OIL WELL TEMPERATURE INDICATOR AND CONTROL

Filed May 19, 1958

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Fig. 2.

Fig. 3.

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The present invention relates generally to heating apparatus, and is more particularly concerned with the heating of subterraneous passages, such as oil wells, and the indication and control of the temperature at the well heater.

Subsurface electrically energized heaters are currently being utilized in oil wells for removing paraffin and asphalt which has clogged a flow passageway. The flow passageway is thereby renewed, and the temperature of the oil well can be increased without the use of conventional oil-casing devices. This heating of the oil well is used for maintaining a constant temperature at the well heater, and to provide suitable control for retaining the temperature of the oil well below a danger point at which the oil well would be rendered useless.

Since these heaters operate in many cases in quite deep wells, and are commonly used in wells which will be from five to ten thousand feet in depth, the utilization of conventional temperature indicating devices becomes relatively expensive and presents problems and difficulties of operation.

Hereofore there has been no device or method for determining the temperature of the subsurface heater, other than by putting an instrument such as a thermometer in the wellbore, thereby being subject to the temperature of the wellbore and the injection fluid in the wellbore. The present invention is concerned with the provision of an improved means and method whereby it will be possible to know the temperature at the subsurface heater without the necessity of having to provide a remotely located temperature sensing device which will transmit signals to the surface or control surface responsive temperature indicating devices.

It is a further object of the invention to provide improved means and method whereby a monitored heater temperature at the well surface will be utilized as a standard for the control of a subsurface heater, and by which the resulting temperature and the subsurface heater will be maintained within safe limits of operation.

Another object is to provide improved means and method for maintaining a desired temperature at a subsurface heater by utilizing comparative wattage ratio with respect to a surface heater, and utilizing temperatures at the latter as a basis for controlling the energization and deenergization of the former.

Still another object is to provide improved control for controlling the operation of subsurface and surface heaters of an oil well in such a manner that the temperature at the subsurface heater will correspond substantially to the temperature maintained at the surface heater.

A still further object is to provide a subsurface heater having leads whereby connection wires may be carried from the exterior of a tubular housing to the interior of the housing within which an electric heating element is mounted.

Further objects of the invention will be brought out in the following part of the specification, wherein detailed description is for the purpose of fully disclosing the invention without placing limitations thereon. Referring to the accompanying drawings, which are for illustrative purposes only:

FIG. 1 is a view diagrammatically illustrating an oil well embodying heater apparatus of the present invention, and schematically illustrating the control therefor;

FIG. 2 is an elevational view, partly in section, showing the details of construction of the subsurface heater and the novel manner in which the connection entrance leads are sealed; and

FIG. 3 is a transverse section through the heater, taken substantially on line 3—3 of FIG. 2.

Referring now more specifically to the drawings, for illustrative purposes, there is shown in FIG. 1 a typical oil well of conventional construction including a subterraneous passage or bore in which the usual casing is placed with the lower end of the casing extending into the ground surface, while the lower portion of the well may or may not contain the casing.

Conventional tubing is shown as extending from the ground surface into the well, where its lowermost end is positioned below an oil level, as indicated by the numeral 13.

The surface ends of the casing and tubing are shown as being connected to a conventional combination tubing and pumping head 14. A sucker rod 15 is supported in the head for reciprocable movement in the usual manner and is connected at its lowermost end to a conventional pump (not shown) positioned adjacent the oil level 13. The pump, when the sucker rod is actuated by a pumping mechanism at the surface, sucks oil through a perforated section 16 of the tubing and discharges pumped oil at the surface through a branch pipe 17 by which it is conducted to a tank or other storage device (not shown).

A subsurface heater 18 is connected below the perforated sections 16. In the present instance, this heater is of the electrical type and comprises a housing which is made up of a top section 19 and a bottom section 20, these sections having confronting threaded ends which are secured together by an appropriate coupling 21.

The bottom section 20 houses a suitable heating element 22 which may, for example, comprise two 5000 watt heating units connected in series to give a total of 10,000 watts. The heating element thus formed is of U-shaped construction with its adjacent ends connected by means of terminal connectors 23 with the end of a connection lead 24 in each case. The upper portion of the housing is provided with a side opening 25 through which the connection lead is carried from the interior of the housing to the exterior. The connection leads are then sealed by filling the interior of this housing section with an insulating material such as porcelain, as indicated by the numeral 26 which is of molded porcelain and the adjacent portion of the lead exterior of the housing so as to provide a complete seal which extends downwardly over the terminal connectors 23 and the connected ends of the heating element 22. The bottom section 20 of the housing is filled with a material having a high heat conductivity characteristic. For such purpose I have used magnesium oxide, as indicated by the numeral 27. The heating element is thus retained in position within the housing section, the heating elements thus being insulated with respect to each other and with respect to the housing wall, as shown particularly in FIG. 3. The connection leads 24 extend along the outside of the tubing 12, and if desired, may be fastened by appropriate means (not shown) at intervals along the tubing.

