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Hafskjold

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[54] **BREAKWATER DEVICE FOR OFFSHORE SUBMERGED FOUNDATION STRUCTURES**

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[30] **Foreign Application Priority Data**

June 13, 1972 Norway 2083/72

[52] **U.S. Cl.** **61/46.5;** 61/1; 61/5; 61/50

[51] **Int. Cl.**[2] **E02D 27/38;** E02B 3/04

[58] **Field of Search** 61/5, 3, 4, 2, 46.5, 46, 61/50

[56] **References Cited**

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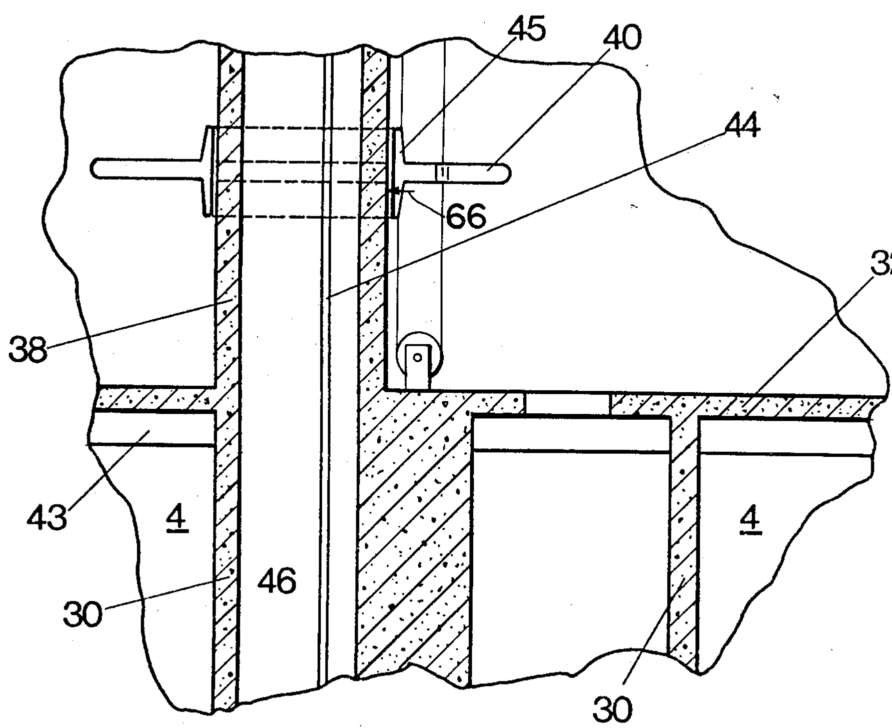
[57] **ABSTRACT**

A submarine foundation and offshore working platform comprising a submersible integral concrete structure adapted to be situated on the sea bottom and having hollow spaces for confining ballast, oil, water etc. Said structure comprises a plurality of vertically arranged cylindrically shaped lower hollow bodies bound together in the contacting areas, and on the overside of said bodies a plurality of platform supporting columns extending above sea level and carrying a platform structure. The columns are provided with breakwater means which comprises a disk-shaped structure slidably mounted thereon.

