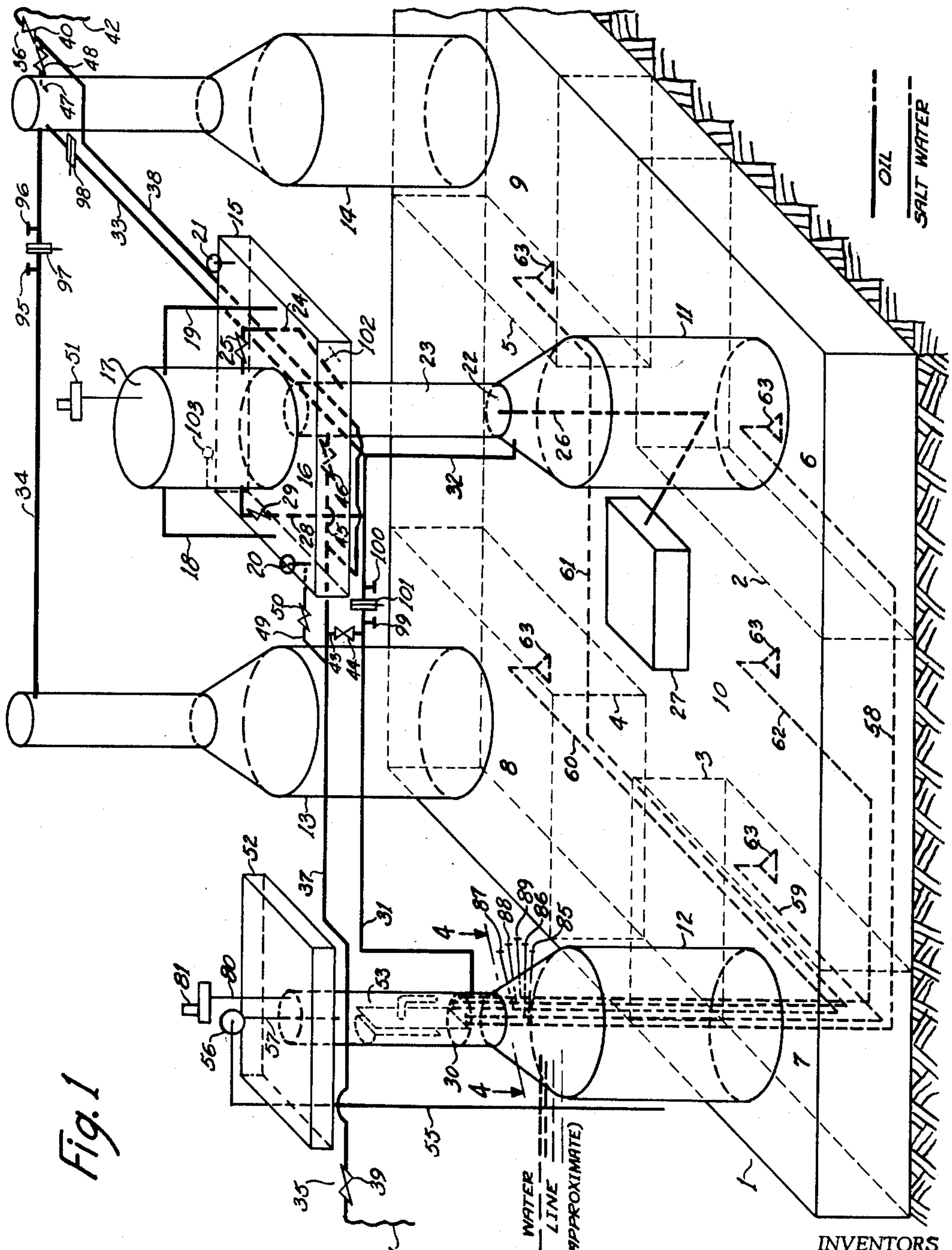
Aug. 25, 1964 J. C. ESTES ETAL 3,146,458

