Sept. 20, 1971 J. L. LEEPER 3,605,885

EARTH FORMATION HEATING APPARATUS

Filed July 14, 1969

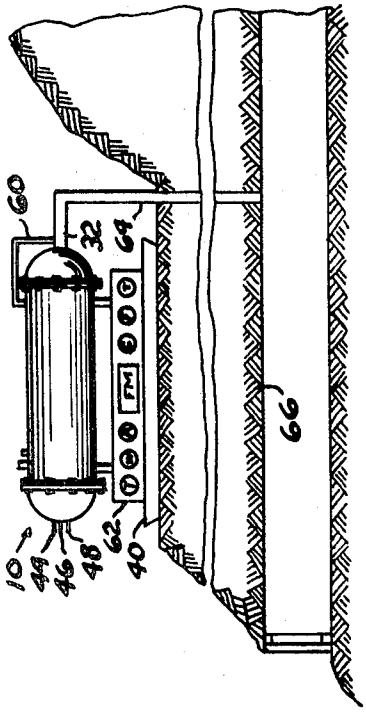


FIG. 4

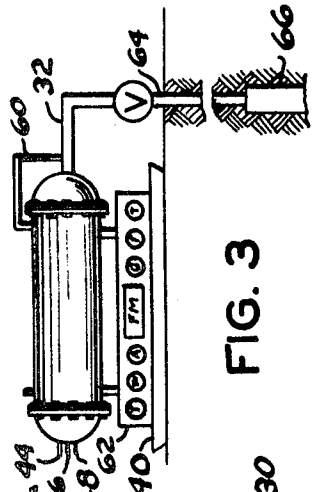


FIG. 3

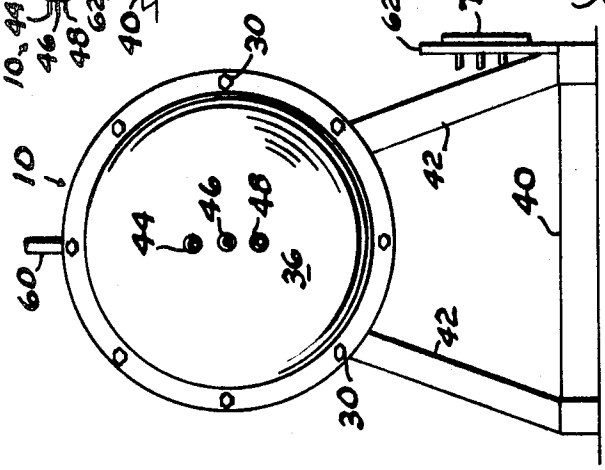


FIG. 2

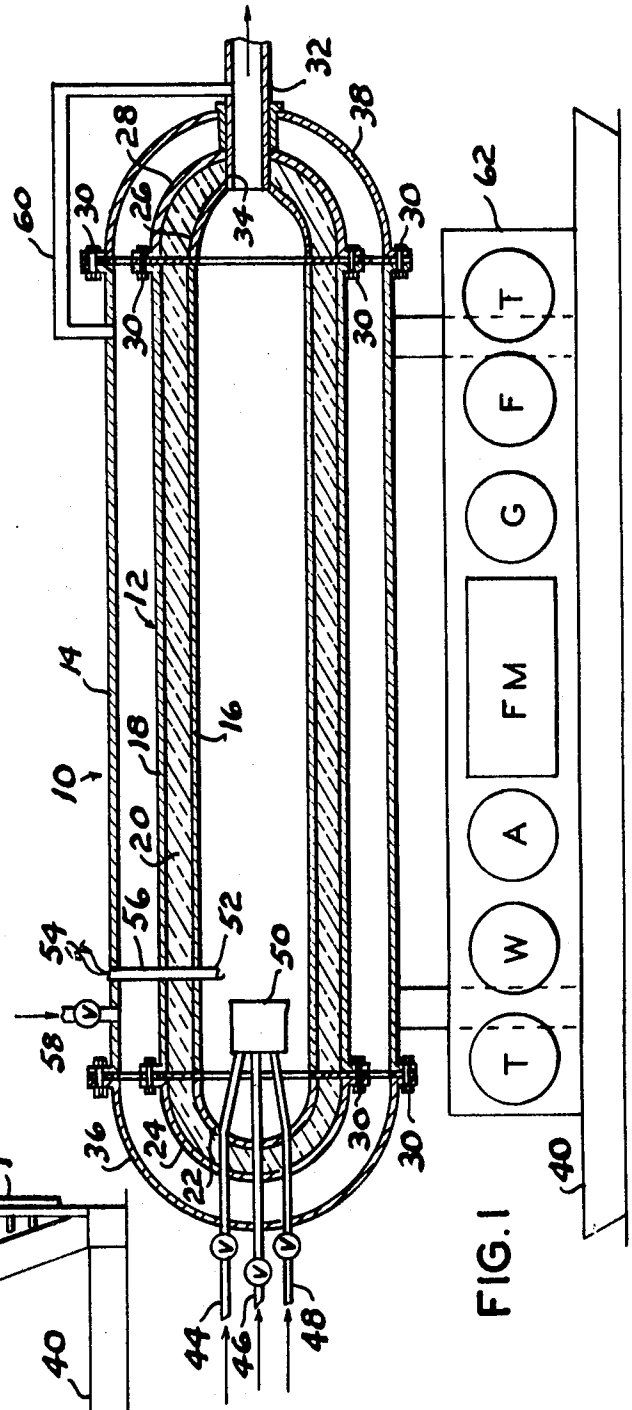


FIG. 1

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EARTH FORMATION HEATING APPARATUS

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ABSTRACT OF THE DISCLOSURE

A double walled insulated combustion chamber having fuel inlet ports and a heated gas exhaust port has its exhaust port connected to tubing extending into a well bore. Water received by a jacket surrounding the combustion chamber is converted to steam and injected into the flow of heated gases down stream from the exhaust port. Pressure generated by combustion forces the heated gases and steam into the well bore for heating pipe and earth formations.

BACKGROUND OF THE INVENTION

(1) Field of the invention

The present invention relates to mineral and oil recovery from earth formations and more particularly to a heater for injecting hot gases into a well bore, or the like.

It is well known that oil producing formations contain considerably more oil than is normally recovered between the initial completion of the oil well and the time that it is no longer economical to attempt to continue production. This is due, in part at least, to the density of the formation and the distance between wells penetrating the oil producing formations. Various attempts have been made in the search for new and better methods for the release and recovery of oil to increase production and obtain all of the oil possible from an otherwise uneconomical producing zone, such as by the use of heat, water or gas.

(2) Description of the prior art

