United States Patent

Romlet et al.

[15] **3,680,275**

[45] **Aug. 1, 1972**

[54] **UNDERWATER STORAGE TANKS**

[72] Inventors: **Jean Romlet,** La Celle Saint-Cloud; **Armand Cimadevilla,** Neuilly Chauts de Seine, both of France

[73] Assignee: **Societe Anonyme Des Entreprises Leon Ballot,** Paris, France

[22] Filed: **Dec. 29, 1969**

[21] Appl. No.: **888,656**

[30] **Foreign Application Priority Data**

Dec. 30, 1968 France 181997

[52] **U.S. Cl.** ..... **52/227,** 52/236, 220/1 B

[51] **Int. Cl.** **E04c 1/40,** E04h 7/20

[58] **Field of Search** ..... 52/169, 742, 249, 223, 248, 52/227–229, 236, 259, 251, 136, 138, 79; 220/1 B

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Primary Examiner—Frank L. Abbott
Assistant Examiner—James L. Ridgill, Jr.
Attorney—Holcombe, Wetherill & Brisebois

[57] **ABSTRACT**

This invention relates to a reservoir suitable for immersion in the sea or like surrounding medium and is mainly intended for the storage of hydrocarbons. The reservoir is formed from elements prefabricated in two-dimensionally prestressed concrete which are held together by a structure of three-dimensionally prestressed concrete. The reservoir is preferably of cellular structure and is adapted to rest freely on the sea floor.

