate, generally helical, longitudinally expandable and contractible electrical conductor disposed longitudinally in said tubing circumjacent said rod, one end of said conductor being connected to said rod, the other end being connected to said member, and means at the top of said well for applying an electric potential between said rod and said tubing, thereby to cause a current to flow in said rod and tubing to heat the oil within the tubing.

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