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R. E. WESTLING

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METHOD AND APPARATUS FOR OFFSHORE ANCHORING

Filed Aug. 11, 1967

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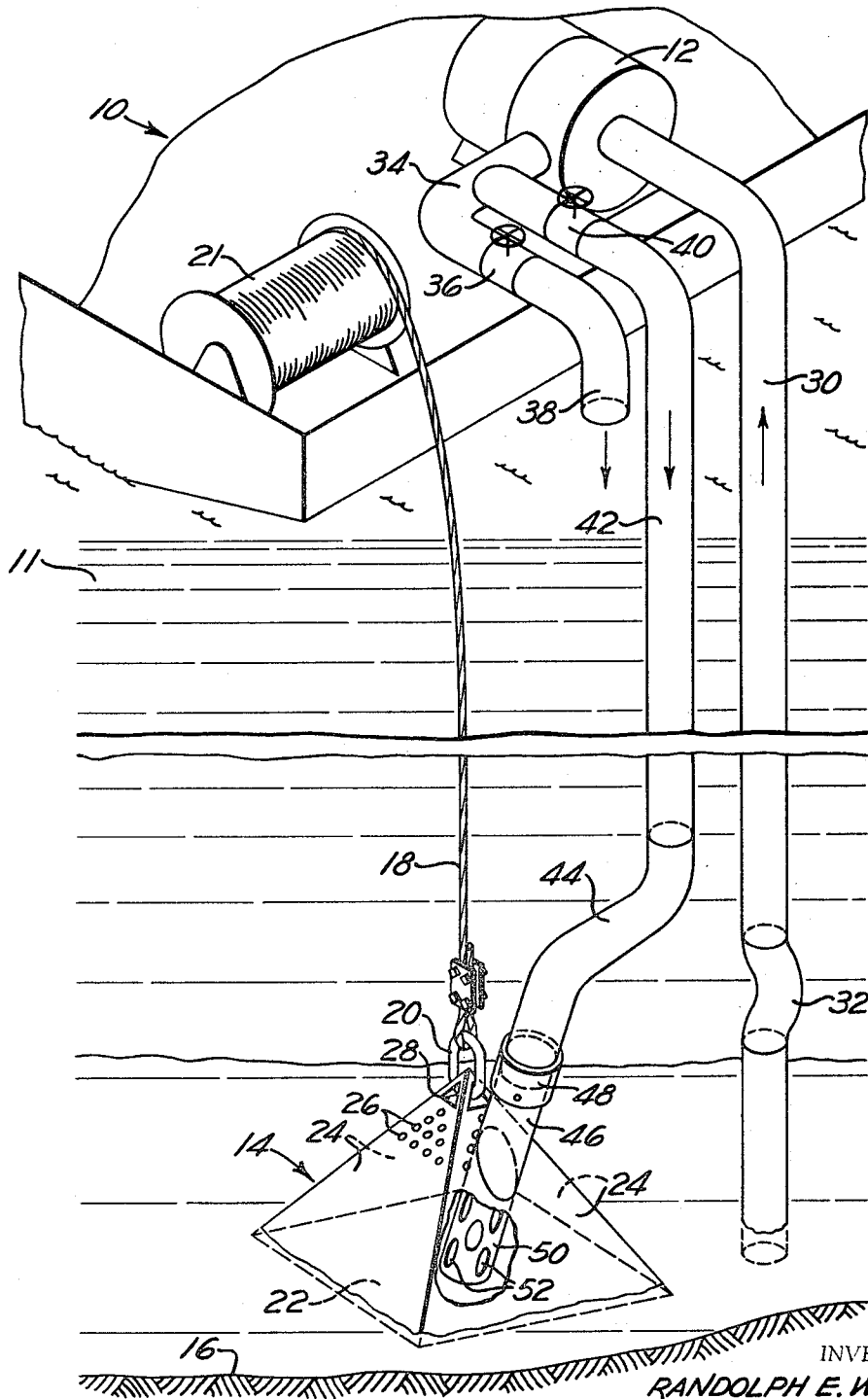


