

Feb. 23, 1971

E. M. BLOUNT ET AL

3,564,856

PROCESS AND APPARATUS FOR CEMENTING OFFSHORE SUPPORT MEMBERS

Filed April 11, 1969

FIG. 1

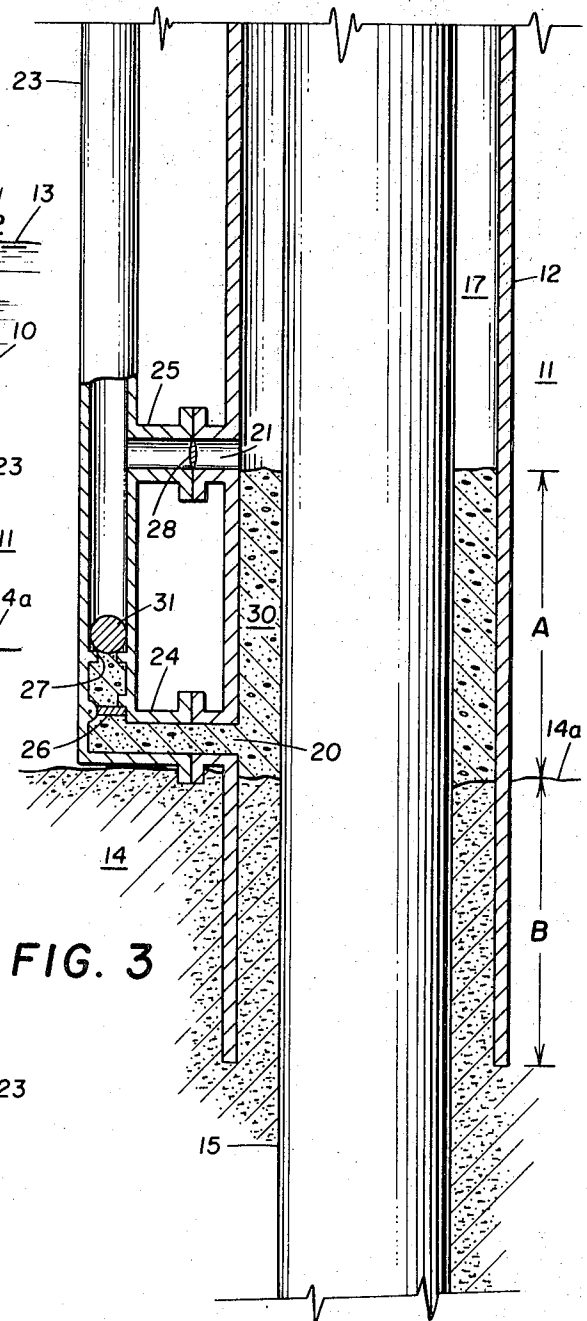
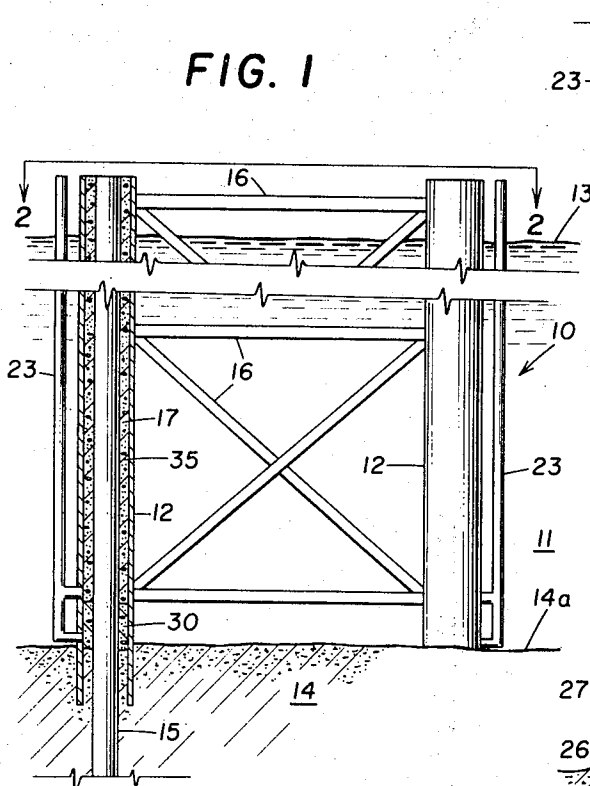


