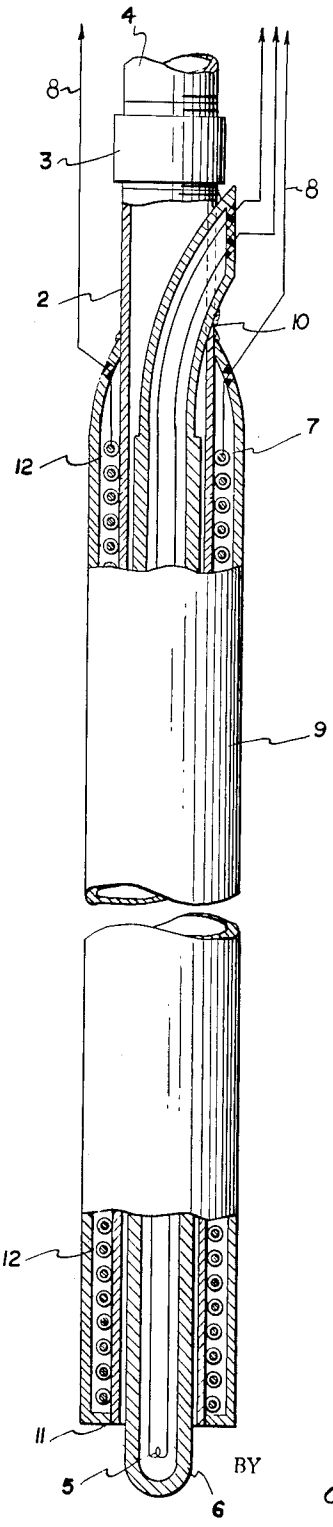
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APPARATUS

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APPARATUS

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1 Claim. (Cl. 166—59)

This invention relates to an apparatus for producing high temperatures in subterranean passages by combustion of oil. More particularly, this invention relates to a bottom hole heater and burner which can be lowered into subterranean passages, such as oil, shale or water wells, and while in this position burn an oil stream passed from the earth's surface to produce high temperatures in the wells which can be followed from the earth's surface.

There have been proposed various methods for treating subterranean passages such as oil, shale and water wells to increase the amount of values recovered from the earth, which methods include initiation and maintenance of combustion of fuels in the passages at or near the point of heat application. I have now devised an apparatus for establishing a highly heated zone at controlled temperatures in these subterranean passages that is simple in construction, relatively simple to operate and economical and that provides adequate means for following temperatures of heating and combustion in the passages. My device is particularly effective in providing a rapid, compact and inexpensive means for igniting oil-bearing sands and in providing control of burning rate and passage temperature over extended periods of time. Ignition of oil-bearing sands provides for increased oil recovery from the strata as liquids, vapors or gaseous decomposition production, e. g., products of combustion. Heated zones are also used in conjunction with small diameter cemented tubing which has been used for water injection and which has become sludged or clogged with foreign agents. These agents may consist of bacterial organisms, insoluble carbonates, or heavy waxy hydrocarbons, and are of such a nature that they are either consumed at the point of clogging or disintegrated thereby to a powdery form by heat or fire. After this treatment, they can be blown from the well by air or flushed to the surface by water.

My invention will be described more particularly with reference to the accompanying drawing which is a cross-sectional view of my bottom hole heater and burner which is suitable for the above and other purposes.

The burner comprises an elongated cylindrical hollow tubing member **2** which is adapted at its upper end to be connected by coupling **3** to a string of hollow tubing **4** which is lowered into the subterranean passage. Tubing **2** is open at its lower end and has projecting from this end a thermocouple **5** situated within a thermowell **6**. The thermowell is a hollow cylindrical metallic tubing, e. g., stainless steel, having a closed lower end which houses the thermocouple. The thermowell extends upwardly into the tubing **2** and through its side at a substantial distance from its lower end. At the point where the thermowell passes through the tubing **2**, it is welded so that no liquid or gas can escape from the tubing. The upper end of the thermowell is either flush with the outside surface of tubing **2** or, preferably, extends just beyond tubing **2** a distance small enough not to interfere with the lowering of the heater into the passage. The thermowell houses the electrical leads leading to the thermocouple, which leads extend to the earth's surface after passing through the top of the thermowell through tight seals. Alternatively, the thermowell could extend to the earth's surface outside of tubing **2** or by passage through tubing **4**; however, in the latter position, it would unnecessarily affect the flow of gas and liquids through the tubing string.