3 Claims, 7 Drawing Figures



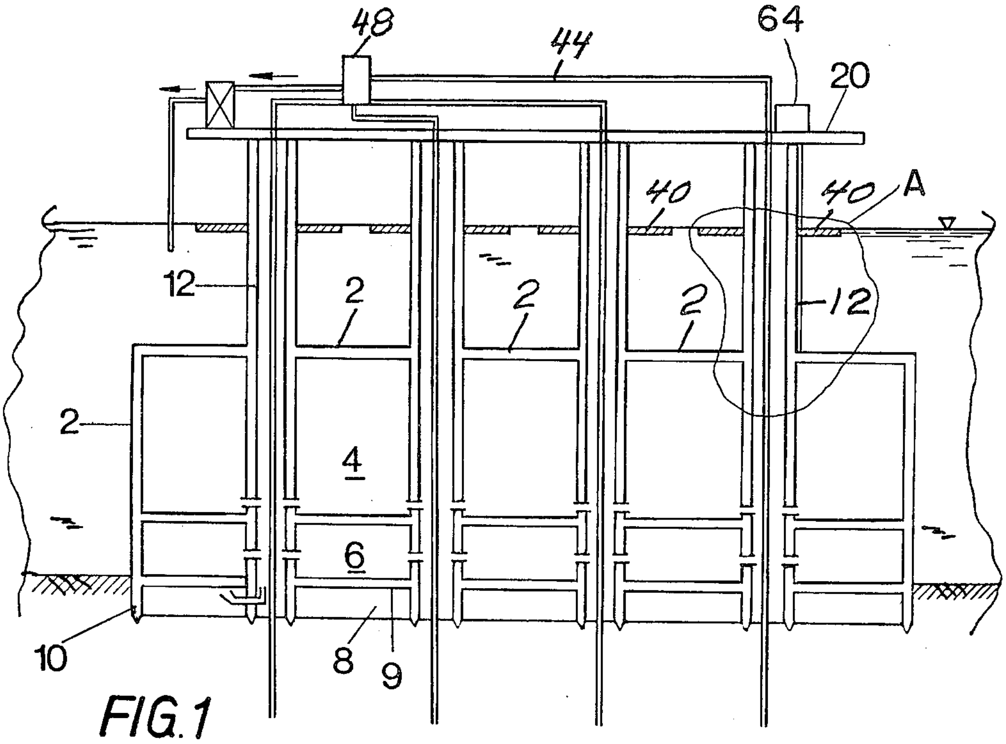


FIG. 1

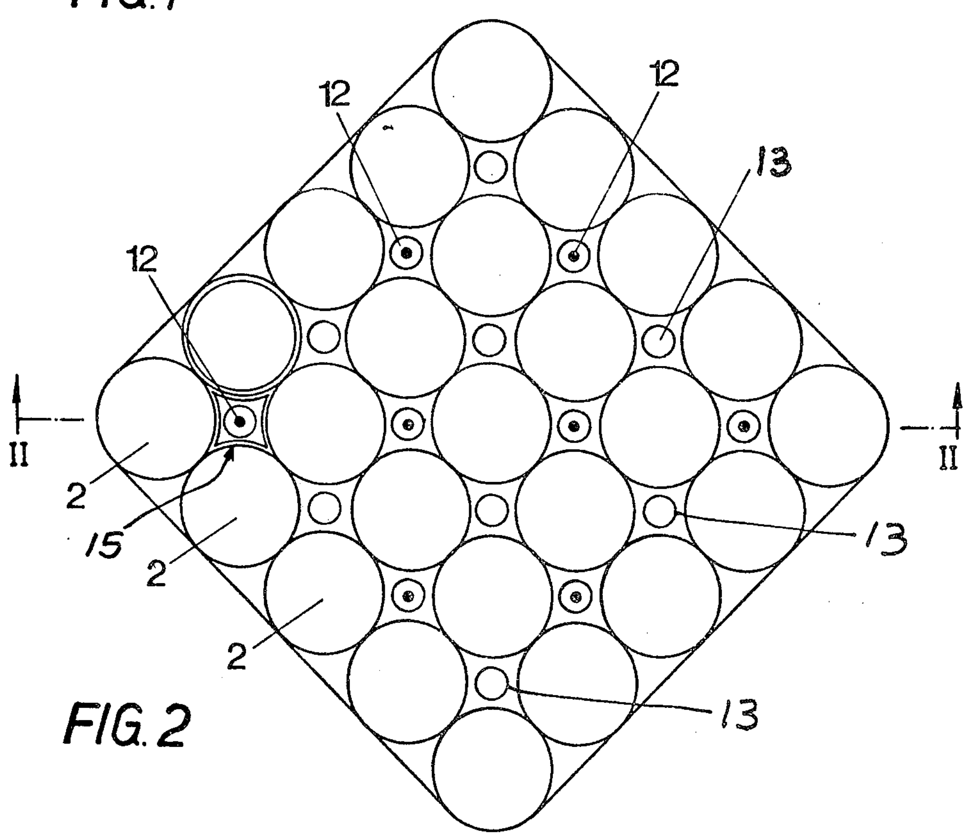


FIG. 2

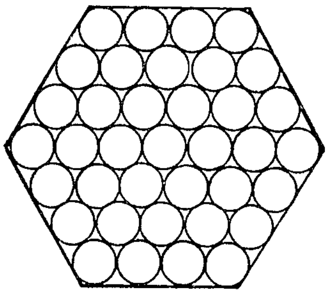


FIG. 3

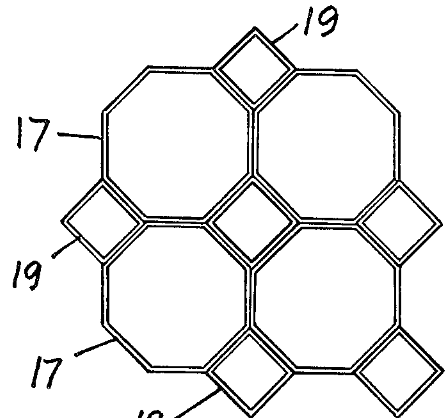


FIG. 6

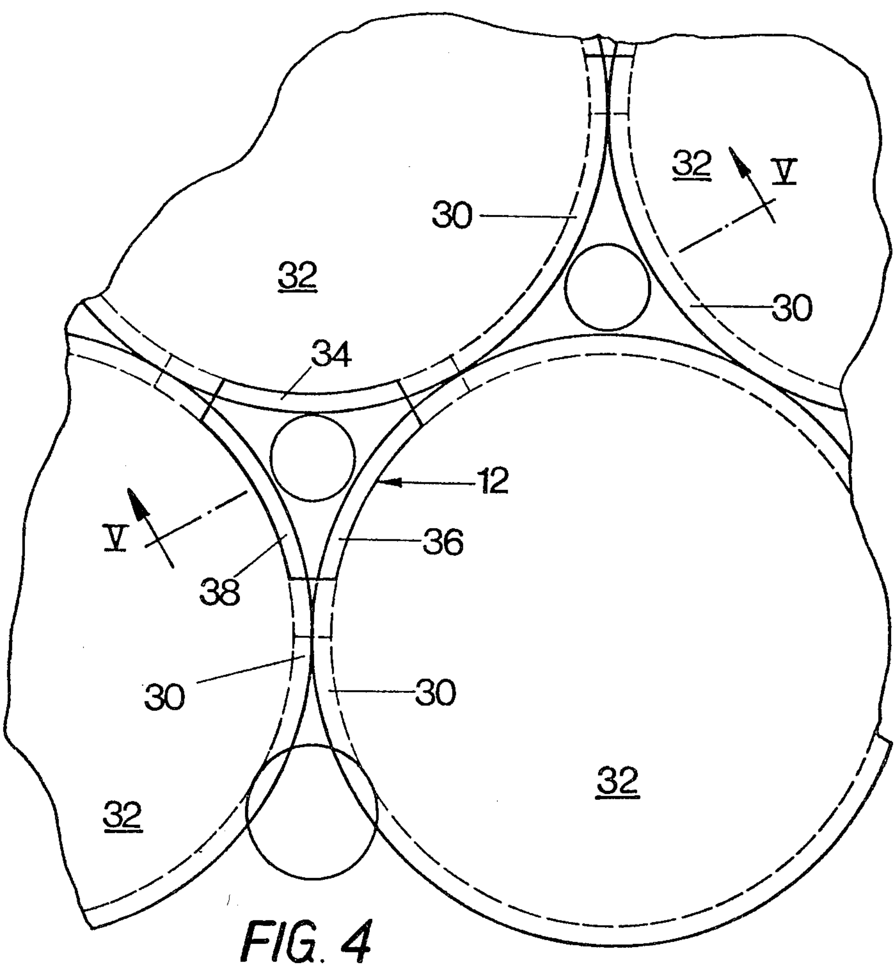


FIG. 4

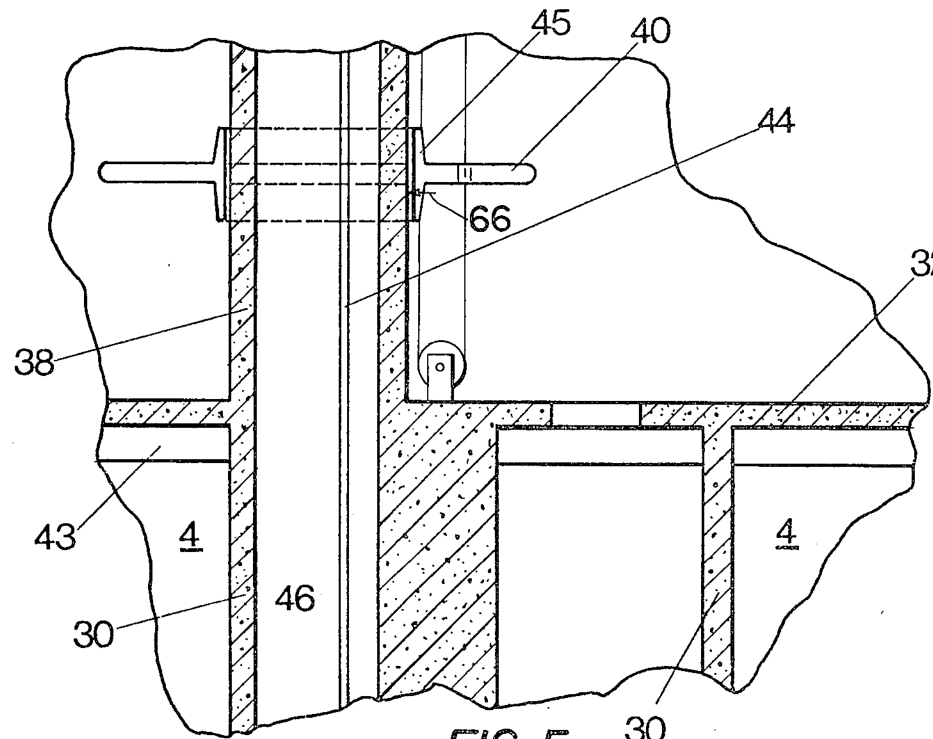


FIG. 5

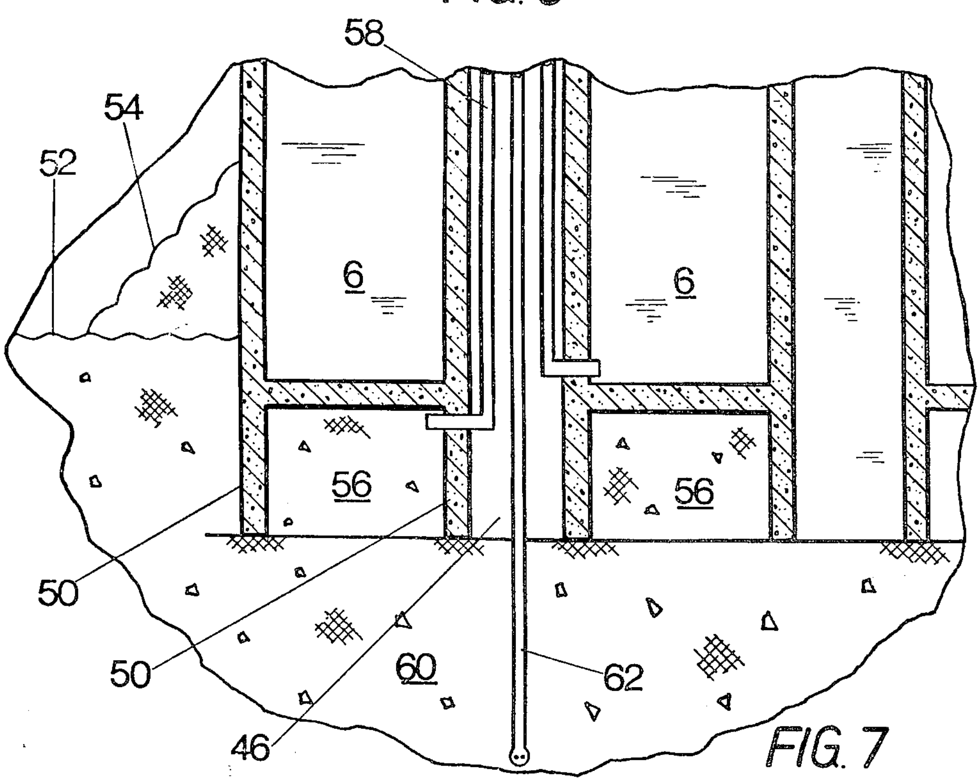


FIG. 7

BREAKWATER DEVICE FOR OFFSHORE SUBMERGED FOUNDATION STRUCTURES

This is a division of application Ser. No. 369,694 filed June 13, 1973.

The present invention relates generally to a new design for a submarine foundation, particularly developed to be used in connection with offshore oil production and oil storage, and particularly developed for underwater storage of oil in relatively shallow sea vicinities, having depths up to 100 to 150 meters.

The invention relates particularly to a supporting column and breakwater structure for submarine foundations.

When in the following specification reference is made to a "submarine foundation", it shall be understood that the foundation, if desired, may include tanks for the storage of oil and may be of the type comprising a plurality of mutually separated, submerged vessels which can be utilized for storage of oil and/or ballast, and which further include parts which extend above the sea level and can be utilized as a working platform, housing mechanical equipment, forming a pier fundament, etc.

