DEVICE AND PROCESS FOR IGNITING AN OIL STRATUM

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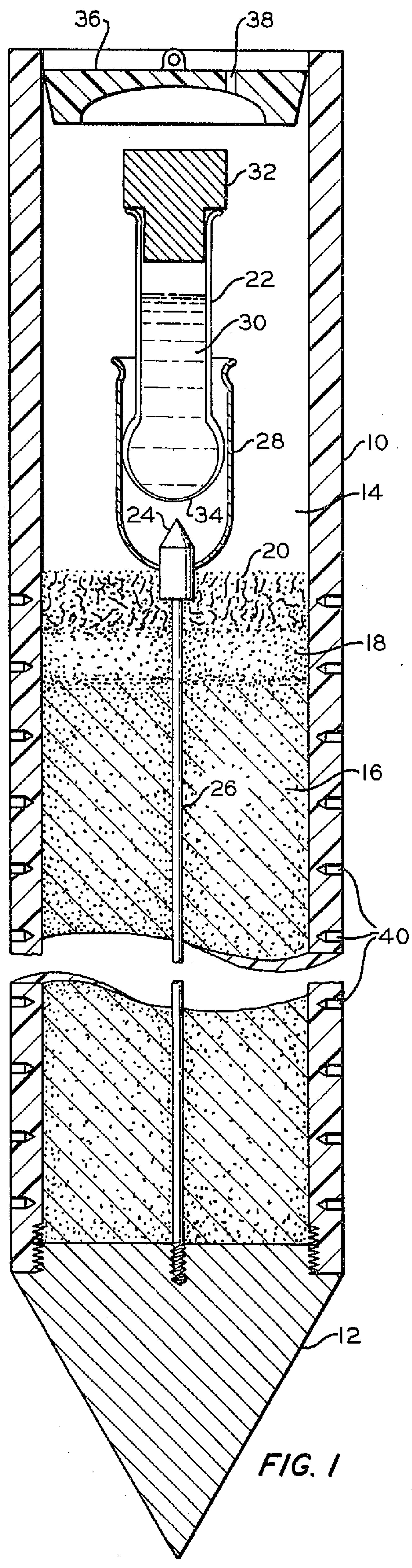

