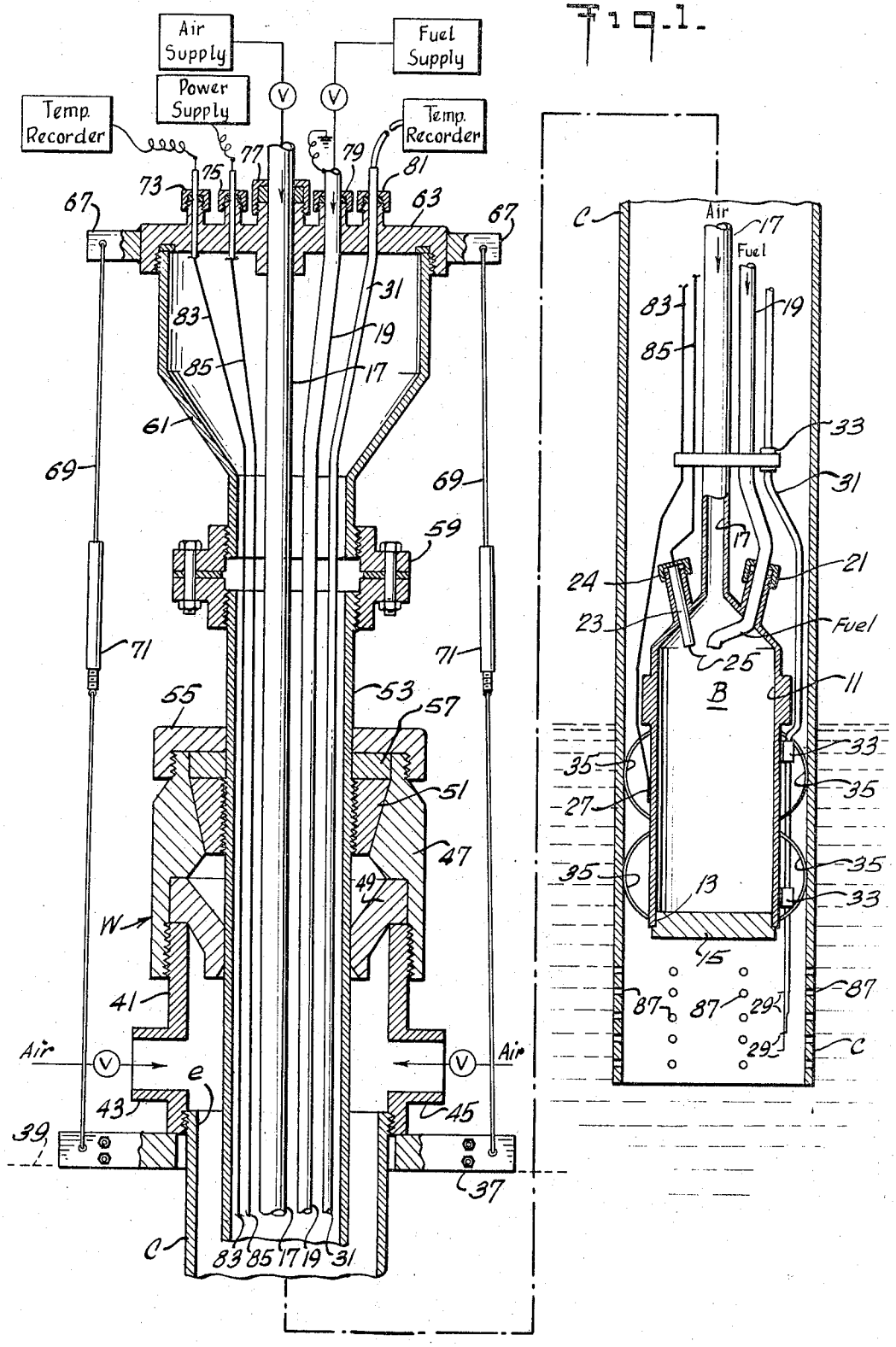
April 25, 1967 W. A. REES, JR 3,315,745

BOTTOM HOLE BURNER

Filed July 29, 1964 2 Sheets-Sheet 1

Fig. 1.

