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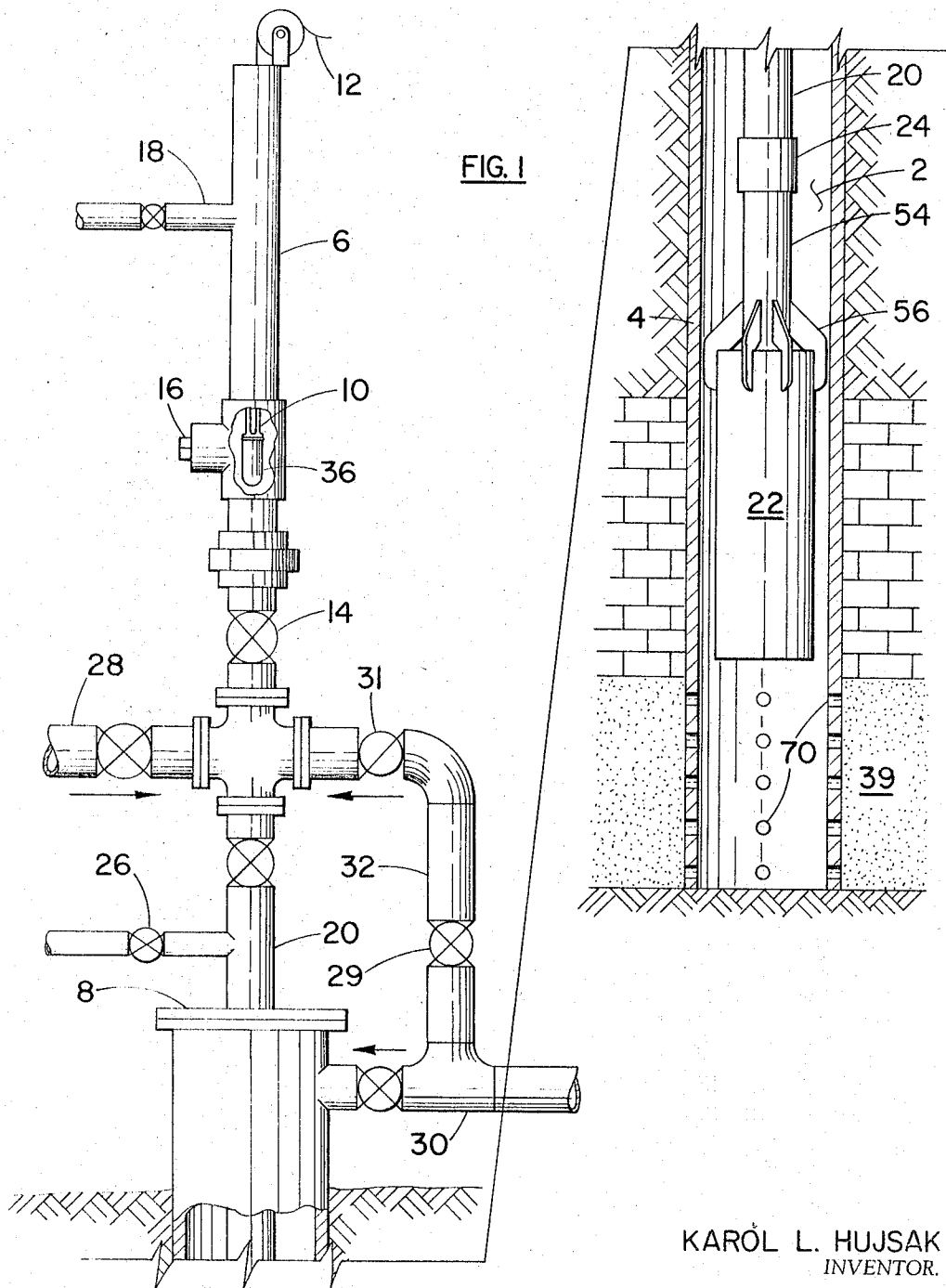
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3,307,609

