

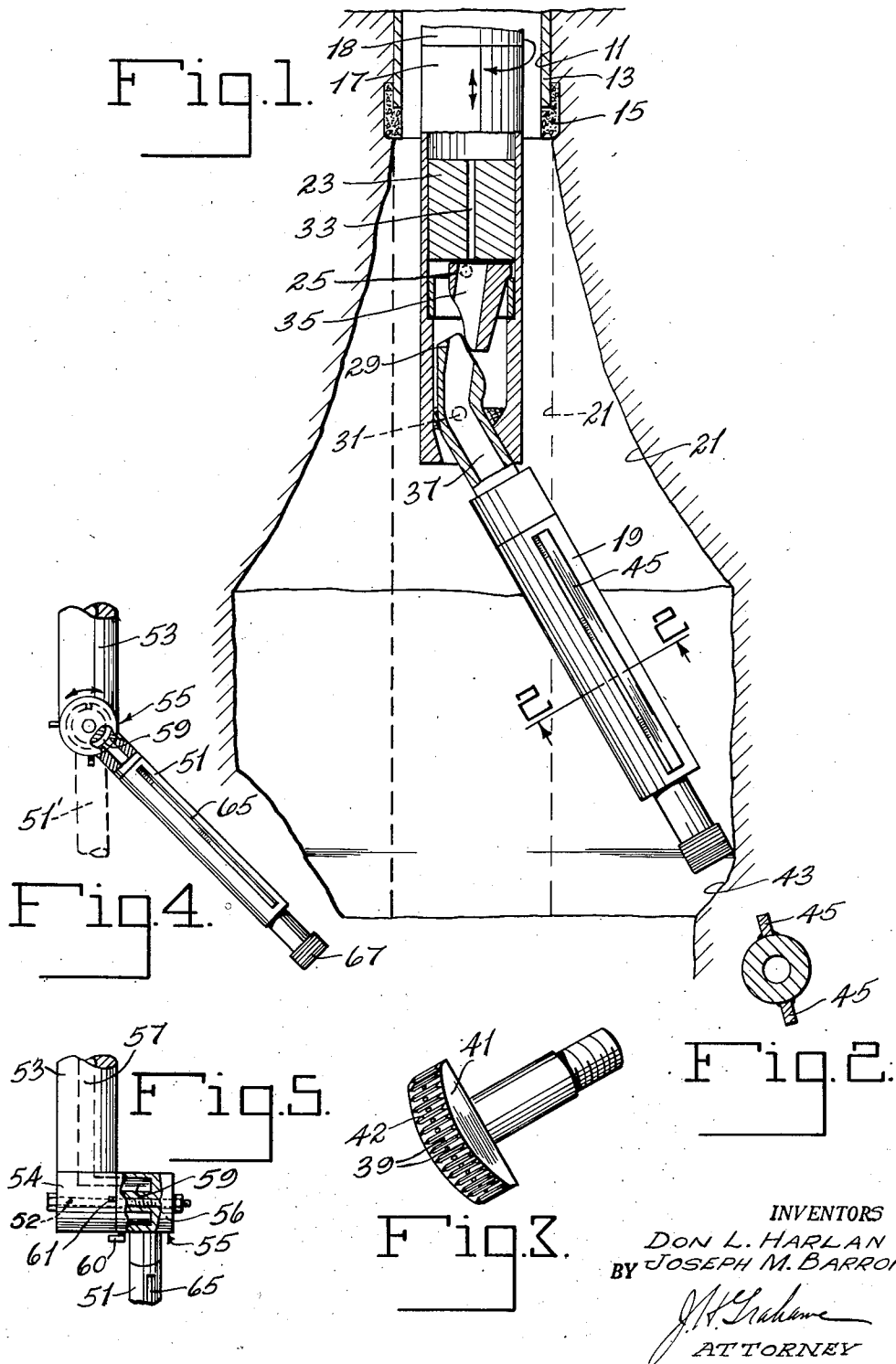
July 16, 1957

D. L. HARLAN ET AL

2,799,475

REAMING APPARATUS

Filed Jan. 8, 1953



INVENTORS
DON L. HARLAN
BY JOSEPH M. BARRON

J. M. Barron
ATTORNEY

1

2,799,475

REAMING APPARATUS

Don L. Harlan, Houston, and Joseph M. Barron, Port Arthur, Tex., assignors to The Texas Company, New York, N. Y., a corporation of Delaware

Application January 8, 1953, Serial No. 330,282

5 Claims. (Cl. 255—1.8)

The present invention relates to a novel apparatus for reaming out a hole which has been drilled in the earth, from a relatively small diameter to a relatively large diameter. More particularly the invention concerns an apparatus whereby an enlarged storage cavity can be formed below the surface of the earth for receiving liquids such as liquefied petroleum gases which are to be stored.

