Nov. 22, 1960 J. T. HAYWARD 2,960,832

SUBMERGIBLE BARGES WITH ANCHOR SPUDS

Filed Aug. 26, 1955 2 Sheets-Sheet 1

Fig. 1

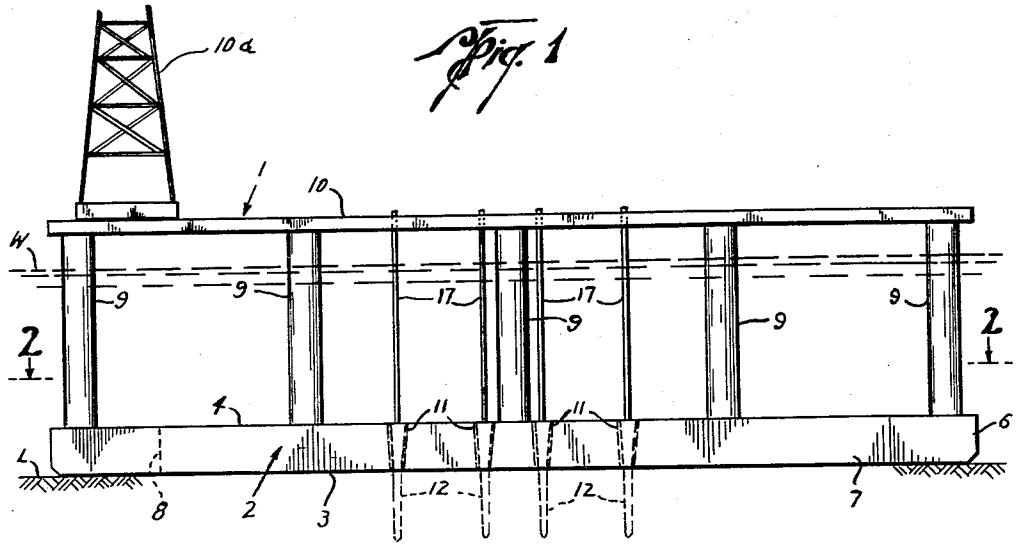
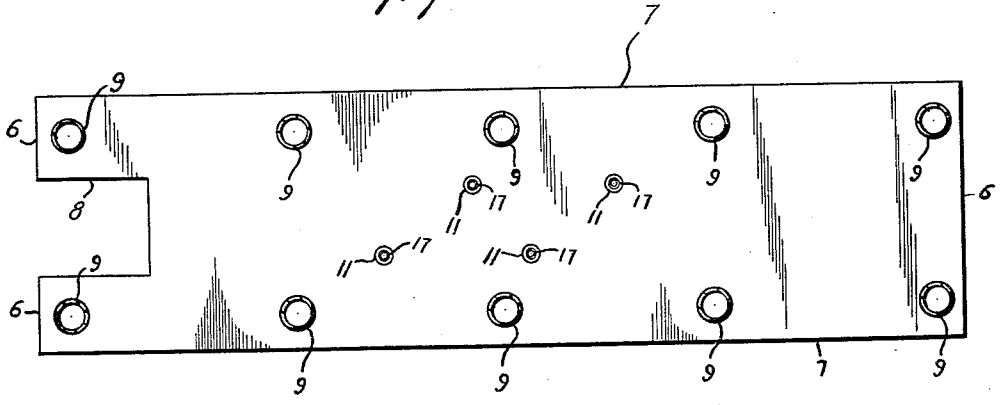


