

Oct. 26, 1965

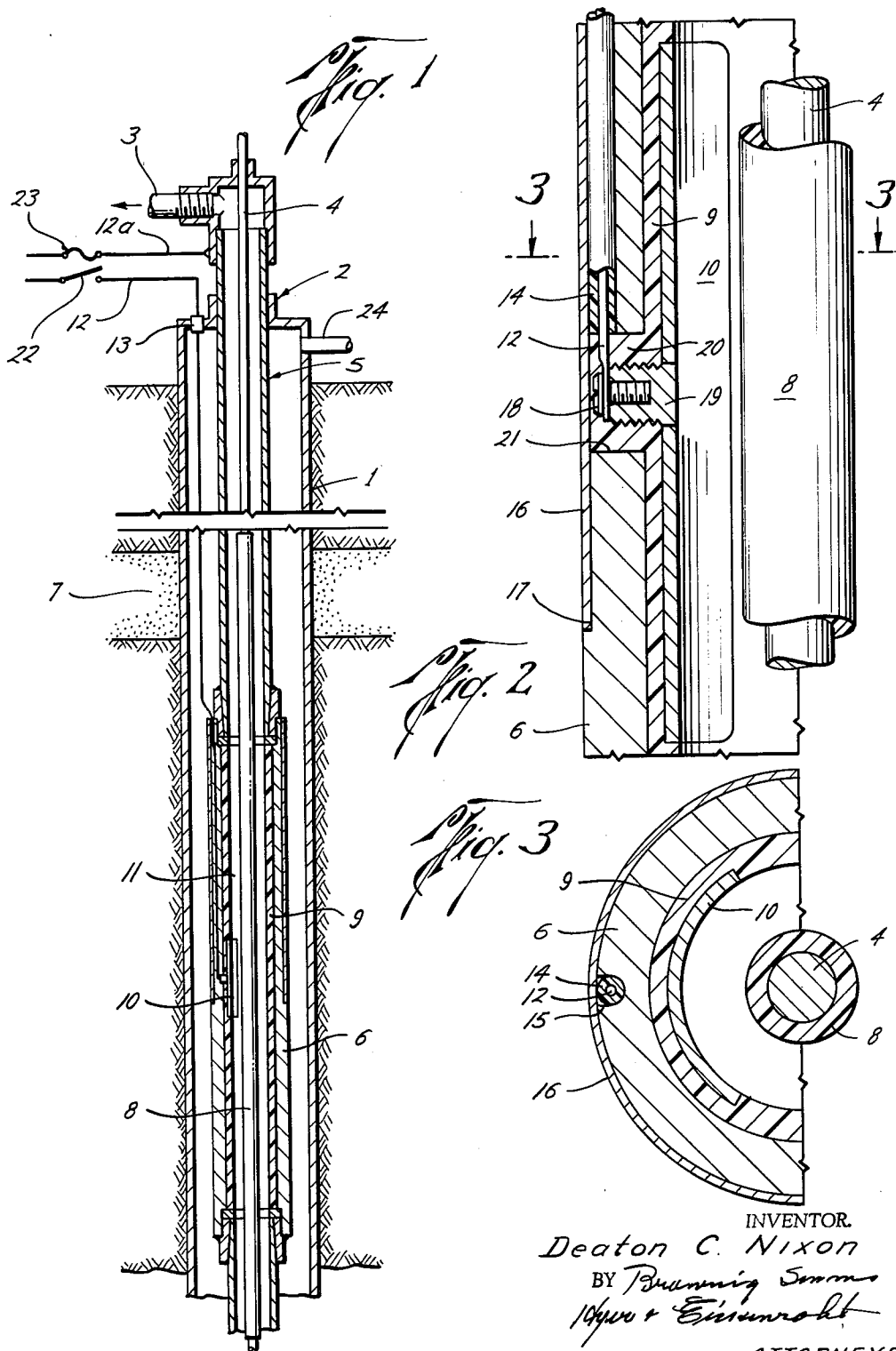
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APPARATUS FOR ELIMINATING PARAFFIN FROM OIL WELL TUBING