It is today known several designs for structures of the above mentioned type. Of somewhat older date are known structures made in steel, while in the later years there is developed foundations and tank constructions made in reinforced concrete. A special problem in connection with steel structures is that the structures possess a large positive buoyancy and must thus be provided with particular ballast in order to be stabilized when submerged. Wholly or partly submerged steel constructions must therefore in many cases be furnished with particular ballast spaces which are filled with sand or the like, and must still be provided with special anchoring in order to bind the tank construction to the sea bottom. The corrosion problem implies also a substantial objection to structures of steel, especially with regard to the danger for oil leakages.

A substantial advantage with constructions made in reinforced concrete rests in that the concrete material makes it easier to give the construction the desired weight, and furthermore one avoids the corrosion problem.

Generally one can say that in building underwater foundations designed for the storage of oil and which preferably shall include a structure above the sea level, it is the experience that the wave stresses and loads imply the most substantial problem. Both directly and indirectly the wave loads imply a danger for that the structure may be damaged presenting a risk for oil leakages, a fact which in view of the relative large oil quantities here spoken of, can result in extensive contaminations and pollutions, deterioration of the fish life, beach areas etc. Safety measures constitute therefore a decisive factor when designing submarine and underwater foundation which also shall be utilized for offshore storage of oil. From a point of view of safety there is again several factors which count, among others one must as far as possible avoid the risk for damages in consequence of collision with ships. Damages in collision with ships may happen in result of a direct collision and in result of a damage caused by a ship anchored to the foundation. Wave actions may otherwise result in direct damages on the structure, particularly the structure above sea level, and may in fact result in that the

entire foundation structure is moved, such as being lifted from the sea bottom or being displaced laterally. It is today known that the wave forces which such structures are subjected to, may be of a vast size. As an example may be mentioned that in the North Sea one may reckon with wave heights up to 20 meters, and that the wave forces on the structure then may act all the way down to the sea bottom at depths of about 100 meters.

With the aim to provide sufficiently stable submerged structures of the type resting on the sea bottom one has hitherto generally solved the problem by giving the foundation sufficient width and length relative to the height and the water depth, simultaneously as the foundations are given sufficient weight, with or without a load of oil.

The object of the present invention has primarily been to provide a new type of structure presenting a large ability to withstand wave actions of various kinds, and which furthermore is specially designed to provide an effective attenuation of the surface waves, in order to thereby increase the usability of the structure as a working platform and as a harbor location for ships.

Further aims for the invention are to provide a construction which to a large degree fulfils the needs for safety measures, particularly in respect of the risk for damages, and possible oil leakages.

A further object of the invention is to provide a construction which simultaneously is attractive from a technical/economical point of view.

The breakwater structure of the invention comprises generally a plurality of upright parallelly located supporting columns extending from a depth below the wave action zone in the sea and to a level above the sea, each of said columns provided with a disk-shaped, substantially horizontally extending structure supported by and encompassing slidably at least a number of said supporting columns, the disk-shaped structures operable to be positioned in any desired level on the columns.

The submarine foundation in accordance with the invention includes also other important features which will appear from the following specification, wherein the invention shall be described with reference to the accompanying schematic drawings illustrating some embodiments of the invention, and wherein:

FIG. 1 is showing a schematic cross-section through a foundation construction equipped with a breakwater structure in accordance with the invention, said section taken along the plane II—II in FIG. 2, and

FIG. 2 is showing a plan view of the construction shown in FIG. 1,

FIG. 3 is showing a plan view of a preferred embodiment of the invention, and

FIGS. 4 and 5 are detail views which in an enlarged scale are showing a plan view and a lateral view of part of the construction shown in FIG. 3, respectively; FIG. 5 showing an elevational section of the region denoted A in FIG. 1.

FIG. 6 is likewise showing a schematic plan view of a part of a further embodiment of the invention.

FIG. 7 is showing a detail view in vertical section and showing the bottom portion of the construction and illustrating how the foundation may be bound to the sea bottom ground.

In FIGS. 1 and 2 the numbers 2,2 etc. designate a number of the socalled main cylinders, which are cast to each other side by side in a right angle positional relationship such that the foundation attains for instance a rectangular or preferably square circumference viewed in plan view such as shown in FIG. 2.

