Oct. 8, 1963 S. S. PRENTISS 3,106,246

MEANS FOR SUPPORTING THE WALLS OF A WELL

Filed May 4, 1959

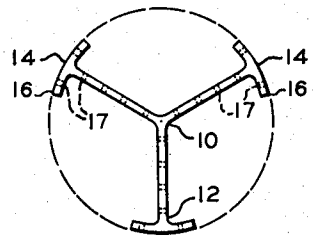


FIG. 1

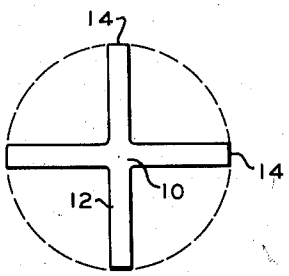


FIG. 2

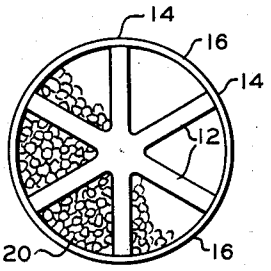


FIG. 3

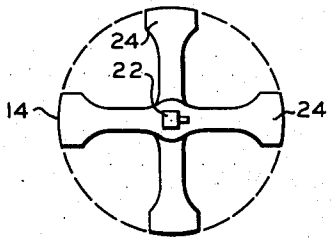


FIG. 4

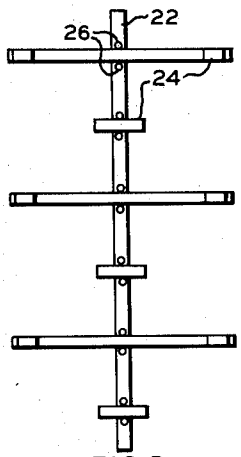


FIG. 5

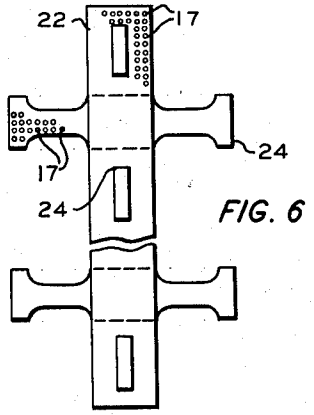


FIG. 6

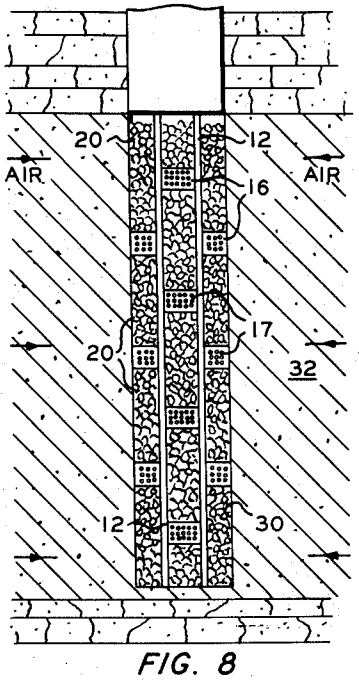


FIG. 8

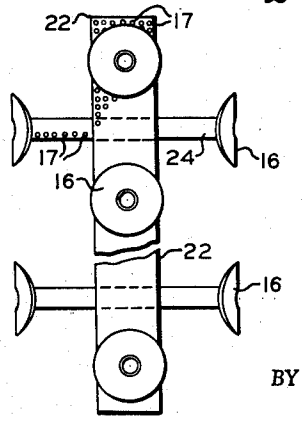


FIG. 7

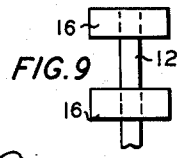


FIG. 9

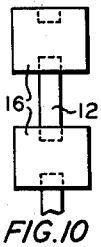


FIG. 10

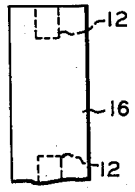


FIG. 11

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3,106,246
MEANS FOR SUPPORTING THE WALLS OF A WELL

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Filed May 4, 1959, Ser. No. 810,862
9 Claims. (Cl. 166—58)

This invention relates to a method and apparatus for supporting the walls of an ignition well to be used in oil production by in situ combustion.

In situ combustion in the recovery of hydrocarbons from underground strata containing carbonaceous material is becoming more prevalent in the petroleum industry. In this technique of production, combustion is initiated in the carbonaceous stratum and the resulting combustion zone is caused to move thru the stratum by either inverse or direct air drive whereby the heat of combustion of a substantial proportion of the hydrocarbon in the stratum drives out and usually upgrades a substantial proportion of the unburned hydrocarbon material.