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2 Sheets-Sheet 1



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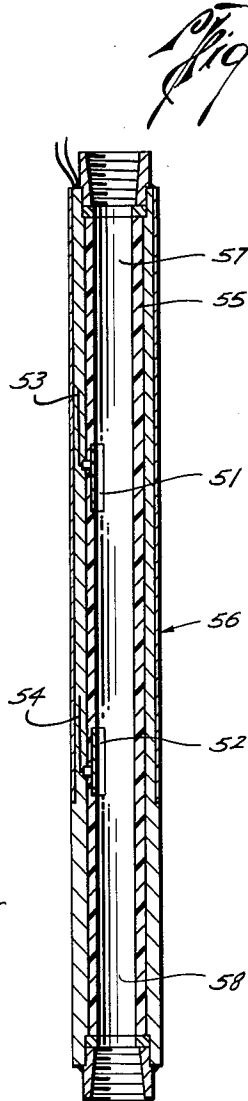
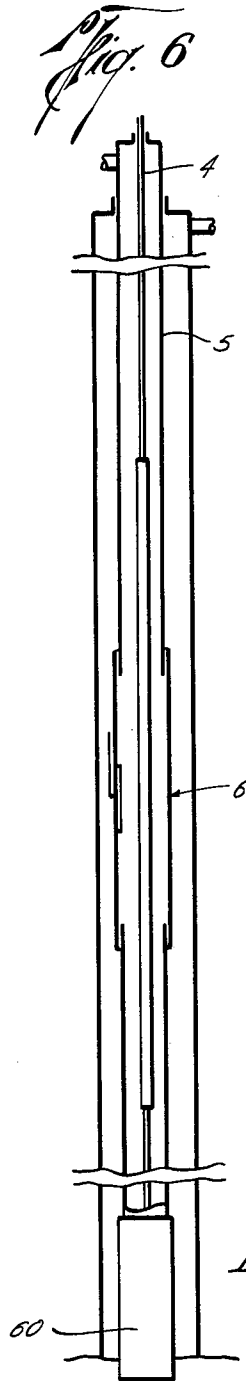
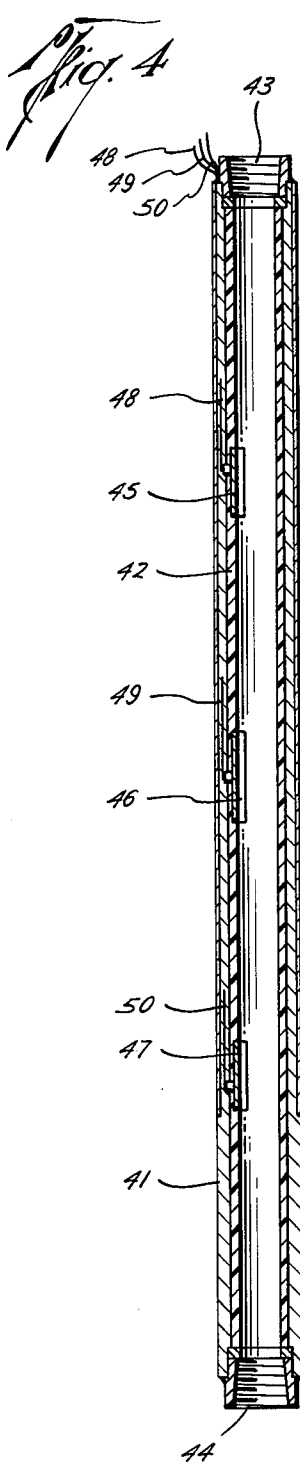
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2 Sheets-Sheet 2



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APPARATUS FOR ELIMINATING PARAFFIN FROM OIL WELL TUBING

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6 Claims. (Cl. 166—60)

This application is a continuation-in-part application of my co-pending application Serial No. 87,307, filed February 6, 1961.

This invention relates to improvements in apparatus for eliminating deposits of paraffinic and asphaltic materials, commonly termed "paraffin," from oil well tubing. It is particularly useful in oil wells which produce small volumes of oil by intermittent operation, but it is not limited to such use.

Accumulation of paraffin deposits in production tubing is a very common difficulty encountered in the oil-producing industry. As a stream of oil passes upward through the production tubing, it gradually cools from temperatures normally present at the bottom of the hole to lower temperatures present in the upper part of the well. As the oil passes through strata usually about 1,000 to 1,500 feet below the surface of the earth, it becomes cooled to a temperature low enough to cause paraffin deposition. The rates of cooling and paraffin deposition are enhanced when the well penetrates water-bearing strata; and a great many, if not all, oil wells do pass through such water-bearing strata.