FIG. 3

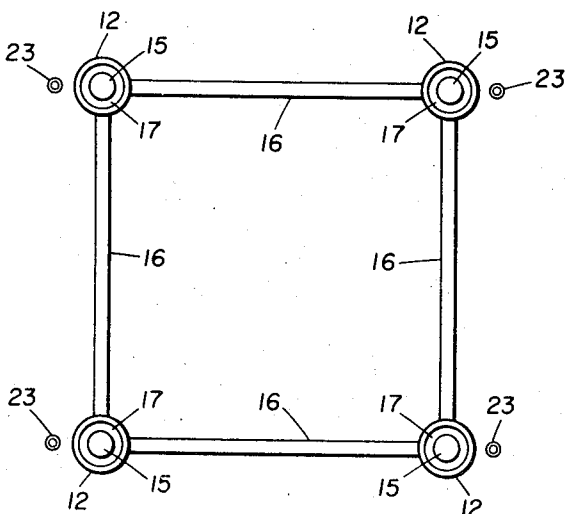


FIG. 2

ELMO M. BLOUNT
JOSEPH U. MESSENGER
INVENTORS

BY *Arude Faulconer*
ATTORNEY

1

3,564,856

PROCESS AND APPARATUS FOR CEMENTING OFFSHORE SUPPORT MEMBERS

Elmo M. Blount, Irving, and Joseph U. Messenger, Dallas, Tex., assignors to Mobil Oil Corporation, a corporation of New York

Filed Apr. 11, 1969, Ser. No. 815,476

Int. Cl. E02d 5/34

U.S. Cl. 61—46

10 Claims

ABSTRACT OF THE DISCLOSURE

The specification discloses a process and apparatus for cementing in two stages an annulus formed between an offshore support member and a pile driven therethrough. The support member is provided with a first port which normally lies adjacent the mudline when the support member is in position and a second port vertically spaced upward from the first port. A batch of quick-setting cement material, e.g., gypsum cement mixtures, is pumped through the first port to fill the annulus to a level approximately adjacent the second port. This material is allowed to set to form a seal at the lower end of the annulus and then additional cement material is pumped through the second port to finish filling the annulus.

BACKGROUND OF THE INVENTION

The present invention relates to a process and apparatus for affixing support members to the bottom of a body of water, and more particularly relates to a process and apparatus for forming a cement bond between an offshore support member and a pile driven therethrough.

In building fixed, offshore platforms to hold petroleum production facilities or the like, a support template is normally fabricated on shore, towed to location, righted, and its legs allowed to settle a short distance into the bottom of the body of water. Then using the template legs as a guide, a pile is driven to refusal through the inside of each of the template legs. The annulus formed between the pile and the template leg is filled with cement through a macaroni string or other means attached to the leg to form a bond between the piling and the template leg, thereby securely anchoring the template to the bottom. However, in most heretofore known cementing operations of this type and purpose, certain difficulties have been encountered which seriously affect the efficiency of the operation and substantially add to the expense of same.

The most serious problems in cementing piles within support members at offshore locations arise when circulation is lost during pumping of the cement into the annulus. Lost circulation occurs primarily when the weight exerted by the head of cement within the annulus forces the cement downward through the mud or the like which normally fills that portion of the annulus below the mudline and out into the soft formations surrounding the support member. Once cement breaks out of the lower end of the annulus, the annulus cannot be filled until circulation is regained.

Prior approaches to solve the problem of lost circulation have included techniques of providing a ring seal or inflatable packer about the lower inside diameter of the support member which in turn cooperates with the pile after it has been driven therethrough to form an effective seal at the lower end of the annulus. Besides the considerable added expense, this technique still fails in a large percentage of its applications due to the seal or packer just being unable to support the weight exerted by the head of cement in the annulus.

Other approaches have included lightening of the

2

cement with pozzolans or gels but this results in weaker bonds and in slower setting times for the cements, especially at ocean temperatures. Also, gravel and quick-setting materials have been used to regain circulation once it has been lost but this procedure is both time consuming and expensive. Still another technique involves merely ceasing operations when circulation is lost until any cement that may be present in the lower annulus has had time to set. Hopefully, the set cement within the annulus will form an effective enough seal to allow the cementing of the annulus to be completed. Apart from the hit-or-miss nature of this approach, it ties up cementing barges for long periods of time which again adds substantially to the expense of the operation.

