# United States Patent [19]

**Phares**

[11] **3,857,247**

[45] **Dec. 31, 1974**


[54] **OFFSHORE TOWER ERECTION TECHNIQUE**


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[73] Assignee: **Raymond International, Inc.,** Houston, Tex.



[22] Filed: **Feb. 6, 1974**

[21] Appl. No.: **440,122**

[52] **U.S. Cl.** ..... **61/46.5,** 61/53.5

[51] **Int. Cl.** ..... **E02b 17/04,** E02d 21/00

[58] **Field of Search** ..... 61/46.5, 46, 63, 53.5; 114/.5 D; 175/9



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*Primary Examiner*—Jacob Shapiro

*Attorney, Agent, or Firm*—Fitzpatrick, Cella, Harper & Scinto



[57] **ABSTRACT**

An offshore tower is erected by positioning an open framework template on a sea bed; jacking a construction barge up onto the template out of the water, installing anchor piles securing the legs of the template to the sea bed by operations carried out from the raised barge, lowering the barge and thereafter raising a large platform up onto the template.


**6 Claims, 17 Drawing Figures**

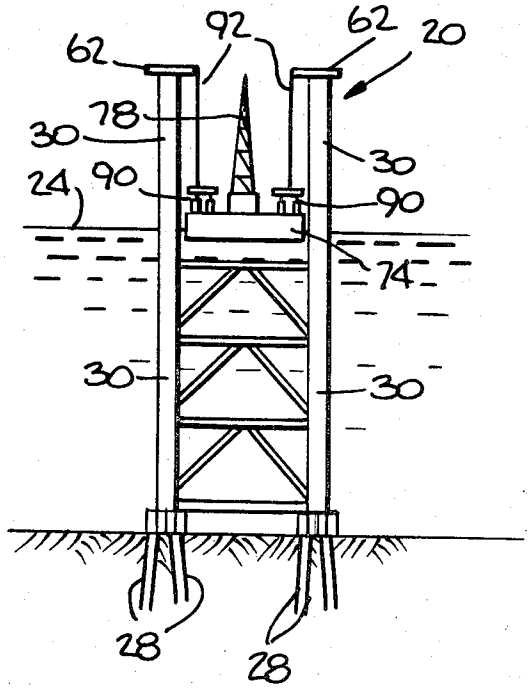


Fig. 1.

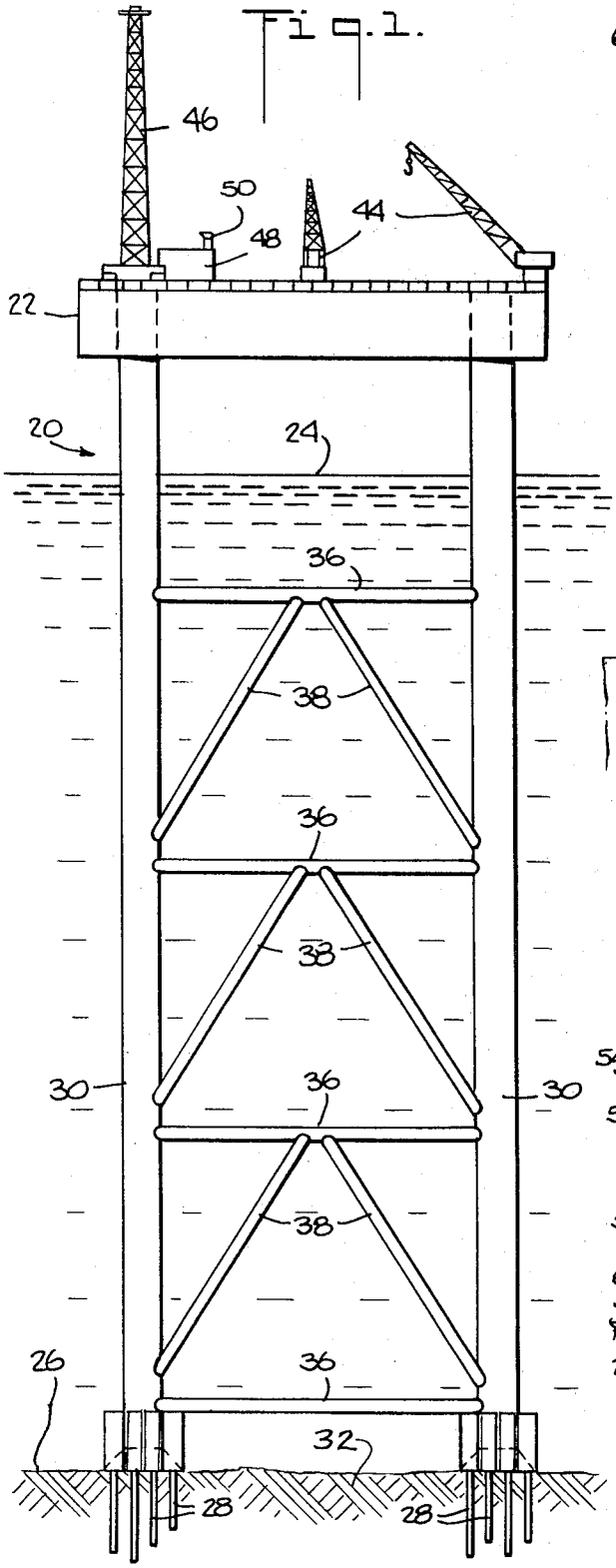
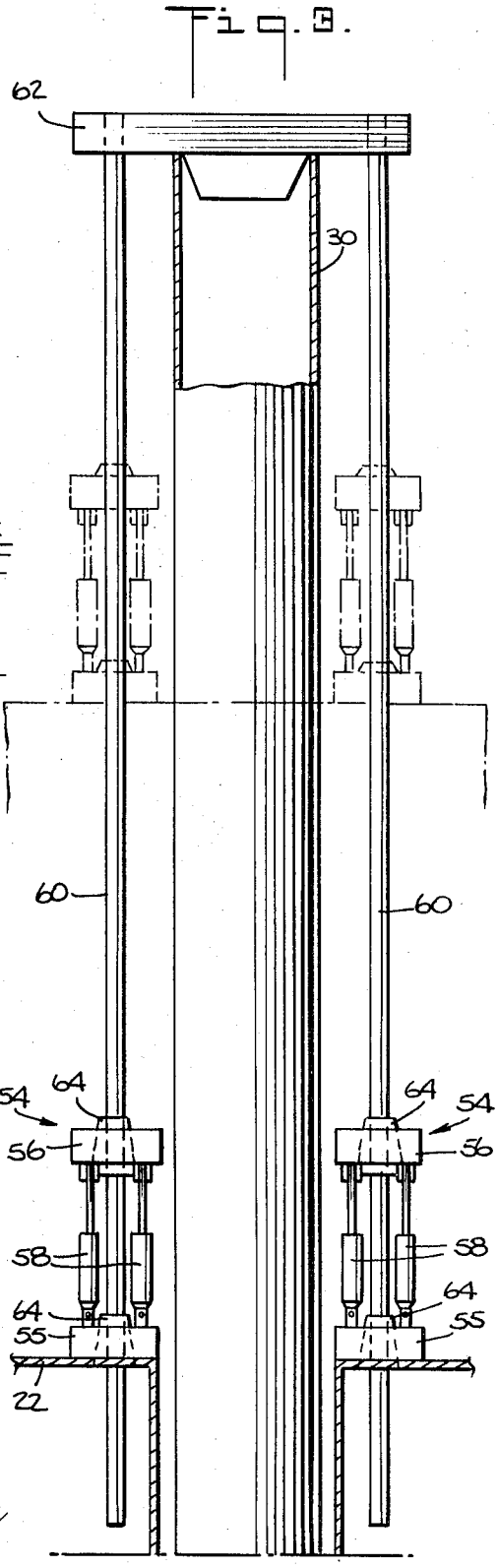