1 Claim, 13 Drawing Figures

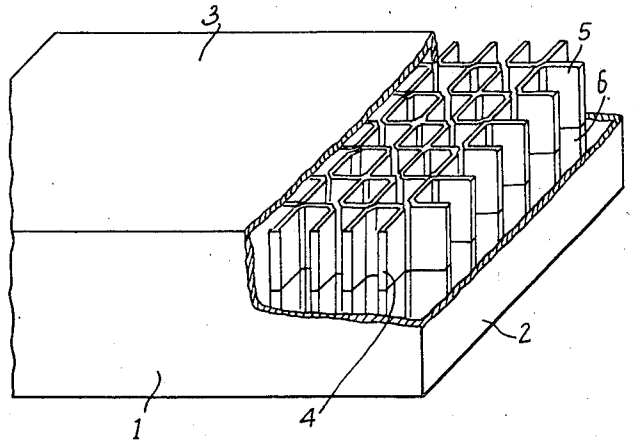


Fig:1

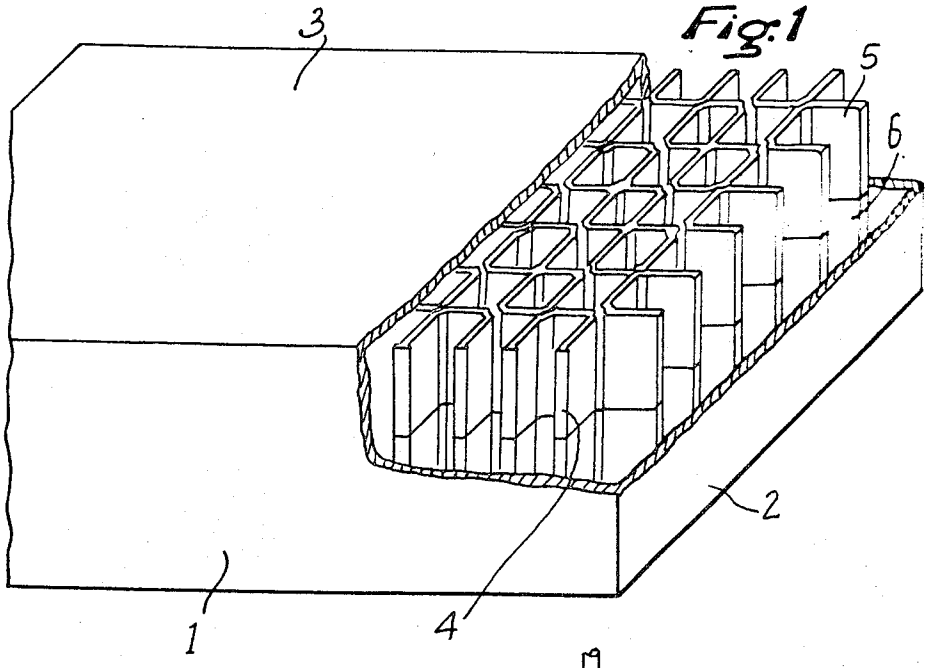


Fig:5

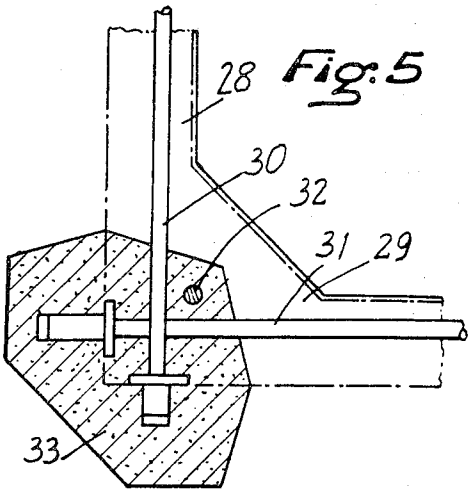


Fig:4

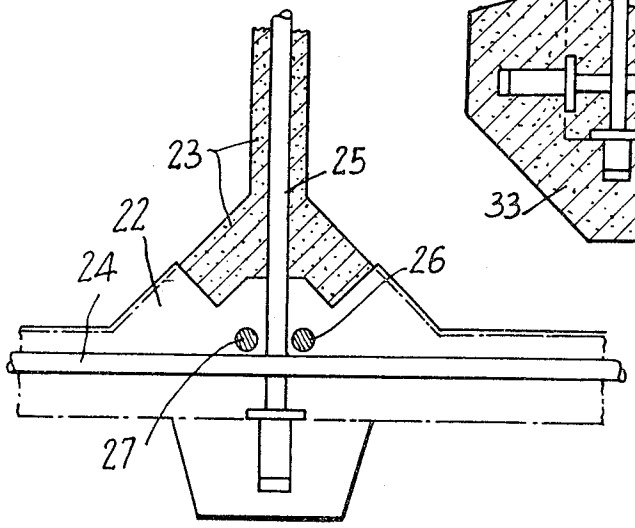


Fig. 2

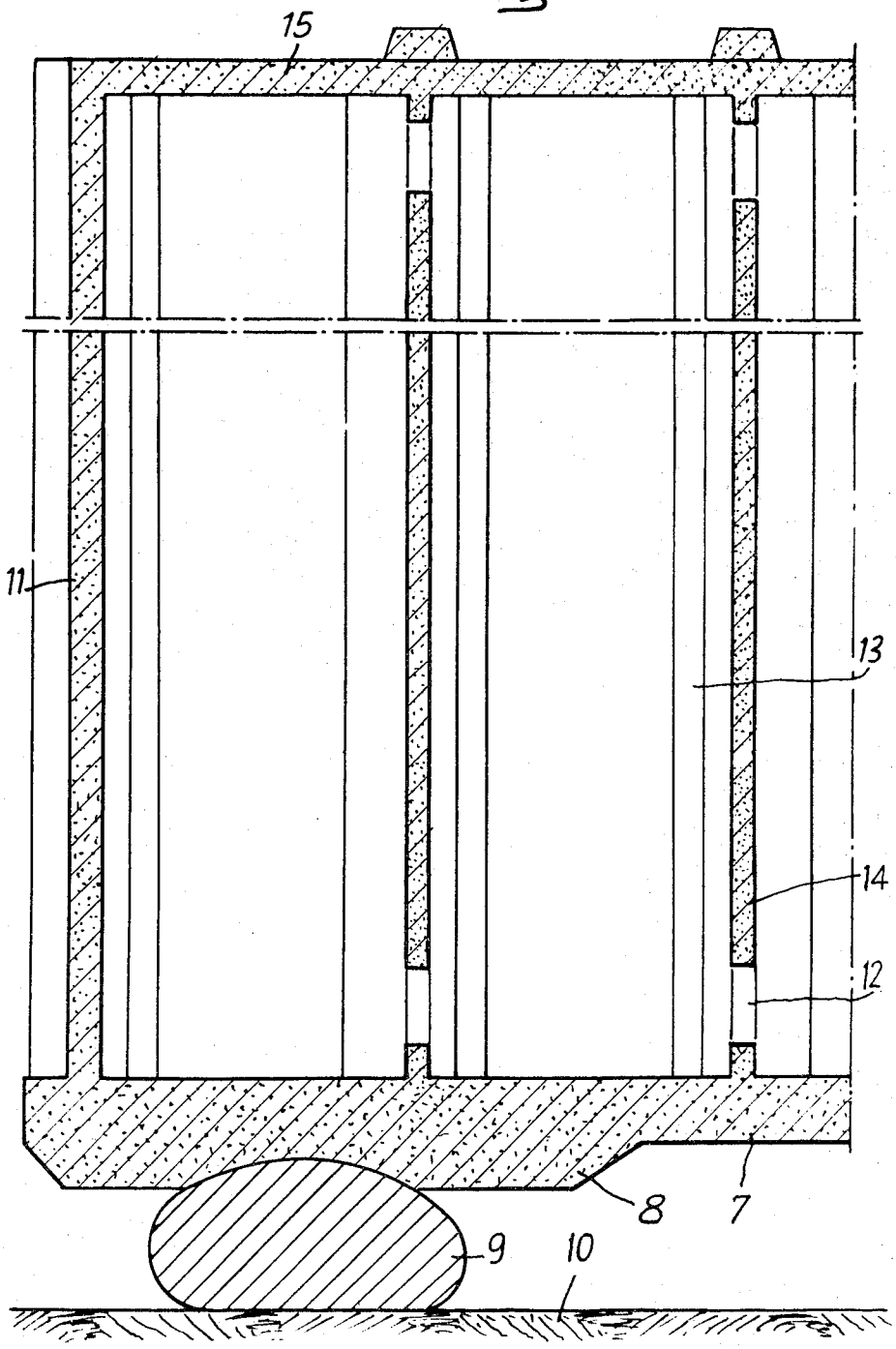


Fig: 3

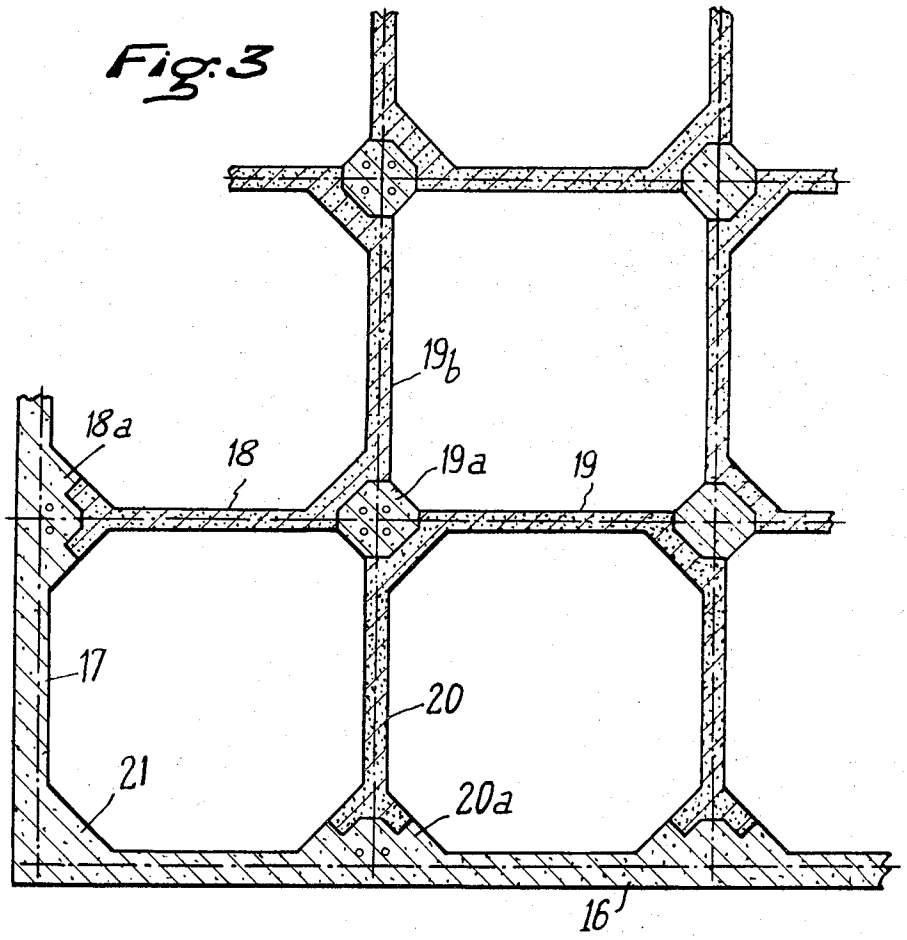


Fig: 6

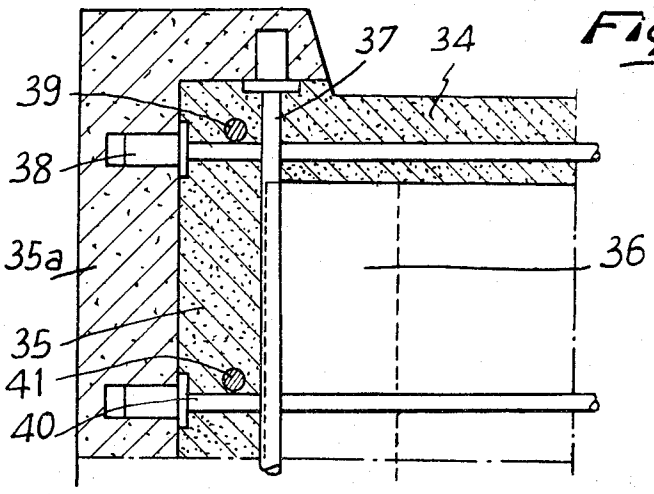


Fig: 7

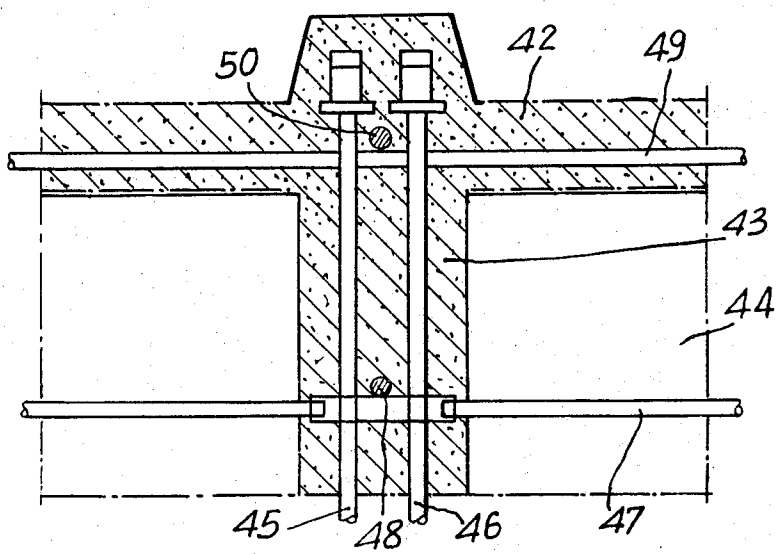


Fig: 8