Fig. 2



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Fig. 3

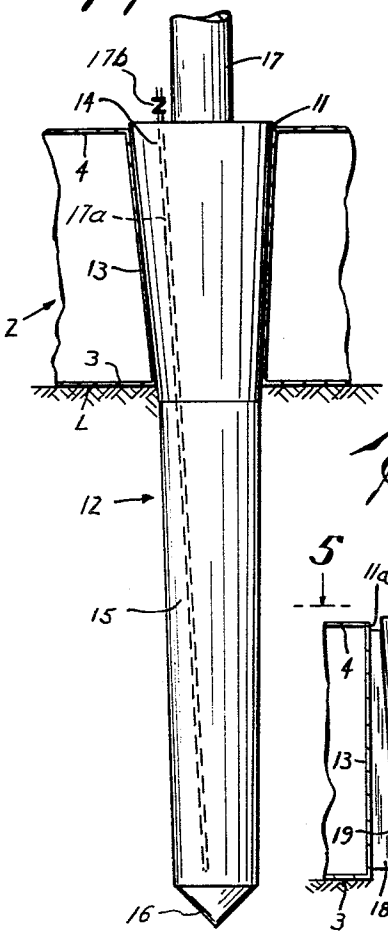


Fig. 6

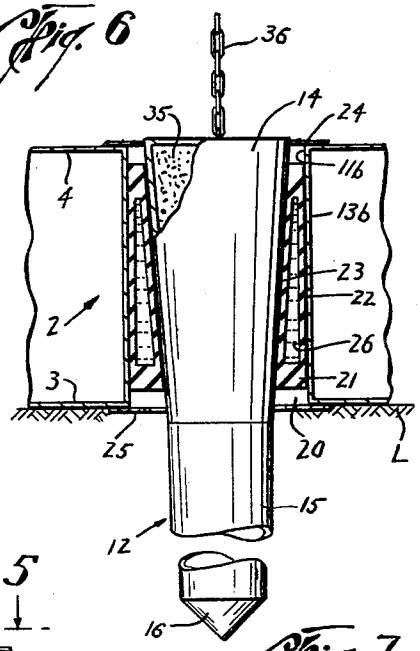


Fig. 4

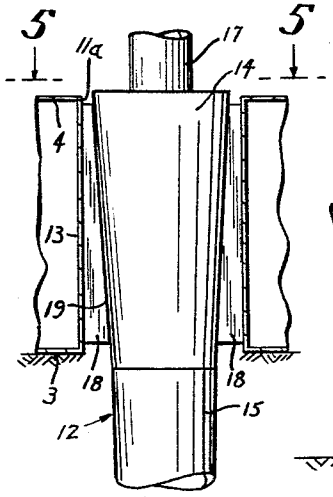


Fig. 7

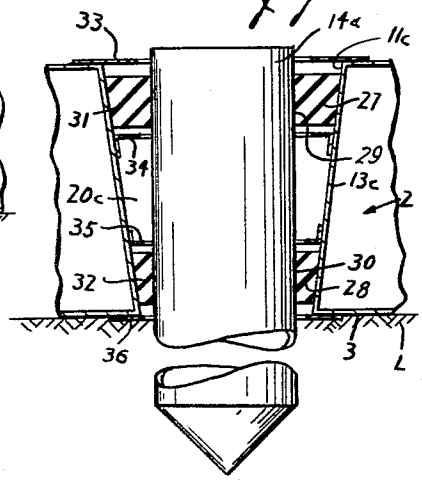
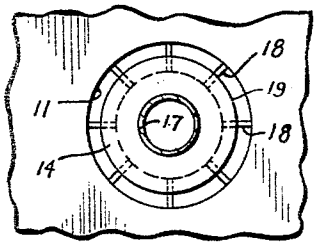


Fig. 5



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SUBMERGIBLE BARGES WITH ANCHOR SPUDS

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13 Claims. (Cl. 61—46.5)

This invention relates to improvements in submergible hulls, particularly submergible drilling barges employed for drilling in open ocean areas such as along the Continental Shelf lining the Gulf of Mexico.

Submergible barges are now being employed for drilling in open ocean water overlying the Continental Shelf and in similar open water areas. Such barges ordinarily comprise a hull, a wave-transparent superstructure generally consisting of a number of spaced columns, and a working platform supported on the columns at a height above the barge hull such that the working platform will be above the crests of any waves which may ordinarily be anticipated in the area of operation when the hull is resting on the underlying subnatant land bottom. Such barge hulls ordinarily have a flat bottom to provide an extended spread footing in contact with the surface of the submerged land in order to provide a firm foundation for the working platform and the load imposed thereon.

One of the problems encountered in connection with such submergible barges is the tendency of such barges to move laterally over the land surface under the forces of wind and wave acting on the superstructure, or of underwater currents exerted against the submerged hull. Various means have been employed to anchor the barge to the land to prevent this lateral movement which can prove very hazardous to drilling operations conducted from such a barge-supported platform.