It has been suggested that liquefied petroleum gases be stored in large cavities formed in earth formations such as beds of salt or clay below the surface of the earth. For example, such a cavity can be formed about 1,000 feet below the surface and can have dimensions such as 1,000 feet in length by 20 feet in diameter so as to store more than 50,000 barrels of liquid.

One method for creating such cavities involves first drilling a hole of relatively small diameter from the surface of the earth down into the formation within which the cavity is to be formed, then circulating water or other material-removing liquid down through the drilled hole to dissolve or otherwise remove material, and concurrently and continuously withdrawing from the hole the liquid containing removed material in a dissolved or suspended state. Plain water can be used for removing salt. A material such as clay requires a deflocculant liquid such as water, preferably including a deflocculation promoter such as the molecularly dehydrated phosphates. Limestone requires an acid solution such as a water solution of hydrochloric acid.

While cavities have been successfully formed as described, the speed of the operation is often less than desired, and it is difficult to control the shape of the cavity so as to obtain a known uniform diameter throughout its length. Low speed may be partly attributed to the fact that when operating with a liquid-filled cavity it has not been possible to employ the eroding action of wash liquid jets impinging directly against the side walls of the hole, since the pool of liquid arrests the motion of such jets after they leave a central wash pipe.

In accordance with the present invention there is provided a novel apparatus for enlarging the diameter of a hole drilled into a bed of salt, clay, or the like in the earth which removes material from a narrow annular zone of the side walls of the hole around its circumference by washing the walls with a stream of material removing liquid while simultaneously mechanically scraping off material from the area washed. The enlarged diameter is extended lengthwise of the hole by similarly removing material from successive adjoining annular zones. During the scraping and washing action a pool of wash liquid accumulates in the hole to receive the scraped and eroded material and form a suspension or solution which is continuously removed from the hole by the application of air or liquid pressure, by pumping mechanically, or in any other suitable way.

Our novel apparatus for carrying out the method described above comprises a stem which is secured on the

2

lower end of a conventional drill string, and an arm mounted at one end on the stem for lateral movement transversely into contact with the side walls of the hole. The arm has one or more orifices at the end remote from the stem for discharging liquid directly against the walls of the hole to wash off portions of the earth walls. On the same end of the arm there is a mechanical scraper which projects in the vicinity of the orifices for scraping the wall of the hole in cooperation with the impinging liquid.

The apparatus also comprises mechanism (not shown) for rotating the stem about a longitudinal axis so as to move the end of the scraper arm through a circle, and for moving the stem longitudinally in the hole so as to extend the reaming operation lengthwise of the hole. A mechanism of the type conventionally employed for rotating and advancing oil well drilling tools can be used.

In the drawings Fig. 1 is a vertical sectional view, parts being in side elevation, of one form of apparatus in accordance with the invention shown in position for reaming out a hole;

Fig. 2 is a cross-sectional view taken along the line 2—2 in Fig. 1;

Fig. 3 is a perspective view of the end portion of a part of the apparatus shown in Fig. 1;

Fig. 4 is a side elevational view, part being shown in section, of another modification of our novel apparatus; and

Fig. 5 is a side elevational view of the apparatus of Fig. 4 as viewed from the left.

More specifically in accordance with the invention, referring to Figs. 1 to 3, a hole 11 is drilled in a conventional manner from the surface of the earth down into the formation of salt, clay or the like in which a storage cavity is to be formed, and is lined with a casing 13 which is sealed by cement at 15 to the earth formation. After completion of the hole the drill string 18 is removed and the drilling cutter is replaced with the reaming apparatus of the present invention, which includes a longitudinal stem 17 mounted on the lower end of the drill string 18 and carrying a transversely movable reamer arm 19 adjacent its lower end for engaging the side wall 21 of the hole.