BOTTOM-HOLE IGNITER TUBE

Filed March 23, 1966

4 Sheets-Sheet 1



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FIG. 2

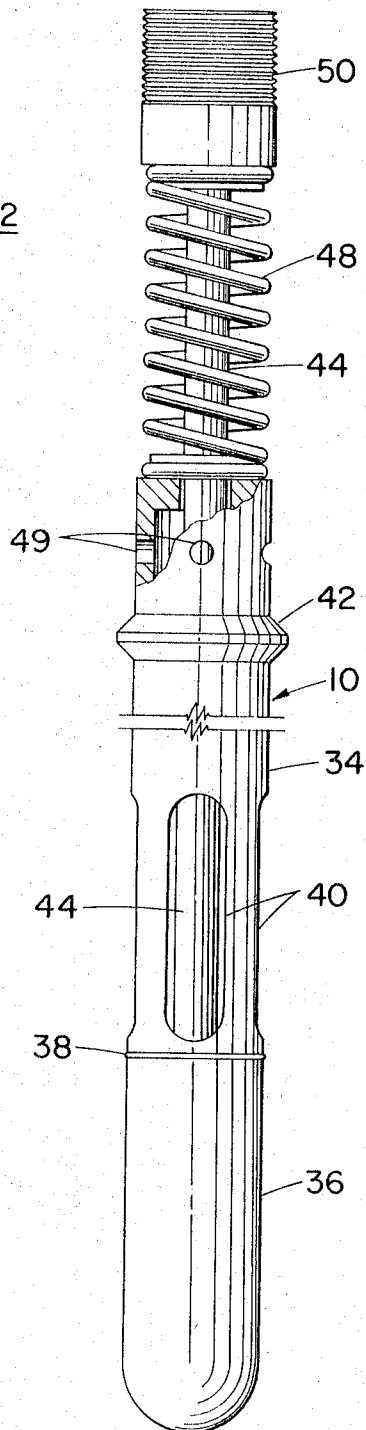
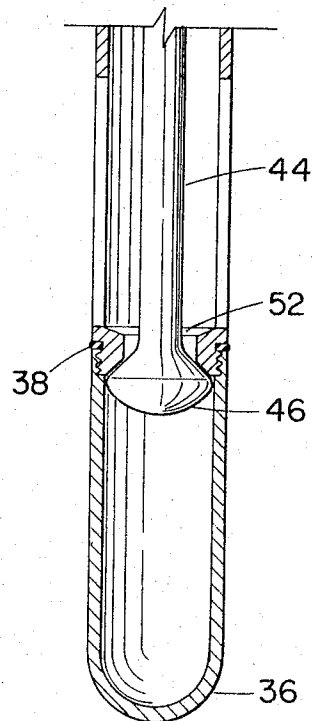