Fig. 1

INVENTOR.
RANDOLPH E. WESTLING

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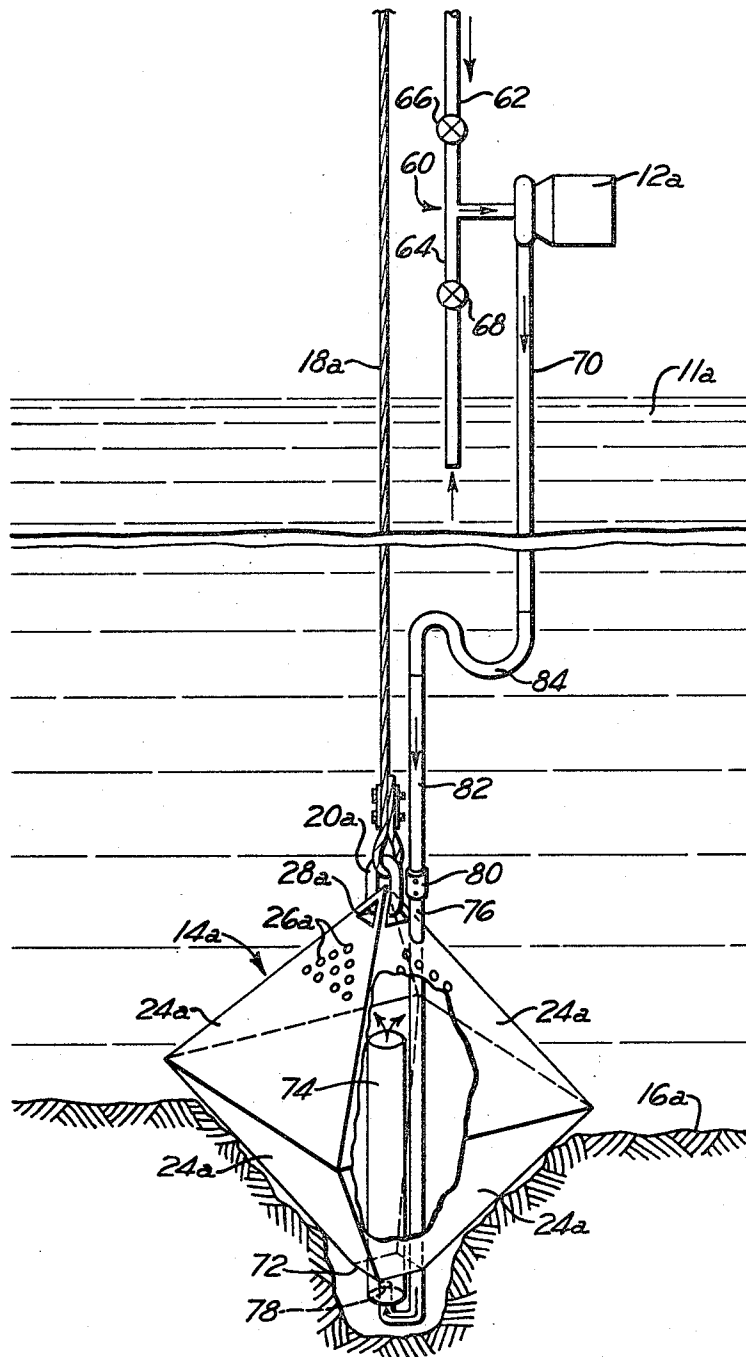


Fig. 2

INVENTOR.
RANDOLPH E. WESTLING

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METHOD AND APPARATUS FOR OFFSHORE ANCHORING

Randolph E. Westling, Miami, Fla., assignor to Gulf
Oil Corporation, Pittsburgh, Pa., a corporation of
Pennsylvania

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ABSTRACT OF THE DISCLOSURE

The invention comprises methods and apparatuses for underwater anchoring comprising a hollow anchor which is filled, by various means, with underwater bottom material, to obtain a larger more efficient anchor with less anchor material than would go into a solid anchor of the same shape or a conventional fluke type anchor of the same anchoring ability.

This invention pertains to methods and apparatuses for underwater anchoring, and in particular is directed to methods and apparatuses to obtain better underwater anchors than were heretofore available with the use of less anchor material, and to increase the anchor's holding power.

The invention is concerned with anchoring in those places in lakes or oceans where the bottom material is in the form of soft mud, silt, sand, gravel, or the like, as opposed to those places where the bottom material is very hard, such as rock or very tightly compacted material. The kind of underwater formations with which the present invention is usable is often found during offshore oil well drilling operations. There are many needs for anchors in such operations, including anchoring of surface vessels, anchoring pieces of equipment, buoys, and the like. The invention is not confined to offshore oil operations, but is useful wherever the underwater soil conditions are of the type with which the invention can be used.