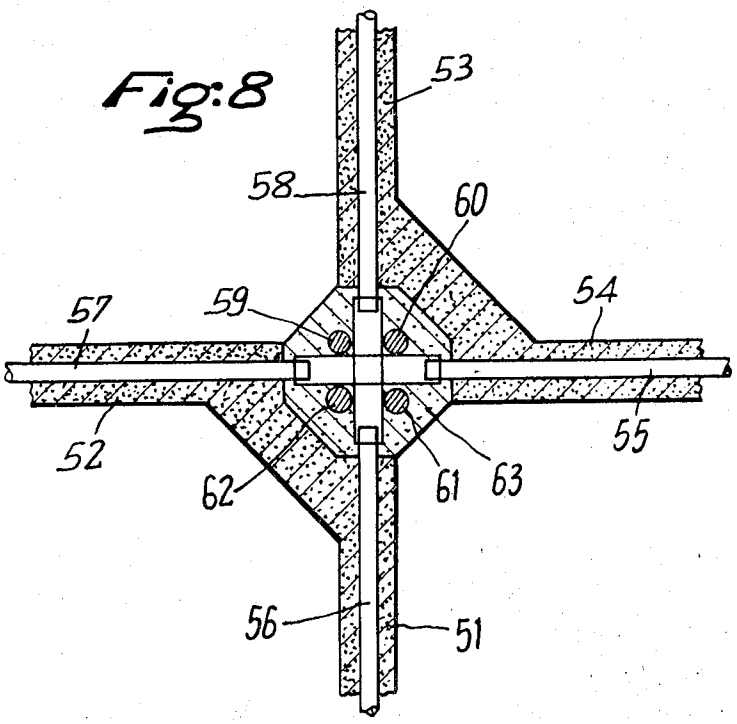


Fig: 9

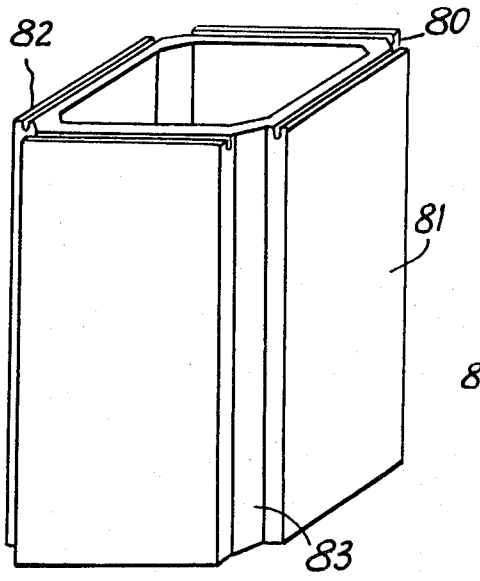


Fig: 10

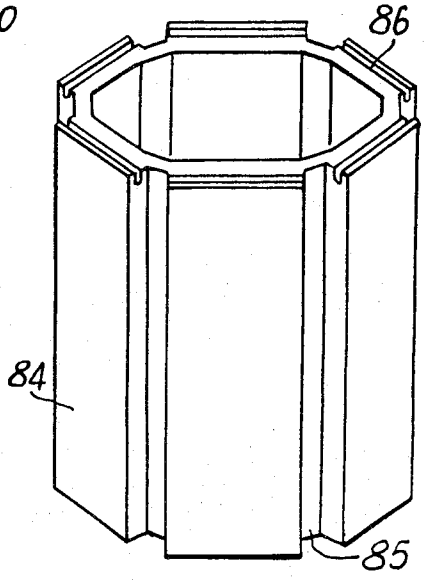


Fig: 11

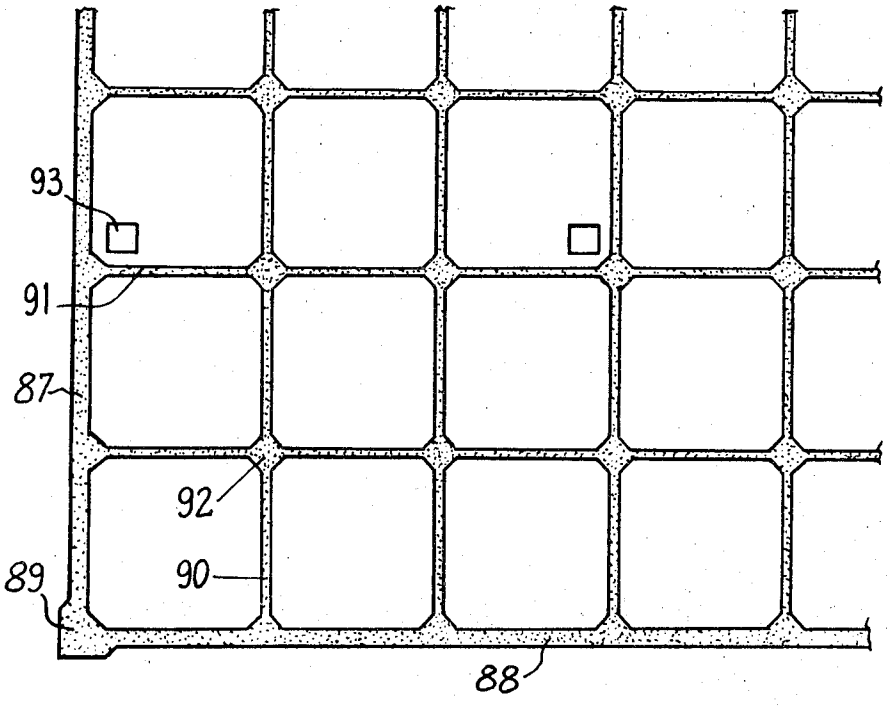


Fig:12

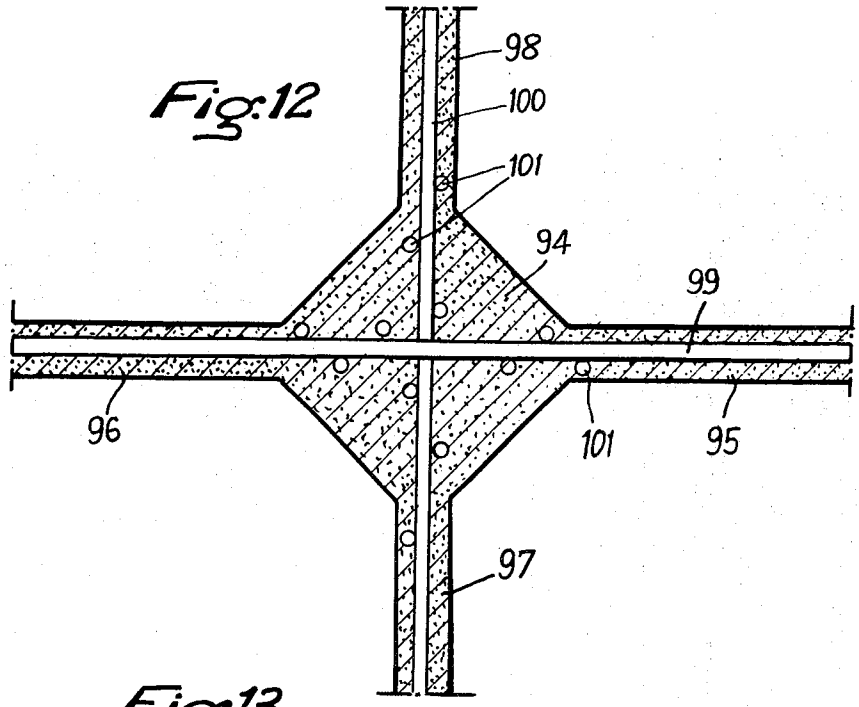
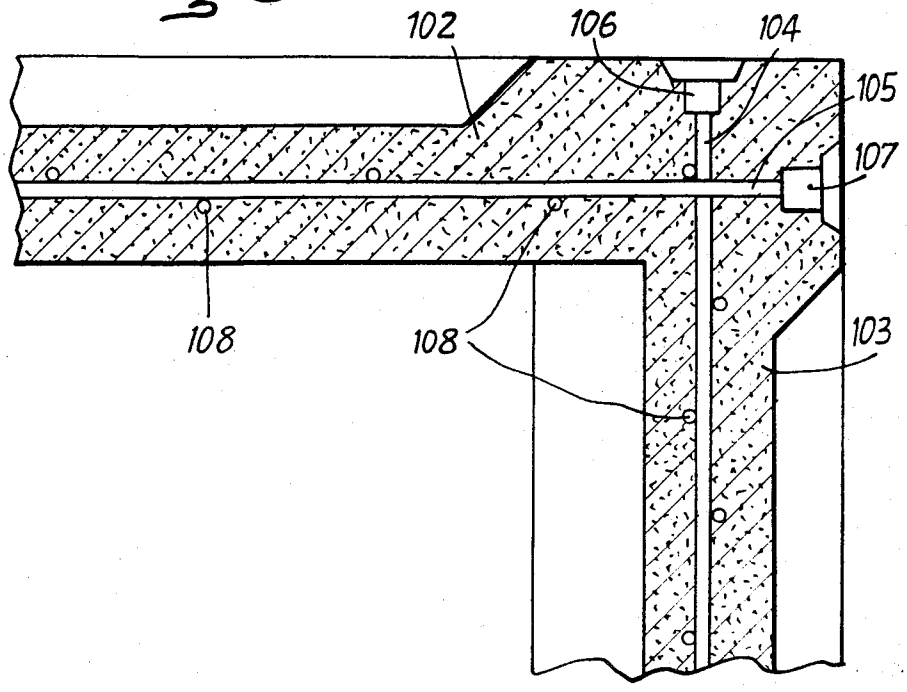


Fig:13



UNDERWATER STORAGE TANKS

SUMMARY OF THE INVENTION

This invention relates to reservoirs which are mainly intended for the underwater storage of hydrocarbons, the said reservoirs being preferentially formed of elements prefabricated in two-dimensionally prestressed concrete, the said elements being connected by a structure consisting of three-dimensionally prestressed concrete.

The invention provides a reservoir which can rest freely on the sea bottom and which ensures its own stability with respect to the stresses to which it is subjected, particularly by the effects of density variation due to the filling with the hydrocarbons and to the swell.

The invention also provides a reservoir which, when positioned on the sea bottom, is capable of resting on any point of the surface capable of serving as a support.

The reservoir of the invention is of cellular structure, composed of a plurality of prismatic elements of any polygonal section, the said elements being connected together by three-dimensionally prestressed junction members which are cast inside spaces left empty between the prismatic elements.

According to the invention, a reservoir for storing fluids is provided comprising a series of prefabricated elements of polygonal form attached together or integral by means of a three-dimensionally prestressed structure to ensure the rigidity of the reservoir in three perpendicular directions.