It is common practice to remove the paraffin deposits when they become objectionably large by the use of scraping tools operable from the surface of the earth by wire-line or sucker rods, or to pull the tubing to the surface of the earth for the removal of the paraffin when this procedure is more economical and effective than scraping practices.

A great many oil wells which produce small volumes of oil intermittently cannot be operated economically when the tubing has to be pulled annually or at shorter intervals, but can continue profitable production of oil if the tubing-pulling jobs can be spaced at intervals of two or three years or more. In wells of this type, paraffin deposits are frequently severe and are the usual cause of the necessity for pulling the tubing.

A great many types of heaters have been suggested for use in production tubing in oil wells. These are of various types but usually are to be installed at a point just below a zone at which paraffin deposition normally occurs in the particular well. The heaters suggested, however, have been of the type in which there is heat transfer from a hot surface to a stream of oil flowing upward through the production tubing. Substantially all crude oil contains considerable quantities of water, and the water usually contains high proportions of dissolved electrolytes which are of scale-forming type. Heaters formerly suggested are subject to the disadvantage of accumulation of scale on the heating surface which insulates the surface from the stream of oil. Thus, heaters of this type work excellently for a short time but soon scale up and become ineffective. It is then necessary to pull the heater and tubing to the surface of the earth for a clean out and repair job.

It is an object of this invention to provide an improved apparatus by which paraffin deposits in production tubing of oil wells can be eliminated for long periods of time.

Another object is to provide an improved apparatus for removal of paraffin deposits from oil well tubing without stopping normal production of oil.

Another object is to provide an apparatus for heating

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a stream of oil flowing upward through a production tubing without the use of a heat-transfer surface.

Another object is to provide such an apparatus which keeps a production tubing open and substantially free from paraffin deposits when operated intermittently.

Another object is to provide an improved heater in which one or more sections of the stream of oil flowing upward are utilized as heating elements.

Another object is to provide an improved electric heater which does not scale up during long use in oil wells.

Another object is to provide an improved electric heater which does not require auxiliary equipment, such as thermostats, at the wellhead and may utilize commonly available 110- or 220-volt alternating current.

Another object is to provide an improved heater of the above type which may be used in conjunction with any means for passing the stream of oil upward through the tubing.

Another object is to provide an improved heater in which the rate of flow through the production tubing is not critical.

Another object is to provide an improved heater which effectively softens and dissolves paraffin deposits in oil flowing upward through the production tubing.

Another object is to provide a heater of the above type which will automatically cut off when oil in the production tubing becomes stationary and overheats.

Another object is to provide a heater for an oil well which is sturdy in construction, easily installed in production tubing, and which is highly efficient for long periods of time.

Another object is to provide a heater of this type which is economical to manufacture in large quantities and is inexpensive enough that it may be installed permanently in a well.

Other objects, advantages and features of this invention will be apparent to one skilled in the art upon a consideration of the written specification, the attached claims and the annexed drawings.

In the present invention one or more sections of a stream of oil flowing upward through a production tubing in an oil well are isolated from lateral contact with electrically conductive material in well equipment, such as the production tubing itself, a sucker rod operating a pump at the bottom of a well, etc. The laterally isolated section of the flowing stream is utilized as a resistance heating element by passing an electric current, preferably alternating current, through the laterally isolated section of the oil stream.

The section of the flowing stream is heated by the passage of the electric current to a temperature sufficiently high that the oil reaches the wellhead at the temperature above that at which paraffin deposition begins. With most oils, this temperature is in the range from about 65° to 70° F., but paraffin deposition may begin at temperatures outside this range with certain oils which contain unusually high or low proportions of paraffin. Heating the oil in the laterally isolated section of the stream to a temperature in the range from about 85° to 110° F., or preferably in the range from about 90° to 100° F., usually is sufficient to result in temperatures of the stream at the wellhead above the temperature at which paraffin is deposited. Certain oils in which the paraffin concentration is unusually high or low may be maintained at a temperature above that at which paraffin deposition occurs by heating to initial temperatures somewhat outside this range and this is especially true when the well penetrates thick, water-bearing strata where the temperature is unusually low and there is increased heat

exchange between oil flowing upward through the production tubing and gas in the annulus of the well.