The main cylinders are cast together along all adjacent contact faces along a suitable wide range or arcs. The main cylinders are in upright direction in the illustrated construction divided into three compartments namely an upper tank space **4**, a ballast space **6** and a downwardly open foundation space **8** which is formed in that the bottom wall **9** of the ballast space is drawn upwards from the cylinder side walls **10** at the bottom, whereby is formed a plurality of "suction cups" along the bottom side of the construction.

From the top side of the main cylinders are provided supporting columns **12,12** etc., which are built upon the adjacent wall sections of an adjacent group of the main cylinders such that the walls of the supporting columns or outer parts of same constitute a geometrical continuation of the below located wall parts of the cylinders. In the shown construction the side walls of the supporting columns are thus constituted by four circular arcs viewed in plan view as indicated at **15** in FIG. **2.** In practice it may be suitable to modify the cross-sectional shape of the main cylinders such that the same are shaped as octagons or modified octagons **17** such as shown in the detail view, FIG. **6**, whereby the supporting columns **19** attain square cross-sectional shape. All wall sections in the main cylinders as well as in the supporting columns may then be given the same width, whereby among other advantages is obtained that one may operate with a standard module, simplifying the productional equipment and the concrete form work.

To position the supporting columns between adjacent main cylinders implies several substantial advantages, namely firstly that the side walls of the main cylinders may be directly utilized as supporting parts for the supporting columns and in fact may constitute a direct continuation of the main cylinder structure. Furthermore is provided a continuous space in the form of a shaft extending from the top of the supporting columns at the platform down to the bottom of the foundation, which shaft can be utilized for positioning pipelines etc. to the various tanks and spaces in the main cylinders. Furthermore these shafts may be utilized for positioning special pipe lines which may serve to increase the pressure between the base of the foundation and the sub layer, that is the sea bottom, by providing a sub-pressure below the main cylinders. This feature of the invention shall be described later in detail.

A special advantage of the construction rests in that the size of the supporting columns, and the shape and positioning of same imply the possibility to arrange a very effective breakwater structure, simultaneously as the construction will not in a substantial degree hinder water flow between the supporting columns.

It is not necessary to provide the foundation construction with supporting columns between all adjacent groups of the main cylinders. In the embodiment shown in FIG. 2 one has thus provided supporting columns at the shown places **12,12** etc., that is such that about one half of the spaces are provided with supporting columns. In those spaces **13,13** etc. where columns are not provided, the foundation is provided with a concrete flooring, possibly with openings, and which suitably is cast flush with the top walls of the main cylinders, such that these spaces may be filled with sea water. The same will count for the shafts through the supporting columns, since same are usually open at the bottom and thus sufficiently vented at the top at the platform **20.**

The embodiment shown in plan view in FIG. **3** is hexagonal, but other shapes may be visualized, for instance triangular, such that all angles between intersecting center lines between the main cylinders will be 60°, the supporting columns also attaining generally triangular shape.

FIGS. **4** and **5** constitute respectively a plan view and a lateral view seen in section along the plane V—V in FIG. **4** and the Figures are showing typical features of the foundation shown in plan view in FIG. **3.**

The reference numbers **30,30** are designating the walls of the main cylinders, **32** the roof of the main cylinders, while **12** designates the supporting columns the walls of which **34,36, 38** as shown constitute geometrical continuations of the below located parts of each of the adjacent main cylinders. A constructional advantage of this design is that the weight of the supporting columns, the platform and the equipment of same will be transferred down to the sea bottom via the walls of the main cylinders as simple compression forces, a fact which among others implies that the roof construction of the main cylinders only can be given the strength necessary to withstand the difference between the internal and the external pressures (water head). The roofing on the main cylinders may preferably be made of reinforced concrete provided with beams **43** on the underside.

On the supporting columns may in accordance with the invention be provided special breakwaters in the shape of disks **40** which preferably are supported in hoistable- and lowerable slide guides **45.** A hoist **64** is provided at the top of the supporting columns to raise and lower the disks **40** as desired. Locking means **66** are also provided, so that the disks may be positioned at the desired elevational level, usually in the level on the sea surface. The number **44** is designating generally the pipelines etc. positioned in the shaft **46** extending through the supporting columns, and which pipes etc. serve as a connection from the equipment **48** in question positioned on the platform (FIG. **1**) down to the various tank spaces in the hollow cylinders and to equipment located at the bottom of the foundation and possibly below same. When the foundation structure is transported to the pre-selected location and has been submerged and anchored, the shafts between the so-called main cylinders may be filled up with sea water, likewise a desired number of the tank spaces in the cylinders are filled with sea water with the aim to reduce the buoyancy of the foundation structure. The shafts between the cylinders not provided with columns, may have open bottoms such that the shafts are automatically filled with sea water during the submersion.