UNDERWATER STORAGE UNIT

Filed Nov. 18, 1960 2 Sheets-Sheet 1



INVENTORS
John C. Estes
Ray S. Lacy Jr.
BY Natt M. Emery Jr.
ATTORNEY

Aug. 25, 1964 J. C. ESTES ETAL 3,146,458

UNDERWATER STORAGE UNIT

Filed Nov. 18, 1960 2 Sheets-Sheet 2

Fig. 2

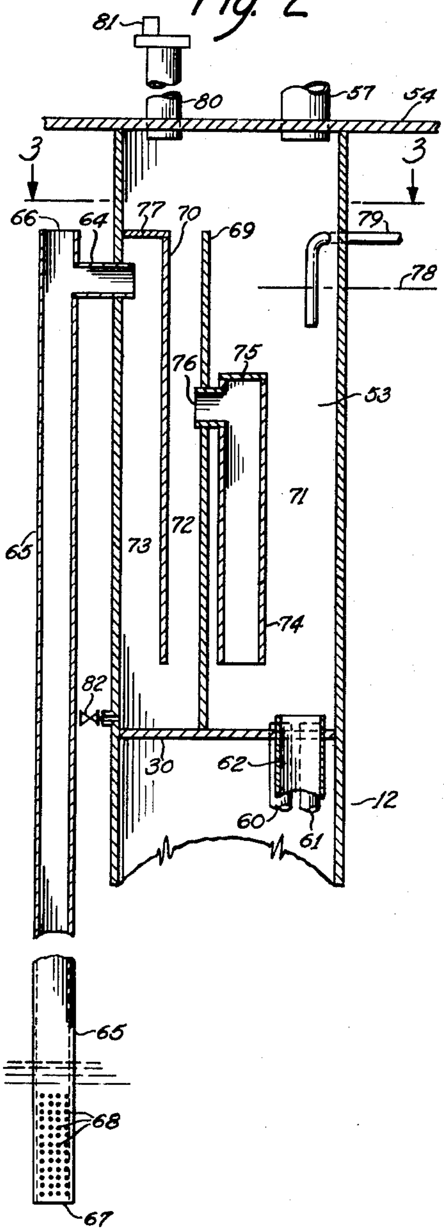


Fig. 3

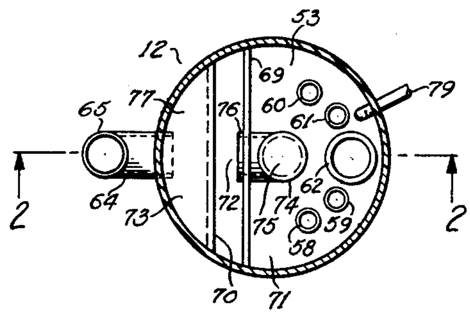
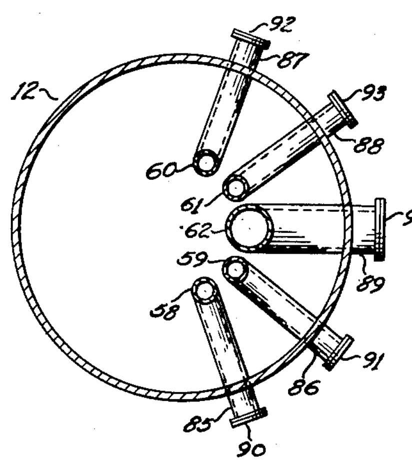


Fig. 4



INVENTORS
John C. Estes
Ray S. Lacy Jr.
BY Natt M Emery Jr.
ATTORNEY

United States Patent Office

3,146,458

Patented Aug. 25, 1964

3,146,458

UNDERWATER STORAGE UNIT

John C. Estes and Ray S. Lacy, Jr., Beaumont, Tex., assignors to Bethlehem Steel Company, a corporation of Pennsylvania

Filed Nov. 18, 1960, Ser. No. 70,149
13 Claims. (Cl. 61—46.5)

This invention relates to a marine structure for the underwater storage of oil in offshore areas, and is a further development of the subject matter disclosed in our earlier-filed copending application Serial No. 848,-466, entitled "Offshore Storage Unit."

Briefly, the present invention comprises a compartmented hull with columns extending upwardly therefrom and adapted to project above the surface of the water when the hull is stably supported adjacent the marine floor. Platforms at the tops of these columns support production equipment, oil treating equipment and similar apparatus. The structure can be floated to location on the buoyancy of the hull, and is set up on location by flooding said hull, stability being maintained by means of the columns. Thereafter, through oil piping communicating between the production platform and the columns and hull compartments, storage and discharge of oil is effected. When it is desired to relocate the structure, the same can be refloated by suitably deballasting the hull and columns.