Stem 17 includes a longitudinally movable control piston 23 which operates on the top of a control lever member 25 pivotally secured to the stem and having a lower end portion adapted to engage the upper end 29 of the reamer arm 19 which is also pivoted at 31 to the stem for swinging movement. Piston 23, lever member 25, and arm 19 all have intercommunicating longitudinal passages 33, 35, and 37, respectively, so that liquid from the stem 17 can flow through the respective passages into the arm 19 and then be discharged in a plurality of high velocity jets through orifices 39 at the end of the arm.

When the reaming device is inserted in the hole 11 the piston 23 is in a raised position so that the lever member 25 is moved to the right in Fig. 1 by the weight of the arm 19 which extends almost vertically downward so as to pass through the narrow drill hole. It is desirable for the arm 19 to lie within the extended outline of the stem 17, although some slight overlapping may be permissible.

Once the reaming apparatus has been inserted in the hole 11 to the position at which reaming is to begin, liquid such as water is introduced into the drill string 18 and the stem 17 under high pressure so as to force the piston 23 downwardly into contact with the lever member 25 which is then forced to the left against the upper end 29 of arm 19 to cause the latter to move transversely of the stem and bring the outer end of the arm into scraping

3

engagement with the side walls of the hole. Simultaneously, liquid flows through the passages 33, 35, and 37 and is discharged with considerable force from the orifices 39 against the walls of the hole to wash away material.

The washing and scraping actions of arm 19 are promoted by constructing the outer end of the arm as a removable and replaceable arcuate head 41 carrying a plurality of straight teeth 42 extending across the arc, and having a liquid jet orifice 39 between each pair of teeth.

The washing and scraping action is extended around the circumference of the hole to remove material from an annular zone by rotating the stem 17 while maintaining the liquid pressure on piston 23 to hold the outer end of arm 19 in contact with the wall 21. Thus an annular shelf 43 is formed.

To extend the reaming operation lengthwise of the hole the stem 17 is advanced continuously lengthwise and downwardly so that the outer end of the arm 19 pursues a spiral path to remove material from successive annular zones. However, it is also possible to remove material satisfactorily by intermittently moving the stem 17 either up or down so as to remove material from successive circular zones instead of employing a continuous spiral movement.

The liquid injected from the orifices 39 gradually accumulates until it forms a deep pool filling the enlarged cavity and the portion of the hole 11 surrounding the stem 17 and the drill string. The continued addition of liquid under pressure then forces liquid from the pool to the surface of the earth where it is discharged. If the material of the formation is soluble, e. g., salt, the dissolved salt is carried to the surface in solution as a concentrated brine. If the material is insoluble, e. g., clay, the finely-divided removed particles are carried to the surface as a suspension in the liquid. The presence of the deep liquid pool submerging the walls of the hole does not interfere with the material-removing operation because the orifices 39 are located immediately adjacent the zone from which material is being removed.

It is also possible to operate satisfactorily when the level of the liquid pool is below the reamer, but an air lift or mechanical pump must then be used to remove the liquid.

We have found that when operating with a cavity full of liquid it is possible to develop a deflecting force between the liquid and the reamer arm 19, as the latter rotates, which aids in forcing the arm into contact with the sides of the hole and thus makes possible a reduction in the pressure of the liquid which is required to force the piston 23 downwardly. In order to use this deflecting force efficiently we provide the reamer arm 19 with one or more longitudinally extending vanes 45 which project radially from the arm at angles such that the pressure of the liquid on each vane forces the arm outwardly. Each vane should be tilted so as to cut the conical surface generated by rotation of the longitudinal axis of arm 19, i. e. to be non-tangent to such surface, the leading vane being inclined upwardly and outwardly and on the outside of said conical surface, and the lagging vane being inclined downwardly and outwardly and on the inside of said conical surface.

More specifically, the leading and lagging vanes 45 are located on opposite sides of the plane which contains the longitudinal axis of the arm 19 and is parallel to the pivot axis 31. Each vane is inclined away from both the arm 19 and such plane; and both vanes are so located as to lag behind such plane during rotation of the reamer.