SUMMARY OF THE INVENTION

The present invention provides a process and apparatus for quickly and efficiently cementing the annulus between a support member or leg positioned on the bottom of a body of water and a pile driven therethrough, thereby establishing an effective bond between the leg and the pile. The cementing process is carried out in two stages. In the first stage, a plug of quick-setting cement material is positioned in the lower part of the annulus and allowed to set to form an effective seal within the annulus. In the present invention, a quick-setting cement material can be defined as one which has sufficient pumping or thickening time for it to be placed safely and then rapidly develops significant compressive strength. In the second stage, a conventional cement material is supplied to the annulus above the set cement material to complete the filling of the annulus.

In carrying out the invention, the support member or leg is provided with two ports near its lower end prior to the positioning of the leg into the water. The first or lower port is positioned so it will be approximately adjacent the mudline when the leg is in position. The second or upper port is vertically spaced upward from the lower port at a distance corresponding with the desired length of the plug formed by the first stage material. A first means for supplying material to the annulus communicates with the lower port and a second means for supplying material to the annulus communicates with the upper port. Once the leg is in position on the bottom and a pile has been driven therethrough, liquid such as sea water is circulated through the first means to clear the lower port and adjacent annulus of mud or the like. Next, a batch of quick-setting cement material is pumped through the first means and lower port into the lower annulus. The volume of the batch of quick-setting cement material is calculated so that when in place it will fill that portion of the annulus that lies between the two ports. Liquid is then circulated through the second means to clear the upper port and adjacent annulus of any excess quick-setting cement material. Then, a regular cement material is circulated through the second means and the upper port to complete the filling of the annulus.

BRIEF DESCRIPTION OF THE DRAWINGS

The actual construction, operation, and the apparent advantages of the invention will be better understood by referring to the drawings in which like members identify like parts in the different figures and in which:

FIG. 1 is an elevational view, partially in section, of a typical template affixed in place in a body of water in accordance with the present invention;

FIG. 2 is a plan view taken along line 2—2 of FIG. 1; and

FIG. 3 is an enlarged view in section of the lower end of a leg of a template made in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring more particularly to the drawings, FIG. 1 discloses a template 10 which has been constructed and affixed in position in a body of water 11 in accordance with the present invention. For illustrative purposes, template 10 is disclosed as having four support members or legs 12 which are connected by usual cross-bracing members 16. However, it should be realized the present invention is not limited to any particular number of support members but is applicable to any number including only one.

In normal application, template 10 is fabricated on shore, towed to location, righted, and the legs 12 sunk a short distance, e.g., 10-15 feet, into bottom 14 of the body of water 11. The legs 12 normally extend above the surface 13 of the water and are adapted to support a production platform or the like (not shown). After template 10 comes to rest, a pile 15 is driven to refusal through each of legs 12. Each of the piles 15 will normally extend from a substantial distance (e.g., 100 feet) below the lower end of its respective leg to a point adjacent the top thereof. The outside diameter of the pile is smaller than the inside diameter of the leg so an annulus 17 is formed in each leg 12 whenever pile 15 is driven there-through. Cement is then supplied to annulus 17 to form a bond between leg 12 and pile 15 to anchor template 10 securely to the bottom.

As mentioned above, in some previous cementing techniques, a rubber seal or inflatable packer (not shown) is mounted on the lower end of each leg to form a seal with its respective pile to close the lower end of annulus 17. Cement is then pumped through a line (not shown) from the surface through an opening in the leg to fill completely the annulus. However, in a large number of actual applications of this technique, the seal or packer breaks down under the weight of the cement and circulation is lost.

In accordance with the present invention, novel apparatus is used to allow a new cementing process to be carried out in two stages which is highly effective and which does not require a separate, positive element of structure to seal the lower end of the annulus.

As seen in FIG. 3, each support member or leg 12 is provided with two ports 20, 21 through the wall thereof. The first or lower port 20 is positioned at a point which will lie approximately adjacent the mudline 14a when leg 12 is in place in the body of water 11. The actual placement of port 20 will depend on how far leg 12 will sink into bottom 14 (see A in FIG. 3) and can be accurately approximated from the known weight of the template, consistency of bottom 14, and prior experience in the area. However, since lower port 20 can be slightly below or above mudline 14a without affecting its function, as will become evident below, the exact placement of port 20 is not critical.

The second or upper port 21 is vertically positioned upward from lower port 20. The exact distance B between ports 20 and 21 is not critical but will be determined by the size of the desired, initial plug of quick-setting cement material as will be more fully discussed below. For example, with support members having lengths of from 50 to 150 feet, a distance B of between 10 to 15 feet will be satisfactory.