One of the objects of this invention is to provide safe and efficient means for the storage and discharge of oil in offshore areas.

Another object of this invention is to provide a structure for the storage and discharge of oil in offshore areas, which structure can be floated to location, set up in a short period of time, and refloated in a short period of time for use at another site.

A further object of this invention is to provide a structure for the storage and discharge of oil in offshore areas, which structure will be stable in all kinds of weather, whether afloat or aground.

Still other and further objects of this invention will become apparent during the course of the following description.

Referring now to the drawings, in which like numerals represent like parts in the several views:

FIG. 1 represents a diagrammatic view in perspective of our underwater storage unit, and shows the various compartments and piping according to our invention.

FIG. 2 represents an enlarged vertical median section of the water receiver of the present invention.

FIG. 3 represents a section in plan of the water receiver of the present invention, taken along the line 3—3 of FIG. 2.

FIG. 4 represents a section in plan of the water lines and the column in which they pass, and shows the individual sinking connections communicating with the water lines and extending outside the column.

The invention is seen to comprise a liquid-tight hull 1, provided with liquid-tight bulkheads 2, 3, 4 and 5, subdividing said hull 1 into corner compartments 6, 7, 8 and 9 and central compartment 10. Liquid-tight columns 11, 12, 13 and 14, communicating with corner compartments 6, 7, 8 and 9 respectively, are secured to hull 1, extending upwardly therefrom, and are of length sufficient to project well above the surface of the water when said hull is stably supported adjacent, as by contact with, the marine floor.

Production platform 15, the walls of which define liquid-tight settling tank 16, is supported on column 11. Oil receiver 17 is mounted on production platform 15 and communicates through conduit means 18 and 19 with the upper portion of settling tank 16, said conduit

means 18 and 19 preferably extending into the upper portion of said oil receiver 17 so as to constitute an overflow weir. Settling tank 16 is provided with oil inlet connections 20 and 21 which may communicate with a source of oil and, preferably, which source may be an oil-water separator (not shown) which may be mounted on the production platform 15. Settling tank 16 may be compartmented so that, for instance, oil inlet connection 20 and conduit means 18 communicate with one such compartment and oil inlet connection 21 and conduit means 19 communicate with another such compartment. Such compartmentation being familiar to those acquainted with the art, the same is not shown in FIG. 1 as it would make the latter more difficult to read.

Column 11 is provided with bulkhead 22 defining oil compartment 23 at the upper portion of said column 11 between said bulkhead 22 and the bottom of production platform 15. Oil conduit means 24, with valve 25 therein, communicates between the lower portion of oil receiver 17 and the upper portion of oil compartment 23. Oil conduit means 26, extending through bulkhead 22, communicates between the lower portion of oil compartment 23 and the upper portion of trunk 27, the latter being a centralized upward extension of central compartment 10 of hull 1. Thus, through oil conduit means 24, oil compartment 23 and oil conduit means 26, oil may be conducted between the lower portion of oil receiver 17 and the upper portion of central compartment 10.

Oil conduit means 28, with valve 29 therein, communicates between the lower portion of oil receiver 17 and the portion of column 12 just below bulkhead 30 therein through oil conduit means 31, between oil receiver 17 and the portion of column 11 just below bulkhead 22 therein through oil conduit means 32, between oil receiver 17 and the upper portion of column 14 through oil conduit means 33, and between oil receiver 17 and the upper portion of column 13 through oil conduit means 34, the upper portion of column 14, and oil conduit means 33. Thus, oil may be conducted between the lower portion of oil receiver 17 and the upper portion of the space or volume defined by corner compartment 7 and that portion of column 12 lying below bulkhead 30 through oil conduit means 28 and 31, between the lower portion of oil receiver 17 and the upper portion of the space or volume defined by corner compartment 6 and that portion of column 11 lying below bulkhead 22 through oil conduit means 28 and 32, between the lower portion of oil receiver 17 and the upper portion of the space or volume defined by corner compartment 9 and column 14 through oil conduit means 28 and 33, and between the lower portion of oil receiver 17 and the upper portion of the space or volume defined by corner compartment 8 and column 13 through oil conduit means 28, 33 and 34 and the upper portion of column 14.