Further according to the invention, the prestressed structure is formed of a floor or lower base surface of suitable thickness for resisting the applied forces, possibly comprising reinforcements intended to be used as a support zone, the said floor being two-dimensionally prestressed, peripheral walls which are two-dimensionally prestressed; prestressed pillars made up of elements of polygonal form; a two-dimensionally prestressed cover closing the effective volume of the reservoir and receiving openings necessary for the operation of the reservoir and in particular an inlet intended to receive a control unit to which are connected all the supply and storage pipes for the stored fluids and the the supervisory equipment.

In a preferred embodiment, two series of internal parallel partitions are provided which cross one another, to divide the enclosed space in the reservoir into a number of elementary standard compartments, and comprising a first series of openings formed in the internal partitions in the vicinity of the floor and a second series in the vicinity if the cover, permitting the horizontal circulation of the hydrocarbons and the water between the different adjacent vertical compartments.

The size of these openings are dependent on the delivery rate of the supply members, so as not to disturb the hydrocarbon-sea water interface.

In one preferred embodiment of the reservoir, the floor, the cover, the walls and the internal partitions are made of two-dimensionally prestressed concrete, connected together in such a way that the whole of the reservoir is three-dimensionally prestressed, the internal partitions being formed of prefabricated hollow prisms with a polygonal base, the said prisms being assembled and integrated into the prestressed reinforced concrete structure, ensuring the lateral closure of the reservoir, the rigidity being given by the prestressing elements anchored in the structure.

The capacity of the reservoirs of this type is unlimited and it is possible to obtain reservoirs having a very large volume.

The external walls can be made of a material which ensures a complementary tightness, either by means of metal, or by means of epoxy-type resin or a mixture of pitch and epoxy-type resin. These fluid-tight layers can be applied both to the interior and the exterior of the enclosed space.

The two embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 shows a reservoir of the invention, part of which has been shown cut away.

FIG. 2 is a vertical section of a part of the reservoir.

FIG. 3 is a horizontal section of part of the reservoir.

FIG. 4 shows the connection of an internal partition to an external wall.

FIG. 5 shows the intersection of two external walls.

FIG. 6 shows the intersection of two external walls of the reservoir with the floor.

FIG. 7 shows the intersection of an internal partition with the cover and with an external wall.

FIG. 8 shows a junction of internal partitions.

FIG. 9 shows a prefabricated element adapted to serve for the construction of the internal part of the reservoir.

FIG. 10 shows a prefabricated element with a hexagonal base.

FIG. 11 shows a part of a reservoir consisting of prestressed concrete and obtained by direct casting.

FIG. 12 shows an intersection of internal partitions of the reservoir.

FIG. 13 shows an angle of the reservoir.

Referring to FIG. 1, there is shown a vertical external wall 1 of the reservoir, a second wall 2 perpendicular to the wall 1, a cover 3 for the reservoir and vertical partitions 5 and 6. In this way, a cellular reservoir is obtained which is composed of a plurality of standard units each capable of containing a certain quantity of petrol, and communicating with one another through openings situated in the vertical partitions.

In FIG. 2 the floor 7 can be seen which comprises a reinforcement 8 in a zone intended to serve as a support for this floor. An injectable pad or cushion 9 can be fitted into this reinforcement 8 permitting the reservoir to rest on the sea bottom 10. Also shown is a vertical end wall 11 of the reservoir and a vertical partition 14 having inlets 12 permitting two adjacent vertical shafts to be brought into communication. Finally, the cover which is adapted to be simultaneously built into the external wall and the internal walls is shown at 15.

Referring to FIG. 3, two vertical external walls 16 and 17 of the reservoir have internal partitions 18 and 20 connected thereto at junctions 18*a* and 20*a*. These partitions are attached to one another by a prestressed concrete junction 19*a* by which the partitions 18, 19, 20 and 19*b* are made fast with one another. An angle junction is shown at 21.

FIG. 4 shows how an internal partition 23 is attached to an external wall 22. This external wall contains prestressing cables 24 which are parallel to one

another. A series of cables **25**, likewise parallel to one another, are also embedded in the partition **23**. In addition, two cables **26** and **27** perpendicular to the plane of the Figure, are also indicated, and these cables, together with the other cables, ensure a three-dimensional prestressing in the junction.

FIG. **5** shows one corner of the reservoir. The series of cables **30** and **31** are embedded in the walls **28** and **29**, one series of perpendicular cables **32** making it possible to ensure a three-dimensional prestressing in the corner. The anchoring means of the prestressing cables are embedded in junction member **33**.