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Fig. 2.


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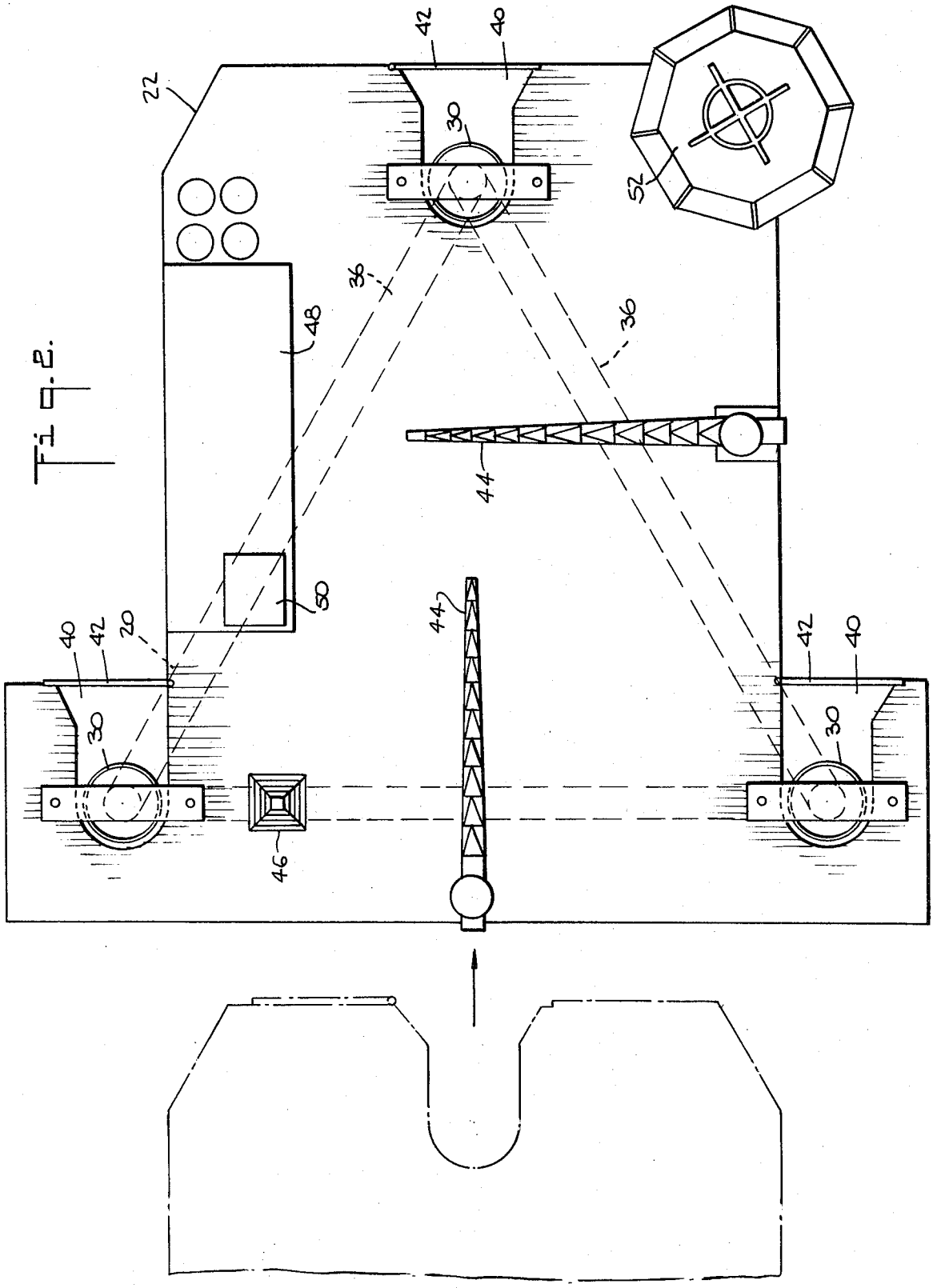