In the illustrated modification, a single string of macaroni tubing 23 or the like is in communication with lower port 20 by means of line 24 and with upper port 21 by means of line 25. A check valve 26 and a valve seat 27 are positioned in string 23 between the two ports as clearly shown in FIG. 3. Valve 26 is shown as a swing type check valve but any type of check valve which allows flow only in a downward direction can be used. A frangible rupture disk 28 is positioned in line 25 to block initial flow from string 23 through port 21.

To carry out the present process with the illustrated apparatus, the template 10 is fabricated and positioned in the body of water 11 so that the support members or legs 12 are partially embedded in the bottom 14, e.g., 10 feet. A pile 15 is driven to refusal through each leg 12 which forms annulus 17 between the pile and the leg. Soft mud or the like normally fills that portion A of annulus 17 which lies below the mudline 14a.

Next, a liquid such as sea water is circulated down string 23, through valves 27, 26, port 20, and up through annulus 17. This clears port 20 and removes any mud or the like that may be present in the annulus above mudline 14a. Then a quick-setting cement material 30, which will be described in detail below, is circulated into annulus 17 through lower port 20 from string 23. The quick-setting cement material is preferably pumped in a slug having a calculated volume necessary to fill annulus 17 to a height approximately adjacent upper port 21 (see B in FIG. 3). A slight excess of quick-setting cement material can be used without affecting the invention since any excess material can be removed in the following step.

After the desired volume of quick-setting cement material 30 has been pumped down string 23, it is followed by ball 31 which seats on valve seat 27, thereby effectively blocking lower port 20. Liquid such as sea water is next pumped down string 23 under sufficient pressure to rupture disk 28 and open port 21. Continued flow of liquid through string 23 will wash any excess quick-setting cement material, mud, or the like away from upper port 21 and circulate it back to the surface through annulus 17. The check valve 26 prevents any backflow of cement material 30 into string 23 during this time. The liquid is circulated until port 21 and the annulus 17 above port 21 is clear. Once cement material 30 sets to its desired compressive strength, a seal in the form of a plug is formed between pile 15 and leg 12 which effectively closes the lower end of annulus 17. Now, any cement 35 (see FIG. 1) normally used in operations of this general type can be injected into annulus 17 through port 21 via string 23 to fill annulus 17 without danger of losing circulation.

A particular apparatus for carrying out the cementing operation has been illustrated but it should be recognized that the same process could be carried out using slightly different apparatus. For example, two separate macaroni strings can be used wherein one macaroni string is attached to lower port 20 and the other string attached to upper port 21. Such an arrangement eliminates the need for valves 26, 27, and disk 28. However, two strings extending all the way to the surface are required. The method and apparatus having been fully described, attention will now be directed to specific examples of various cementing materials which can be used in the invention.

Quick-setting cement material used in the first stage of the present invention can be selected from any cement material whose pumping or thickening time is short but one which can be controlled so that the cement slurry can be placed safely and at the same time which sets in a relatively short period of time to yield a compressive strength necessary to support an annulus full of cement (e.g. 100-1000 p.s.i. in 30 minutes). The actual time for setting of quick-setting cement materials depends on several variables which are particular to the environment in which the invention is actually carried out. For example, the temperature of the water has a direct bearing on setting times; the length of the annulus to be filled bears on the compressive strength required; etc.

Further, a practical consideration arises from the time that a cementing barge has to be tied up in any one particular operation. For example, in cementing a template having four legs as that illustrated, it is desirable to run the first stage in one leg, move to a second and run the first stage, then to the third, and finally the fourth.

At the completion of the first stage in the fourth leg, it

5

is desirable for the quick-setting cement material in the first leg to have developed sufficient compressive strength so that the barge can return to the first leg to carry out the second stage without delay. The second stage is then carried out successively in each of the other three legs. Therefore, where only one support member is to be cemented, a quick-setting cement material having very rapid setting time would be preferred, while operations involving the cementing of several members could utilize cement material having longer setting times.

Numerous quick-setting cements, e.g., gypsum cements, are commercially available which can be tailored to set anywhere in the range of 30 to 90 minutes at 40°–75° F.; e.g., a quick-set gypsum cement comprised primarily of plaster of Paris ($\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$) is marketed by Halliburton Company under the trademark "Calseal." If a more rapid set is desired, then mixtures of gypsum cement or plaster of Paris and portland cement (API Class, A, B, C, G, or H) can be tailored to set throughout the range of 5–30 minutes. For example, a gypsum cement—API Class A cement mixture of the proportion of sixty 100-lb. sacks to one hundred 94-lb. sacks, respectively, produces a quick-setting cement material which will set at 40°–60° F. in one-half to one hour and develop a compressive strength of 320 p.s.i. during that time. This is adequate for most operations.