The ignition of carbonaceous material in a stratum around a borehole therein followed by injection of air thru the ignition borehole and recovery of product hydrocarbons and combustion gas thru another borehole in the stratum is a direct air drive process for effecting in situ combustion and recovery of hydrocarbons from the stratum. In this type of operation the stratum usually plugs in front of the combustion zone because a heavy viscous liquid bank of hydrocarbon collects in the stratum in advance of the combustion zone which prevents movement of air to the combustion process. To overcome this difficulty and to permit the continued progress of the combustion zone thru the stratum, inverse air injection has been resorted to. By this technique, a combustion zone is established around an ignition borehole by any suitable means and air is fed thru the stratum to the combustion zone from one or more surrounding boreholes.

In situ combustion techniques are being applied to tar sands, shale, Athabasca sand and other strata in virgin state, to coal veins by fracturing, and to strata partially depleted by primary and even secondary and tertiary recovery methods.

Oil sands or other hydrocarbon-containing strata frequently are poorly consolidated so that removal of the combustible material from such a stratum around an ignition borehole leaves the adjacent sand or rock free to cave into the well. Caving with filling of the borehole adjacent the producing stratum with sand and/or rock interferes with the production of the well, particularly in inverse air injection processes. Various methods have been suggested for consolidating the sand around an ignition well to prevent caving. It also has been proposed to extend the casing into the stratum to be produced with perforations in the casing opposite the stratum to allow heat and fluids to pass therethru. When utilizing such a liner in the well opposite the stratum, it is difficult if not impossible to satisfactorily ignite the adjacent stratum by the usual methods without melting the metal liner or casing. A recent U.S. patent, No. 2,877,847, is directed to a process for igniting a stratum around an ignition well for a direct drive process which avoids overheating the perforated casing within the stratum, but this process is not adaptable to an inverse drive process in which the hot gases from the burning stratum are recovered thru the ignition borehole.

Another proposal for eliminating or reducing caving during ignition and in situ combustion around a well comprises packing the well with granular ceramic material

such as broken fire brick, pebbles, coarse rock aggregates, etc. This method provides mechanical support for the walls of the well but severely restricts the volume of solid fuel that can be introduced to the borehole for ignition purposes and it also renders it impossible to add solid fuel to the well adjacent the stratum during initiation of combustion therein. Since igniting a stratum around an ignition well is effected most readily by burning solid fuel such as charcoal briquettes or other particulate charcoal in the ignition well, packing of the well opposite the stratum to be produced with particular non-combustible mechanical support material greatly hampers the ignition process.

Accordingly, it is an object of the invention to provide an ignition-well support device which supports the walls of the well and allows the use of solid fuel material in the support structure adjacent the stratum. Another object is to provide a process for igniting a combustible stratum around in ignition well and simultaneously supporting the walls of the well to prevent substantial caving thereof as the stratum is denuded of combustible material. Another object is to provide an apparatus and process for igniting a carbonaceous stratum of a relatively unconsolidated structure which permits the use of solid particulate fuel within the well opposite the stratum while preventing borehole caving after the carbonaceous material is burned out of the stratum adjacent the well. A further object is to provide a borehole support within an unconsolidated combustible stratum which allows direct contact between a burning fuel in the borehole and radiation from the burning fuel pack over the major portion of the well wall. Other objects of the invention will become apparent to one skilled in the art upon consideration of the accompanying disclosure.

The support of the invention comprises a refractory device having an elongated axial portion concentric with the axis of the well and a plurality of radial arms attached thereto and of substantially equal radius extending outwardly from the axial portion at longitudinal intervals up to several feet and at circumferential intervals of not more than 120°, the outermost circumferential surfaces of the arms lying in a cylinder and forming a support for the well wall. The area of the circumferential surfaces of the support arms should not exceed 20 percent of the area of the cylinder in which they lie, it being the approximate area of the well wall to be supported. The support structure occupies only a minor proportion of the borehole volume within the stratum between the ends of the support so that the space intermediate its arms and intermediate its axial portion and the borehole wall provides ample space for packing sufficient solid fuel for ignition of the stratum. The void space referred to is continuous from top to bottom of the support device so that fuel can be added to the burning mass during the ignition process in instances where required.