Two tanker loading stations 35 and 36 are provided, one on either side of the Underwater Storage Unit, either or both of which may be used at any one time, through oil discharge conduit means 37 and 38, with valved connections 39 and 40 therein respectively, to which hose lines 41 and 42 from the tankers may be secured. Through oil conduit means 43, with valve 44 therein, either or both loading stations 35 and 36 may be placed in communication with oil conduit means 31, 32, 33 and 34 and thus with the upper portion of the space or volume defined by corner compartment 7 and that portion of column 12 lying below bulkhead 30, with the upper portion of the space or volume defined by corner compartment 6 and that portion of column 11 lying below bulkhead 22, with the upper portion of the space or volume defined by corner compartment 9 and column 14, and with the upper portion of the space or volume defined by corner compartment 8 and column 13. Through oil conduit means 45, with valve 46 therein, either or both loading stations 35 and 36 may be placed in communication with the upper portion of oil compartment 23. Through oil conduit means 28, either or both loading stations 35 and 36 may be placed in communication with the lower portion of oil receiver 17.

Conveniently, and as an alternative to oil conduit means 43, either or both loading stations 35 and 36 may be placed in communication with the upper portions of the several oil storage spaces or volumes in the structure through oil conduit means 47, with valve 48 therein, communicating between the upper portion of column 14 and oil discharge conduit means 38, as will be evident upon inspection of FIG. 1.

Either or both loading stations 35 and 36 may be placed in communication with settling tank 16 of production platform 15 through oil conduit means 49 with valve 50 therein. If said tank 16 is compartmented, then each of said compartments will be provided with its own oil conduit means 49 and valve 50.

The upper portions of all oil storage spaces or volumes are vented. This may conveniently be done through the several oil conduit means 31, 32, 33 and 34 which are pitched downwardly from a high point adjacent column 11 at oil conduit means 28. Thus, concomitant with the initial sinking operation, air from those volumes or spaces defined by corner compartment 7 and that portion of column 12 lying below bulkhead 30, corner corpartment 6 and that portion of column 11 lying below bulkhead 22, corner compartment 9 and column 14, and corner compartment 8 and column 13 will pass through oil conduit means 31, 32, 33 and 34 to oil conduit means 28 and thence to oil receiver 17 and will vent out to the atmosphere through combination pressure-vacuum relief valve 51. Air from central compartment 10 will pass through trunk 27, oil conduit means 26, oil compartment 23, oil conduit means 24 to oil receiver 17 and thence to the atmosphere through said combination pressure-vacuum relief valve 51. It will be apparent that settling tank 16 vents through oil conduit means 18 and 19 to oil receiver 17 and valve 51.

Pressure-vacuum relief valve 51 performs several important functions. It permits venting as previously described. When set to vent slightly above atmospheric pressure, it permits a slight pressure on the oil in the structure and thereby reduces volatilization of the oil which otherwise would occur at atmospheric pressure under certain conditions of temperature. The vacuum feature of valve 51 provides a minimum pressure on the oil contents of the structure thereby preventing excessive flashing or vaporization of the oil which otherwise would occur under certain conditions of temperature if the pressure fell too much. In the preferred embodiment, the pressure-vacuum relief valve is set for 4 oz. p.s.i.g. pressure and ½ oz. p.s.i.g. vacuum.

Column 12, carrying pump platform 52, is provided with bulkhead 30 defining water receiver 53 at the upper portion thereof between said bulkhead 30 and the bottom 54 of said pump platform 52. Water conduit means 55 communicates between the surrounding water and the suction inlet of water pump 56. Water conduit means 57 communicates between the discharge outlet of water pump 56 and the upper portion of water receiver 53, extending through the bottom 54 of the pump platform 52 as shown in FIG. 2. Water conduit means 58, 59, 60, 61 and 62, extending through bulkhead 30, communicate between the lower portion of water receiver 53 and the lower portions of corner compartments 6, 7, 8 and 9 and central compartment 10, respectively, through funnel fittings 63.