One of the attempts to increase production from an oil bearing formation has been the injection of steam into the bore holes, commonly referred to as "steam flood" or "steam soak." This is accomplished by converting water to steam which is injected into the down hole oil bearing formation of an oil well. After the injection of steam no attempt is made to produce the well for a selected period of time in order to allow heat convection into the formation to occur. The viscosity of the crude oil is reduced and some of the lighter oil is heated to a sufficient temperature to generate some gas. The thinned oil is later propelled into the well bore by these gases and the well is again produced.

The advantage of this process is that steam is a good conductor of heat and relatively simple equipment may be used, however, the disadvantages outweigh the advantages, such as the availability of water supply, the cost of operation in treating the produced fluid to remove the water and that only some earth formations are receptive to treatment for oil recovery by steam.

The most commonly used process for oil recovery from partially depleted oil reservoirs is known as water flooding. This is accomplished by injecting water into the oil formation or reservoir of a well or wells at selected locations in the area wherein the water tends to displace the oil in the formation and forces it toward and into adjacent well bores having oil recovery equipment installed therein. This method has a history of satisfactorily increasing oil recovery in certain reservoirs and is relatively simple in operation, however, some reservoirs will not respond to water flooding for various reasons, such as the viscosity of the oil, permeability of the formation and the depth of the well bore.