In any case, heating in the laterally isolated section of the flowing stream of oil is such that the stream of oil is maintained at all points above the isolated section at temperatures above that at which paraffin is deposited. Thus, there is a tendency for any deposits of paraffin which may have occurred above the isolated section to be dissolved and flushed out of the tubing in the oil produced.

It is preferred that the heating be intermittent. Ordinarily, about five or six hours per month are sufficient to maintain the production tubing clear of objectionable paraffin deposits and there is no point in wasting electric power by continual heating.

The location of the section of the stream of oil to be heated is selected by reference to known characteristics of the particular well; that is, the heating should occur at a depth a little below that at which beginning of paraffin deposition is expected. Any means for isolating a section of an upward flowing stream of oil from lateral contact with electrically conductive material in this location may be used, but it is preferred that this means include electrically insulating material applied to the interior of a relatively short section of the production tubing. This short section, or sleeve, preferably is of enlarged diameter so that the presence of insulation on the interior thereof does not constrict the bore of the tubing and offer increased resistance to the passage of oil.

When a sucker rod or other element made of electrically conductive material extends downward through the interior of the production tubing, this element is insulated; and in the case of a sucker rod, it is covered with an insulating coating for a length equal to that of the insulating material on the interior of the production tubing plus the length of stroke of the reciprocating sucker rod so that, when the rod is reciprocated, no uninsulated part of the rod is moved into the insulated section of the production tubing.

The insulated section, or sleeve, of enlarged diameter need not be a long one. For example, it has been found that lateral insulation of a section of the stream of oil for a distance of ten inches on each side of a single electrode disposed in the insulated sleeve centrally between ends of the insulated portion gives very satisfactory heating results with most oils. It will be seen that arrangement of insulation and a central electrode in this manner may result in two superimposed sections of the stream of oil located above and below the single electrode which are electrically isolated from lateral contact with electrically conductive material.

The insulation may be of any type desired which has long life in oil well service. One preferred type of insulation is a fiberglass-reinforced resin commonly sold as a thick, viscous liquid which sets to solid state on evaporation of solvent. An insulating material of this type may be applied by supporting one or more electrodes within the pipe section to be insulated at a selected distance from the interior of the pipe wall and spinning the pipe around its longitudinal axis until the resin sets. During this operation, the fiberglass-resin mixture flows in between the electrodes and pipe to fill the space between them and on setting becomes bonded to the interior surface of the pipe and to the electrode. Fiberglass-resin mixtures commonly sold for insulation purposes resist much higher temperatures than those encountered in heaters of the present type, are resistant to crude oil containing water and electrolytes dissolved therein, and bond well to the pipe and electrodes.

A single electrode disposed substantially midway between ends of insulation in a sleeve of this type or a plurality of electrodes may be used for passing the electric current through the oil. A single electrode is ordinarily preferred however since it may be used with a

very simple wiring system in which the production tubing serves as one conductor in a circuit.

In the attached drawings, wherein like reference numerals indicate like parts throughout:

FIG. 1 is a schematic representation of a vertical section through an oil well having one preferred type of heater operable according to principles of this invention installed therein;

FIG. 2 is an enlarged section through one wall of the heater of FIG. 1 showing the relationship of an electrode carried by the wall to an insulated section of a sucker rod;

FIG. 3 is a horizontal section through the device of FIG. 2 on the line 3—3;

FIG. 4 is a vertical section through a modified heater;

FIG. 5 is a vertical section of another modified heater operating according to principles of this invention; and

FIG. 6 is a vertical section through a well showing the relationship between production tubing, heater and a means for passing oil upward through the tubing.

The invention will be described in detail with reference to a well having a pump attached to the lower end of the production tubing and operated by a conventional reciprocating sucker rod extending downward through the tubing into operative connection with the pump. It is to be understood, however, that the type of means for passing a stream of oil upward through the tubing is immaterial to the present invention. It is merely necessary that the stream flow through the tubing and any means for accomplishing this result may be used. For example, this means may be any type of mechanical, electrical or fluid-operable pump, any type of gas lift apparatus, or may be merely a naturally occurring pressure differential between bottom hole pressure and pressure at the surface of the earth.

In the drawings, the reference numeral 1 indicates a casing terminating at its upper end in a wellhead designated generally as 2 above the surface of the earth. The wellhead 2 has an outlet line 3 for oil produced from the well and has an opening for receiving a reciprocable sucker rod 4 for operating a pump at the bottom of the well according to known practice.