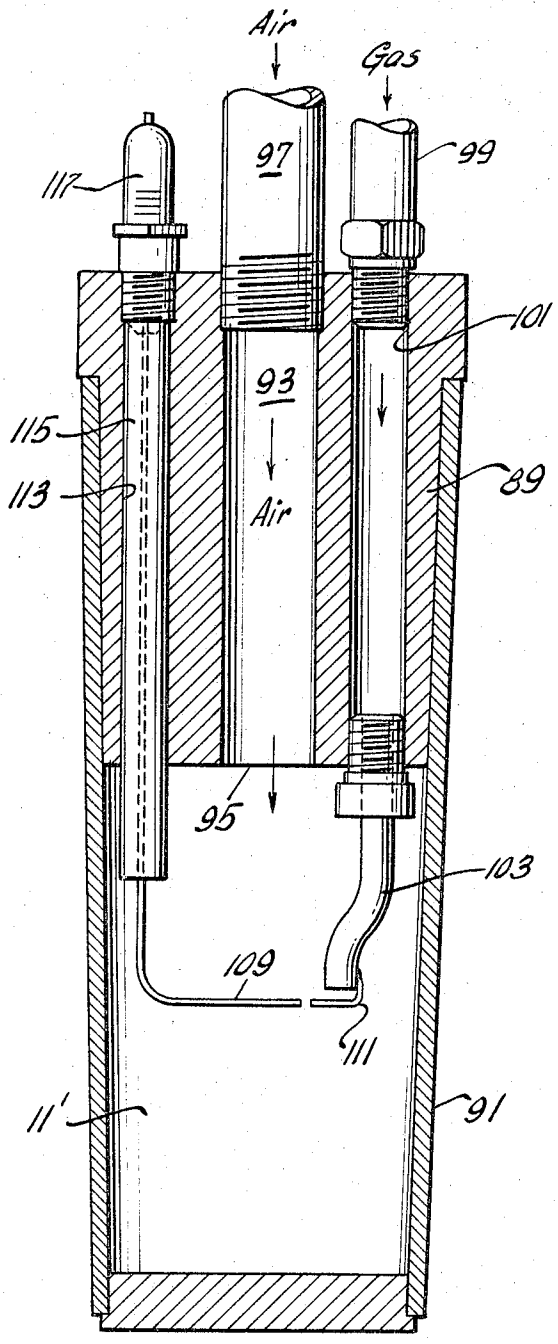


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Fig. 2.



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BOTTOM HOLE BURNER

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The present invention relates to a burner for introducing heat into an oil well, and is particularly applicable for use in a well which initially contains a pool of liquid such as oil, water, or a mixture at the point where heating is desired. The burner and its method of operation is particularly advantageous for initiating an in situ combustion operation in an injection well to drive oil through an earth formation to nearby production wells.

Burners for use in oil wells are well known, and a number of patents have been issued covering various designs. However, the burners of the prior art are subject to certain disadvantages which are overcome by my novel burner construction. One type of burner disclosed in U.S. Patent 2,668,592 has a combustion zone with a bottom outlet which is always open. This type of burner is not employable in wells which contain liquids at the point of heating because the liquid tends to enter the combustion zone and prevent ignition of the combustible gases therein. A burner which would not be subject to this disadvantage is shown in U.S. Patent 1,626,940, but this burner relies wholly upon indirect heat transfer to the formation fluids because the bottom of the combustion chamber is permanently closed so that the gases of combustion are carried back up to the surface of the earth through an auxiliary conduit associated with the burner.

Burners of the prior art also lack means for measuring temperatures at various points within a well so as to determine whether or not combustion is proceeding efficiently. Moreover, they are not adequately constructed adjacent the surface of the earth for assuring maintenance of a high gas pressure within the well, while at the same time permitting movement of the burner up or down in the well for extending the heating operation over the full length of a producing zone.

My burner and its method of operation will overcome the disadvantages of the prior art discussed above and assure satisfactory burning of a combustible gas mixture within a well at great depths, whether or not the well is partially full of liquids at the start of the operation.

In its broader aspects my bottom hole burner for introducing heat into an oil well comprises a combustion chamber having an upper end and a lower end, a fuel gas and a combination-supporting conduit each connected to the upper end of the combustion chamber, for separate delivery of these gases thereto to form a combustible gas mixture therein.