Fig. 2.

Fig. 4.

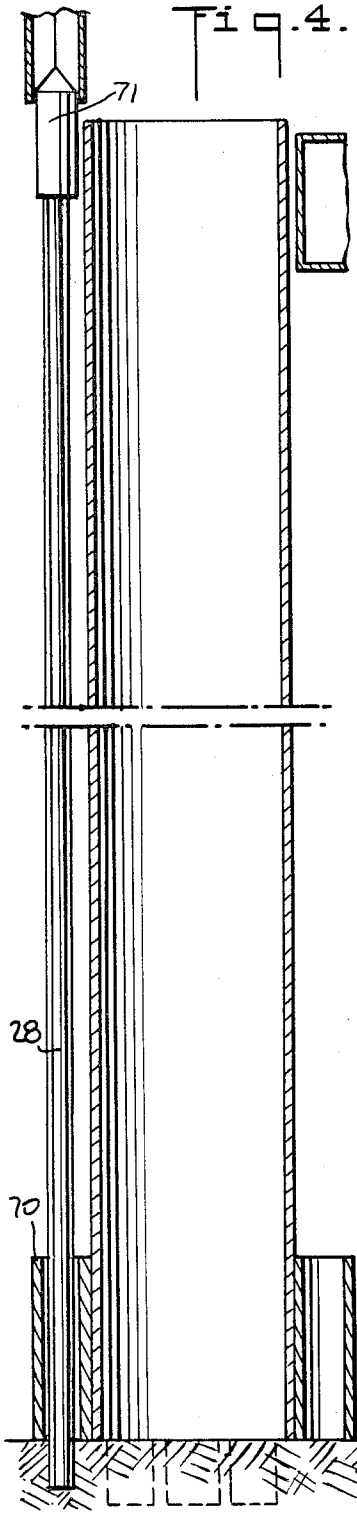



Fig. 5A.

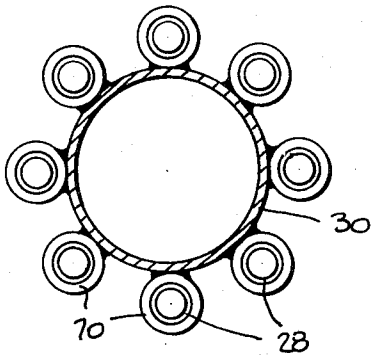



Fig. 5.