FIG. 3



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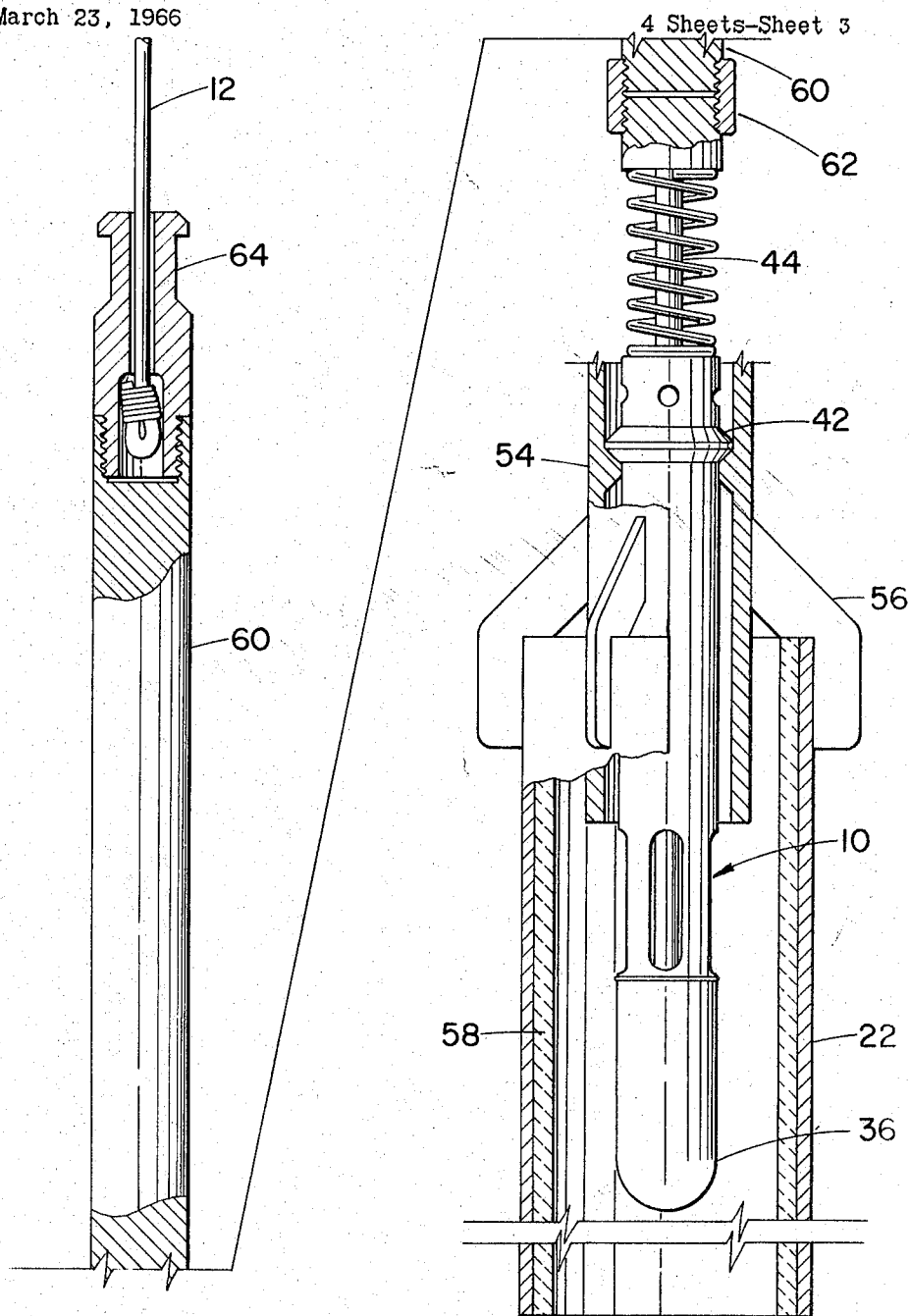