A string of production tubing, designated generally as 5, extends downward through the wellhead and within the casing to a producing formation (not shown) and the reciprocable sucker rod 4 extends downward through the production tubing to operate a pump shown only in FIG. 6, located at or below the producing formation and serving as a means for passing oil from the well upward through production tubing 5 to the surface of the earth.

The string of production tubing includes a short joint, or sleeve, of enlarged diameter designated as 6 and installed in the string of production tubing at a distance somewhat below the location of a formation 7 where paraffin deposition normally occurs within the production tubing when oil is passed upward through production tubing extending through the formation.

Sucker rod 4 is covered with an insulating coating 8 for a length sufficient that reciprocation of the sucker rod through its normal distance of travel will not bring an uninsulated portion of the rod within sleeve 6. The interior of sleeve 6 has an insulating coating 9, bonded thereto and an electrode 10 is carried by the insulation 9 in position to make electrical contact with a stream of oil flowing upward through annulus 11 in the production tubing around the insulated sucker rod 4.

It will thus be seen that a stream of oil flowing upward through the tubing will have two sections in annulus 11 located above and below electrode 10 which are completely isolated from lateral contact with electrically conductive material.

Means are provided for passing an electric current through the laterally isolated sections of the oil stream. This means includes electrode 10 and a pair of electric leads 12 and 12a leading to a suitable source of electric

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current (not shown). The lead 12 passes through a plug of insulating material 13 in the wellhead and extends down the annulus of the well outside the production tubing to sleeve 6. This lead is covered with electrical insulation 14 shown only in FIGS. 2 and 3 and preferably is received in a longitudinal slot 15 in the exterior of sleeve 6 as shown in FIG. 3. Lead 12 is retained therein by a suitable retaining cover, preferably a spirally wound strip of metal 16 disposed around an upper portion 17 of sleeve 6 of sufficiently smaller diameter than the remainder of the sleeve that the exterior of the cover 16 lies flush with the exterior of the remainder of sleeve 6.

Lead 12 is electrically connected to electrode 10 in any manner desired. In the preferred form illustrated, this connection is formed by a screw 18 which clamps the end of lead 12 firmly against a stud 19 made integral with electrode 10 and electrically isolated from contact with the wall of sleeve 6 by an extension 20 of insulation 9 extending through an opening 21 in the wall of the sleeve 6 around stud 19.

One of the leads, illustrated as lead 12, contains a switch 22 so that electric current may be applied and discontinued when desired. In the arrangement illustrated, the lead 12a containing a means for breaking the circuit in response to overload, illustrated as fuse 23, and the production tubing itself complete the path for current flow through oil passing upward in the tubing. Thus, an electrical impulse on closing switch 22 flows through the insulated lead 12 to the stud 19 and electrode 10 mounted thereon within the tubing. This electrode is in contact with a stream of oil flowing upward through the outlet 3 of the production tubing 5. Since all crude oil contains some water and electrolytes dissolved therein, this oil is not an insulator but conducts electric current both upward and downward within the bore of tubing 5 bounded by insulation 9 through upper and lower electrically isolated sections of the stream to the production tubing. Current flowing through the tubing passes through lead 12a containing a fuse 23 to the source of current (not shown).

Few crude oils contain so little water that the electrical resistance is too great for adequate heating. When this unusual circumstance occurs, it is easily overcome by introducing water through line 24 into the oil. If desired, this may be done by draining water from a separator of the type usually operated with oil wells for separating small quantities of water from crude oil into line 24.

In operation of the apparatus shown in FIG. 1, the insulating sleeve 6 is connected into a string of production tubing and the tubing is run into the well. To prevent undue abrasion of lead 12 which is run into the well at the same time the tubing is installed, this lead may be clamped to the production tubing about every 50 or 60 feet or so by an ordinary hose clamp to prevent slack from developing and abrading insulation of the lead against the interior of the casing.

After the production tubing is run into the well, a stream of oil can be passed upward through the tube by reciprocating the sucker rod which is attached in the usual manner to a pump at the bottom of the production tubing.

Ordinarily, paraffin deposition will begin and these deposits will slowly accumulate in the well, but it is unusual for the deposits to interfere with pumping for at least several days and the tube frequently remains clear for a month or more. Upon the beginning of noticeable paraffin deposition, switch 22 is closed and a current of electricity, preferably 220-volt alternating current, is sent through the electrically isolated sections of the stream of oil flowing in the production tubing above and below electrode 10.

