Oct. 10, 1961 J. K. JORDAN 3,003,322

OIL STORAGE

Filed June 6, 1958

FIG. 1.

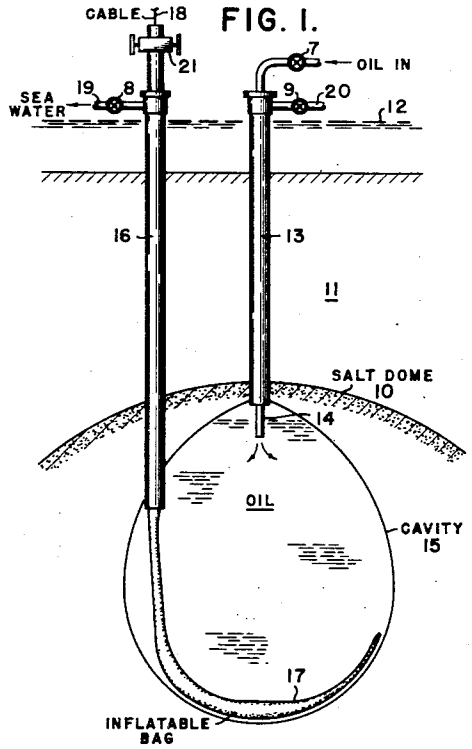


FIG. 2.

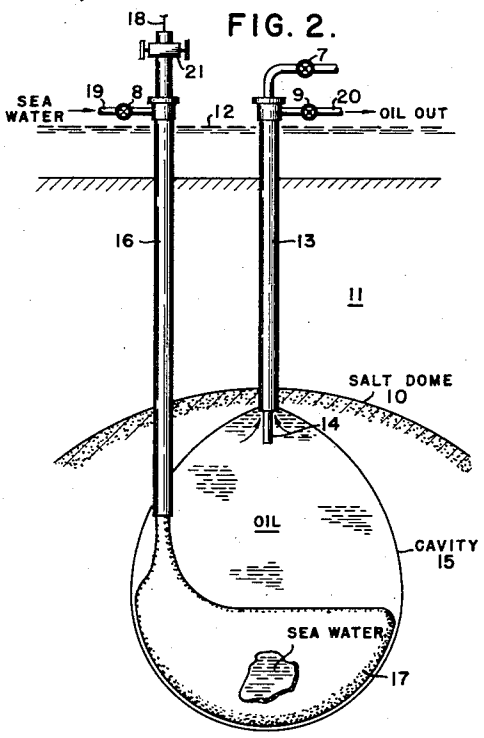


FIG. 3.

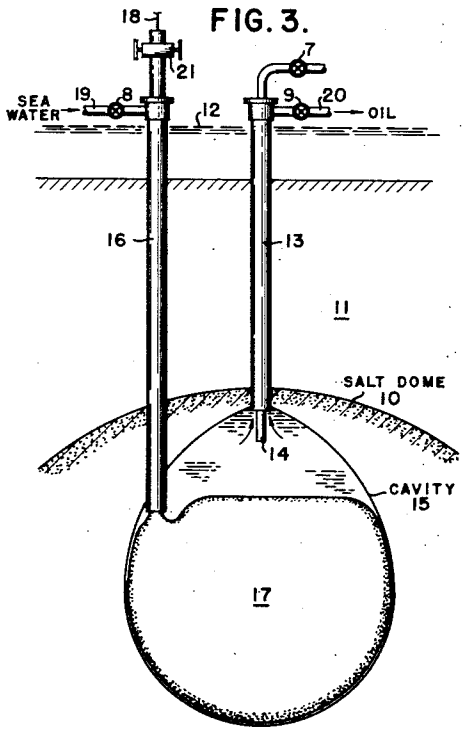


FIG. 4.

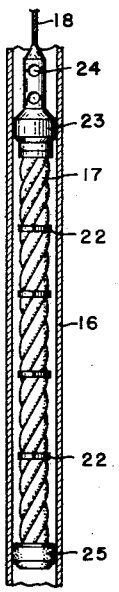
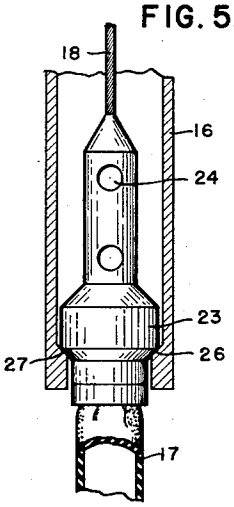


FIG. 5.