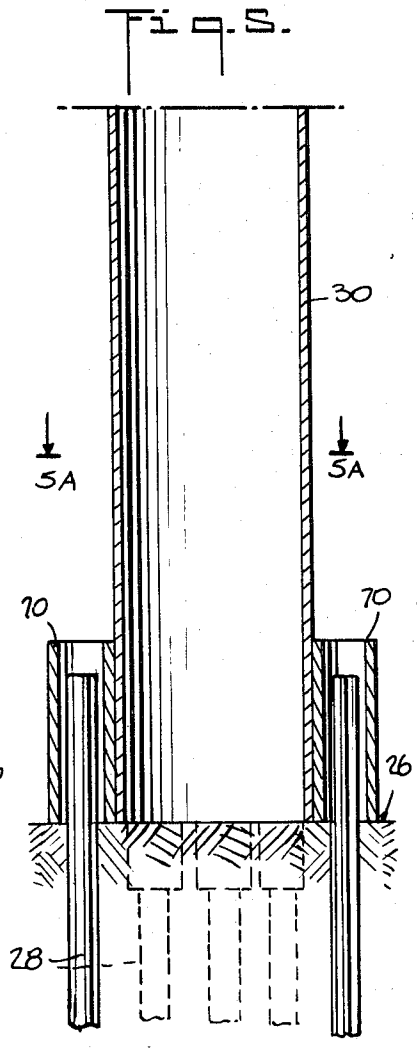
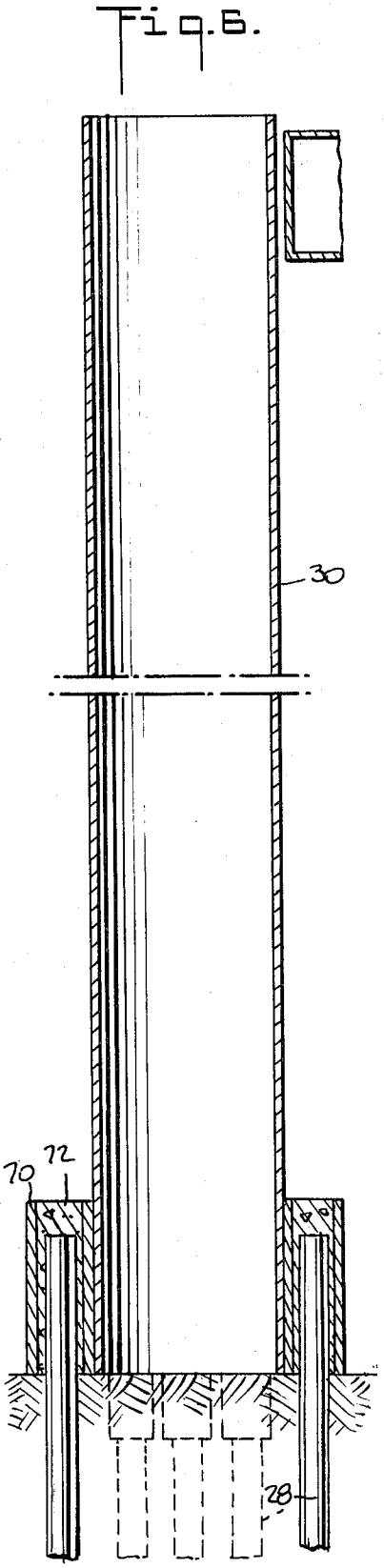



Fig. 6.



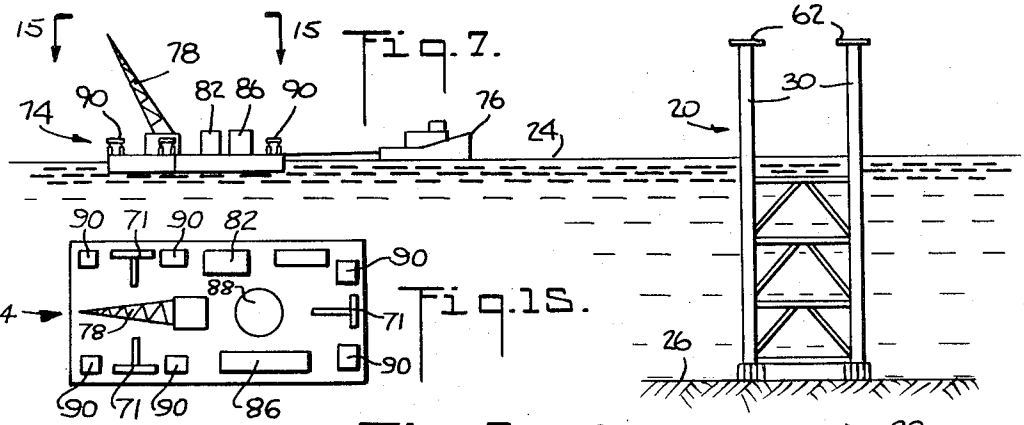



Fig. 7.




Fig. 15.

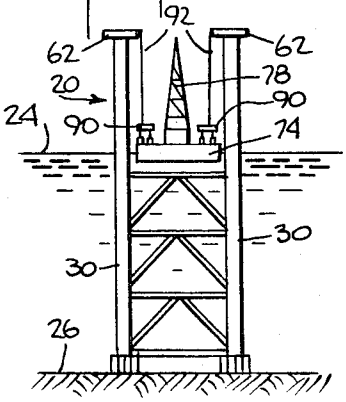



Fig. 8.

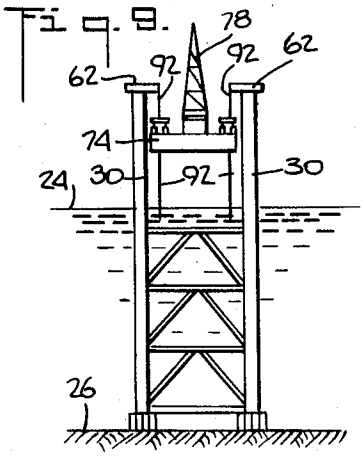



Fig. 9.

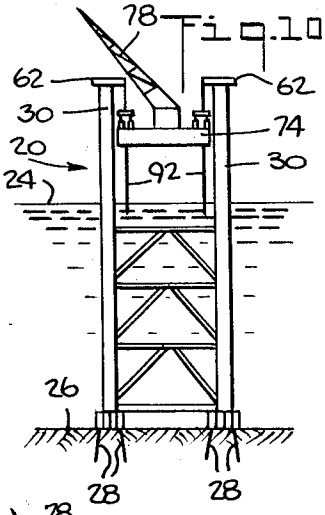



Fig. 10.