The resistance of the oil is sufficient that no rheostat or other means at the wellhead is required to prevent current surges, especially since the length of the laterally isolated sections of the stream may be selected according to the resistance of the particular crude oil to be produced.

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With most oils the length of these sections need not be greater than about 10 inches or so when 220-volt alternating current is used to get good heating and to prevent large current surges.

The current is passed through the isolated sections of the stream of the production tubing at a rate which results in heating the oil to a temperature sufficient to maintain the stream at a temperature above that at which paraffin deposition normally occurs until the stream reaches the wellhead. Depending upon the characteristics of the particular oil and its tendency to deposit paraffin, the heating in the isolated sections may be to any temperature in the range from about 85° to 110° F. but may be outside this range if the oil is of such nature that greater or lesser heating is required. Heating the oil in the laterally isolated sections to temperatures in the range from 90° to 100° F. usually is sufficient to maintain the oil at temperatures at which the solubility of paraffin is greatly increased at all points between the heated sections and the surface of the earth.

It is to be noted that one advantage shown by this heater is that it is self regulating in that oil flowing upward at a high rate of speed reaches the wellhead at substantially the same temperature as oil flowing slowly upward in the tube. This is due to the fact that, when the rate of flow of the stream of oil is low, it requires a longer time to traverse the electrically isolated sections of the production tubing where heating occurs; and the oil is thus heated to a higher temperature than would be the case if the stream were flowing at higher velocity. However, as the stream of oil continues upward to the production tubing at low rate of speed, there is increased total heat transfer from warm oil within the production tubing to gas in the annulus of the well due to longer time of transfer so that the higher temperature to which oil was originally heated results in substantially the same temperature of the stream at the wellhead as occurs when a rapidly flowing stream is heated to lower temperature.

Another advantage that has been found in the use of this heater in oil wells is that the heater does not scale up. The alternating current prevents accumulation of products of electrolysis upon the electrode and on the production tubing surface. Such products of this type as are formed apparently are in powdery condition and are swept away by the flowing stream of oil and carried upward to be discharged through line 3.

This apparatus also has shown another advantage in that it is self regulating in case the stream of oil is stopped while switch 22 is still on and electric current is flowing through the oil. It has been found that only a short time is required for carbeurization to occur in the oil within the electrically isolated sections. The carbon produced forms a soft gelatinous mass in the laterally insulated section which has high electrical conductivity. A very short length of time is required for carbeurization to occur in this manner and to form a short circuit between electrode 10 and production tubing 5. When this short circuit occurs, a means for breaking the circuit in response to overload is activated, illustrated as fuse 23, which is blown and the circuit is broken. The carbeurized mass of oil within the insulated section of the production tubing remains of soft consistency so that, when production is resumed, the stream of oil carries away the carbeurized material and it is not necessary to pull the tubing to clean out the isolated sections.

A modified type of sleeve which may be substituted for the sleeve of FIGS. 1 to 3 if desired is shown in FIG. 4. This sleeve is necessarily of greater length than that shown in the preferred form in FIG. 1. Briefly, it includes a cylindrical wall 41 having electrical insulation 42 upon its interior surface and having suitable connections 43 and 44 to upper and lower sections of the production tubing. Three electrodes 45, 46 and 47 are electrically connected to leads 48, 49 and 50 and are isolated from wall 41 of the tubing by insulation 42.

The leads 48, 49 and 50 preferably are those of an ordinary three-wire, 220-volt circuit and in this particular modification the production tubing is not used in the return circuit.

It will be seen that the apparatus of FIG. 4 inherently requires the longer sleeve than that of the preferred type illustrated in FIG. 1 since an electrically isolated section of the stream of oil must be maintained between each of the end electrodes 45 and 47 and the production tubing in order to prevent stray currents. In the apparatus of FIG. 4, current normally flows from electrode 45 to electrode 46, from electrode 47 to electrode 46, passing through laterally insulated sections of a stream of oil flowing up through tubing 5. This figure also illustrates an application of this apparatus which does not include a sucker rod or other element extending down through the center of the rod as a part of a means for passing a stream of oil to the surface of the earth. The type of means used to provide upward flow of oil is immaterial to the present invention and may be of any kind desired. One type of pump and its conventional attachment in a string of oil production tubing is shown in FIG. 6. In this figure, a reciprocating sucker rod 4 passes downward through the production tubing 5 including a sleeve 6 constructed according to FIG. 1 and connected to operate a conventional pump 60 when the sucker rod 4 is reciprocated. The pump 60 of course passes the stream of oil upward through the tubing and in its upward passage it is heated as described in the operation of FIG. 1 above.