The present invention comprises, in its basic essentials, hollow anchors of predetermined shapes, which are filled with bottom material, and sunk into the bottom. By making the anchor hollow, a much larger anchor can be obtained for the same weight of anchor material. A larger anchor has a greater surface area to hold the anchor in place as opposed to a solid anchor of the same weight of material. By filling the anchor with bottom material, a heavier anchor is obtained for the same amount of anchor material as would go into a solid anchor. By filling the anchor with bottom material removed from the bottom at or near the anchoring location, the need to transport mud, gravel, or other filling material out to the anchoring location is eliminated. Thus, one major advantage of the methods and apparatuses of the present invention is that underwater anchoring is made easier and more economical while obtaining more efficient anchors, and while reducing the weight of materials to be transported out to the location. The invention also comprises various methods of filling and sinking such anchors.

Another advantage of anchors embodying the invention is that they can be more easily salvaged and moved to another location than can conventional anchors. A diver could insert air or water hose into the anchor of the invention, blow out most or all of the material in the anchor, and then the empty anchor could be easily raised and moved.

Still another advantage of anchors embodying the invention is that they can be easily floated out from shore to their anchoring location. By filling the anchor with

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enough water to give it a slight negative buoyancy, and then tipping it, it would be virtually weightless in the water, due to the entrapped air, and easily moved with a smaller vessel and with lighter lifting and handling equipment than required for conventional types of anchors of the same anchoring ability.

In the accompanying drawing forming a part of this disclosure: FIG. 1 is an elevational view showing a first embodiment of the invention; and FIG. 2 is a view somewhat diagrammatic and somewhat similar to FIG. 1 showing a second embodiment.

Referring to FIG. 1, 10 designates a ship or barge or other suitable vessel adapted to carry the equipment needed to practice the method of the invention. The vessel floats in water 11 covering the desired anchoring location. On board vessel 10 is a pump 12, adapted to pump water and bottom material. An anchor 14 rests on the bottom 16. A cable 18 is attached to an anchor hook or link 20 in the top of anchor 14. Cable 18 is played off a suitable reel of cable 21 on board vessel 10. After the anchor is emplaced, the cable may be used to attach a buoy or for like purposes.

Anchor 14 is hollow and is in the shape of a four-sided pyramid with a square base. It is made up of a square bottom plate 22 and four side plates 24 which are of equilateral triangular shape. Plates 22 and 24 are joined together by any suitable means such as welding to form the anchor. Each plate 24 is formed with a plurality of openings 26 near the top. The apex of the anchor is formed with suitable means, such as openings 28 in each of the side plates, to receive the connecting link 20.

Means are provided to fill the inside of anchor 14 with bottom material 16. To this end, a suction pipe 30 is connected to the inlet side of pump 12 and terminates at the bottom 16. Suction pipe 30 includes a flexible section 32 to permit movement of vessel 10 in response to wave action and the like, while maintaining the lower end of the suction pipe in contact with bottom 16.

The discharge of pump 12 is connected to the upright of an F shaped pipe connection 34. One leg of connection 34 is connected by a valve 36 to a bypass discharge pipe 38. The other leg of connection 34 is connected by a valve 40 to an anchor filling line 42. The lower end of fill line 42 is connected to a flexible section 44, which serves the same purpose as flexible section 32, with regard to the anchor 14. The lower end of flexible section 44 is connected to a pipe 46 passing through one triangular side wall 24 of the anchor. Pipe 46 is connected to flexible section 44 by a shear pin connector 48. Connector 48 is of the type that will break apart in response to a force larger than that experienced because of normal wave action, but less than that necessary to move the anchor once it is in place.

Pipe 46 may be formed integrally with the anchor 14. A portion 50 of pipe 46 is positioned within the anchor and is formed with a plurality of discharge openings 52.

In operation, the anchor, prefabricated on land or on the vessel, is lowered on cable 18 with its fill line 42 and connector 48 attached. Pump 12 is operated to pump bottom material into the anchor. The bottom material settles in the anchor and the water flows out openings 26 and 28. Openings 26 serve as an automatic full anchor bypass also, i.e., since the holes are at the top, no destructive back pressure will be created on the pump by continued pumping after the anchor is full, since continued filling thereafter will simply overflow through openings 26 and 28. Depending on the condition and nature of the particular bottom material, and other factors, it may be desired to use suction pipe 30 to create an opening into which the anchor can be dropped. When this is desired, the valves 30 and 40 are operated so that the

bottom material goes through bypass pipe 38. When a large enough opening has been created, the anchor may be lifted and dropped into the opening by means of cable 18. In other circumstances, the weight of the anchor alone may be sufficient for it to sink into the bottom material and the second step may not be necessary. In either case, once the anchor is emplaced and filled, the fill line 42 is pulled from anchor 10 to break the shear pin or like device in connector 48, and the operation is completed.