One such anchor means which has been used comprises a plurality of spuds which are passed through openings in the barge and into the underlying land. This arrangement while generally effective to prevent lateral movement of the hull, is nevertheless subject to considerable difficulty arising from the clearance which is ordinarily present between the cylindrical spud surface and the wall of the hull opening in order to provide free movement of the spud through the opening. By reason of this clearance, even though small, a small amount of lateral movement of the hull relative to the spuds can occur. As a result, slight shifting of the hull will cause the spud to bind against the hull at the corners corresponding to the upper and lower ends of the hull openings. The tremendous forces involved may often kink or bend the spuds at the points of contact with the hull and will make very difficult the later withdrawal of the spuds in order to release the hull for re-floating and movement to other locations.

The present invention contemplates improvements in the spud anchoring structure to obviate the difficulty, mentioned above, arising with conventional spud anchoring constructions.

In accordance with the present invention, the portions of the spuds passing through the openings and the surrounding walls of the openings are shaped to define between them co-operating downwardly tapering frusto-conical surfaces which will serve to seat the spuds in the hull openings in such a manner as to maintain continuous engagement between the spuds and the hull. This will prevent relative movement between these members and

thereby obviate the difficulty mentioned above, while at the same time permitting easy withdrawal.

The tapered surfaces contemplated by the present invention may be obtained by providing hull openings having downwardly tapering frusto-conical shape and by forming the portion of the spud positioned within such an opening with a complementary shape. Other suitable arrangements may be employed to provide the desired tapered seating surfaces, as will appear hereinafter.

Another condition encountered in marine drilling with submergible hulls of the kind described is a small oscillatory or rocking movement of the hull which frequently occurs when the hull is resting on the submerged land. It is thought this rocking movement is due to the slight elasticity which appears to be characteristic of the soft land bottoms underlying off-shore waters in many localities. As the submerged hull is of substantial length, very often a wave will be passing above one end of the hull while simultaneously a trough may be above the opposite end of the hull. The greater head of water represented by the wave will, by reason of the slight elasticity of the supporting land, tend to press the underlying portion of the barge downwardly slightly while the lesser head of water over the opposite end of the hull will allow the latter to rise slightly, this movement being alternated and repeated as a succession of waves pass over the submerged hull.

Where spuds are employed to anchor the hull to the land bottom, this oscillatory or rocking movement tends to produce a loosening of the spuds in the underlying ground and thus reduce the anchoring effectiveness of the spuds. The present invention contemplates additional modifications which will obviate this condition while simultaneously maintaining secure seating engagement of the spuds in the hull.

In accordance with these additional embodiments, one or more resilient spacer or filler rings or sleeves, constructed of rubber or other resilient composition material, are concentrically interposed between the spud and the wall of the opening through which the spud passes. The inner and outer peripheries of these spacer or filler elements are shaped to complement the adjacent surfaces of the spud and the hull opening to provide the tapered seat surfaces for the spud and hull opening which will provide the continuously maintained contact between the spud and the wall of the opening adapted to prevent lateral movement between the hull and the spuds. At the same time, by their resilient construction, the filler devices will absorb the rocking movement, produced as above described, and thereby prevent loosening of the spud in the underlying ground.

Accordingly, it is a primary object of this invention to provide in combination with a submerged hull, means for effectively anchoring the hull to the land surface on which it rests.

A further object is to provide a hull construction having spud receiving openings therein and spuds passing through said openings into the underlying ground, the spuds and openings having co-operating engaging surfaces adapted to prevent lateral movement between the hull and the spuds.

An additional object is to provide anchoring means for submerged hulls which include openings through the hull and spuds extending through the openings, there being resilient fillers between the adjacent surfaces of the spuds and the openings adapted to absorb oscillatory movement of the hull relative to the spuds.

Another object is to provide an anchoring arrangement employing one or more resilient filler rings disposed in a hull opening between the opposed wall surfaces of the hull opening and the spud passing therethrough, at least one of the opposed surfaces being downwardly

tapered and the filler rings having peripheral faces engaging both said surfaces and complementary in shape thereto.

A more specific object is to provide an anchoring means including a plurality of spaced-apart downwardly tapering frusto-conical openings through a submerged hull and a spud passing through each opening, each spud having a downwardly tapering frusto-conical portion complementary to the shape of the hull opening whereby to fit snugly therein.