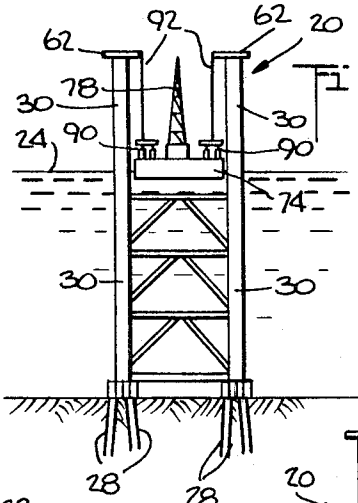



Fig. 11.

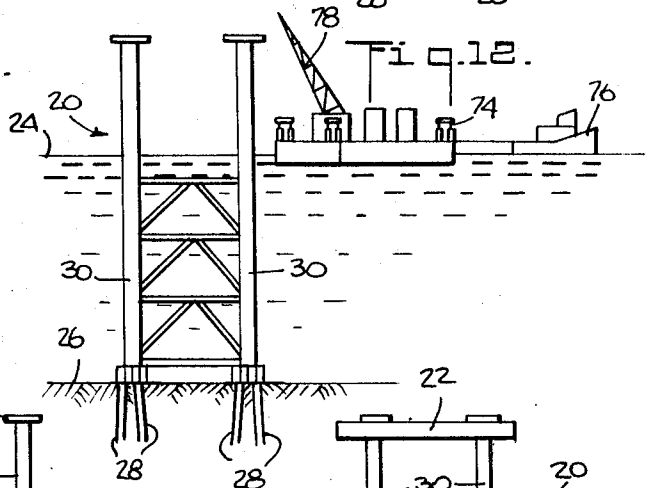



Fig. 12.

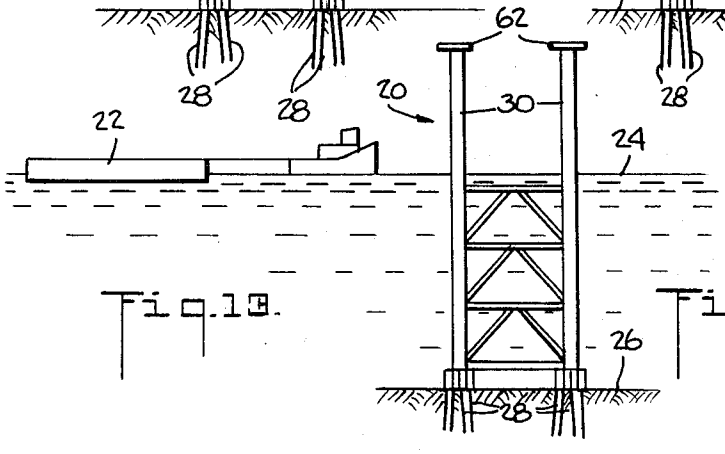



Fig. 13.

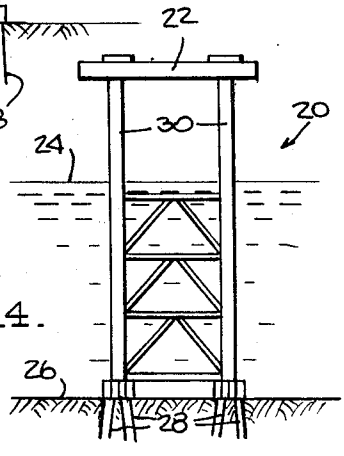



Fig. 14.