The suction and fill lines 30 and 42 are shown close together. In some cases where the bottom material at the location at which it is desired to place the anchor is not suitable, suction line 30 may be placed out from vessel 10 to draw suitable material with which to fill the anchor.

The overflow feature yields an additional advantage. By permitting the anchor to overflow, the excess material will fill the area outside the anchor as it sinks or after it is placed into a created excavation.

The invention is applicable for use with any size or shape of anchor. The square-based, four-sided pyramid 14 shown is by way of example only, but it is a shape which has been long used in solid form, usually a block of concrete. This shape is desirable because of its large bottom area which gives it good holding ability, its low center of gravity, and its relatively large volume.

Anchor 14 described above, and anchor 14a described below, are shown made from plates. It is also possible to fabricate anchors embodying the invention from expanded metal screening. An anchor made of such screening would be particularly adapted for use where the bottom material contains gravel or is mostly gravel. In such case, the lighter mud and silt which carries the gravel would work out of the anchor, and the screening would hold the gravel, the screen opening size being selected for the particular gravel, of course. The use of such screening further increases the advantages of the present invention by further reducing the weight of anchor material required. Other materials which may be used to fabricate the anchors of the invention includes slabs of reinforced concrete.

Referring now to FIG. 2, there is shown a second embodiment of the invention in which elements similar or analogous to those described above in regard to FIG. 1 are indicated by the same reference numeral followed by a.

The embodiment of FIG. 2 is adaptable to be operated with either water or air, and therefore "pump" 12a will be understood to represent either a water pump or an air compressor. The suction side of pump 12a is connected to a T fitting 60. A pipe 62 connects one leg of T fitting 60 to atmosphere, and a pipe 64 connects the third leg of T fitting 60 to the water 11a. The two valves 66 and 68 controlling pipes 62 and 64, respectively, are somewhat diagrammatic, in that either air or water will be used as the intake depending on the nature of "pump" 12a. The output side of pump 12a is connected to an output line 70.

The anchor 14a of the embodiment of FIG. 2 is in the form of a double, four-sided pyramid arranged base-to-base with the length of all edges being equal. While this shape is particularly suited to the embodiment of FIG. 2, it will be understood that it is interchangeable with anchor 14 shown in FIG. 1, with only minor changes or with any other hollow shape. The lower apex of anchor 14a is truncated to form an inlet opening 72. Anchor 14a comprises a standpipe 74 fixed to the edges of opening 72 by any suitable means and extending into anchor 14a.

Means are provided to draw bottom material 16a through standpipe 74 to fill anchor 14a. To this end, a jet pipe 76 extends through the anchor and terminates at its lower end in a jet nozzle or orifice 78 positioned just inside of the lower end of standpipe 74. Jet pipe 76 may be integral with the anchor and passes through the upper end of one of the triangular side plates 24a making up

the anchor. A shear pin or like type connector 80 joins the upper end of jet pipe 76, outside of the anchor, to a connecting pipe 82 which is joined to the lower end of output line 70 by a flexible joint 84 similar to the flexible sections 32 and 44 of anchor 14.

The embodiment of FIG. 2 has the advantage of creating its own excavation into which the anchor drops as it is filled. Just as in the embodiment of FIG. 1, the openings 26a and 28a serve as a separator of the water from the sea bottom material and as an overflow to permit continued flow to bury the anchor deeper. Once buried, the equipment is removed, just as in FIG. 1, by breaking connector 80.

The two anchors 14 and 14a shown have shapes which are commonly used and therefore were selected for illustration purposes, but it will be understood that the methods of the invention are applicable to hollow anchors of any shape.