Other and more specific objects and advantages of this invention will become more fully apparent from the following detailed description when read in conjunction with the accompanying drawing which illustrates several useful embodiments in accordance with this invention.

In the drawing:

Fig. 1 is a side elevational view of a generally conventional form of submergible drilling barge, showing a number of anchoring spuds passing through the hull portion thereof into the underlying submerged land;

Fig. 2 is a plan view looking downwardly along line 2—2 of Fig. 1;

Fig. 3 is an elevational view of one embodiment of a spud form and related seating structure in a hull opening;

Fig. 4 is an elevational view, generally similar to Fig. 3, illustrating another embodiment in accordance with the present invention;

Fig. 5 is a view looking downwardly along line 5—5 and the upper end of the structure shown in Fig. 4; and

Figs. 6 and 7 are views similar to Figs. 3 and 4 of still other embodiments in accordance with the present invention.

Referring to the drawing, there is shown in Figs. 1 and 2 a generally conventional form of submergible drilling barge, designated generally by the numeral **1**, which includes a generally rectangular hull, designated generally by the numeral **2**, having a substantially flat bottom **3**, deck **4**, and end and side plates **6** and **7**, respectively. The hull may also be provided with a slot **8** in one end, commonly termed a "drilling slot," through which the drilling tools are projected in the underlying ground. A plurality of tubular columns **9—9** are secured to the hull to extend vertically above the hull deck. The columns support on their upper ends a working platform **10** on which is mounted a conventional drilling derrick **10***a* positioned over the drilling slot **8**. The height of columns **9** will be made such that when the hull is resting on the subnatant land L beneath the surface of a water body W, the working platform **10** will be elevated at a sufficient height above the normal water level to clear the crests of any waves which might occur in the area in which the barge structure is being used. The number of columns **9** and their spacing will ordinarily be such as to provide a maximum degree of wave transparency through the superstructure supporting the working platform. The molded depth of the hull, that is, the height from bottom **3** to deck **4**, will ordinarily be from about 10 to 15 feet.

It will be understood that hull **2** will be suitably compartmented and provided with conventional ballast transferring and handling gear for sinking and re-floating the barge structure, such equipment and arrangements being well understood by those skilled in the art and form no part of the present invention. It will also be understood that by the use of conventional operating procedures and means, the hull may be submerged to rest on the subnatant land L to provide a firm foundation for drilling or other operations to be conducted from platform **10**.

To prevent lateral movement of the hull over the land surface during operations, hull **2** is provided with one or more vertical openings or wells 11 which extend entirely through the hull opening through the bottom thereof into communication with land L. Elongate spuds **12—12** are inserted through openings **11** into land L to

effectively anchor the hull against lateral movement relative to the land.

Openings **11** and the portions of spuds **12** enclosed within the openings **11** are designed, as illustrated in Figs. 3 and 7, to prevent or reduce lateral movement between the hull and the spuds once the latter have been inserted through the openings into the underlying land. As illustrated in Fig. 3, opening **11** is defined by a wall **13** which is shaped to provide a downwardly tapering frusto-conical opening through the hull. Spud **12** is ordinarily of tubular construction having its upper end portion **14** of downwardly tapering frusto-conical shape complementary to the shape of opening **13**, so that as the spud is inserted through opening **13** and into the underlying land, opening **13** will form a seat for portion **14** of the spud which will provide maintained engagement between the spud and the hull at all times to thereby prevent any lateral movement of the hull relative to the spud. The lower or anchor portion **15** of the spud which projects into the underlying land may be made cylindrical, but is preferably made with a slight downward and inward taper throughout its length, the downward taper of portions **14** and **15** making insertion of the spud into the underlying ground relatively easy, and also enabling the spud to be withdrawn from the land and from the seat formed by opening **11** with minimum effort. The lower end of the spud is closed and may be provided with a pointed tip **16** to enhance its ground penetrating qualities. The spud may be provided with an elongate stem **17** connected to its upper end and projecting upwardly through the working platform **10**. By the use of this stem, the spud may be pushed downwardly through opening **11** into the underlying land and retracted therefrom when desired by operations conducted from the working platform.