FIG. 4

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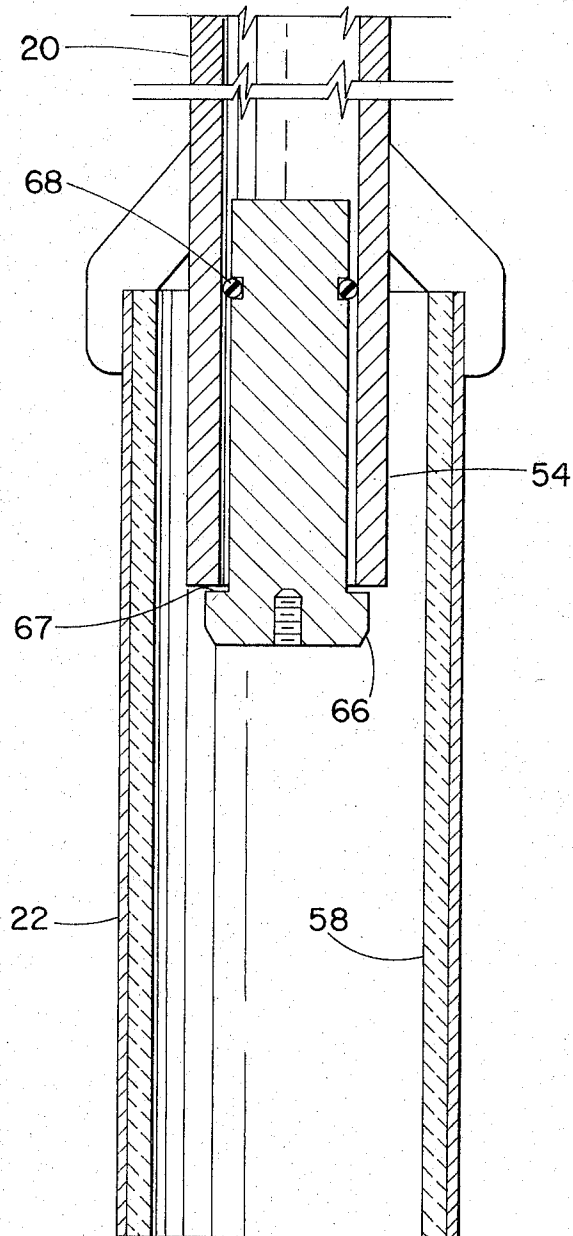


FIG. 5

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3,307,609

BOTTOM-HOLE IGNITER TUBE

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8 Claims. (Cl. 158—28)

The present invention relates to a novel ignition tube to be used in conjunction with a bottom-hole heater or igniter for supplying heat to a hydrocarbon containing formation to stimulate the flow of oil therefrom or to ignite said formation to effect combustion thereof. More particularly, the igniter tube of my invention is designed to prevent loss of volatile igniter fluid therefrom by spilling or evaporation prior to reaching the level in the well where ignition is to be carried out.

Many methods have been employed in the prior art for applying heat to hydrocarbon-containing formations such as, for example, by electrical means, by injecting heat transfer agents such as steam, hot oil, etc., into the well and by burning natural gas in the well bore. One of the principal difficulties has been that in the course of heating the formation to ignition temperature, the casing or screen as well as any other equipment in the vicinity of the heated zone is damaged by the excessive temperatures generated. In fact, the temperatures produced have been so high that the burner itself was considered an expendable item. The electric heaters employed for ignition and for paraffin deposition control have been subjected to a number of practical problems, including shorting out; in some instances, such equipment has been lost in the hole and is extremely difficult to recover.

In my U.S. 3,223,165, I describe a device similar to this invention in which the ignition chemical—a pyrophoric material—is lowered in an open cup through tubing in an inert atmosphere on a wire line and seated in a suitable heat shield located usually several feet above the level to be ignited. The use of this igniter tube, having an open cup to hold the pyrophoric liquid, has resulted in difficulties in deep wells where the temperatures are relatively high, i.e., 150° to 200° F., because the volatile igniter fluid evaporates before the desired level is reached.

Briefly, the igniter tube of my invention comprises an elongated tubular member having a hollow cup-shaped element detachably mounted to said member. Near the base of the tubular member are a number of openings or ports so that at the proper time the volatile igniter fluid can flow out of the device into the well bore. Running substantially the length of the igniter is a steel shaft or plunger, having a head on the lower end thereof, and normally forming a seal with the underneath side of a seating ring located slightly below said openings. The plunger head is held in sealing relationship with the seating ring by means of a spring or equivalent device surrounding the upper end of the shaft. The base of the spring rests on the top of the igniter tube while the upper portion of the spring is affixed to a head adapted to be attached to a sinker bar, tubing, or the like, which may be used to reciprocate the shaft, resulting in the breaking and forming of the seal.

In the accompanying drawings:

FIGURE 1 is a vertical elevational view, partly in section, of the over-all apparatus used in conjunction with the igniter tube of my invention.