FIG. **6** represents an angle of the reservoir and includes a horizontal wall **34**, a vertical wall **35** and a vertical wall **36** which is perpendicular to the wall **35**.

A concrete sealing arrangement **35***a* is provided which enables the anchoring means of the prestressing cables to be protected from corrosion. These prestressing cables are shown at **37**, **38**, **39**, **40** and **41** and form, in fact, three orthogonal grids or networks, so that it is clearly apparent that the reservoir is always maintained under three-dimensional stress.

FIG. **7** shows the junction of a partition **43** with firstly the cover **42** and secondly a vertical wall **44** which is perpendicular to the cover and partition. The cable networks **45**, **46**, **47**, **48**, **49** and **50** form three orthogonal networks which also permit a three-dimensional stress to be obtained.

FIG. **8** shows a junction between two networks of internal partitions. These vertical internal partitions are shown at **51**, **52**, **53**, **54**, and the intersection is effected in a nodal element **63**. This nodal element or junction is formed by an element through which extend horizontal prestressing cables **55**, **56**, **57** and **58**. Four vertical prestressing cables are shown at **59**, **60**, **61**, **62**. Thus, three-dimensional prestressing exists at each nodal element or junction, so that the stresses are distributed in every direction in this reservoir.

FIG. **9** illustrates a prefabricated element or standard unit, in which four prestressed concrete partitions are provided in such a way that they form a vertical shaft, having a wall **81**, and a groove **82** by means of which the elements are assembled. A recess **83** permits the casting or pouring of the nodal element or junction for the assembly of the shafts.

A prefabricated element of hexagonal section is shown in FIG. **10**. By means of similar elements, it is possible to provide a network enabling a reservoir for hydrocarbons to be obtained. One wall **84** of the hexagonal hollow prism is contiguous with a recess **85** designed to enclose the pillar in which the prestressing cables are placed. A groove **86** permits the hexagonal elements to be assembled one above the other, so as to provide a vertical shaft.

FIG. **11** illustrates part of a cellular reservoir, of which the elements are of square section. Two external partitions **87** and **88** of the reservoir are provided with a corner piece **89** having a reinforcement designed to seal off the anchoring heads of the prestressing cables. Two series of internal partitions **90** and **91** perpendicular to one another are fitted together inside the reservoir by means of an intersection nodal element **92** which will be discussed in detail below.

An opening **93**, formed in the floor, permits the reservoir to be brought into communication with the outside medium.

The detail of an intersection nodal element or junction of two series of internal partitions is better illustrated in FIG. **12** which shows reinforcing post or pillar **94** which receives four partitions **95**, **96**, **97**, **98**. Two series of cables **99** and **100** are placed in these partitions, the vertical cables **101** being embedded in these partitions and in the pillar **94**. The assembly of these elements is effected during the same concreting operation.

In FIG. **13**, a corner piece of the reservoir is shown in which are embedded two external walls **102** and **103**. Two networks of cables **104** and **105** are placed in these walls. They are brought and maintained in tension by the anchoring heads **106** and **107**. Vertical cables **108** ensure a vertical prestressing and all the cables are disposed inside sheaths, the internal space being filled by an injection of cement mortar.

The operation of these reservoirs is as follows:

Hydrocarbons are supplied to the upper part of the reservoir. The different compartments of the reservoir communicate with one another through two series of openings formed in the horizontal partitions in the immediate vicinity of the cover and the floor.

This series of openings thus permits the distribution of the hydrocarbons throughout the reservoir, the hydrocarbons driving ahead of them the sea water, which can pass through the openings formed in the floor communicating with the external medium, either directly, or by means of pipes discharging at the level of the cover.

I claim

1. A floatable reservoir for the underwater storage of hydrocarbons which is divided into a plurality of compartments and comprises a plurality of polygonal prefabricated two-dimensionally prestressed internal and external concrete wall members, at least one floor member and at least one roof member, said members being connected together by three-dimensionally prestressed concrete junctions to form a reservoir prestressed in three directions perpendicular to each other so as to resist flexing stresses in any direction, with each of said internal wall members defining at least one corner and a plurality of the sides of one of said compartments, said corners being connected by three-dimensionally prestressed vertical junction members, and said internal walls being provided with a first series of openings adjacent said floor member and a second series of openings adjacent said cover, which openings interconnect at least the majority of said compartments.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,680,275 Dated August 1, 1972

Inventor(s) JEAN ROULET and ARMAND CIMADEVILLA

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

[72] Inventors: JEAN ROULET

Signed and sealed this 9th day of January 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

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* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334