The length of portion **15** is preferably made from about one to about two times the molded depth of the hull. Thus, in a case of a hull having a molded depth of 10 feet, for example, portion **15** will have a length of from 10 to 20 feet, this range in length relative to the molded depth of the hull being found generally sufficient to effectively anchor the hull to the underlying land.

With the described arrangement, it will be seen that as the spud is forced into the land and tapered portion **14** is fed through tapered opening **11**, the spud will become tightly seated in the hull and lateral movement of the hull relative to the spud will be effectively prevented. At the same time owing to the taper of the spud it will be immediately freed from the hull upon the application of an upward force.

Figs. 4 and 5 illustrate a modification of the structure shown in Fig. 3. As it is sometimes difficult to shape the hull plates so as to provide a suitably tapered opening **11**, the embodiment shown in Fig. 4 will provide a practical alternative while still retaining the tapered seating connection between the hull and the spud. In this embodiment opening **11***a* is generally vertically straight or cylindrical. Secured to wall **13***a*, which defines opening **11***a*, is a plurality of radially inwardly projecting, angularly spaced ribs **18** having their inner edges sloped downwardly and inwardly to collectively define a downwardly tapering frusto-conical passage **19**. The frusto-conical passage thus defined provides the seat for receiving tapered portion **14** of spud **12** in the same manner as in the embodiment illustrated by Fig. 3.

It will be understood that other structural arrangements may be employed, it being necessary only that they provide the downwardly tapered co-operating seating surfaces corresponding functionally to those illustrated by the embodiments of Figs. 3 and 4.

Figs. 6 and 7 illustrate further embodiments which retain the tapered seating engagement between the hull and the spuds while at the same time providing means for absorbing small rocking or oscillatory movements of

the hull, such as those heretofore described, in order to obviate the loosening effect which such movement might otherwise have upon spuds which are directly engaged with the hull.

In Fig. 6, hull **2** is provided with a vertically straight opening **11***b* to receive a spud corresponding in external form to spud **12** of the previously described embodiments; that is, the spud being provided with a frusto-conical downwardly tapering upper section **14** and an anchor section **15** having the point **16**. Since opening **11***b* is substantially cylindrical while portion **14** of the spud is downwardly tapering, there is provided between the surfaces of wall **13***b* and spud portion **14** a downwardly diverging annular space **20**. Interposed in this annular space is a sleeve member **21** of massive resilient construction, made of rubber or similar resilient material, having its outer periphery **22** cylindrical in shape to conform to the cylindrical shape of opening **11***b* and having its inner periphery **23** downwardly tapering frusto-conical shape complementing in shape spud portion **14**. The sleeve **21** thus provides a flexible resilient spacer or filler member which provides the tapered seat in the opening for receiving the tapered spud to thereby maintain continuous engagement between the spud and the hull. The upper and lower ends of opening **11***b* may be provided with inwardly projecting annular flanges **24** and **25**, respectively, to serve as stops or keepers to prevent sleeve **21** from being drawn or pushed out of opening **11***b*. Sleeve **21** is made slightly shorter in length than the distance between flanges **24** and **25** to provide a small amount of axial movement of the sleeve in opening **11***b* to allow effective seating of the spud in the hull opening and to allow the spud to be readily released when it is to be withdrawn. Sleeve **21** may be hollow, having the internal chamber **26** which, however, is filled with liquid in order to prevent collapse of the sleeve under pressures due to the hydrostatic head of the sea above the hull. Although the liquid in chamber **26** is incompressible and renders the sleeve structure as a whole incompressible, the resilience of the walls of the sleeve will allow deformation to absorb the slight oscillatory or rocking movements of the hull relative to the spud while, at the same time, maintaining the continuous engagement between the spud and the hull necessary to prevent substantial lateral movement of the hull relative to the spuds.