FIGURE 2 is an isometric view showing the igniter tube of my invention.

FIGURE 3 is a sectional view of the lower portion of the igniter tube shown in FIGURE 2, illustrating the structure of the sealing mechanism employed to confine the volatile igniter fluid.

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FIGURE 4 is a detailed sectional view of the heater employing the igniter tube of my invention.

FIGURE 5 shows a cross section of the apparatus and associated equipment used to prevent fluids from entering the tube when the latter is lowered into a well containing fluids and prior to placing the igniter tube in operating position.

Referring now to FIGURE 1, a well 2 having a protective casing 4 is equipped with a lubricator 6 affixed to wellhead 8. Igniter tube 10 is lowered on cable or wire line 12 into lubricator 6 while valve 14 is closed. The igniter tube comes to rest in the lubricator at a level such that the lower portion of the igniter is opposite T-plug 16. A valved line 18 enters lubricator 6 a short distance above plug 16 and is used as a conduit through which inert purge gas is introduced into the lubricator. Tubing string 20, secured at the top by wellhead 8 carries heat shield 22 held on the lower end of said string by means of threaded coupling 24. In addition to flow line 26, the well is equipped with valved fuel line 28 which carries gas flowing into tube 20, combustion air line 30 opening into the well annulus, and a second air line 32, off of line 30, fitted with valve 29 and check valve 31 and communicating directly with tubing 20.

In FIGURE 2 igniter 10 comprises an elongated tubular member 34 having hollow cup 36 affixed to the lower end thereof, as illustrated in FIGURE 3. Plastic gasket 38 between the top of cup 36 and the base of member 34 serves to make a gas-tight joint. If desired, this gasket may be made of a soft metal such as, for example, copper. Also at the lower end of member 34 are elongated slots 40 which serve to allow the volatile igniter fluid to flow out into the well bore. Near the top of tubular member 10 is an annular beveled shoulder 42 which forms an essentially gas-tight seal with seating nipple 54, as shown in FIGURE 4, when said tube is in operating position. A shaft, or plunger 44, the lower end of which is equipped with a head 46, is urged upwardly by means of spring 48 between the top of tubular member 34, having gas ports 49, and threaded head 50. Normally, spring 48 serves to hold plunger head 46 in sealing relationship with the underneath side of ring 52.

In FIGURE 4, igniter tube 10 rests in seating nipple 54. A relatively tight seal above and below the seating position is provided by beveled shoulder 42 landed in seating nipple 54. The latter is held in position by means of spacer bars 56, the opposite ends of which are anchored to heat shield 22, having a refractory cement lining 58. The upper end of igniter 10 is engaged to a sinker bar 60 by means of threaded coupling 62. The upper portion of sinker bar 60 is threadedly engaged to cable head 64. Cable 12 is secured to the inside of cable head 64 by tying the end of said cable as shown.

The burner assembly confines the flame and protects the casing from excessive temperatures. Assemblies constructed of Inconel, type 316 and type 304 stainless steel, have been used with success. The diameter of heat shield 22 should be as large as practical for the size casing in the well at the level the heater is to be used. Also, it is important that the openings between supports 56 be as large as possible to permit the flame temperature inside shield 22 to be maintained as low as possible.

Referring to FIGURE 5, there is shown a plug 66 resting in the lower portion of nipple 54. The plug which may be composed of a laminated plastic, or a soft metal, such as aluminum, is held by friction in nipple 54 through the use of O-ring 68 and is prevented from moving further into nipple 54 by means of shoulder 67. Plug 66 serves to prevent entry of fluids into the tubing when the burner assembly, i.e., heat shield 22 and seating nipple 54, is lowered into the well. The burner assembly with

the tubing plug installed is attached to the lowermost joint of tubing 20 and should be landed so that the bottom of heat shield 22 is about two feet or so above the highest level of perforations 70, or open hole.