FIG. 5 shows another modification of a sleeve to be included in an oil well production tubing having only two electrodes 51 and 52 energized by leads 53 and 54, respectively. Insulation 55 is provided on the interior of this sleeve, which is designated generally as 56, and is arranged to isolate a section of the upward flowing stream between electrodes 52 and 51 from lateral contact with electrically conductive material. Insulation 55 also provides laterally isolated sections 57 and 58 above and below the pair of electrodes, respectively, to prevent current flowing from the electrode to a production tubing rather than between the electrodes.

The operation of the device of FIG. 5 is substantially the same as that described under that for FIG. 1 above except that this particular modification has flow of electric current between only two electrodes rather than between one electrode and the production tubing. Again, 220-volt alternating current is the preferred type of current and heating the oil is accomplished as described in the operation of FIG. 1.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus and process.

It will be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. Apparatus for eliminating paraffin deposits from oil well production tubing comprising in combination a string of production tubing disposed in an oil well to conduct oil from a lower part of the well to the surface of the earth; means for passing a stream of oil containing an aqueous solution of electrolytes upward through the tubing; electrical insulation extending around the inner circumference of the string of tubing and vertically along a

selected length thereof so as to isolate at least one section of said stream from lateral contact with electrically conductive material; and means for passing an electric current through the laterally insulated section of the stream at a rate sufficient to maintain the stream at a temperature above that at which paraffin deposits normally occur including a first electrode carried by and insulated from the tubing and situated intermediate the ends of said electrical insulation for contact with said oil stream and a second electrode, which may be the tubing, spaced vertically from the first electrode and electrically insulated therefrom also for contact with said oil stream.

2. The apparatus of claim 1 wherein said tubing has a section of enlarged diameter and wherein said insulation and said first electrode are disposed within said section of enlarged diameter.

3. Apparatus for eliminating paraffin deposits from oil well production tubing comprising in combination a string of production tubing disposed in an oil well to conduct oil from a lower part of the well to the surface of the earth; means for passing a stream of oil containing an aqueous solution of electrolytes upward through the tubing; electrical insulation extending around the inner circumference of the string of tubing and vertically along a selected length thereof so as to isolate at least one section of said stream from lateral contact with electrically conductive material; means for passing an electric current through the laterally isolated section of the stream at a rate sufficient to maintain the stream at a temperature above that at which paraffin deposits normally occur including a first electrode carried by and insulated from the tubing and situated intermediate the ends of said electrical insulation for contact with said oil stream and a second electrode, which may be the tubing, spaced vertically from the first electrode and electrically insulated therefrom also for contact with said oil stream; and means responsive to overload of electric current in the laterally isolated section for discontinuing passage of electric current through the laterally isolated section.

4. Apparatus for eliminating paraffin deposits from oil well production tubing comprising in combination a string of production tubing disposed in an oil well to conduct oil from a lower part of the well to the surface of the earth, means for passing a stream of oil containing an aqueous solution of electrolytes upward through the tubing; electrical insulation extending around the inner circumference of the tubing and vertically along a selected length thereof to isolate said stream from lateral contact with electrically conductive material; an electrode carried by and insulated from the tubing and situated intermediate the ends of the electrical insulation and also being exposed for contact with said stream of oil; and means, including said electrode and tubing, for passing an electric current between the electrode and said tubing through the laterally isolated sections of the stream at a rate sufficient to maintain the stream at a temperature above that at which paraffin deposits normally occur.

5. The apparatus of claim 4 wherein the means for passing an electric current through the laterally isolated section of the stream includes one lead of an electric circuit electrically connected to the production tubing; a second lead insulated from the production tubing and electrically connected to said electrode.

6. The apparatus of claim 5 wherein a switch is included in one of said leads; and a means for discontinuing flow of electric current and responsive to overload is connected into a lead.

References Cited by the Examiner

UNITED STATES PATENTS

2,597,261 5/52 Rhoads ----- 166-60 X

CHARLES E. O'CONNELL, *Primary Examiner*.