Fig. 7 illustrates an arrangement employing the resilient spacer elements which provide an alternative arrangement to that illustrated in Fig. 6. As shown in Fig. 7, the hull is provided with the downwardly tapering frusto-conical opening **11***c* defined by correspondingly shaped wall **13***c*. Spud portion **14***a*, which extends through opening **11***c*, is made vertically straight instead of tapered, as in the previously described embodiments, thus again providing an annular space **20***c* between the opposing surfaces of the spud portion **14***a* and wall **13***c*. In this case, the space thus provided is downwardly converging. Interposed between spud portion **14***a* and wall **13***c* are two vertically spaced upper and lower filler rings **27** and **28**, respectively. These rings are of massive resilient construction made from rubber or similar resilient composition. The peripheries **29** and **30**, respectively, of the upper and lower rings define co-axial vertically straight cylindrical surfaces complementing the cylindrical surfaces of spud portion **14***a*. The outer peripheries **31** and **32**, respectively, of the upper and lower rings are made downwardly and inwardly tapering to define downwardly tapering frusto-conical surfaces complementing the shape of opening **11***c*. The thickness of the filler rings **27** and **28** is made such as to provide continuous engagement between opposing surfaces of spud portion **14***a* and wall **13***c*. Keeper flanges **33**, **34** project from wall **13***c* inwardly of opening **11***c* above and below upper ring **31** and similar keeper flanges **35** and **36** enclose lower filler ring **28**, the keeper flanges being spaced somewhat from the adjacent ends of the related rings to permit limited axial movement of the rings in the openings.

With the arrangement shown in Fig. 7, it will be seen that a vertically straight spud may be inserted through the bores defined by the inner-peripheral surfaces **29** and **30** of the filler rings. As it is moved downwardly through opening **11***c* the friction between the spud and the filler rings will urge them downwardly along the inner-face of wall **13***c* and will produce a wedging action between the spud and the wall of the opening, thus rings **27** and **28** become, in effect, resilient wedges. This embodiment is particularly useful where the spud, as it moves downwardly through the underlying land, encounters relative hard formations, such that it might be impractical to employ a form such as illustrated in Figs. 3 and 4 which would require sufficient downward movement to seat the tapered spud portions **14** fully in the tapered seats in the hull. With the embodiment illustrated in Fig. 7, downward movement of the spud to any extent will produce the wedging action between the spud and the hull, which will effectively prevent substantial lateral movement of the hull relative to the spud while, at the same time, providing a degree of resilience in the connection which will absorb the previously described rocking or oscillatory movement of the hull.

It will be understood that the spuds in each of the several embodiments may be equipped with stems, such as stem **17**, for forcing the spuds into the underlying land. Fig. 6 illustrates an alternative arrangement useful particularly in cases where the underlying land is quite soft, as is frequently the case in various points along the Gulf Coast. In this modification, the spud may be filled with a weighting material, such as concrete **35**, which will provide sufficient weight to cause the spud to move downwardly the requisite distance under its own weight. Chains **36** may be connected to the upper end of the spud and extended to the working platform to permit withdrawal of the spuds when it is desired to move the barge.

Another effective way of causing the spuds to penetrate the land underlying the hull is to ballast it by introducing sea water to the interior thereof in any convenient manner, as through extension or stem **17**. Similarly, the removal of the spuds may be facilitated by de-ballasting. To do this, air may be introduced in any suitable and known manner to the interior of the spud and the pressure thereof employed to eject the ballast through a pipe **17***a*, shown in broken lines in Fig. 3, which extends through the interior of the spud to a point near its lower end and has its upper end fitted with a check valve **17***b* and communicating with the water body exteriorly of the spud.

The number of spuds employed for any barge and their spacing and locations in the hull may be varied widely, depending upon the dimensions of the hull, the character of the land bottom, and other conditions encountered in the areas of employment of the barge. In some cases, only a few spuds may be required, and in others a relatively large number. In many cases it may be preferable to group the spuds in the center portion of the barge but, as noted, their particular locations and spacing will depend upon the conditions encountered and the circumstances of each individual case. The spuds, themselves, may be of varying dimensions, so far as diameter is concerned, diameters of three to six feet being a generally satisfactory size. Their length will depend generally upon the molded depth of the hull, as previously noted.

It will be understood that various other alterations and modifications may be made in the details of the illustrative embodiments within the scope of the appended claims but without departing from the spirit of this invention.