Since the tubing **2** is hollow and is connected to a tubing **4** leading to the earth's surface, oil or oil and air can be passed downwardly through the string of tubing **4** and tubing **2** of the burner. The thermowell **6** is of such diameter that its cross section occupies a substantial portion of the cross sectional area of the tubing **2**, thus providing narrow but free passages between the thermowell and tubing **2** for passage of the oil and air descending from the earth's surface. Disposed around a substantial lower portion of tubing **2** is heating wire **7** which has electrical connecting leads **8** passing to the surface of the ground. The heating wire is held out of contact with tubing **2** by insulating beads **12**. A protective sheath **9** is disposed around the heating coil **7** and encloses the coil in a chamber formed between it and tubing **2** by meeting the tubing at points **10** and **11**.

In operation, my bottom hole heater and burner is attached to the end of a string of well tubing and lowered into the passage, e. g., an oil well. As it is lowered the thermocouple leads and electrical coil leads are extended so that their upper ends are at the earth's surface. The outside diameter of the burner defined by the protective sheath is such that a space is left between it and the passage bore, its casing or tubing as the case may be. Thus the outside diameter of the protective sheath must be smaller than the internal diameter of the structure into which it is being lowered to permit lowering and, possibly, passage of air to help support combustion.

After appropriate surface connections and seals have been made, air or any oxygen-rich gas is introduced through or around the tubing string **4** and burner tubing **2**, and it passes the thermocouple situated in the lower end of the thermowell projecting beyond the burner tubing. As the air passes down the well it is heated by the electrical heating coil surrounding the burner tubing. When the thermocouple indicates a temperature above about 500° F., oil is fed through the tubing **2** and the heating of both the oil and the air is continued until combustion is initiated. As noted, the air to support combustion can pass inside of tubing **2** or outside of sheath **9** or can take both courses. Temperature of the burning is followed by noting at the earth's surface the reaction of the thermocouple. The temperature is regulated by adjusting the air-fuel ratio and can vary, depending upon the results to be accomplished, e. g., removal of clogging material from tubing, ignition of oil sands, etc. Once the burning has started the electrical heat input can be discontinued.

In constructing the bottom hole burner, its length will be a matter depending upon the conditions to be observed. For instance, the length is sufficient to heat the air and oil to combustion initiating temperatures. Factors which will affect the length then include the amount of oil and air to be heated, the size of the passage between thermowell and tubing **2**, the temperature of the subterranean passage, the amount of current passing to the heating coil, etc. It also follows that the width of the elongated circular passage between the thermowell and tubing **2** can vary and is sufficient to permit the air and oil to form a combustible mixture. The width should not be so great that the air and oil cannot be heated even at low flow rates to temperatures to initiate combustion. Also, the width should not be so small as to require extremely high pressures for passing combustible fluids through the circular passage. For instance, the width is advantageously about

10 to 20 thousandths of an inch when tubing 2 has an internal diameter of one-half inch.

Thus it is seen that my invention provides a compact, efficient, rapid and inexpensive means for initiating and maintaining combustion in subterranean passages. It also provides simple and adequate means for following at the earth's surface temperatures of heating and combustion in the passages.

I claim:

A bottom hole burner comprising a vertically elongated tubing having an open lower end, a cylindrical thermowell disposed within said tubing and having a diameter which permits flow of combustible fluids between the outside of the thermowell and the inside of the tubing, said thermowell having its lower end projecting just beyond the lower end of the tubing, a thermocouple disposed within and at the lower end of said thermowell, an electrical heating coil disposed around said tubing at its bottom and along its length sufficient to heat the combustible fluids to combustion temperature, and a protective sheath disposed around said electrical heating coil.

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