FIG. **7** is a detailed sectional, enlarged view illustrating a typical part of the bottom section of a foundation structure as shown in FIG. **1.** As shown the downwardly protruding, free-standing portions of the walls **50,50** of the cylinders are moved a distance down into the sea bottom, here designated with the number **52,** partly by means of the weight of the foundation, partly in that the sea bottom below is removed in a desired degree (it is here pre-supposed that the sea bottom is not consisting of stone or rock). On the outside of the cylinders located along the circumference of the foundation is preferably positioned a stabilizing dike **54,** for instance by dumping down stones and gravel. The free-standing wall sections **50,50** on the cylinders are in direction downwards defining downwardly open spaces **56** which as previously mentioned constitute suction cups directed against the mass underneath, and these spaces may by means of pipings **58** be connected to a vacuum pump plant on the platform and subjected to a state of vacuum. Preferably one has furthermore via the shafts **46** pressed down into the ground **60** special suction pipes **62,** which may be positioned therein by making bore holes or alternatively these pipes may constitute a drill pipe string.

At the bottom end these pipes are provided with openings such that the ground below the sea bottom also may be subjected to a state of sub-pressure having into effect that the entire foundation structure in fact will be pressed against the sea bottom. Practically speaking one has hereby made the entire foundation structure heavier, since the part of the sea bottom below the foundation which is maintained to a vacuum will constitute part of the real weight of the foundation structure. These means will to a large degree increase the stability of the foundation structure and thus contribute to the anchoring of the foundation to the sea bottom.

A further advantage with the suctions cups **56** and the suction means **58** and **62** rests in that same may be utilized to release the foundation from the sea bottom when same shall be elevated and brought up to a floating condition, for instance in order to be transported to another location. The suction cup spaces **56** and the sea bottom are then subjected to high pressure by means of compressed air or compressed water.

In regard the dimensions of the foundation these must be adapted to the sea depths in question and the desired storing capacity for oil. In regard the question of safety and the breakwater effect it is preferred that the distance from the sea level down to the top wall of the main cylinders at least is approximately 15–20 meters. The height of the cylinders should obviously be conformed to the local conditions. The same counts for the number of supporting columns relative to the number of cylinders. Normally it will be suitable to provide supporting columns at about each second one of the confined areas between an adjacent group of cylinders. In order to further reduce the danger for damage of the foundation with oil leakages in result it may further be practical to utilize those cylinders positioned along the circumference only as ballast spaces, for instance by filling same with water or sand.

In regard the supporting columns these are inherently with the general design given a sidewall presenting a number of faces preferably having concave form, a shape which is obtained by utilizing the shape of the areas between any selected group of the cylinders. Confer the configuration illustrated in FIGS. **2** and **4.** A such shape will result in the particular effect that the wave flows are diverted or directed laterally, whereby the waterflow may hit against oppositely directed wave flows from other supporting columns, whereby wave forces are dissipated. In regard the disks positioned on the columns, same may in many cases with advantage be shaped as lenses seen in cross-section and may in some instances be designed such that they have a tilt. In any event, the disks **40** are rigidly fixed to the slide guides **45** so that the disks are fixed against tilting movement with respect to the supporting column.

What is claimed is:

1. An offshore submerged foundation structure comprising:

vertical supporting columns extending from below sea level up to a working platform above sea level;

at least one breakwater device comprising a collar member defining an opening through which one of said supporting columns extends and a disk-shaped element secured rigidly to and surrounding said collar member;

hoist means mounted on said structure and secured to the breakwater device to raise and lower the breakwater device along said one supporting column; and

releasable locking means locking the breakwater to said one supporting column at a selected position therealong.

2. A structure as claimed in claim **1,** wherein said one supporting column has a generally sqaure cross-section, each side of said cross-section being concavely curved, and the collar member conforms to the configuration of said one column.

3. A structure as claimed in claim **1,** wherein said one supporting column has a generally triangular cross-section, each side of said cross-section being concavely curved, and the collar member conforms to the configuration of said one column.

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