What I claim and desire to secure by Letters Patent is:

1. In combination with a submerged hollow hull resting on a subnatant land surface and having vertically

spaced upper and lower walls, at least one generally vertical opening extending entirely through the hull including said walls, and an elongate spud member extending from above the surface of the water body in which the hull is submerged through said opening into anchoring engagement in the underlying land, the opposing portions of the spud member and the wall of said opening being relatively shaped to define cooperating downwardly tapering frusto-conical seating surfaces operable when engaged to prevent relative lateral movement between the hull and the spud member and to facilitate withdrawal of the spud member.

2. In combination with a submerged hollow hull resting on a subnatant land surface and having vertically spaced upper and lower walls, a plurality of generally vertical openings extending entirely through said hull including said walls in laterally spaced-apart relation, and elongate spud members extending from above the surface of the water body in which the hull is submerged through said openings into anchoring engagement in the underlying land, the opposing portions of said spud members and the walls of said openings being relatively shaped to define cooperating downwardly tapering frusto-conical seating surfaces operable when engaged to prevent relative lateral movement between the hull and the spud members and to facilitate withdrawal of the spud members.

3. In combination with a submerged hollow hull resting on a subnatant land surface and having vertically spaced upper and lower walls, a plurality of generally vertical openings extending entirely through said hull including said walls in laterally spaced-apart relation, and elongate spud members extending from above the surface of the water body in which the hull is submerged through said openings into anchoring engagement in the underlying land, said openings being downwardly and inwardly tapered to provide frusto-conical seats, said spud members having upper frusto-conical portions receivable in said seats and having lower anchor portions projecting from said seats into the underlying land surface.

4. A structure as defined by claim 3 wherein the lower portions of said spud members have a length of from one to two times the molded depth of said hull.

5. A structure as defined by claim 3 wherein said lower portions of said spud members are of downwardly tapering frusto-conical shape.

6. In a structure as defined by claim 3, means connected to the spud members for inserting and extracting them into and out of said openings.

7. In combination with a submerged hull resting on a subnatant land surface, a plurality of generally vertical openings extending entirely through said hull in laterally spaced-apart relation, and elongate spud members extending through said openings into anchoring engagement in the underlying land, the opposing portions of said spud members and the walls of said openings being relatively shaped to provide a frusto-conical annular space therebetween, and resilient ring means positioned in said space in resilient wedging engagement between said opposing portions of the spud members and the walls of said openings.

8. A structure as defined by claim 7 wherein said resilient ring means comprises a longitudinally tapered sleeve member constructed of resilient non-metallic composition material shaped to conform to the shape of said annular space.

9. A structure as defined by claim 7 wherein said resilient ring means comprises a pair of longitudinally spaced tapered rings constructed of flexible, non-metallic composition material.

10. In combination with a submerged hull resting on a subnatant land surface, a plurality of generally vertical openings extending entirely through said hull in laterally spaced-apart relation, and elongate spud members extending through said openings into anchoring engagement in the underlying land, said openings being defined by vertically straight cylindrical walls, the portions of said spud members enclosed within said openings having downwardly tapering frusto-conical shape, and means positioned within said openings forming seats complementary in shape to said portions of the spud member.

11. A structure as defined by claim 10 wherein said means comprises a plurality of longitudinally extending angularly spaced ribs secured to the wall of each of said openings to project radially inwardly therefrom, the inner longitudinal edges of said ribs sloping downwardly and inwardly with respect to the axis of said openings to complement the taper of said spud portions.

12. Anchor means for a submerged hull resting on a subnatant land surface, comprising in combination with a hull having a spud-receiving opening extending generally vertically therethrough, said spud and the wall of said opening having cooperating surfaces shaped to prevent lateral movement between the spud and the hull, and resilient filler means interposed between said surfaces to absorb oscillatory movement of the hull relative to the spud.

13. Anchor means for a submerged hull resting on a subnatant land surface, comprising in combination with a hull having a spud-receiving opening extending generally vertically therethrough, a hollow elongate spud member closed at its lower end extending from above the surface of the water body in which the hull is submerged through said opening into the underlying land, said spud member and the walls of said opening having cooperating engaging surfaces of downwardly tapering frusto-conical shape to prevent lateral movement between the hull and the spud member, the portion of the spud member extending below the hull opening into the underlying land being downwardly and inwardly tapered to facilitate its withdrawal from said land, and means for ballasting and de-ballasting the spud member operable respectively to force it into said land and to facilitate its withdrawal therefrom.

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