INVENTOR.
JAMES K. JORDAN,
BY John A. Schneider
ATTORNEY.

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3,003,322

OIL STORAGE

James K. Jordan, Houston, Tex., assignor, by mesne assignments, to Jersey Production Research Company, Tulsa, Okla., a corporation of Delaware

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1 Claim. (Cl. 61—.5)

This invention concerns method and apparatus for delivery of fluids. More particularly, the invention concerns method and apparatus for the storage of oil in subterranean cavities located offshore and delivery of the oil therefrom.

The development of large oil reserves offshore has introduced many problems relative to the transportation and storage of produced oil. In one known practice the oil is produced and then moved by pipe line or barge to a shore terminal. From the terminal the oil is sent to a central tanker loading terminal or refinery. This practice is disadvantageous because movement of oil by barge is expensive and subject to weather conditions; costly offshore tank battery installations are required for the disposition of separator gas; and laying offshore pipe lines from the tank battery installations to shore installations is expensive and prohibitively so for installations in producing areas far from shore.

On the other hand, the ability to handle offshore oil at or near the production area provides many advantages. For example, barge loading facilitiese both on shore and offshore are eliminated or the necessity for laying offshore pipe lines to shore terminals is eliminated; shore terminals and large storage and tanker loading facilities at deep water ports are eliminated; and the time required for tankers to enter, load and leave the deep water ports is reduced.

One method for handling oil production offshore at or near the area of production is the construction of an offshore underground storage in conjunction with a tanker loading terminal. Thus, for example, an underground salt cavity of sufficient size to hold many days' oil production may be leached out and facilities may be installed for handling this oil at a tanker loading terminal near the salt cavity.

One desirable method for bringing the oil stored in the salt cavity to the surface at high flow rates is by displacement with the readily available sea water. However, since the sea water used is relatively fresh with respect to a saturated brine solution, each time the fresh sea water is used to displace the oil in the salt cavern, an additional portion of the salt cavity is leached out. This operation would ruin the salt cavity eventually.

Therefore, an object of this invention is to provide a method and system for storing oil in underground cavities and in displacing the stored oil with water whereby a continuous leaching process is avoided.

In a broader aspect an object of the invention is to provide improved method and apparatus for displacing a fluid contained in a receptacle by another fluid wherein the latter displacing fluid is maintained separate from the fluid being displaced.

Briefly, the method of the invention provides for removing fluids from a subterranean cavity which comprises injecting a first fluid into the cavity to force a second fluid contained in the cavity to the surface while maintaining the first fluid separate from the wall of the cavity and separate from the second fluid.

The system of the invention for removing fluids from a subterranean cavity comprises at least a first conduit extending from the surface into the cavity, at least a second conduit extending from the surface into the cavity,

and an inflatable bag arranged in the cavity, the neck thereof being arranged in the second conduit.

The above objects and other objects of the invention will be apparent from a more detailed description of the invention taken in conjunction with the drawing wherein:

FIG. 1 is a vertical view through a section of the subsurface showing the bag in deflated position;

FIG. 2 is a vertical view through a section of the subsurface and showing the bag partially inflated;

FIG. 3 is a vertical view through a section of the subsurface and showing the bag substantially completely inflated;

FIG. 4 is a vertical view of the inflatable bag in lowering-in position; and

FIG. 5 is an enlarged vertical view of the coupling connecting the inflatable bag to the cable landed in the pipe.

FIGS. 1 through 3 show a cavity **15** formed in a salt dome **10** located in the ground **11** underlying a body of water **12**. Concentric pipes **13** and **14** are arranged to extend from above the surface of the water to the upper part of cavity **15** and a pipe **16** is arranged to extend from above the surface of the water into cavity **15**, as shown. An inflatable bag **17** is arranged in cavity **15** and is connected to a cable **18** which extends through the upper end of pipe **16**. A conduit **19** is connected to pipe **16** and a conduit **20** is connected to pipe **13** and fluidly communicates with the annulus between pipes **13** and **14**.

Valves **7**, **8**, and **9** are provided on conduits **14**, **19**, and **20**, respectively, to control the flow of fluid through these pipes. A coupling provided with a stuffing box **21** which seals off around cable **18** is connected to the upper end of pipe **16**.