An igniting device, positioned in the upper end of the combustion chamber, may be either an electrical spark producing device or a high resistance electrical heating wire, or even a spontaneously combustible chemical device.

In order to prevent the access of well liquids into the combustion chamber, its lower end is closed by a plug which is blown away from the chamber when a predetermined higher gas pressure is developed therein.

The upper end of the burner also has certain novel aspects for maintaining a pressure tight seal at the well head, while the various gases and electrical currents are passed from outside the well head into the burner. The well head also is so constructed that a gas, such as air or nitrogen, can be supplied thereto for passage down through the well on the outside of the burner for expelling liquids from the well into the formation as well

as for sustaining in situ combustion of oil in the formation surrounding the well. The well head is so designed that the burner can be raised or lowered in the well without destroying the pressure tight seal at the surface of the earth.

The invention will be described more in detail in connection with the accompanying drawings, wherein:

FIG. 1 is a vertical sectional view, parts being in elevation, of a burner embodying the novel features of the invention, and

FIG. 2 is a vertical sectional view, parts being in elevation taken through the lower end of a modified form of burner.

Referring to FIG. 1, the lower end of a burner B comprises a cylindrical combustion chamber **11** which is formed of heat resistant metal such as steel, with or without a refractory ceramic lining, and has a flame outlet **13** at its lower end which is closed by a blowout plug **15** frictionally fitted into the chamber. Chamber **11** can be any suitable length, e.g. ranging from as short as 6 inches to as long as 6 feet. Plug **15** can be formed of any suitable material, but it is preferably a plastic material such as polyethylene which will burn and be destroyed in the well after it is blown out and the flame impinges thereon.

The upper end of chamber **11** is frusto-conical in shape and merges into a compressed air conduit **17** of considerably smaller diameter than the chamber. There is also connected into the upper end of the combustion chamber a fuel conduit **19** which enters through the frusto-conical wall and is sealed in pressure tight relationship by a packing gland **21**.

Conduits **17** and **19** extend upwardly in the well and pass through a well head W at the surface of the earth in pressure tight relationship thereto so as to prevent the escape of gases out of the hole, and to permit the injection of gas under high pressure for expelling liquid from the well. This well head will be described more in detail hereinafter.

Also affiliated with the combustion chamber **11** are a spark plug **23** which extends in pressure tight relationship through a packing gland **24** in the frusto-conical wall of the chamber and has a single electrode **25** positioned in slightly spaced relationship to the end of the metal fuel conduit **19** so as to produce a spark therebetween when energized.

Additionally, several thermocouples are carried on the outside of the combustion chamber for measuring the temperature at various points within the well, one of these being the thermocouple **27** clamped on the side of the chamber **11** for monitoring its temperature, and the others being the thermocouples **29** which project down below the combustion chamber for measuring the temperature at the face of the producing sand. All of these thermocouples are connected by suitable electrically conductive wires to recording devices at the surface of the earth, with the wires extending in pressure tight relationship through the well head. The conductive wires of the thermocouples **29** are formed into a multiconductor cable **31** which passes through a series of supporting sleeves **33** on the sides of the combustion chamber and the upper portions of the burner, a loose fit being maintained so that the burner can be moved up and down in a well for heating the full length of a producing formation while the thermocouples are maintained stationary. If no movement is needed, the cable can be clamped tightly to the burner.

Centralization of the burner B within the well is assured by a plurality of spacers **35** which are spaced from one another at quarter points circumferentially around the combustion chamber, and engage the walls of the well (or of a perforated casing C therein when a casing is used).

Now referring to the well head W, the casing C is held by a conventional casing clamp **37** which lies on the surface **39** of a platform or the earth. Clamp **37** comprises a pair of mating half cylinders having flanges together. A sleeve **41** having a pair of inlets **43** and **45** for a gas such as air is threaded over the upper end of the casing C and abuts against the casing clamp **37** so that air may be introduced into the casing and flow downwardly therethrough in the annular space surrounding the burner.

On the top of sleeve **41** there is secured a well head collar **47** provided with appropriate pressure sealing packers **49** and **51** for engaging a lubricator pipe **53** which is adapted to move upwardly and downwardly through the well head while maintaining a pressure tight seal. The top of collar **47** is closed by a cap **55** threaded over the collar and bearing against a gasket **57**.