FIG. 1

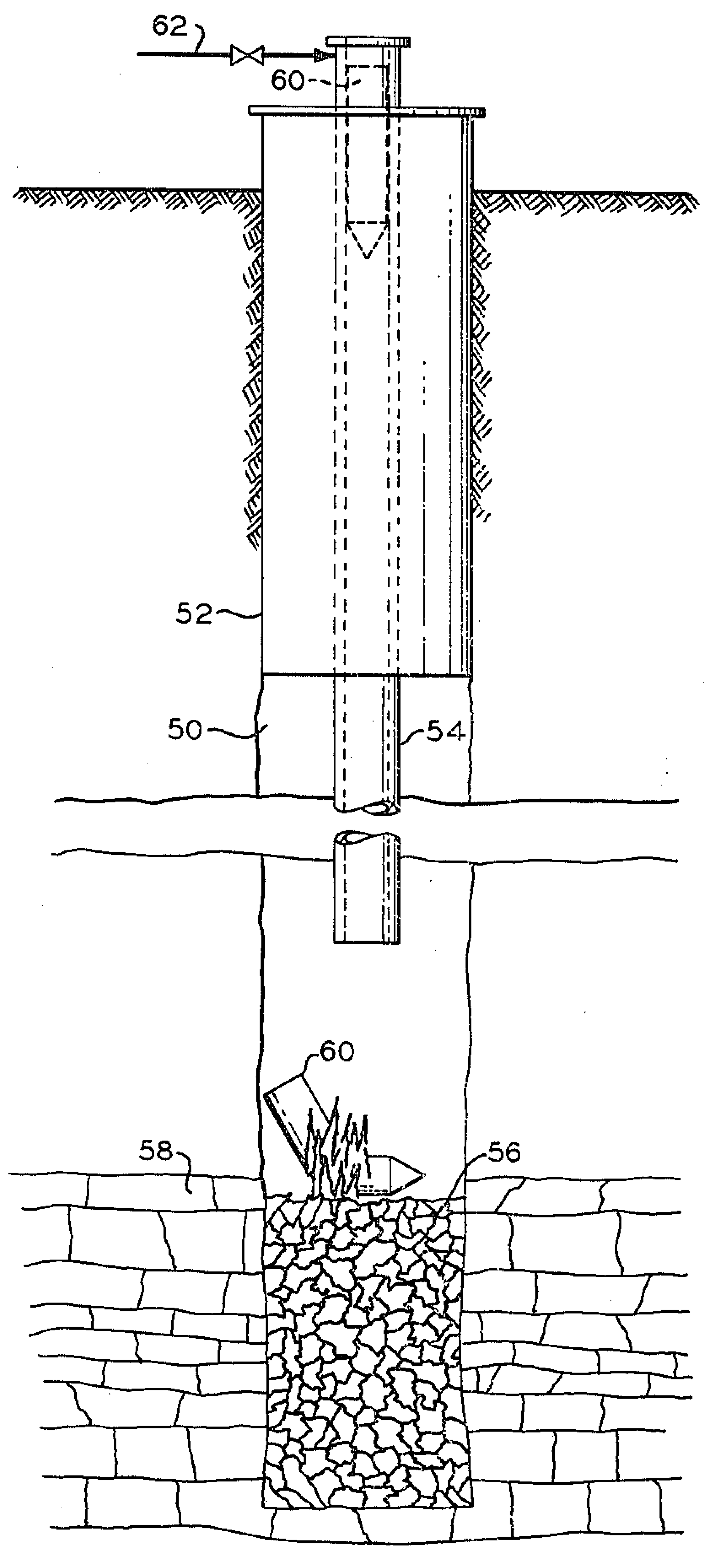

FIG. 2

INVENTOR.
H. W. PARKER

BY Young & Quigg

ATTORNEYS

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DEVICE AND PROCESS FOR IGNITING AN OIL STRATUM

Harry W. Parker, Bartlesville, Okla., assignor to Phillips Petroleum Company, a corporation of Delaware

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This invention relates to a process and a device for igniting a carbonaceous stratum around an ignition well therein.

The application of in situ combustion in the production of oil from a subterranean carbonaceous stratum is becoming more prevalent. In order to produce oil in this manner, the stratum to be produced is ignited around an ignition well therein and the resulting combustion zone is driven to one or more offset wells either by injecting combustion-supporting gas, such as air, thru the ignition well or thru the offset well. Injection of air thru the ignition well drives the combustion zone by direct drive toward the surrounding offset well which serves as a production well, while injection of air thru the offset wells moves the combustion zone inversely or countercurrently to the flow of air and the ignition well functions as a production well.

One of the ways in which the stratum adjacent the ignition well is ignited comprises packing the well within the stratum to be ignited with a particulate fuel pack such as charcoal or porous ceramic pieces soaked with heavy fuel oil and igniting the fuel pack by some suitable means. One method commonly used has been to drop an ignited railroad fuse down the well onto the fuel pack while supplying air thereto. This method has been utilized very successfully in shallow wells but when applied to wells about 1600 feet deep it was not successful. This invention is concerned with a device and process for igniting deep strata.

Accordingly, it is an object of the invention to provide an improved process and device for igniting deep carbonaceous strata around an ignition well therein. Another object is to provide an incendiary bomb which ignites on impact. Other objects of the invention will become apparent to one skilled in the art upon consideration of the accompanying disclosure.

A broad aspect of the invention comprises an upright tube closed at the bottom end so as to form a fuel chamber in which are positioned in ascending order (1) a mass of thermite, (2) a mass of ignition powder, (3) a particulate mixture of sodium peroxide and a solid fuel, and (4) a frangible vial containing a flammable liquid which ignites in contact with the sodium peroxide, said vial being loosely disposed above said mixture, there being a breaking means in said chamber below said vial so that said vial is broken by impact when the device is dropped on its bottom end.

The process comprises packing the well within the stratum to be ignited with a particulate fuel pack, preferably charcoal; extending a tubing string from the well head to a level adjacent the top of the fuel pack; inserting the bomb in the tubing string and causing it to descend onto the fuel pack so that the impact ignites the bomb and provides ample heat for igniting the charcoal; and supplying air to the fuel pack and the adjacent or surrounding stratum so that as the fuel pack burns and the stratum is heated to ignition temperature, ignition of the stratum is effected. In order to assure descent of the bomb onto the fuel pack with sufficient force to cause ignition, compressed air is usually injected into the tubing string behind the bomb as it is released.