As shown in FIG. 1, a surface heating element 28 of substantially U-shaped configuration is supported in the branch pipe 17, this heating element having its ends brought out to terminals 29—29. The heater 28 is utilized
as a monitor and is of proportional wattage, in this case 1000 watts, as compared to the 10,000 watt rating of the subsurface heater. By control arrangements to be subsequently described, the temperature adjacent the surface heater will also serve as substantially indicating the temperature at the subsurface heater. Thus, by controlling the temperature of the surface heater so as to maintain the adjacent temperature below a predetermined value, it is possible by sensing this temperature to modulate the control of the subsurface heater so that its temperature will be maintained within a safe range below that at which cooking might take place.

Electrical supply is obtained from a suitable source, in this case a 440 volt A.C. supply as indicated by the numeral 30. This supply is connected through a main switch 31 with a step down transformer 32 which reduces the voltage to 220 volts. The low voltage side of this transformer is connected to one set of contacts 34a of an electrically operable switch or contactor 35 having an operating coil 36. The contacts 34a control the supply of electricity to the terminals 29—29 of the surface heating element 28. A second set of contacts as indicated at 34b control the supply of electricity from the high voltage or 440 volt side of the transformer 32 to the connection leads 24—24 of the subsurface heater 18.

As thus far described, it will be observed that the contactor 35 opens and closes its contacts to simultaneously control the supply of electrical energy to both the surface heater as well as the subsurface heater. It has been found that once the desired temperature is established in the oil at the subsurface heater, it is not necessary to keep the heater energized continuously and valuable material savings may be effected by operating the heaters at predetermined "on" and "off" operating intervals. This is accomplished in the present control by providing a time switch 37 of conventional construction, this switch being energized directly through conductors 38—38 from the 440 volt A.C. supply. The time switch has contacts 39 which are operable to open and closed positions in accordance with the settings of the time switch to control the supply of current to both the surface heater 28 and subsurface heater 18. Control of the contactor 35 is initially responsive to the action of the time switch for the reason that the operating coil 36 of the contactor is energized through an energizing circuit containing the timing switch contacts 39 and including conductors 40 and 41 which are connected to the 440 volt supply.

A visual indication of the voltage being supplied for the surface heater may be obtained by placing a suitable voltage meter across the heating coil 25. The meter may be made by a suitable ammeter 42. Current supply to the subsurface heater 18 may be indicated by a suitable ammeter 43 placed in one of the current supply conductors 24. Provision is also made for visual indication, if desired, the temperature adjacent the heating element 28 of the surface heater, this temperature indicator being identified by the numeral 44. By utilizing the comparative or ratio method of control as described herein, the temperature of the indicator 44 will correspond with that at the subsurface heater 18.

Provision is made for automatic regulating the energization and deenergization of the subsurface heater and the surface heater in such manner as to maintain a predetermined temperature at the monitor or surface heater, and by other control which will subsequently be described. Corresponding temperatures will be maintained above and below the temperature of the subsurface heater 18. The temperature of the surface heater is controlled automatically, during the energizing interval determined by the time switch, by means of a thermostat switch 45 of conventional construction having a temperature sensing bulb 46 placed adjacent the heating element 28. By suitable control mechanism, a dial 47 is actuated by the device at a desired predetermined temperature. Contacts 48 are arranged to open when the predetermined set temperature occurs, and will close when the temperature falls below the preset value. The contacts 48 are in series with the contacts 39 of the timing switch in the energizing circuit of the control coil 36 of the contactor.

For example, if it is desired to maintain a temperature of 175° F. at the subsurface heater 18 in the well, the thermostatic switch 45 would be set at that temperature. Now, when the temperature reaches this value and goes above it, the thermostat will open its contacts and thus deenergize the operating coil 36 of contactor 35, providing the timing switch is in an energizing interval with its contacts 39 closed. The contactor thus opens and deenergizes both the surface heater 28 and the subsurface heater 18.

When the temperature at the heating element 28 falls below 175° F. temperature, the thermostatic switch 45 closes its contacts so as to energize the contactor 35 thereby putting both heaters back into operation. Opening of contacts 39, during a deenergizing interval of the timing switch, of course overrides control of the contactor 35 by the thermostatic switch 45.