In operation heat shield 22 and seating nipple 54, which constitute the burner assembly, together with tubing plug 66 are lowered down the well on tubing string 20 to a level of about two to five feet above the top row of perforations 70, or open hole, whichever the case may be. After wellhead 8 has been assembled and the necessary surface installations completed, it is preferable to run a sinker bar on cable 12 through the lubricator to tubing plug 66 in order to locate the seating nipple accurately. With both tubing and casing open to air flow via lines 30 and 32, displacement of well fluids is begun. When the liquid level reaches top perforations 70, casing or annulus pressure drops. Check valve 31 prevents equalization of pressure via lines 30 and 31, resulting in a differential being created between tubing string 20 and the annulus. This pressure differential generally is great enough to force plug 66 out of the lower end of nipple 54 and into the well. When pressures equalize, a sinker bar should again be run through seating nipple 54 to confirm removal of plug 66.

When plug 66 is removed, fuel gas flow in line 28 is started down tubing 20. Valve 29 is closed and air flow is commenced down the annulus via line 30. From the fuel gas injection rate and tubing capacity, the time to completely displace the air from the tubing can be determined. It is usually desirable to inject two tubing volumes of fuel gas to insure complete purging of the air.

Igniter tube 10 should be installed in lubricator 6 and then located at the level shown in FIGURE 1, allowing said tube 10 to come to rest on a temporary support, not shown. The weight of sinker bar 64 then forces shaft 44 downwardly thus opening the seal at the top of cup 36. Lubricator 6 is next purged free of air with cylinder nitrogen by pressuring to about 50 p.s.i.g. through line 18 and then depressuring. When the purging step is completed, T-plug 16 is removed and cup 36 is filled, essentially to the top with triethylborane. This can be done conveniently through the use of a one-foot length of 1/8 inch copper tubing attached to a cylinder of triethylborane. After the igniter is full of triethylborane, T-plug 16 is replaced and tightened in the lubricator T. The entire operation of filling cup 36 with triethylborane should be done quickly and with minimum opportunity to introduce air into lubricator 6. Tubing valve 14, below lubricator 6, should be opened as soon as the loading step is completed. Igniter tube 10 is then lowered to within about 20 or 25 feet of seating nipple 54. At this time gas flow is stopped while air flow is continued via line 30 and the well annulus in order to purge the well below heat shield 22 free of the gas-air mixture. In this manner air and combustible gas are driven into formation 39 via perforations 70 so that only air remains below the burner assembly. Igniter tube 10 is then lowered to seating nipple 54, and sinker bar 64 allowed to rest its full weight thereon whereby plunger head 46 is lowered further into cup 36, thus permitting the vaporization of triethylborane into the well bore via ports 40. Gas flow is started down tubing 20 at a previously determined rate into igniter 10 via ports 49. Successful ignition is generally evidenced by an immediate drop in air rate and a rise in injection pressure. The rate of pressure rise may be high enough to stop the flow of gas out of the end of tubing 20, causing the flame to go out. The maximum tolerable rate of pressure rise should be calculated in advance and the actual rate of pressure rise held to not over about one half that value by reducing air flow at a suitable bleed valve (not shown) upstream in air line 30.

After about 3 or 4 minutes with igniter tube 10 in seating nipple 54, the tube should be pulled off the seat and up the well about 20 feet. This prevents sticking on the

seat and insures the possibility of removal for re-ignition in case it is necessary as the result of a flow interruption. Igniter tube 10 may be lowered periodically to seating nipple 54 to test the temperatures. If desired, the Inconel end of igniter tube 10 may be filed or polished to brightness before running to seating nipple 54. The polished area will be straw colored or blue after exposure to heat.

After the desired amount of heat has been injected, tubing string 20 should be purged free of natural gas. This operation is conveniently carried out by introducing about two 220 s.c.f. cylinders of nitrogen into the suction gas compressor, followed by opening the suction to air. The time required for nitrogen to reach the burner should be computed. The burner can generally be observed to go out as the result of smooth action of the air rate and pressure pens on the air meter at about the calculated time.