A more complete understanding of the invention may be had by reference to the accompanying schematic drawing, of which FIGURES 1, 2, 3, and 4 are plan views of various types of support structures in accordance with the invention; FIGURE 5 is an elevation of the support device of FIGURE 4; FIGURES 6 and 7 are elevations of other embodiments of the support device; FIGURE 8 is an elevation of the support device of FIGURE 3, positioned in a well in a combustible carbonaceous stratum with a fuel pack therein; and FIGURES 9, 10, and 11 are elevational radial sections of various embodiments of support arms.

Referring to FIGURES 1, 2, and 3, each support device comprises an axial section **10** and a plurality of radial arms **12** extending therefrom to the position of the well wall (when the same is positioned in a well) so that the outermost surface or edge **14** of each arm forms a wall

support which lies in a cylinder coaxial with the axial portion of the support device. In FIGURE 1, surface 14 of each arm is increased by circumferential sections 16 which may be perforated by holes 17, along with arms 12. The perforations in the circumferential sections and in the arms reduce the weight of the support and permit flow of gases from section to section of the fuel pack.

In FIGURE 1 radial arms 12 may extend continuously from one end to the other of the support or they may be discontinuous with short intervals between them in each of the three planes in which they lie. The arcuate end section 16 may also be continuous from end to end of the support or they may be discontinuous, with short intervals between, which may or may not coincide with the intervals in the radial arms. FIGURE 9 shows a suitable structure for FIGURE 1 wherein radial arms 12 are continuous and arcuate support members 16 are distinuous or made up of individual arcuate plates. FIGURE 10 shows a structure wherein both members of the arms are discontinuous; and FIGURE 11 shows a structure wherein arcuate support member 16 is continuous and radial arm 12 is discontinuous.

In FIGURE 3 radial arms 12 are 60° apart as contrasted with those of FIGURE 1 which are 120° apart and those of FIGURE 2 which are 90° apart. In addition, in FIGURE 3, arcuate support members 16 connect the outer ends of the radial arms and are discontinuous from top to bottom of the support as shown in FIGURE 8. This structure leaves a major proportion of the borehole wall in contact with a solid fuel within the support structure. Numeral 20 designates the solid particulate fuel pack within the support device and within the well

FIGURE 4 illustrates a support structure utilizing an axial support rod 22 and a plurality of support arms 24 spaced at intervals along the support rod, each arm being at right angles to the adjacent arm. The arms 24 are held in position by suitable pins 26 which project from support rod 22. Arms 24 may be positioned at intervals of less than 90°, such as 60°.

The structure of FIGURE 6 is similar to that of FIGURE 5, except that axial support member 22 is of tubular construction, perforated by holes 17. Arms 24 are positioned edgewise vertically or parallel with the axial support conduit. Both conduit 22 and arms 24 may be perforated as at 17 or they may be solid and imperforate.

The structure of FIGURE 7 is similar to that of FIGURES 5 and 6, the principal difference being in the use of tubular radial arms 24 and circular support members 14 on the ends of tubes 24, the outer surface of members 24 lying in the cylinder represented by the wall of the borehole.

In FIGURE 8, a borehole 30 penetrates a carbonaceous stratum 32 and is packed with the support device of FIGURE 3 and with a charcoal pack 20. The packing may be effected in either of two ways, that is by first lowering one or more support devices into the borehole within the carbonaceous stratum to be produced and then introducing the charcoal or other fuel pack into the open space within the support structure; or by enclosing the support structure in a thin combustible sheath such as perforate heavy waxed paper, polyethylene, cloth, etc., and filling the open space within the structure with a suitable solid fuel pack. The assembled packed structure is then lowered into the well and bottomed in the stratum to be produced.

It is also feasible to construct the support device of porous material such as porous ceramic material (alumina, silica-alumina, silica, etc.) and soak the entire support structure and fuel pack with a heavy oil to increase the available fuel within the packed structure. This can be accomplished before introducing the pack and structure to the well or after the same has been placed in position. It is also feasible to utilize porous ceramic material within the fuel pack, either alone or in admixture with charcoal, and saturate the same with a heavy fuel oil.