The upper portion of lubricator pipe **53** includes a flange joint **59** and terminates in an enlarged frustoconical and then cylindrical section **61** having an open top which is closed by a cap **63** threaded on the cylindrical section.

A pair of radially extending ears **67** on the cap are connected to the casing clamp **37** by a pair of cables or chains **69** maintained in tension by turnbuckles or other device **71** for assuring pressure tightness, and also to provide a means for forcing the lubricator pipe downwardly through the well head when movement of the burner at the sand face is desired, and also for preventing the burner and associated pipe from moving up or blowing out of the well under high pressure therein.

The top of cap **63** is provided with appropriate packing glands **73, 75, 77, 79** and **81** for the heater thermocouple wire **83**, the high tension spark wire **85**, the air pipe **17**, the fuel pipe **19**, and the thermocouple multiconductor cable **31**, respectively, all of which are connected to suitable sources of supply of the appropriate gases and electrical currents, or to temperature recording devices on the outside of the well. Ignition can be accomplished by an automotive type ignition system.

Appropriate control valves and switches are provided in the various supply lines for gases and electricity, respectively.

In the preferred method of operating the burner described in detail above, it is lowered into the hole until the combustion chamber **11** is opposite the formation to be treated, after which a large supply of high pressure gas such as air or nitrogen is introduced through the inlets **43** and **45** to force the pool of formation liquids out into the porous formation surrounding the well. The liquids pass out through apertures **87** in casing C opposite the producing formation. After the well has been freed of liquid, a combustion-supporting gas such as air or oxygen is supplied under high pressure to the conduit **17** and develops sufficient pressure in the chamber **11** to blow out the plug **15**.

Then the flow of fuel gas such as natural gas through the conduit **19** is commenced to mix in chamber **11** with the air to form a combustible mixture. An air:fuel ratio greater than 10:1 is desirable. At this time a high tension electrical current is supplied to the electrode **25** and arcs across to the fuel conduit **19** to ignite the combustible gas mixture and create a high temperature flame which extends downwardly through the chamber **11** and the outlet **13** to the interior of the well. The hot gases of combustion pass outwardly through the apertures **87** and into the formation, eventually heating the formation hydrocarbon material to a temperature at which in situ combustion develops and a flame front is created which extends outwardly from this injection well to force formation liquids to a producing well nearby.

As in known oil field practice, as the burner is lowered additional joints of pipe are connected together to create the long pipes which may be several hundred feet long. During lowering the thermocouple wires and ignition wire are strapped to the pipes and the fuel gas pipe **19** is clamped to the air pipe **17**. When the burner reaches the formation the various supply lines are threaded through lubricator pipe **53**, flanged joint **59**, chamber **61** and cap **63**. The whole unit is then lowered so that lubricator pipe **53** can be hung in the slips of the well head. If the burner is not to be moved in operation, the lubricator pipe can be attached directly to the collar **47**, and packer **51** screwed onto pipe **53**, as shown in FIGURE 1. The flange joint **59** is then made up and the installation is complete.

Instead of a spark gap for ignition, a high resistance glow wire can extend from the ignitor **23** to direct contact with the fuel conduit **19**, or to another electrically conductive part of the burner, to form a glowing hot wire.

Still another means for igniting the combustible gas mixture involves the provision of a liquid absorbent wick of cotton or other material suspended within the upper portion of the combustion chamber **11**, and the injection through one of the conduits **17** or **19** of a spontaneously ignitible liquid such as linseed oil containing a catalyst and promoter, for example cobalt naphthenate and dimethyl aniline. The flow of air through conduit **17** is inaugurated and causes the wick and the absorbed fluid to ignite spontaneously and ignite the combustible gas mixture.

Referring to FIG. 2 of the drawings, there is shown a combustion chamber **11'** comprising a metal head piece **89** from which there projects downwardly a tubular skirt **91** which is sleeved over the outside of the head piece. The head piece **89** contains a central bore **93** having an outlet **95** at its lower end and at its upper end connected to an air conduit **97** which is threaded thereto. Similarly, fuel gas is supplied through a conduit **99** threaded into the upper end of a bore **101**, the lower end of which carries a projecting metal nozzle **103** threaded into the bore and inclined over toward the center line of the combustion chamber.