It will be appreciated that less energizing current will be required to sustain the desired temperature at the subsurface heater 18, once the desired temperature is attained. A progressive type of control is therefore provided to prevent overrunning or hunting of the temperature at the subsurface heater. This control will now be described. Referring again to FIG. 1, it will be noted that one of the 440 volt connection leads to the transformer 32 is carried through reactor coils 49 and 50 of a saturable reactor generally identified by the numeral 51. Current flow is regulated by a saturating coil 52 which is supplied with direct current by reason of rectifiers 53 which are in circuit with a variable resistor 54 forming a part of the progressive type thermostat as generally identified by the numeral 55. This thermostat includes a temperature sensor 55 and is so arranged that as the temperature adjacent the heating element 28 increases, the effective resistance of the resistor 54 is increased with the result that the voltage applied to the saturating coil 52 is reduced, and as a consequence the reactor coils reduce the current flow to the subsurface heater 18 as well as the current flow to the surface heater 28 via the transformer 32. Conversely, when the temperature at the heating element 28 is less than the desired value, the operation permits greater flow of current to the heaters 18 and 28. A modulating control is thus obtained for the heaters 18 and 28 in response to changes in sensed temperature at the monitoring heater element 28.

From the foregoing, it is to be appreciated that the present invention provides a unique control and temperature indication which overcomes the difficulties and problems attending the use of conventional devices in which it is necessary to obtain the temperature in the oil well by remote indicating methods which introduce many problems.

From the foregoing description, it will be realized that other modifications may suggest themselves to those skilled in the art without departing from the spirit of my invention, and, hence, I do not wish to be restricted to the specific form or forms shown or used, mentioned, except to the extent indicated in the appended claims.

I claim:

1. In combination: an electrically energizable subsurface heater for heating the oil in an oil well; means for moving oil from the well to the surface; an electrically energizable heater at the surface in the path of the moved oil; means for changing the temperature of oil adjacent said heater at the surface; an electrical supply source for said heater; means cooperative with said temperature responsive means for simultaneously controlling energization and deenergization of said heaters depending upon whether the temperature adjacent said heater at the surface is above or below a predetermined value; and control means including a temperature sensor adjacent said surface heater for modulating the energiza-
tion of said heaters in accordance with changes in the temperature adjacent said surface heater.

2. In combination: an electrically energizable subsurface heater for heating the oil in an oil well; means for moving oil from the well to the surface; an electrically energizable heater at the surface in the path of the moved oil; means responsive to changes in the temperature of oil adjacent said heater at the surface; an electrical supply source for said heaters; means cooperative with said temperature responsive means for simultaneously controlling energization and deenergization of said heaters depending upon whether the temperature adjacent said heater at the surface is above or below a predetermined value; control means including a temperature sensor adjacent said surface heater for modulating the energization of the subsurface heater and the surface heater in accordance with changes in the temperature adjacent said surface heater; and overriding control means for connecting and disconnecting said heaters with respect to said supply source for predetermined timed "on" and "off" periods.

3. In combination: an electrically energizable subsurface heater for heating the oil in an oil well; means for moving oil from the well to the surface; an electrically energizable heater at the surface in the path of the moved oil; means responsive to changes in the temperature of oil adjacent said heater at the surface; an electrical supply source for said heaters; means cooperative with said temperature responsive means for simultaneously controlling energization and deenergization of said heaters depending upon whether the temperature adjacent said heater at the surface is above or below the predetermined value; control means including a temperature sensor adjacent said surface heater for modulating the energization of said heaters in accordance with changes in the temperature adjacent said surface heater; and a timing switch for connecting and disconnecting said heaters with respect to said electrical source.

4. In combination: an electrically energizable subsurface heater for heating the oil in an oil well; means for moving oil from the well to the surface; an electrically energizable heater at the surface in the path of the moved oil; means responsive to changes in the temperature of oil adjacent said heater at the surface; an electrical supply source; energizing circuits respectively for said heaters; electrically controlled switch means for simultaneously connecting and disconnecting said heaters with respect to said supply source, including a control circuit; means controlled by said temperature responsive means for energizing and deenergizing said control circuit depending upon whether the temperature adjacent the surface heater is above or below a predetermined value; a saturable core reactor having a saturating coil connected to a potential source and reactor coils in the energizing circuits of said heaters for controlling the current supply thereto; and means including a temperature sensor adjacent said surface heater for varying the potential applied to said saturating coil in accordance with variations in the temperature adjacent said surface heater.

5. In combination: an electrically energizable subsurface heater for heating the oil in an oil well; means for moving oil from the well to the surface; an electrically energizable heater at the surface in the path of the moved oil; means responsive to changes in the temperature of oil adjacent said heater at the surface; an electrical supply source; energizing circuits respectively for said heaters; electrically controlled switch means for simultaneously connecting and disconnecting said heaters with respect to said supply source, including a control circuit; means controlled by said temperature responsive means for energizing and deenergizing said control circuit depending upon whether the temperature adjacent the surface heater is above or below a predetermined value; a saturable core reactor having a saturating coil connected to a potential source and reactor coils in the energizing circuits of said heaters for controlling the current supply thereto; and means including a temperature sensor adjacent said surface heater for varying the potential applied to said saturating coil in accordance with variations in the temperature adjacent said surface heater.

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