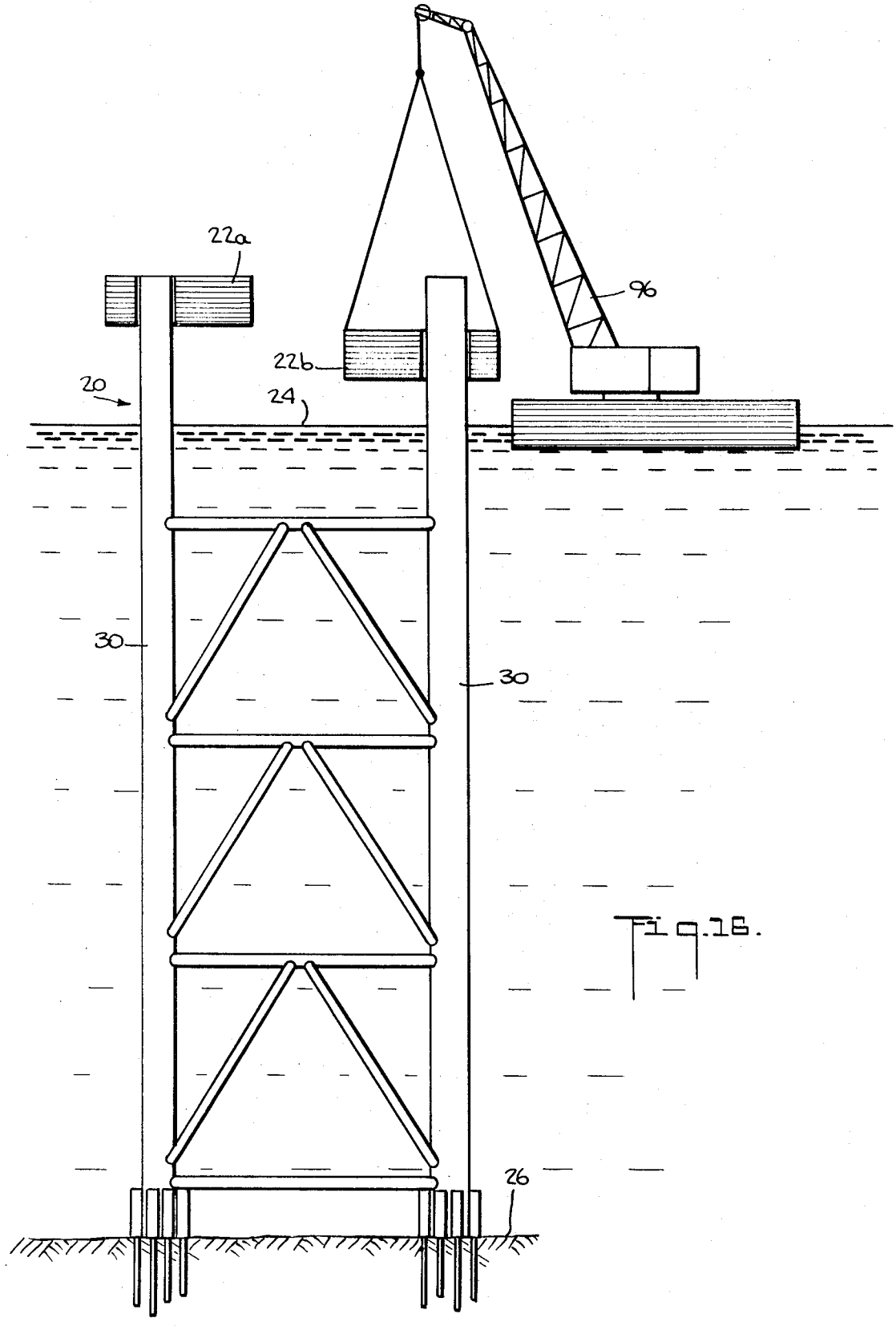



Fig. 1B.

# OFFSHORE TOWER ERECTION TECHNIQUE

This invention relates to the erection of structures and more particularly it concerns novel techniques for the construction of offshore platforms.

Offshore platforms are large structures supported up above the surface of the sea by open framework formations known as templates. These templates are anchored to the sea bottom by means of piles or similar elements; and they rise from there to a location well above the surface of the sea. The templates are sufficiently sturdy to support the large platform structure; and their open framework construction enables them to be only minimally affected by waves and other sea movements. The raised platform is thus held in a steady position, free of wave action; and it is thus well suited to drilling for exploration and recovery of oil and other resources from below the sea bottom.

Difficulties have been experienced in erected offshore towers due to their size (which may be several hundred feet in height) and due to the large wind and wave forces which are usually present during the erection operations. In many cases, the open framework template is floated out, as a single integral unit, to the erection location; and it is then submerged, in a controlled manner, so that it comes to rest in an upright position on the sea bed. The platform structure is floated out to the template as a separate unit and then is jacked up onto the template until it is clear of the water. The template itself must be anchored to the sea bed by means of piles or other such elements so that it can support the platform in a safe and reliable manner. It has been quite difficult, however, to carry out the pile driving operations required for this anchoring, particularly in high winds and rough seas.

It has been proposed to handle and drive anchor piles from a derrick barge moored alongside the template prior to jacking up of the platform. This technique, however, requires a very large barge in order to ensure stability in even moderate seas. Further, the barge can be effectively stabilized for pile driving only at one template leg at a time so that the time required for anchoring the pile becomes quite extensive. In sea areas where good weather conditions prevail for only short periods of time this drawback becomes quite serious.

It has also been proposed to drive anchor piles using pile drivers previously mounted on the tops of the template legs. This technique, however, requires special equipment designed to fit in a rather restricted space. Also, the pile driving equipment must be waterproof, if the template is to be floated out to a location in a horizontal condition.

Finally, it has been proposed simply to jack the platform structure up onto the template and to drive anchor piles from the raised platform structure itself. This last mentioned technique is even less feasible than the other two since the large raised platform makes the unanchored template quite unstable. Further the deck of an offshore tower platform extends laterally a considerable distance beyond the template legs and tends to restrict access to the piles.

The present invention overcomes these difficulties of the various prior art tower erection techniques; and it instead permits the rapid and efficient installation of anchor piles with a minimum of danger. According to the present invention, a construction barge, outfitted with anchor pile installation equipment is floated to a



template resting in upright position at a desired location on the sea bottom. The barge is moored in between the legs of the template and is then jacked up free of the water onto the template. The raised barge, which is not so large as to make the unanchored template unstable, is then used as a base for the driving of anchor piles, and for drilling, grouting and handling of all other operations related to securing the template to the sea bed. Afte this has been completed, the barge is lowered to the water and disengaged from the template. Thereafter the tower platform is floated into place, jacked up on the now-anchored tower and secured to the tower.

There has thus been outlined rather broadly the more important features of the invention in order that the detailed description thereof that follows may be better understood, and in order that the present contribution to the art may be better appreciated. There are, of course, additional features of the invention that will be described more fully hereinafter. Those skilled in the art will appreciate that the conception on which this disclosure is based may readily be utilized as the basis of the designing of other structures and techniques for carrying out the purposes of this invention. It is important, therefore, that this disclosure be regarded as including such equivalent constructions and techniques as do not depart from the spirit and scope of the invention.