In the modification shown in Figs. 4 and 5 the reamer arm 51 is forced into contact with the sides of the hole solely by the deflecting force of the liquid pool thereon. Arm 51 is pivotally mounted on the lower end of a stem 53 by a swing joint construction 55, comprising mating relatively rotatable members 54 and 56 held together

4

by a bolt 52, which permits liquid from a passage 57 in the stem 53 to flow into an annulus 59 and thence into the arm 51. The rotatable member 56 of the swing joint carries a stop member 60 which is adapted to engage a stop pin 61 on the mating member 54 so that when the arm 51 is in relaxed position it assumes a slight angle with respect to the longitudinal axis of the stem 53 as shown at 51' in Fig. 4.

When starting reaming operations with the apparatus of Figs. 4 and 5 the hole is first filled with liquid to a depth such that the arm 51 is submerged. Then rotation of the stem 53 is started which causes the vanes 65 to plane through the liquid pool so that force exerted between the pool and the vanes forces the end 67 of the arm 51 into scraping contact with the wall of the hole to remove material therefrom. At the same time, liquid flows through the arm 51 and is discharged against the hole walls to remove material.

Obviously, many modifications and variations of the invention as hereinabove 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.

We claim:

1. Apparatus for reaming a hole drilled in the earth comprising a hollow stem; an arm pivotally mounted at one end thereof on said stem for swinging movement transversely thereof in a first plane parallel to the longitudinal axes of both said stem and said arm, said arm having a longitudinal passage communicating with the interior of said stem for receiving liquid therefrom; means for moving said arm transversely of said stem; said arm having scraper means carried at the opposite end thereof, said scraper means comprising a head having a segmental surface of revolution whose axis extends transversely of the longitudinal axis of said arm, and a plurality of teeth arranged on said segmental surface, said head also having a plurality of orifices located between said teeth for discharging liquid therefrom to wash portions of the earth in contact with said teeth, and said head having fluid conducting channels therein establishing communication between said orifices and said passage.

2. Apparatus in accordance with claim 1 wherein said means for moving said arm transversely of said stem comprises at least one vane projecting laterally from said arm and lying in a second plane which forms an acute angle with said first plane, said vane acting to develop a deflecting force between a pool of liquid in said hole and said vane during rotation of said stem and arm at least to assist in forcing said scraper means into contact with the walls of said hole.

3. Apparatus in accordance with claim 2 wherein said means for moving said arm comprises a pair of said vanes projecting in opposite directions from said arm, both of said vanes lying in said second plane.

4. Apparatus for reaming a hole drilled in the earth comprising a stem; an arm pivotally mounted at one end thereof on said stem for swinging movement transversely thereof in a first plane parallel to the longitudinal axes of both said stem and said arm; means for moving said arm transversely of said stem; said arm having scraper means carried at the opposite end thereof, and orifice means adjacent said opposite end for discharging liquid therefrom to wash portions of the earth in contact with said scraper means; means for moving said arm transversely of said stem comprising a pair of vanes projecting laterally from said arm in opposite directions, both of said vanes lying in a second plane which forms an acute angle with said first plane, said vanes acting to develop a deflecting force between a pool of liquid in said hole and said vanes during rotation of said stem and arm at least to assist in forcing said scraper means into contact with the walls of said hole.

5. Apparatus in accordance with claim 4 also comprising stop means for maintaining an angular relation

5

between said arm and the longitudinal axis of said stem
when said arm is in relaxed position.

References Cited in the file of this patent

UNITED STATES PATENTS

162,163	Frisbee	Apr. 20, 1875
973,752	Cahn et al.	Oct. 25, 1910
1,427,944	Crotto	Sept. 5, 1922
1,559,761	Nebergall	Nov. 3, 1925

5

1,739,206
1,908,174
2,069,482
2,072,859
2,234,451
2,251,916
2,284,170
2,285,213
2,324,682

6

Buchanan	Dec. 10, 1929
O'Grady	May 9, 1933
Seay	Feb. 2, 1937
Grant	Mar. 9, 1937
Ransome	Mar. 11, 1941
Cross	Aug. 12, 1941
Santiago	May 26, 1942
Le Bus	June 2, 1942
De Long	July 20, 1943