Ignition of the combustible gas stream is accomplished by means of a spark created between an electrode **109** and an electrode **111** on the lower end of nozzle **103**. Electrode **109** extends upwardly through another bore **113** in the head piece in spaced relation to the walls thereof and is insulated from the metal head piece by suitable insulating material **115** such as Teflon resin or epoxy resin in the annular space surrounding the electrode. A connector **117** at the top of the head piece is threaded into bore **113** for conducting electricity to the electrode.

The apparatus described above is particularly applicable to the initiation of in situ combustion operations in oil bearing formations. However, the burner also can be used for the elimination of formation restrictions, (1) caused by naturally occurring fluids, extraneous fluids or combinations of the two; (2) caused by liquids or solids deposited from drilling fluids; (3) caused by dehydratable or oxidatable substances occurring naturally in the formation; (4) caused by extraneous substances placed in the well bore or formation including cement, plastics, gelled liquids and other chemicals used in the drilling completion or treatment of a well.

It is useful for any other operation or procedure where the application of heat to the well bore formations, or substances in the vicinity of the well bore, or the equipment or substances within the well bore is advantageous, e.g., consolidating sand by warm air coking.

Under some conditions the gases of combustion are returned up through the casing, a back pressure being maintained thereon so that when the restriction breaks up the gases enter the formation. Where initiation of in situ combustion is not an object, then nitrogen can be sent down the casing to help eliminate restrictions.

Obviously, other modifications and variations of the invention, as hereinbefore set forth, may be made without departing from the spirit and scope thereof, and therefore only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. A bottom hole burner for introducing heat into an oil well comprising, in combination, a combustion chamber having an upper end and a lower end, a first and a second conduit each joined to said upper end of said combustion chamber for communication with supply sources on the surface of the earth, one of these conduits providing a fuel gas and the other thereof providing a combustion-supporting gas, means for igniting a combustible mixture positioned adjacent said upper end of said combustion chamber, a closure plug for said lower end of said combustion chamber positioned therein for disengagement therefrom by a predetermined pressure exerted from within said combustion chamber, said means for igniting comprising an electrode positioned adjacent but spaced from one of said conduits, means for supplying electrical current to said electrode, and means for conducting electrical current from said one of said conduits whereby a spark is created between said last mentioned conduit and said electrode.

2. A bottom hole burner in accordance with claim 1, including thermocouples mounted on said burner, and electrical conductor means leading from said thermocouples along said burner to said well head.

3. A bottom hole burner in accordance with claim 1, including a plurality of circumferentially arranged spacers on the outside of said burner.

4. A bottom hole burner in accordance with claim 1, also comprising a pressure tight well head, said conduits extending through said well head in pressure-tight relationship thereto, and means outside of said well head for supplying fuel gas and combustion-supporting gas in communication with the respective conduits.

5. A bottom hole burner in accordance with claim 4, also comprising means for supplying combustion-supporting gas to said well head for passage down said well outside of said burner for sustaining an in situ combustion in an oil formation after ignition thereof by said burner.

6. A bottom hole burner in accordance with claim 4 wherein said well head comprises a casing clamp, a pressure tight cap above said clamp through which said conduits pass, said cap being seated on the top of a lubricator pipe, and tension means connecting said cap to said casing clamp for lowering the burner in a well and for preventing the burner from moving up said well when pressuer is applied therein.

7. A bottom hole burner in accordance with claim 1, wherein said combustion chamber comprises a block, an elongated skirt secured to said block and projecting outwardly therefrom, and wherein the first and second conduits comprise bores in said block and supply pipes secured in the upper ends of said bores and extending away therefrom.

8. A bottom hole burner in accordance with claim 7, also comprising a nozzle secured in the lower end of the bore for fuel gas and projecting outwardly therefrom.

9. A bottom hole burner in accordance with claim 8 wherein said nozzle acts as an electrode, said burner also comprising a second electrode positioned close to but spaced from said nozzle, said second electrode extending up through a bore in said block, and electrical insulation surrounding said second electrode in said bore.

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