Particular arrangements for carrying out the invention have been chosen for purposes of illustration and description, and are shown in the accompanying drawings forming a part of the specification, wherein:

FIG. **1** is an elevational view of an offshore tower which has been erected in accordance with the present invention;

FIG. **2** is an enlarged plan view of the top of the offshore tower of FIG. **1**;

FIG. **3** is a fragmentary elevational view of one of the legs and a portion of the platform of the tower of FIGS. **1** and **2** and illustrating a jacking arrangement for same;

FIGS. **4–6** are further fragmentary elevational views, taken in section, showing successive steps in the driving of anchor piles through one of the legs of the tower of FIGS. **1** and **2**;

FIG. **5A** is a cross section view taken along line **5A—5A** of FIG. **5**;

FIGS. **7–14** are a series of diagrammatic views illustrating a procedure for erecting offshore towers using the present invention;

FIG. **15** is an enlarged plan view taken along line **15—15** of FIG. **7**; and

FIG. **16** is a view similar to FIG. **13** but showing an alternate platform installation technique.

As shown in FIG. **1**, an offshore tower erected according to the present invention comprises a template **20** of open framework configuration and a tower platform **22** supported by the template above a water surface **24**. The template **20** itself rests upon and is anchored to a sea bottom **26**. The particular manner of anchoring depends upon the nature of the sea bottom; however, in most cases the anchoring is accomplished by means of a plurality of anchor piles **28** driven down from the bottom of legs **30** of the template and into solid material **32** below the sea bottom **26**.

As can be seen in FIGS. **1** and **2** the template **20** is made up of three legs **30** in triangular array extending

up from the sea bottom **26** to a substantial distance above the water surface **24.** A number of braces **36** and trusses **38** interconnect the legs **30** at various locations along their length to hold them in structurally solid parallel alignment.

The platform **22,** as shown in FIG. **2,** is of generally T shaped configuration; and it is provided with parallel slots **40** in the base, and in each of the arms of the T, to accommodate the template legs **30.** This allows the platform to float up to the template and engage each of its legs simultaneously, as indicated in phantom outline in FIG. **2.** Gates **42** close the open ends of the slots **40,** after the platform has been floated into place, to hold the platform in reasonably close alignment with the template during the initial stages of jacking.

The platform **22** is outfitted for the particular use to which the offshore tower is to be put. In most cases, however, the platform is provided with one or more cranes **44** for lifting supplies and other materials up onto it from floating barges or supply ships, as well as one or more drilling and pumping towers **46,** a warehouse **48,** a crew quarters **50** and a helicopter pad **52.**

While the size of the tower may vary according to its use or location, the present invention is particularly suited for use with large towers which can be installed in water depths well over 400 feet. In such case, the tower legs themselves would have a diameter of about 21 feet and a mutual spacing of about 180 feet. Also, in order to maximize the area of the sea bottom which may be explored or worked for any one position of the platform, the platform is dimensioned to overhang the template legs by some 30 feet on each side. In order to accommodate tides and waves the platform **22** is maintained at a height of about 100 feet above mean low water level.

As shown in FIG. **3** the platform **22** is jacked up along the legs **30** of the template **20** by means of jacking assemblies **54.** These jacking assemblies comprise lower blocks **55** secured to the platform, and upper blocks **56.** The blocks **55** and **56** are interconnected by double acting hydraulic piston and cylinder assemblies **58** which are powered and controlled by external means (not shown). A pair of jacking tubes **60** are suspended from a bridge **62** which lies across the top of the template leg **30.** These tubes extend down alongside the leg **30** and pass through the upper and lower blocks **56** and **54.** Gripper devices **64** selectively interconnect the blocks with the jacking tubes for lifting and lowering the platform. To lift the platform, the gripper device **64** on the lower blocks **55** secures the jacking tubes **60** and those on the upper blocks **56** slide along the jacking tubes as the hydraulic piston and cylinder assemblies **58** are extended. Thereafter the gripper devices **64** on the upper blocks **56** are engaged with the jacking tubes **60** and the other gripper blocks are released as the hydraulic piston and cylinder assemblies are retracted. This procedure is repeated and the platform is thereby lifted up along the legs **30** and out from the water. The platform **22** is lowered in similar manner except that the gripper devices **64** are engaged and disengaged in opposite sequence to that described for the lifting operation.

FIGS. **4–6** illustrate the manner in which the anchor piles **28** are installed to secure the template **20** to the sea bottom **26.** As shown in FIG. **4,** a template leg **30** rests on the sea bottom **24.** A plurality of pile sleeves **70** are welded to the leg at different locations about its lower periphery. Anchor piles **28** are lowered down along side the leg **30** and are driven down into the adjacent sea bed, within the pile sleeves **70,** by means of a suitable hammering device **71.** FIGS. **5** and **5A** show the arrangement of the anchor piles **28** inside their sleeves **70.** Thereafter, as shown in FIG. **6,** grout or concrete **72** is pumped down into the pile sleeves **70** to lock the anchor piles **28** to the lower end of the leg **30.**

It will be appreciated that with the water depths and size of the tower components described above it would be extremely hazardous to drive the anchor piles **28** from the platform **22.** The weight and overhang of the platform renders the overall tower structure quite unstable while unanchored; so that during periods of high winds or waves there is a danger of the entire structure toppling. Also, because of the large overhang of the platform **22,** it becomes quite difficult to operate on the anchor piles **28** from the edge of the platform.