After positioning the support structure and the fuel pack in the well within the stratum to be ignited, the fuel may be ignited by dropping a lighted incendiary device, such as a railroad fusee or other combustible material containing its own oxygen supply, onto the top of the pack. The top of the fuel pack is then burned by feeding combustion-supporting gas thereto either from above, whereby the combustion zone is driven thru the pack by direct drive, or from below whereby the combustion zone is moved thru the fuel pack by inverse drive. The air or other combustion-supporting gas may be fed upwardly into the ignited section of the fuel pack by injecting the same thru a stratum from one or more offset injection walls therein, or it may be injected by extending a tube or conduit from the well head to the bottom of the fuel pack. It is also feasible to extend a tubing string from the well head to the bottom of the fuel pack and ignite the fuel pack at the bottom by dropping a lighted incendiary device down the tubing and injecting air thru the tubing into the fuel pack so as to drive the resulting combustion front upwardly therethru.

When utilizing inverse air injection to ignite the stratum and move the resulting combustion front therethru countercurrently to the flow of air, air is passed thru the stratum from offset injection wells when a sizeable annulus of stratum around the well has been heated to at least the combustion temperature of the combustible material therein. In order to facilitate the ignition of the stratum, a fuel gas such as a normally gaseous hydrocarbon, or natural gas is incorporated in the injected air in a concentration in the range of about 1 to 3 volume percent.

The support structure may be constructed of any refractory material which withstands temperatures of the order of about 2,000° F., since the borehole temperature during ignition and during the production phase of the process, utilizing inverse air injection, can be maintained well below this temperature, as in the range of about 800 to 1650° F. The device may be fabricated from high temperature alloys or ceramic materials, such as those used in fire brick.

The support structure has distinct advantages over a liner which has the disadvantage of shielding the stratum from direct radiation from the hot solid fuel during the combustion process. The structures shown cover only a small fraction of the area of the well wall covered by liners and are therefore much more effective in allowing transfer of heat to the stratum by radiation as well as by direct conduction from the incandescent fuel pack. In addition, a liner has no continuous radial support from inside the wall as is provided by the supports disclosed herein and, when becoming hot and soft when constructed of ordinary metal, the same is subject to collapse into the well.

In general the dimensions and configuration of the borehole support will be governed by the degree of bridging in the unconsolidated sand under the conditions of operation. Where this bridging strength is relatively high, the support provided by the structure can be at a minimum. Under these circumstances, the support structure can be conceived of as an assemblage of radial arms and vertical planes with the cross sections or plan of FIGURE 2, including anywhere from 3 to 6 or 8 vertical planes in which the arms are positioned. If the bridging strength of the sand is somewhat less, the use of arcuate members 16 as in FIGURES 1 and 3 is desirable in order for the support structure to be effective, or a device of the configuration and structure of FIGURE 7 is effective because of the increased wall support area provided by arcuate discs 16. Another method of providing additional support along the wall of the well comprises forming radial arms 12, as in FIGURE 2, in a spiral pattern or of wave configuration, thereby providing a greater length of contacting surface 14 between the ends of the device.

Certain modifications of the invention will become apparent to those skilled in the art and the illustrative de-

tails disclosed are not to be construed as imposing unnecessary limitations on the invention.

I claim:

1. In combination a refractory device within a carbonaceous stratum in a well to prevent caving and sand infiltration during production of the adjacent stratum and to provide space in the device for a fuel pack, comprising an elongated axial portion concentric with the axis of said well; a plurality of radial arms of substantially equal length attached to and extending outwardly from said axial portion, said arms being spaced apart longitudinally and circumferentially with intervening space for fuel pack and gases; arcuate supports on the outer ends of said arms forming sections of a common cylinder adjacent the wall of said well to support said wall, the area of said supports adjacent said wall not exceeding 20 percent of the area of said cylinder and said device occupying only a minor portion of the volume of said cylinder; and a pack of solid particulate fuel filling said intervening space and contacting the wall of said well.

2. The device of claim 1 constructed of ceramic material to withstand temperatures of at least 2000° F.

3. The device of claim 1 constructed of nickel-chrome-steel alloy capable of withstanding temperatures of at least 2000° F.

4. The combination of claim 1 wherein said device is constructed of porous ceramic material and same is saturated with oil for fuel.

5. The combination of claim 1 wherein said device is constructed of porous ceramic material, said fuel pack comprises porous refractory particles saturated with a heavy oil, and said device is soaked with a heavy oil.

6. The combination of claim 5 including charcoal admixed with said porous refractory particles.

7. The combination of claim 1 wherein said fuel comprises charcoal.

8. The device of claim 1 wherein the outer ends of said arms are of substantially greater area than the intermediate cross sectional area thereof.

9. The combination of claim 1 including a plurality of said refractory devices placed end to end axially of said well, with said fuel filling said intermediate space within each device.

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