FIG. 4 is a detailed view of the bag in deflated lowering-in position arranged in pipe **16**.

Bag **17** is compressed as by wrapping, as shown. Split rings **22** retain the bag in wrapped position until the bag begins to inflate. Other devices such as frangible rings, releasable sheaths, etc. may be used in place of the split rings. The neck of the bag is connected to a coupling **23** which is a hollow member secured to cable **18** and provided with openings **24** which openings fluidly communicate with the interior of bag **17**. The lower end of bag **17** has attached thereteo a cup packer **25** which may be used to aid in moving bag **17** downwardly through pipe **16**.

In FIG. 5 is illustrated coupling **23** and landing apparatus which restrains or prevents the coupling from moving out of the lower end of pipe **16**. The landing apparatus includes a shoulder portion **26** formed on coupling **23** which is adapted to engage with or land on a shoulder **27** formed on the lower end of tubing **16**.

Cavity **15** is formed by drilling a hole into salt dome **10** and setting pipe **13** therein. Pipe **14** is arranged to extend through pipe **13** and a portion of the salt dome is leached out by circulating water down one pipe and up the other pipe. After the cavity has been formed sufficiently large a second hole is drilled to cavity **15** and pipe **16** is set in this hole. Then bag **17** is lowered through pipe **16** on cable **18** until shoulder **26** of coupling **23** is landed on shoulder **27** of pipe **16**.

Cavity **15** is filled with oil by pumping oil through pipe **14**. The water used in leaching will be displaced by the oil to the surface through the annulus between pipes **13** and **14**. When it is desired to remove the oil from the storage cavity sea water is pumped through pipes **19** and **16**, through openings **24** and into the interior of bag **17**. As bag **17** begins to inflate, retaining rings **22** release and permit continued inflation of the bag. Inflating of bag **17** displaces the stored oil through the annulus between pipes **13** and **14** or through pipe **14**.

When it is desired to again store oil in cavity **15**, oil is pumped downwardly through pipe **14** or through the annulus between pipes **13** and **14** into the cavity **15**. This displaces the sea water contained in bag **17** and deflates the bag. The salt water is displaced through coupling **23** and pipe **16** to the surface. When it is desired to remove the deflated bag, it is pulled through pipe **16** by means of cable **18**.

The operation of valves **7**, **8**, and **9** is considered apparent consequently the manipulation of these valves during the storage-displacement cycle was not described. Stuffing box **21** is used to seal off the annulus about cable **18** after the bag has been arranged in the cavity and bag inflating fluid is about to be pumped through pipes **19** and **16**.

Although only one bag was illustrated in the description of the invention for sufficiently large cavities more than one bag may be used and in accordance therewith an access hole having a pipe **16** set therein would be employed for each bag.

The bag is preferably formed of a material not affected by hydrocarbons such as synthetic or neoprene rubber or a plastic material such as polyethylene. It is of sufficient thickness and ductility to prevent damage to it by contact with the rough wall of the cavity and by the continuous folding and unfolding required by the continual storing and displacement of the oil.

Although the invention has been described with regard to displacement of oil by salt water, the scope of the invention is not to be considered limited to such use. The scope of the invention encompasses displacement of any fluid by any other fluid. As an example, a gas such as air or natural gas may be used as the bag inflating medium to displace water.

Having fully described the method, apparatus and objects of the invention, I claim:

A system for the storage of oil in a subterranean location underlying a body of sea water and for removal of oil stored in this location comprising an offshore subterranean salt dome provided with a cavity; at least a first conduit extending from above the surface of the water into the upper portion of said cavity; at least a second conduit extending from above the surface of the water into said cavity and provided with a shoulder adjacent the lower end thereof; an inflatable, deflatable bag arranged in said cavity, the neck portion of said bag being provided with a coupling having a shoulder engageable with said second conduit shoulder, said shoulders cooperating to prevent further downward movement through said second conduit of the neck portion of said bag; a cable connected to said coupling adapted to lower said bag deflated through said second conduit into said cavity; said first conduit being a conductor of oil from said cavity and said second conduit being a conductor of sea water into said bag when it is desired to displace oil stored in said cavity from said cavity by supplying said bag with sea water and said conduit being a conductor of sea water from said bag and said first conduit being a conductor of oil into said cavity when it is desired to store oil in said cavity.

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