Oct. 26, 1971 W. G. GILL 3,614,986

METHOD FOR INJECTING HEATED FLUIDS INTO MINERAL BEARING FORMATIONS

Filed March 3, 1969

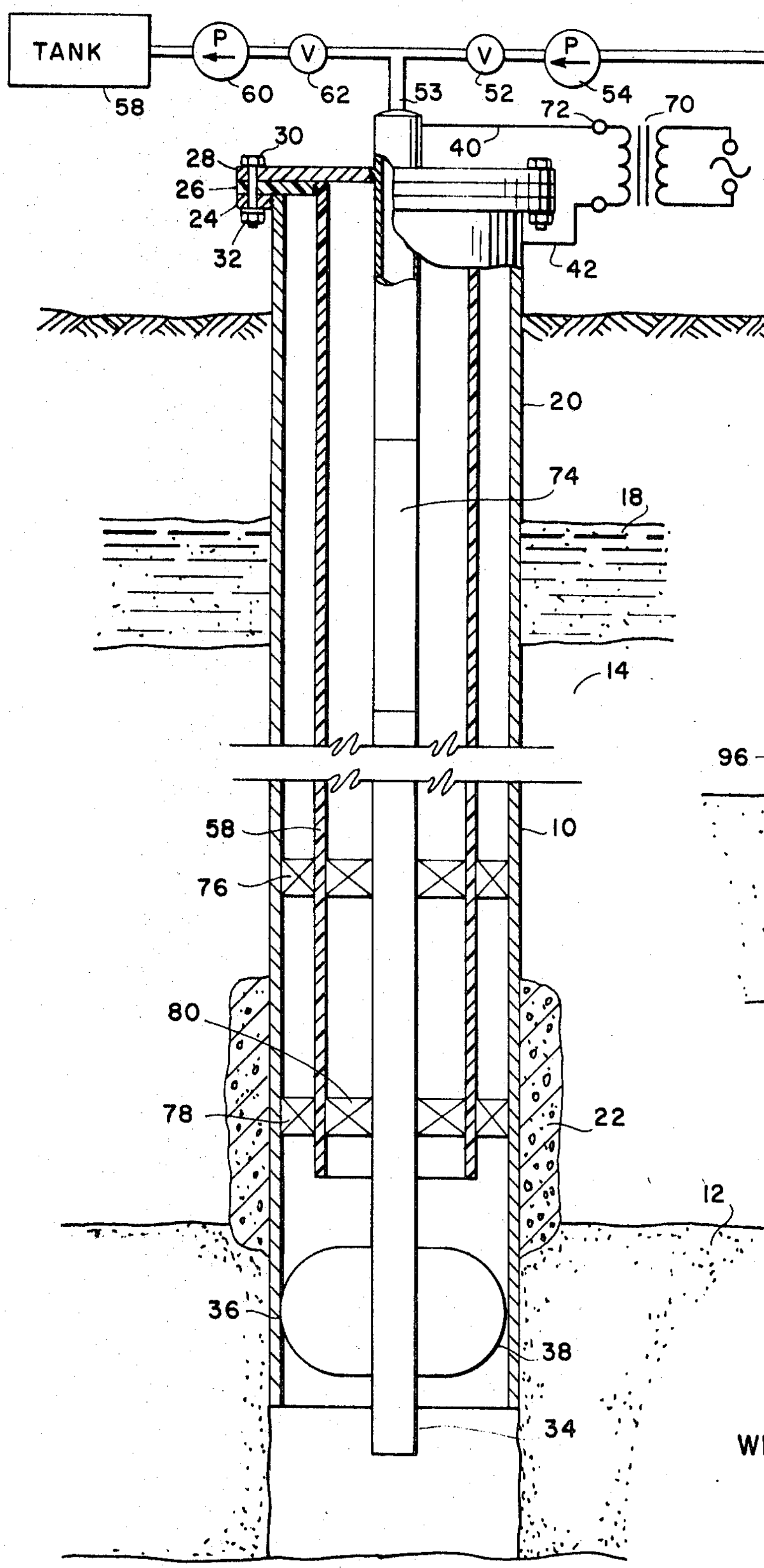

FIG. 1

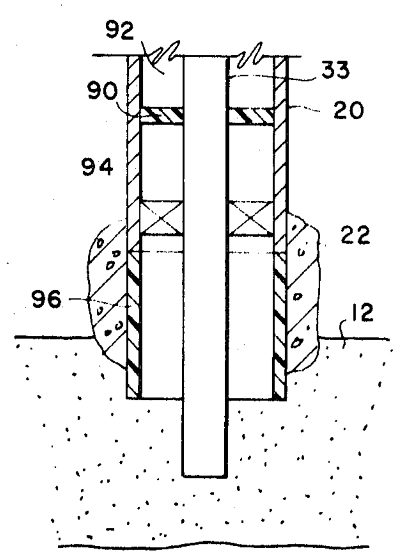

FIG. 2

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3,614,986

Patented Oct. 26, 1971

1

3,614,986

METHOD FOR INJECTING HEATED FLUIDS INTO MINERAL BEARING FORMATIONS

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Filed Mar. 3, 1969, Ser. No. 803,533

Int. Cl. E21b 43/24

U.S. Cl. 166—303 6 Claims

ABSTRACT OF THE DISCLOSURE

Heated fluids are injected into mineral bearing formations while flowing electrical current through tubing through which the fluids are injected at a rate to produce heat in the tubing sufficient to prevent loss of heat by the fluids while moving through the tubing.