A more complete understanding of the invention may be had by reference to the accompanying schematic drawing of which FIGURE 1 is a longitudinal cross section

of a preferred embodiment of the bomb and FIGURE 2 is an elevation of an ignition well in partial section illustrating the invention.

Referring to FIGURE 1, the bomb comprises a tube or shell **10** closed at the lower end by a plug **12** so as to form a fuel chamber **14**. The principal fuel comprises a mass of thermite **16** which is a mixture of aluminum in the form of fine grains with a powdered oxide of a chemically weak metal, usually iron. This material is sold under the trade name "Thermit." On the top of thermite **16** is positioned a mass of ignition powder **18** which may comprise sodium peroxide mixed with a similar quantity of thermite. "Thermit" ignition powder is commercially available. On top of ignition powder **18** is positioned a mixture **20** of sodium peroxide and a solid fuel such as aluminum and/or magnesium foil. The foil usually amounts to from 5 to 10 weight percent of the mixture. Finely divided fuel such as charcoal or metal powders may be used with the sodium peroxide but these can be ignited readily by water alone and burn more rapidly and are not as safe.

A vial **22**, preferably made of glass although any frangible material will serve, is positioned and held loosely above a breaking point or target **24** which is supported on the upper end of a rod **26**. This rod is attached to closure **12** and extends axially thru the fuel chamber. Vial **22** is supported loosely by fingers **28** so as to align the vial with the target **24**. Fingers **28** may comprise strips of metal or other relatively rigid but flexible material capable of maintaining the vial in alignment with the target and either spaced therefrom or directly thereon. In one arrangement, four of these fingers spaced at 90° intervals around target **24** are attached thereto below the upper end thereof. It is also feasible to support the guiding fingers **28** from the inner wall of shell **10**. Also, target **24** can be supported by a spider arrangement from the inner wall of the shell.

Vial **22** contains a flammable liquid **30** which is readily ignitable when contacted with sodium peroxide. Glacial acetic acid functions well as the vial liquid and so does a mixture of about equal volumes of methyl and/or ethyl alcohol and water.

The upper end of vial **22** is closed by stopper **32** which is preferably made of a heavy, dense material, such as metal, so as to aid in the impact of the vial upon target **24** when the device bottoms in the well. The lower end of vial **22** preferably comprises a thin-walled bulb **34** which aids in the breakage of the vial.

The upper end of shell or tube **10** may be open but is preferably closed by a stopper **36** which is provided with an air passage **38**. A simple laboratory stopper has been used successfully as this closure member.

In order to facilitate the melt or burn-thru of the fuel, holes **40** may be drilled almost thru the walls of the tube. While closure member **12** is shown in the form of a nose cone, it may be a simple cylindrical plug in the end of the tube. This cone is preferably formed of combustible material such as magnesium, aluminum, or plastic, such as polyolefin. Tube **10** is also preferably formed of such combustible material so as to aid in supplying heat to the charcoal to be ignited and leave no trash in the well. Poyethylene, or other polyolefin, is an excellent material for fabricating the shell of the ignitor or bomb.

In FIGURE 2, a well **50** is provided with casing **52** and tubing **54** extending to just above the charcoal pack **56** within stratum **58**. Bomb **60** is released in tubing **54** at the well head and may be propelled thru the tubing by compressed air introduced thru line **62**. Upon bottoming on fuel pack **56**, bomb **60** ignites as vial **22** breaks and glacial acetic acid is released into the aluminum foil and sodium peroxide mixture **20**, thereby igniting the acid and foil. The resulting burning ignites ignition powder **18** which in turn ignites thermite **16**. The intense heat from the combustion of the fuel masses causes ignition of the charcoal or other fuel pack particles in contact with air supplied thru stratum **10** or thru either tubing **54** or line **62** and the tubing-casing annulus. Combustion of the fuel pack causes ignition of the adjacent stratum with the air being supplied thereto.

Several tests of the device and process were made utilizing a bomb or ignitor constructed substantially as shown in FIGURE 1. In most instances the lower end of the bomb was closed by a metal plug in the form of a disk or cylinder. The contents of the bomb in each test were as follows:

"Thermit" (14 inches deep in the bomb)	gr	427
"Thermit" Ignition Powder	gr	10
Aluminum Foil [1]	gr	1
Sodium Peroxide	gr	20
Glacial Acetic Acid	ml	12

[1] 0.02 mm. thick and 2 to 5 mm. square.