The manner in which the present invention is employed to overcome these difficulties is illustrated in FIGS. **7–15.** In FIG. **7** there is shown an unanchored tower template **20** resting in upright position at a desired location on the sea bottom **26.** A floating construction barge **74** is towed, by means of a tug **76,** toward the template. As can be seen in FIG. **15,** the barge **74** is provided with a construction crane **78** for handling piles and other equipment, a plurality of pile drivers **71,** grout mixing and pumping equipment **82,** storage and supply areas **84,** crew quarters **86** and a helicopter pad **88.** The barge is also provided with hydraulic jacking devices **90** similar to the jacking assemblies **54** of the platforms **22.** Those jacking devices are also provided with associated jacking tubes **92** which can be erected and secured to the bridges **62** atop each of the template legs **30.** As shown in FIG. **8,** after the barge **74** has been towed up to the template **20,** it is moored loosely between the template legs **30.** The barge **74** is considerably lighter than the platform **22** and it does not extend beyond the legs of the template. The barge jacking tubes **92** are erected and secured to the bridges **62** on the template. The jacking devices **90** are then actuated in the same manner as described above in connection with the platform jacking assemblies **54,** to lift the barge up out of the water, as shown in FIG. **9.** Thereafter, as shown in FIG. **10,** pile driving and grouting operations are carried out from the barge **74** using the equipment and supplies carried on the barge. It will be appreciated that during these operations the barge **74** is free of wave and other water action so that the pile installation operations can be carried out rapidly and efficiently. Also, it is possible to carry out these installation operations at each of the various template legs **30** simultaneously.

After the anchor piles **28** have been fully installed, the jacking devices **90** are actuated in reverse manner to lower the barge **74** back to water level as shown in FIG. **11.** Thereafter the jacking tubes **92** are disconnected and the barge is towed away from the now secured template **20.** As shown in FIGS. **13** and **14,** the large permanent platform **22** is then towed to the template and raised up onto it as previously described. After the template has been raised to its ultimate height, it may be permanently secured to the template legs by welding or other equivalent means; and then the

jacking tubes **60** and related equipment may be removed.

Instead of installing a completed platform **22** as a unitary structure on the template **20,** it is possible with the now securely anchored template to assemble the platform **20** in place by separately lifting individual platform segments or modules **22***a*, **22***b* etc. up onto the template from a floating derrick **96** moored alongside the template as shown in FIG. **16.** These platform segments are separately constructed on-shore where all necessary deck equipment, etc., is built in advance. The modules are then floated out to the template after it has become anchored in place.

It will be appreciated that the above described technique, in addition to allowing a rapid and safe installation of template anchor piles, also provides a test and rehearsal procedure whereby potential inadequacies in either equipment or procedures can be identified before the actual platform lifting operations begin.

Although particular arrangements for carrying out the invention are herein disclosed for purposes of explanation various modifications thereof, after study of this specification, will be apparent to those skilled in the art to which the invention pertains.

What is claimed and desired to be secured by Letters Patent is:

**1.** A method of erecting an offshore tower comprising the steps of positioning a template on a sea bed with the upper end of the template extending above the sea surface, floating a barge out to the template and positioning the barge between the legs of the template, jacking the barge up on the legs of the template and out from the water, driving anchor piles from the barge down through the bottom of the template and into the sea bed to anchor the template in place on the sea bed, thereafter lowering said barge to a floating position, floating said barge away from said template, floating a permanent tower platform to the anchored in place template and jacking the platform up on the template to a raised position above the surface of the sea.

**2.** A method of erecting an offshore tower comprising the steps of positioning an elongated open framework supporting structure in upright position at a predetermined location on the sea bed with the upper end of said structure extending up beyond the level of the sea water, mooring a floating platform in between the legs of said structure and then jacking said platform up onto said structure and out of the water, operating from the thus raised platform to anchor the bottom of said structure to the sea bed, thereafter lowering the platform and replacing same by a large permanent raised platform.

**3.** A method according to claim **2** wherein the barge is jacked up on jacking tubes secured to the upper ends of the template and extending down alongside legs of the template.

**4.** A method according to claim **2** wherein the template includes a plurality of legs and wherein operations anchoring several of said legs are carried out simultaneously.

**5.** A method of erecting an offshore tower comprising the steps of positioning a template on a sea bed with the upper end of the template extending above the sea surface, floating a barge out to the template and positioning the barge between the legs of the template, jacking the barge up on the legs of the template and out from the water, driving anchor piles from the barge down through the bottom of the template and into the sea bed to anchor the template in place on the sea bed, thereafter lowering said barge to a floating position, floating said barge away from said template, floating a plurality of separate platform modules out to the anchored template and lifting the modules onto the template and assembling them in place thereon.

**6.** A method of erecting an offshore tower according to claim **5** wherein said modules are raised onto said template by means of a floating derrick moored alongside said template.

* * * * *

# UNITED STATES PATENT OFFICE
# CERTIFICATE OF CORRECTION

Patent No. 3,857,247 Dated December 31, 1974

Inventor(s) LINDSEY J. PHARES

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

Title page, under number [75], "Lane" should read -- Land --.

Signed and sealed this 15th day of April 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
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