BACKGROUND OF THE INVENTION

The present invention relates to the recovery of minerals from sub-surface formations more particularly to method for injection of heated fluids in the subsurface formations for treating same.

It is oftentimes desirable to treat a subsurface formation with heated fluids. For example, sulphur is most commonly mined by injecting heated water into the sulphur bearing formation for the purpose of melting the sulphur and permitting it to flow to the surface. One of the methods for treating paraffin blocks in the production of oil is to inject hot oil into the formation. Hot water, steam and heated gases are often injected for repressuring petroleum bearing formations. However, a definite limitation has been placed on the depth at which formations can be treated with heated fluids because of loss of heat of the fluids into the strata above the desired formation as the fluids flow through tubing from the surface to the formation of interest. Thus, because of the above-mentioned cooling effect, it is generally not considered feasible to produce sulphur by the Frasch process at depths below 1500 feet. Similarly, efforts to treat oil bearing formations with heated fluids such as oil, gas or water at depths in excess of 2000 feet are generally not economical.

SUMMARY OF THE INVENTION

In accordance with the method of the present invention, a well bore is drilled which extends from the surface into a mineral bearing formation positioned below other formations. At least one tubular member of electrically conductive material is positioned in the well bore. The fluids to be injected into the formation are heated and caused to flow through the tubular member into the mineral bearing formation while causing current to flow through the tubular member for generating heat and reducing loss of heat from the heated fluids into strata above the mineral bearing formation.

In accordance with the preferred embodiment of the invention, the tubular member is positioned within a string of conductive casing, but electrically insulated therefrom except at its bottom portion. Accordingly, the path of the flow of current will be down the tubular member to the mineral bearing formation, thence up to the conductive casing. If desired, the tubular member can be made of material having a resistivity to provide the desired amount of heat. This is most often necessary when the mineral bearing formation is at relatively shallow depths. Alternatively, high resistance sections can be provided in the tubular member producing additional heat at the high resistance portions.

Many objects and advantages of the invention will become apparent to those skilled in the art as a detailed description of the preferred embodiment of the invention unfolds in conjunction with the appended drawings wherein like characters denote like parts and in which:

2

FIG. 1 is a side elevation view diagrammatically illustrating a well bore penetrating the earth surface into a mineral bearing formation; and

FIG. 2 is a side elevation view similar to FIG. 1, but only showing the lower portion of an installation in accordance with a second embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

There is shown in FIG. 1 of the drawings a well bore **10** which penetrates the earth into a mineral bearing formation **12**. One or more strata **14** are positioned between the mineral bearing formation **12** and the surface **16** of the earth. Typically, among the formations penetrated by the well bore would be a formation **18** containing cold water. A string of casing **20** is positioned in the well bore **10** and extends from the surface to the mineral bearing formation **12**. In the specific example of the invention shown, an open hole completion is contemplated and the casing **20** only extends partially into the formation **12** whereas the well bore **10** suitably extends through the formation. Concrete **22** is suitably forced into the formation above the mineral bearing formation and around the casing **20** for the purposes of limiting or restricting any tendency for the wall of the well bore to cave into the mineral bearing formation and for holding the casing **20** in place.

Threadedly connected to the upper of the string of casing **20** is a flange **24**, suitably one formed of an insulating material. There is also provided an insulating flange member **26** which supports a string of insulating pipe **30**. A string of conductive tubing **33** is supported by yet a third flange member **27**, also suitably of insulating material. The three flange members **24**, **26** and **27** are connected into a unitary structure by a plurality of bolts **30** and nuts **32**. The lower portion **34** of the string of tubing is electrically connected to the lower portion **36** of the string of casing **20** by suitable means such as a centralizer **38** formed of conductive material. It will be noted that the well head structure comprising the flanges **24**, **26** and **27** in combination with the string of insulating pipe **28** effectively electrically insulates the string of tubing **33** from the string of casing **20** such that when a source of alternating current supply voltage is connected to the string of tubing **33** by a conductor **40** and to the string of casing **20** by conductor **42**, the path of the flow of current will be along the entire length of the strings of tubing **33** and return through a path including casing **20** and the connecting member **38**. It will be appreciated, in this regard, that so long as one of the flanges **24** and **27** is of insulating material that the tubing will be insulated from the casing at the head of the well and that the insulated head could be provided by other means, such as utilizing only the flange **26** to be of insulated material and insulating the bolt **30** from the flanges **27** and **24** or by using insulating bolts in combination with an insulating flange **26**.