Two kinds of thermite were used in these bombs, black Thermit, from a commercial source, and home-made thermite composed of 75 percent red iron oxide powder and 25 percent (by weight) granular aluminum of 8 mesh and finer. Both kinds were entirely satisfactory.

In the first test (a simulated test) the bomb was dropped thru 45 feet of two-inch pipe into a container 7 inches in diameter and 30 inches deep. The container was filled to a depth of one foot with charcoal briquettes, the top layer of which was soaked in paraffin wax. Air at approximately 500 s.c.f.h. was admitted to the bottom of the container. Within three seconds after impact, flame and smoke came out of the top of the bomb, and after 75 seconds the entire container was filled with flame.

In a second test the bomb was dropped thru a two-inch tubing onto a bed of charcoal within the Strawn Sand in a 1600-foot deep well in Cooke County, Texas. Preliminary to the dropping of the bomb, air was injected into an offset well spaced from the ignition well a distance of about 500 feet until the air-oil ratio reached 18,300 s.c.f./bbl. The produced gas before ignition showed substantial quantities of fuel gas to be present. The fuel pack consisted of 100 pounds of paraffin wax-impregnated charcoal which was dropped thru the casing. The total depth of the well before the dropping of the fuel pack was 1608 feet and the top of the charcoal was found to be 1597 feet. The diameter of the well bore within the stratum in which the charcoal resided was 7⅞ inches. The tubing in the well extended to within 17 feet of the fuel pack. At the time of the dropping of the bomb, the well was producing oil as a rather stable foam. Hence, it is assumed that the ignition of the bomb occurred after it penetrated some 17 feet of foam below the end of the tubing before it bottomed on the charcoal pack. The result was combustion of the charcoal and adjacent stratum which was actively sustained for an extended period.

In a third test in a well in the Strawn Sand under substantially the same conditions but with direct injection of air thru the ignition well, the bomb was dropped in the tubing followed by compressed air injection to increase the speed of impact. The success of the ignition of the charcoal pack was signaled by a "kick" on the injection pressure record. This indication lasted the length of time calculated for the consumption of the charcoal pack. The injection pressure rose substantially indicating that a liquid bank was building up in the formation, but this did not persist for more than 4 hours. Evidence that the direct drive combustion was easily accomplished could be seen in the 7 percent carbon dioxide and about 8 percent oxygen content in the first gas produced from the formation after reversing the air flow.

Prior to the construction of the bomb of the invention, several unsuccessful attempts with railroad fusees were made to ignite the charcoal without success. In a total of

11 bomb drops during the tests, only three failed to ignite and theses failures were probably due to the fact that the ignition well was full of liquid oil at the time of the drop.

In the tests the casing or shell of the bomb was formed of 1⁹⁄₁₆-inch O.D. Marlex (Trademark of Phillips Petroleum Company) polyethylene pipe. The inside diameter of the well tubing was two inches, leaving about ⁷⁄₁₆-inch clearance or an annulus around the bomb of only ⁷⁄₃₂-inch thickness. This clearly indicates the need for propelling the bomb thru the tubing with compressed air in order to obtain rapid descent of the bomb and good impact on the charcoal to ignite the bomb.

An additional feature of the invention comprises positioning vials containing gasoline or other easily ignitable fluid on top of the fuel pack. When the igniter or bomb is dropped onto the fuel pack, one or more of the vials break or melt and release the fuel for quick heating of the fuel in the fuel pack (charcoal) to ignition temperature. The vials may be made of glass or of a material, such as plastic, which melts at a relatively low temperature to release the fuel inside. The plastic also serves as fuel. Polyolefins such as the polymers of 1-olefins disclosed in Hogan and Banks U.S. Patent 2,825,721 are suitable for this purpose. Polyolefin vials filled with feed can be dropped down the well, without breaking, to await the ignition of the bomb or other igniter before releasing the fuel therein. Another fuel which may be used in the vials is napalm. In addition to napalm, and low ignition point hydrocarbon liquids, a slurry of yellow phosphorus in hydrocarbon or phosphorus dissolved in carbon disulfide are excellent fuels.

Certain modifications of the invention will become apparent to those skilled in the art and the illustrative details disclosed are not to be construed as imposing unnecessary limitations on the invention.