Another method of oil recovery comprises the injection of gas into the oil reservoir. Where natural gas produced is reinjected into the reservoir it has the advantage of maintaining the energy of the reservoir and forces some of the oil into the reduced pressure areas of the formation, however, this has the disadvantage of loss of revenue from gas sales and the cost of additional equipment necesary to accomplish the reinjection of the gas.

Carbon dioxide, in liquid form, has been injected into oil bearing formations which is satisfactory from the standpoint of dissolving certain formation, such as lime and dolomites as well as reducing the viscosity of the oil, however, the expense of transporting and the cost of liquid carbon dioxide generally proves this method uneconomical.

SUMMARY OF THE INVENTION

Stated briefly this invention comprises injecting heated gases and steam into a well bore for heating oil and earth formations. This is accomplished by forming a combustion chamber having a fuel injection end and an exhaust port connected with tubing extending into a well bore. Water injected into a jacket surrounding the combustion chamber is converted into steam by the heat of combustion and is injected into the stream of heated gases emitting from the exhaust port to reduce the temperature of these gases to approximately 700° F. Fuel used in combustion comprises a small amount of gas and air mixed with fuel oil. The heated gases are usually injected into the casing surrounding the tubing in a pumping oil well which melts any accumulation of paraffin within the tubing and reduces the viscosity of the oil in the oil bearing formation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical cross-sectional view of the device, partially in elevation;

FIG. 2 is a left end elevational view of FIG. 1;

FIG. 3 is a side elevational view, partially in section, of the device when used with a well bore; and,

FIG. 4 is a view similar to FIG. 3 illustrating the manner of heating earth formation intersected by a mine shaft.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Like characters of reference designate like parts in those figures of the drawings in which they occur.

In the drawings:

The reference numeral **10** indicates the device, as a whole, which is generally cylindrical in overall configuration comprising a combustion chamber **12** and a surrounding outer jacket **14**. The combustion chamber is formed by spaced-apart inner and outer tubes **16** and **18**, respectively, having insulating material **20** interposed therebetween. The inlet end of the combustion chamber

is closed by hemispherical similarly spaced-apart and insulated inner and outer dome-like end members **22** and **24**. The other or outlet end of the combustion chamber is similarly closed by substantially hemispherical inner and outer end members **26** and **28**. The respective end members **22–24** and **26–28** are, respectively, connected with the inner and outer tubes **16** and **18** by bolts **30** extending through cooperating flanges on the respective members in a conventional manner. The end members **26** and **28** are concentrically apertured for receiving a tube or pipe **32** forming an outlet or exhaust port **34**.

The outer jacket **14**, having similarly shaped and connected inlet and outlet end members **36** and **38**, respectively, surrounds the combustion chamber **12** in spaced relation with the exhaust pipe projecting through the outlet end member **38** of the jacket. The entire unit is mounted on a suitable base **40** by legs **42**.

A plurality of pipes, such as gas **44**, air **46** and fuel oil **48**, each having an interposed control valve, extend inwardly through the end members **22**, **24** and **36** and are connected with a shell forming a mixing chamber **50** within the combustion chamber. A conventional ignitor plug **52**, positioned within the combustion chamber adjacent the mixing chamber **50**, is energized by electrical energy conducting wires **54** projecting through a conduit **56** extending through the jacket and combustion chamber walls.

A water inlet pipe or port **58** extends through the wall of the jacket **14** adjacent its end opposite the outlet port **34**. A steam bypass line **60** communicates with the jacket **14** at one end and communicates with the pipe **32** at its other end.

A control panel **62**, mounted on the base, supports a pair of temperature gages T respectively connected with the combustion chamber and exhaust tube. Supply controls air A, gas G and fuel oil F and are mounted on the control panel **62** and connected with a conventional manner in the respective supply lines. Similarly, a water control W is mounted on the control panel and a flow meter FM is connected with the exhaust tube **32**.

OPERATION

In operation the device **10** is positioned adjacent a well bore and the exhaust tube **32** is connected with the well pipe or casing **64** for injecting heated gases into the earth formation **34** at the bottom of the well bore **66** through a valve V, if desired.