Refractory cement 58 may be chosen from a wide range of materials such as the high alumina cements which generally contain from 35 to 40 percent Al_2O_3 , 30 to 35 percent CaO , 10 to 15 percent Fe_2O_3 , and a combined percentage of silicon and magnesium oxides of from 5 to 10 percent. Any castable refractory material capable of withstanding temperatures of at least about 3,000° F. is suitable. One particular refractory I have found useful for this purpose is Alfrax refractory cement manufactured by the Carborundum Company, Perth Amboy, New Jersey. This is a castable material which can be applied as a mud after mixing with water. The refractory sets within about 24 hours and generally firing before use is unnecessary.

Substantially any pyrophoric material, liquid or solid, is satisfactory for my purpose. Thus, in addition to alkyl boranes, typified by triethylborane, there may be mentioned pyrophoric metals, phosphorous, aluminum borohydride, aluminum alkyls, pentaborane, and the like.

A burner of the type herein described and equipped with the igniter tube of my invention is capable of use over a wide range of conditions, e.g., bottom-hole pressures from 250 to 3,000 p.s.i., depths of the order of about 5,000 feet, and heat output rates up to about 10-million B.t.u. per day, based on natural gas consumed. At depths of 5,000 feet and temperatures of about 175° F., four attempts with the igniter tube described in U.S. 3,223,165 were required before ignition could be effected. In order to ignite with such equipment, the lubricator had to be chilled with Dry Ice and the igniter tube chilled in the same manner and then the cup containing the igniter fluid insulated on the inside with a plastic material so that said fluid would not evaporate. With the igniter tube of my invention, and at essentially the same depth and temperature as mentioned immediately above, ignition of the formation was readily effected on the first attempt.

I claim:

1. In an igniter tube the combination comprising an elongated hollow tubular member closed at one end thereof,

ports in said member intermediate the ends thereof adapted to permit the flow of fluids into and out of said member, and

valve means within said member between said ports and said closed end thereby defining a fluid-tight chamber in said member adapted to hold a pyrophoric material, said valve means when in the open position permitting direct fluid communication between said ports and said chamber.

2. The combination of claim 1 wherein said valve means is pressure responsive.

3. The combination of claim 2 wherein said valve means comprises a seating ring within said member between said ports and said closed end,

a shaft mounted axially with respect to said member extending partially within said member running through said ring and having a head on one end of said shaft adapted to fit in sealing relationship with the underneath side of said ring, and

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resilient means affixed to the opposite end of said member and to a portion of said shaft whereby said shaft is normally urged in an upward direction to form a seal between said head and said ring.

4. The igniter tube of claim 3 wherein it is detachably mounted in and surrounded by a hollow open ended member,

an elongated housing open at both ends, said open ended member being partially recessed into one end of said housing, and

spaced members about said one end of said housing holding said hollow member in alignment with the longitudinal axis of said housing and in substantially concentric relationship with said housing.

5. The combination of claim 2 wherein said tubular member has a sealing shoulder on the outside thereof between said ports and the opposite end of said member.

6. The combination of claim 5 wherein said tubular member has a second set of ports between said shoulder and said opposite end.

7. The combination of claim 6 wherein said valve means comprises a seating ring within said member between said first mentioned ports and said closed end,

a shaft mounted axially with respect to said member ex-

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tending partially within said member running through said ring and having a head on one end of said shaft adapted to fit in sealing relationship with the underneath side of said ring, and

resilient means affixed to the opposite end of said member and to a portion of said shaft whereby said shaft is normally urged in an upward direction to form a seal between said head and said ring.

8. The igniter tube of claim 1 wherein it is surrounded by a hollow open ended member having means there-within for holding said tube in a detachably mounted position.

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