I claim:

1. A bomb for ignition of a fuel pack in a well by dropping same onto said fuel pack comprising an upright combustible shell closed at the lower end and forming a fuel chamber; a mass of thermite in the lower end of said chamber; a mass of ignition powder on top of said thermite; a particulate mixture of sodium peroxide and a solid fuel on top of said ignition powder; a glass vial containing a flammable liquid which ignites in contact with sodium peroxide, loosely positioned upright in said shell above said mixture; and means for breaking said vial by impact when said bomb lands on said fuel pack.

2. A bomb which ignites by impact when dropped on its lower end comprising an upright elongated shell forming a fuel chamber and having closure means on its lower end; a mass of thermite in the lower section of said chamber; a mass of ignition powder in said chamber on top of said thermite; a particulate mixture of sodium peroxide and a solid fuel in said chamber on top of said powder; a frangible vial containing a flammable liquid which ignites in contact with said sodium peroxide, loosely disposed above said mixture; and breaking means in said chamber below said vial for causing said vial to break by an impact on the bottom end of said shell.

3. The bomb of claim **2** wherein said ignition powder consists essentially of a mixture of sodium peroxide and thermite.

4. The bomb of claim **2** wherein said solid fuel comprises bits of metal foil selected from the group Al and Mg.

5. The bomb of claim **2** wherein said flammable liquid consists essentially of acetic acid.

6. The bomb of claim **2** wherein said ignition powder consists essentially of a mixture of sodium peroxide and thermite; said mixture consists essentially of sodium peroxide and metal foil selected from the group Al foil and Mg foil; and said flammable liquid consists essentially of acetic acid.

7. The bomb of claim 2 wherein said means for causing said vial to break upon impact comprises a hard target supported rigidly from said shell and a guide for holding said vial in alignment with said target.

8. The bomb of claim 7 wherein said target is supported on the upper end of a rod extending upwardly from said closure means thru said mixture and said guide comprises a plurality of upright fingers closely surrounding said vial.

9. The bomb of claim 2 wherein said shell is combustible.

10. The bomb of claim 9 wherein said shell is fabricated of polyolefin.

11. A bomb which ignites by impact when dropped axially on its lower end comprising an upright cylindrical combustible tube having a closed lower end to form a fuel chamber therein; a relatively large mass of thermite in the lower section of said chamber; a relatively small mass of ignition power in said chamber on top of said thermite consisting essentially of a mixture of powdered sodium peroxide and thermite; a relatively small mass of a mixture of aluminum foil fragments in minor proportion and a major proportion by weight of sodium peroxide on top of said ignition powder; a readily breakable glass vial containing a flammable liquid ignitable in contact with sodium peroxide, said vial being held slidably in place above said foil and sodium peroxide by support means comprising an axial rod supported from the bottom of said tube and a plurality of flexible fingers extending upwardly from a section of said rod below its upper end and around at least the lower section of said vial whereby the upper end of said rod functions as a breaking point for said vial.

12. The bomb of claim 11 including a dense relatively heavy stopper in the upper end of said vial.

13. The bomb of claim 11 including a relatively thin bulb on the lower end of said vial.

14. A process for igniting a carbonaceous stratum around an ignition well which comprises packing said well within said stratum with a combustible fuel pack; providing tubing extending from the well head to a level adjacent said fuel pack; inserting in said tubing the bomb of claim 1 wherein said shell comprises an elongated cylinder having a diameter slightly less than the inside diameter of said tubing, in upright position so that said tubing serves as a guide for said bomb; releasing said bomb so that it descends said tubing and ignites and burns as it strikes said fuel pack; supplying combustion-supporting gas to said fuel pack during the burning so as to burn said fuel pack and heat said stratum to ignition temperature; and continuing the supplying of combustion-supporting gas so as to ignite the hot stratum.

15. The process of claim 14 wherein compressed air is injected into said tubing behind said bomb to assist in its descent and increase the impact on said bomb as it lands on said fuel pack.

16. The process of claim 14 wherein said fuel pack consists principally of charcoal pieces and at least the upper section of said pack is impregnated with paraffin.

17. The process of claim 14 wherein at least one vial of fuel is positioned on top of said fuel pack prior to dropping said bomb, said vial being adapted to release its fuel onto said pack upon arrival of said bomb.

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CHARLES E. O'CONNELL, *Primary Examiner.*

BENJAMIN HERSH, *Examiner.*