Alternatively the pipe **32** may be connected with the casing of a producing well, not shown, having a pump equipped tubing string therein, not shown. Electrical energy, from a suitable source, not shown, is applied to the ignitor plug **52** by wires **54** and a desired rate of flow of the fuel comprising the gas and fuel oil is admitted to the mixing chamber **50** through the respective lines **44** and **48** with a desired quantity of air through the pipe **46** so that the ignitor plug initiates combustion and after starting combustion is maintained by the burning gases which are exhausted through the pipe **32** and into the well bore. When combustion of the fuel has heated the combustion chamber **12**, water is admitted at a controlled rate into the jacket **14** through a valve in the pipe **58** wherein the heat of the combustion chamber converts the water to steam which is in turn injected into the exhaust pipe **42** by the bypass line **60**.

As stated hereinabove, the purpose of the steam is to reduce the temperature of the burned gases to approximately 700° F. resulting in a mixture of heated gases and superheated steam which is exhausted by the pressure of the burned gases directly into the well bore or the casing surrounding the pumping tubing when used in a pumping well. The composition of the burned gases is nitrogen, carbon dioxide, hydrogen and water. The heat serves to reduce the viscosity of the oil in the oil bearing formation in a more efficient manner than is possible with hot water as a result of the injection of steam only. Heat also serves to shrink bentonites and melt paraffin solids that have accumulated near the well bore. The nitrogen, after being forced into the formation, tends to raise the formation pressure and stabilize at the increased pressure to be utilized as reservoir energy for propelling oil toward the well bore. The nitrogen also combines with some water to form nitric acid which is advantageous in oil recovery from well bores having formations containing iron oxides and iron sulfides commonly known as "fines" which concentrate around the well bore and tend to restrict oil flow. The carbon dioxide combines with water to form carbonic acid reducing viscosity of the oil and dissolving some formations, such as lime as mentioned hereinabove. The water injected in the form of steam acts as a carrier of heat and liberates hydrogen. The hydrogen tends to reduce the oil viscosity by linking up with the hydrocarbon chain of the oil in the formation and serves to boost the reservoir energy of the formation. Each of the above reactions complement each other in increasing the efficiency of oil recovery from most oil producing formations.

Obviously the invention is susceptible to changes or alterations without defeating its practicability, therefore, I do not wish to be confined to the preferred embodiment shown in the drawings and described herein.

I claim:

1. A heater, comprising:

an elongated tubular member having closed ends forming a combustion chamber having inlet ports for fuel and air at one end and an exhaust port at its other end;

said closed end elongated tubular member having inner and outer spaced-apart walls;

a layer of insulating material between said inner and outer walls;

a jacket loosely surrounding said elongated tubular member, said jacket having a fluid inlet port and an outlet port;

a bypass line connecting the outlet port of said jacket with the exhaust port of said combustion chamber;

a shell forming a fuel mixing chamber within said combustion chamber adjacent the inlet ports;

an ignitor plug adjacent said mixing chamber;

said ignitor plug being connected with a source of electrical energy;

a supply pipe extending through each respective inlet port and connected with said mixing chamber; and

control means including a control valve interposed in each said supply pipe and the air supply pipe.

2. A heater in combination with a well bore penetrating a selected earth formation, said well bore having piping therein providing communication between the formation and the surface of the earth, the improvement comprising:

an elongated tubular member forming a combustion chamber having inlet ports for fuel and air at one end and an exhaust port at its other end,

said closed end elongated tubular member having inner and outer spaced-apart walls;

a layer of insulating material between said inner and outer walls;

a jacket loosely surrounding said elongated tubular member, said jacket having a fluid inlet port and an outlet port;

a bypass line connecting the outlet port of said jacket with the exhaust pipe of said combustion chamber;

an exhaust pipe connecting the exhaust port with the piping in said well bore;

a shell forming a fuel mixing chamber within said combustion chamber adjacent the inlet ports;

an electric ignitor plug connected with a source of electrical energy and disposed adjacent said mixing chamber;

a supply pipe extending through each respective inlet

port and communicating with the mixing chamber; and

control means including a control valve interposed in each said supply pipe and the air supply pipe.

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