Examples of other quick-setting cement materials which can be used include:

(a) Mixtures of calcium aluminate cement and portland cement (API Class A, B, C, G, or H);

(b) Accelerated cements which are mixtures of portland cement (API Class A, B, C, G, or H) and accelerators, e.g., calcium chloride (2–4% by weight of cement) sodium chloride (0–10% by weight of mixing water), or sodium silicate;

(c) Densified cements which are mixtures of portland cement (API Class A, B, C, G, or H), an accelerator such as mentioned above, and a friction reducer mixed 1–2 pounds per gallon above the normal slurry weight. Examples of friction reducers include alkyl aryl, sulfonates, polyphosphates, lignosulfonates, lactones and gluconates, synthetic polymers, organic acids, etc. The above cements are described for the purpose of illustrating the wide variety of quick-setting cement materials that can be used in the first step and should not be considered as all inclusive. It should be recognized each actual environment will dictate the actual material to be used and the material is then tailored accordingly.

The cement material used for the second stage can be selected from any commercially available conventional cements, such as portland API Class A, B, C, G, or H, suitably tailored in accordance with known practices in the art for the particular locale in which it is to be used. In some instances, the quick-setting cement material used in the first stage may also be used for the second stage provided it manifests the strength, thickening time, and permanence required.

We claim:

1. A process for cementing the annulus formed between an offshore support member and a pile driven therethrough comprising:

flowing a batch of quick-setting cement material into the lower portion of said annulus;

allowing the batch of quick-setting cement material to set to form a seal between said support member and said pile; and

flowing additional cement material into said annulus above said seal to finish filling said annulus.

2. A process for cementing the annulus formed between an offshore support member and a pile driven therethrough comprising:

providing a first and second port through the wall of said support member, said first port being positioned to lie approximately adjacent the mudline when said support member is in position in an offshore location,

6

said second port being vertically spaced upward from said first port;

flowing a quick-setting cement material into said annulus through said first port until said annulus is filled to a point approximately adjacent said second port;

allowing the quick-setting cement material to set to form a seal in the lower portion of the annulus; and flowing additional cementing material into said annulus through said second port to complete the filling of said annulus.

3. The process of claim 2 including:

circulating a liquid through said first port to clean the annulus adjacent the first port prior to flowing said quick-setting cement material into said annulus.

4. The process of claim 3 including:

circulating a liquid through said second port after flowing said quick-setting cementing material into said annulus to clean any excess quick-setting cement material from the annulus adjacent or above said second port.

5. The process of claim 2 wherein:

said quick-setting cement material comprises gypsum cements.

6. The process of claim 2 wherein:

said quick-setting cement material comprises a mixture of gypsum cement and portland cements.

7. The process of claim 2 wherein:

said quick-setting cement material comprises a mixture of calcium aluminate cement and portland cements.

8. The process of claim 2 wherein:

said quick-setting cement material comprises an accelerated cement.

9. The process of claim 2 wherein:

said quick-setting cement material comprises a densified cement.

10. Apparatus for supporting an offshore production platform or the like in a body of water comprising:

a hollow support member of a length necessary to extend from slightly below the mudline of the bottom of said body of water to a point above the surface of said body of water, said support member adapted to have a pile driven therethrough;

a first port in the wall of said support member and being positioned to lie approximately adjacent the mudline when said support member is in position in said body of water;

a second port in wall of said support member spaced vertically upward from said first port;

a macaroni string extending from near the mudline to the surface;

a first line connected at one end to said first port and to said macaroni string at its other end;

a second line connected at one end to said second port and to said macaroni string at its other end;

a check valve in said macaroni string between said first line and said second line allowing flow in a downward direction only;

a valve seat in said macaroni string between said first line and said second line and above said check valve, said seat adapted to receive a valve means to effectively close said first port; and

a frangible valve means normally closing said second port.

References Cited

UNITED STATES PATENTS

2,653,451	9/1953	McCullough	61—46
3,209,544	10/1965	Borrmann	61—46.5
3,213,629	10/1965	Manning	61—46X

J. KARL BELL, Primary Examiner

U.S. Cl. X.R.

61—53.5, 56

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,564,856 Dated February 23, 1971

Inventor(s) Elmo M. Blount and Joseph U. Messenger

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 69, after "packer" the following should be inserted --being damaged when the pile is driven therethrough or due to the seal or packer--.

Column 4, line 63, "materials" should be --material--;
line 70, "ony" should be --any--.

Signed and sealed this 15th day of June 1971.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents

L