In the following table the economic advantages flowing from the use of the hollow, bottom material filled anchors of the present invention are illustrated by comparison with solid anchors of the same shape. For comparison purposes, it will be assumed that 1,000 pounds of iron or steel is used for all anchors. This material has a weight of about 500 pounds per cubic foot and a volume of about 2 cubic feet. It will be assumed for this example that the anchor is to be buried under sea water. The sea bottom material will be assumed to have a weight of 100 pounds per cubic foot. This has been found to be about the average for sea bottom materials adapted for use with the invention. The sea water will be assumed to have a weight of 64 pounds per cubic foot.

The factors effecting the efficiency of any anchor are its total weight, the amount of surface area it presents to the material in which it is anchored, and the negative effect of buoyancy. Surface area has a relationship to three other separate effects, i.e., the drag, suction, and overburden effects.

$$\text{Effectiveness} = \text{Total weight} - \text{Buoyancy effect} + \text{Drag effect} + \text{Suction effect} + \text{Overburden effect}$$

Total weight for the conventional anchor is 1000 pounds. For anchors 14 and 14a total weight is:

$$\text{Total weight} = 1,000 \text{ pounds} + (\text{Internal volume} \times 100)$$

Buoyancy, according to Archimedes Law for a sunken object, is equal to the weight of the water displaced, hence:

$$\text{Buoyancy} = \text{Total volume of water displaced in cubic feet} \times 64.$$

Drag is a direct function of the surface area of the anchor presented to the mud. It is related to the shear strength of the mud since the mud must slip or break down to allow the anchor to move through it. For comparison purposes, the nature of the mud can be assumed to be constant, so that the relative effectiveness is a function of surface area only. Any motion in the mud or other bottom materials also effects drag, but that, too, can be considered constant for comparison purposes.

Suction effect is basically a function of the largest transverse cross-sectional area of the object normal to the line of the withdrawing force, times atmospheric pressure, but it also is significantly effected by the rate of withdrawal from the bottom material, any motion of the bottom material, and other factors. For comparison purposes, the effectiveness ratio is in direct proportion to the ratio of these cross-sectional areas, all other factors being constant.

The effect of the overburden is a function of depth of burial and the largest cross-sectional area of the object normal to the line of the withdrawing force. The shape of the column of bottom material that must be moved is thought to be an inverted truncated pyramid, rather than a column, with said cross-sectional area forming the smaller base of the pyramid. Thus, depth of burial being constant, the effectiveness ratio is proportional to

the ratio of the cross-sectional areas, but the advantages of the larger cross-sectional area of anchors embodying the invention is even further enhanced because of the geometric multiplication factors of the pyramid of overburden to be moved.

It has been assumed that the 1,000 pounds of metal is in the form of 1/4 inch plates fabricated into the shapes shown in the drawing. 1,000 pounds of 1/4 inch plates have an area of about 100 sq. feet. In the case of anchor 14, this produces a pyramid having a square base about 6.05 feet on a side and equilateral triangular sides to produce a total volume of about 52 cubic feet of which 50 are internal. In the case of anchor 14a 1,000 pounds of 1/4 inch plate produces an octahedron about 5.37 feet on an edge with a total volume of about 73 cubic feet of which 71 are internal.

Results of these formulas as applied to anchors 14 and 14a and solid metal anchors of the same shapes are presented below:

Anchor	Weight in air (pounds)	Total volume (ft. ³)	Total weight (pounds)	Buoyancy (pounds)	Effective- ness	Weight advantage
14-----	1,000	52	6,000	3,328	2,672	} 3.1
Solid (like 14)-----	1,000	2	1,000	128	872	
14a-----	1,000	73	8,100	4,672	3,428	} 3.9
Solid (like 14a)-----	1,000	2	1,000	128	872	

Since there are many factors effecting the drag, suction and overburden effects, the comparisons here must be in terms of ratios only.

Anchor	Transverse cross- sectional area (ft. ²)	Suction advantage	Overburden advantage	Total surface area (ft. ²)	Drag advantage
14-----	36.6	} 8.8-1	} 8.8-1	100	} 12.9-1
Solid (like 14)-----	4.16			7.76	
14a-----	28.5	} 10.9-1	} 10.9-1	100	} 22.1-1
Solid (like 14)-----	2.62			4.54	

Thus, anchor 14 has an effective advantage over a solid anchor having the same shape and made of the same weight of material ranging from about 3 to about 13 times, average of about 8.5 times. In the case of anchor 14a, this advantage figure is from about 4 to about 22 times, average of about 12 times. The obtaining of a more effective anchor with the same weight of material is an important advantage for the present invention, since it means that there is that much less weight to be transported out to the anchoring site. Turning the figures the other way, the same effectiveness of anchoring can be obtained with the present invention by using only about 10% the weight of metal.