Water receiver 53 is provided adjacent its upper portion at a predetermined height, for a purpose which will be explained further on, with an overflow 64 acting as a weir and communicating with overflow conduit means 65, the latter being open at the top 66 for venting itself and being open at the bottom 67 and adjacent thereto provided with a multiplicity of perforations 68 for diffusion.

The Underwater Storage Unit is operated on hydraulic displacement principles and, in connection therewith, water and oil will at various times be in contact at an interface. As a result, it may happen that some oil will be entrained in the water. As will be explained further on, water overflows water receiver 53 through overflow 64 and is discharged through overflow conduit means to the surrounding body of water. There arises the problem of avoiding pollution of the surrounding water by entrained oil, it being almost invariably the case that anti-pollution laws apply. The magnitude of this problem can readily be appreciated when it is considered that, in one jurisdiction, such pollution cannot lawfully exceed 5 parts per million of oil in water. Also, excessive oil in the surrounding area can create a serious fire hazard. To resolve such problems of contamination, the water receiver 53 of the present invention is provided with plate baffles 69 and 70 dividing said water receiver 53 into three chambers 71, 72 and 73. Pipe 74, closed at its upper end by plate 75, communicates between the lower portion of chamber 71 and chamber 72 through conduit 76 extending through plate baffle 69. Chamber 72 communicates, beneath the lower edge of plate baffle 70, with chamber 73, the latter being closed at the top by plate 77 and communicating with overflow 64. The level of the water in water receiver 53 will generally be at the approximate position of line 78. Any entrained oil will separate out and rise to the top of chamber 71, whence said oil will be withdrawn by skim suction conduit 79, the latter being connected to a suitable source of suction. Any small remaining quantity of entrained oil carried over to chamber 72 will rise to the top thereof and will not carry over to chamber 73 as communication with the latter is through the lower portion of chamber 72.

Water receiver 53 is, additionally, provided with vent conduit 80 which may lead to a combination pressure-vacuum relief valve 81, and with valved drain 82. Valve 81 performs substantially the same functions within water receiver 53 as valve 51, and in the preferred embodiment, is set for the same values of pressure and vacuum.

In order to selectively ballast the several volumes or spaces in the hull 1 and columns 11, 12, 13 and 14, during the initial sinking operation, whereby to control the trim of the structure during such sinking operation, there are provided sinking connections 85, 86, 87, 88 and 89 connected to water conduit means 58, 59, 60, 61 and 62 respectively, and extending outside the wall of column 12 at an elevation which will remain above the level of the surrounding water when the structure is finally stably supported adjacent the marine floor. When not in use, sinking connections will be closed as by blank flanges 90, 91, 92, 93 and 94 respectively.

In order to selectively deballast the several volumes or spaces in the hull 1 and columns 11, 12, 13 and 14, during the refloating operation, whereby to control the trim of the structure during such refloating operation, compressed air may be introduced into such spaces or volumes to displace the water therefrom to the water receiver 53 and thence through overflow 64 to the surrounding water. Thus, compressed air connections 95 and 96 and spectacle flange 97 are provided in oil conduit means 34, spectacle flange 98 is provided in oil conduit means 33, compressed air connections 99 and 100 and spectacle flange 101 are provided in oil conduit means 31, and compressed air connection 102 is provided in oil conduit means 24. In place of spectacle flanges 97, 98 and 101, valve means may be used but, in any event, when the compressed air connections 95, 96, 99, 100 and 102 are not in use, the same must be closed and spectacle flanges 97, 98 and 101 or the equivalent valve means must be open.

Platforms (not shown) are mounted on columns 13 and 14, in similar manner as platforms 15 and 52 on columns 11 and 12 respectively, and may be used for a heliport and crew's quarters. In any event, all of the valves and various fittings are accessible from the platforms mounted to the several columns, except for sinking connections 85, 86, 87, 88 and 89, and these latter will be accessible from ladders and walkways (not shown) mounted to column 12.

The operation of the Underwater Storage Unit will now be described.