The string of tubing **33** is connected to a tank **50** through a valve **52** and a pump **54**. The tank **50** suitably contains fluid to be injected into the formation **12** and associated therewith is a heater **56** for heating the fluids to the desired temperature. There can also be provided a second tank **58** which is connected to the string of tubing **33** at pump **60** and a valve **62**. The tank **58** and its associated pump **60** and valve **62** would only be provided, however, if it was desired to also remove fluids from the formation through the tubing **33**. It will be noted in this regard that the pump **60** is effective when operated to produce a flow of fluids from the tubing **33** into the tank **58** whereas the tank **54** when operated will produce a flow of fluids from the tank **50** into the tubing **33**. In accordance with the method of the present invention, the valve **62** and **52** would be closed and the pumps **54** and **60** would not be operated until such time as the fluids within the tank **50** were heated to a desired temperature by the heater **56**. Electrical current is then caused to flow through the tubing **33** in casing **20** to produce heat. In this connection, it is preferred that the source of supply of voltage be connected to the conductors **40** and **42** through a transformer **70** having a plurality of taps **72** in order that the potential impressed across the circuit comprising the casing **20** in the tubing **33** can be varied. Also, the string of tubing can include one or more sections **74** of higher resistivity material in order to increase the resistance of the current path. As a greater amount of heat will be produced in the vicinity of the joints of high resistivity material, these can preferably be positioned in the vicinity of water bearing sand such as the sand **18** or other strata having high coefficient of thermal conductivity.

The valve **52** is opened and the pump **54** operated to cause heated fluids to flow from the tank **50** into the mineral bearing formation **12**. Heat produced in the string of tubing **33** and the string of casing **20** as a result of flow of electrical current will effectively reduce the loss of heat from the heated fluids into the formations above the mineral bearing formations. Accordingly, it will be possible for the heated fluids from the tank **50** to arrive at the mineral bearing formation **12** at substantially the same temperature as that at which the fluids left the tank **50**. It is important to note, in this regard, that when conventional installations are used for injection of heated fluids into subsurface formations that substantially no benefit will be obtained if the formation is more than 2000 feet deep as the temperature of the fluids reaching the formation will be substantially at formation temperature.

If an installation as shown in FIG. 1 is used, essentially all of the electrical energy will be converted to heat in the tubing as the casing becomes part of a conductor of indefinite area (the earth). The amount of heat which would be lost by the fluid if heat were not provided can easily be computed and the applied voltage controlled to provide the desired amount of heat.

In order to reduce the amount of heat required, the tubing **33** can be thermally insulated from the formation **14** by applying thermal insulation to the casing or tubing or by centering the tubing **33** and pipe **28** with spacer **76** and sealing the annulus with packer **78** and **80** to provide air spaces with a miminimum of contact area.

The installation of FIG. 1 can be modified as shown in in FIG. 2. Thus, it is feasible to insulate the tubing **33** from the casing **20** by using spacers **90** of insulating material and filling the annulus **92** above packer **94** with an insulating fluid. Further, if it is desired to provide heating in the formation **12** as well as the casing **20**, a path for flow of current through the formation can be provided by providing a length of insulating casing **96** at the lower end of the string of casing or by extending the tubing **33** below the insulating pipe **28** with the insulating pipe **28** extending below the casing **20**. By controlling the length of the joint **96** of casing or the distance the insulating pipe extends below the casing, the resistance of the current path in the formation can be varied to control the amount

of heating in the tubing and the formation. Such a procedure is especially useful in the treatment of formations containing paraffin base oils.

Although the invention has been described with reference to a particular preferred embodiment thereof, many changes and modifications will become apparent to those skilled in the art in view of the foregoing description which is intended to be illustrative and not limiting of the invention defined in the appended claims.

What is claimed is:

1. The method of treating a subterranean mineral producing formation wherein a well bore extends from the surface into a mineral bearing formation positioned below other formations that comprises providing sections in a tubular member having a higher electrical resistivity than the remainder, positioning at said tubular member in said well bore extending downward from the surface into the mineral bearing formation and flowing heated fluids through the tubular member from the surface into the mineral bearing formation while causing electrical current to flow through said tubular member for generating heat and reducing loss of heat from said heated fluids into the other formations above said mineral bearing formations.

2. A method as defined in claim **1** wherein the sections are positioned adjacent strata having a high coefficient of thermal conductivity.

3. A method as defined in claim **1** further including the step of thermally insulating said tubular member from the other formations.

4. The method of treating a subterranean mineral producing formation wherein a well bore extends from the the surface into a mineral bearing formation positioned below other formations that comprises positioning at least one tubular member in said well bore extending downward from the surface into the mineral bearing formation while causing electrical current to flow through said at least one tubular member for generating heat and reducing loss of heat from said heated fluids into the other formations above said mineral bearing formation and controlling the flow of electrical current to control the heat produced in said tubular member to be substantially equal to the heat which would be lost by the heated fluids in the absence of heating of the tubular member.

5. A method as defined in claim **4** further including the step of simultaneously heating the tubing and the mineral bearing formation adjacent said well bore.

6. A method as defined in claim **4** further including the step of thermally insulating said tubular member from the other formations.

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U.S. Cl. X.R.

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