One use of the anchors of the present invention is in making offshore loading and mooring facilities for oil tankers. At present, conventional fluke type anchors are used. For example, a five point mooring facility may have three anchors at each of the five points weighing about two, eight and ten tons, making a total weight of about 100 tons, which must be hauled from manufacturer to site. With the present invention an anchoring facility of equal holding power could be produced with only a small fraction of the 100 tons of metal now required. It is contemplated that no more than 30 tons of metal plate would be needed, including a large safety factor. Another advantage of anchors embodying the invention is that the metal plate or other material is commonly available and relatively easily handled, whereas a 10 ton fluke anchor must be specially ordered, only limited sources are available to supply them, and such a heavy anchor requires heavy and expensive handling equipment. Another advantage of the present invention is that a large temporary or emergency anchor could be relatively quickly set where an equivalent holding power conventional anchor could not be for a relatively long period of time.

While the invention has been described in detail above, it is to be understood that this detailed description is by way of example only, and the protection granted is to be limited only within the spirit of the invention.

I claim:

1. A method of anchoring in an underwater location comprising the steps of lowering a substantially enclosed hollow anchor to said anchoring location, filling said anchor with bottom material, and continuing to pass bottom material through said anchor after said anchor is substantially full by overflowing the additional bottom material out of openings formed in said hollow anchor, whereby the overburden of bottom material on said anchor may be greater than the amount of bottom material within said anchor.

2. The method of claim 1, and locating said filled anchor in the excavation created by the removal of the bottom material used to fill said anchor.

3. The method of claim 1, wherein said anchor is filled with bottom material by pumping said bottom material from locations spaced from said anchor into said anchor.

4. The method of claim 1, wherein said anchor is filled with bottom material by pumping a stream of at least one of water and air through said anchor to draw bottom material into said stream of at least one of water and air passing through said anchor to fill said anchor with bottom material.

5. An anchor for an underwater location comprising wall means defining a substantially enclosed hollow body adapted to contain and hold bottom material, said hollow body comprising a bottom portion adapted to first contact the underwater location, a plurality of openings formed in said wall means, conduit means having a portion passing through said wall means and extending into said hollow body towards said bottom portion, said conduit means having an end portion within said anchor at a location below at least some of the openings of said plurality of openings formed in said wall means, the location of said conduit means end portion being more closely spaced to said bottom portion than to the location of entry of said conduit means through said wall means into said hollow body, and means to pump a fluid through said conduit means, whereby said hollow body may be filled with bottom material.

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6. The anchor of claim 5, said anchor being formed with an opening at said bottom portion thereof, said anchor comprising a double open-ended standpipe having one end positioned in said opening and extending into said anchor therefrom, and said end portion of said conduit means being positioned within the lower portion of said standpipe.

7. The anchor of claim 5, wherein said anchor comprises a pyramid having a base and sides, and said plurality of openings being formed in at least one of the sides adjacent the upper end of said anchor.

8. The anchor of claim 5, wherein said anchor comprises an octahedron having the shape of two square based pyramids arranged base to base, said plurality of openings being formed in at least one of the side walls thereof adjacent the upper end of said anchor, and said bottom portion of said anchor being formed with an opening to permit entry of bottom material therethrough into said anchor.

9. The anchor of claim 5, the portion of said conduit means extending into said hollow body being formed with a plurality of openings.

10. Underwater anchoring apparatus comprising means to lower a hollow anchor from a vessel to an anchoring location, means to fill said hollow anchor with bottom material, wherein said anchor comprises an octahedron having the shape of two square based pyramids arranged base to base, a plurality of openings formed in at least one of the side walls thereof adjacent the upper end of

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said anchor, and a bottom portion of said anchor being formed with an opening to permit entry of bottom material therethrough into said anchor.

11. The apparatus of claim 10, and said anchor comprising overflow means at the upper end thereof.

12. Underwater anchoring apparatus comprising means to lower a hollow anchor from a vessel to an anchoring location, means to fill said hollow anchor with bottom material, said filling means comprising a pump mounted on said vessel, said pump comprising means to pump at least one of air and water through said anchor, the apparatus comprising means to cause the stream of at least one of air and water passing through said anchor to draw bottom material through said anchor, and said anchor comprising overflow means at the upper end thereof.

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