With hull 1 and columns 11, 12, 13 and 14 sufficiently empty so that the structure is buoyant, the latter is towed to location. At the site, the structure is submerged to engagement with the marine floor. This may be done as follows. Blank flanges 90, 91, 92, 93 and 94 are removed from sinking connections 85, 86, 87, 88 and 89, and hose lines from water pumps on an auxiliary vessel moored alongside are connected to said sinking connections 85, 86, 87, 88 and 89 and water pumped therein to ballast, respectively, the space or volume defined by corner compartment 6 and that portion of column 11 lying below bulkhead 22, the space or volume defined by corner compartment 7 and that portion of column 12 lying below bulkhead 30, the space or volume defined by corner compartment 8 and column 13, the space or volume defined by corner compartment 9 and column 14, and central compartment 10, the air from said spaces or volumes venting out through pressure-vacuum relief valve 51 as previously described, valves 25 and 29 being open for this purpose. In the preferred embodiment, central compartment 10 has been so proportioned that, when it is filled with ballast water, the structure will float with about one foot of freeboard and, in the initial sinking operation of said preferred embodiment, the central compartment 10 will be filled with ballast water first and thereafter, the remaining spaces or volumes of hull 1 will be ballasted to complete the sinking operation. This method results in the elimination of the large free surface effect of water ballast in central compartment 10 before the water plane thereof is lost. Obviously, the structure may be kept under control during the sinking operation by regulating the flow of ballast water to the several volumes or spaces being ballasted. When the structure is grounded in final position, the hose lines are removed, and blank flanges 90, 91, 92, 93 and 94 are reinstalled on sinking connections 85, 86, 87, 88 and 89 respectively.

Oil may now be introduced into settling tank 16 through oil inlet connections 20 and 21. When settling tank 16 is full, the oil will rise in oil conduit means 18 and 19 and will overflow into oil receiver 17. It will be noted that oil receiver 17 is at a level considerably higher than the level of overflow 64 in water receiver 53, and the ratio of the height of oil receiver 17 above the marine floor to the height of overflow 64 above the marine floor is greater than the ratio of salt water density to oil density. Therefore, by well-known displacement principles, with valves 25 and 29 open, oil will flow from oil receiver 17 through oil conduit means 28 and 31 to that portion of column 12 lying below bulkhead 30, through oil conduit means 28 and 32 to that portion of column 11 lying below bulkhead 22, through oil conduit means 28 and 33 to the upper portion of column 14, through oil conduit means 28, 33 and 34 to the upper portion of column 13, and through oil conduit means 24, oil compartment 23, and oil conduit means 26 to central compartment 10, the water displaced from said spaces or volumes passing through water conduit means 59, 58, 61, 60 and 62 respectively into water receiver 53, in which any entrained oil settles out as previously described, and thence out through overflow 64 and overflow conduit means 65 to the surrounding water. As this process continues, the volumes or spaces defined by corner compartment 7 and that portion of column 12 lying below bulkhead 30, corner compartment 6 and that portion of column 11 lying below bulkhead 22, corner compartment 9 and column 14, corner compartment 8 and column 13, and central compartment 10 will gradually fill with oil, it being understood that unless tankers are at the same time loading at either or both loading stations 35 and 36, valves 44, 50, 39, 46, 40 and 48 will normally be closed. In order to prevent overfilling with oil, and to keep the oil-water interface above the bottom of funnel fittings 63 (as, otherwise, large volumes of oil would escape through the several water conduit means to the water receiver 53 and thence to the surrounding water), a high level float shut-off 103 is provided and which functions by means of a piping and control system (not shown, but understood by those familiar with the art) to shut off the flow of oil into oil inlet connections 20 and 21.

Tankers may be loaded at either or both loading stations 35 and 36, after the structure has been filled with oil or while the structure is being filled with oil. Thus, the tankers are moored alongside columns 12 and/or 14, and hose lines 41 and/or 42 from said tankers are connected to valved connections 39 and 40 respectively. Valved connections 39 and 40 are opened or closed depending upon whether one or both loading stations or one loading station are in use, and if the latter, then upon which loading station is in use, as will be evident to those familiar with the art. Valves 44, 46, 48, 29 and 25 are open. Oil in oil receiver 17 will then flow by gravity to the tanker or tankers, and water pump 56 is operated to introduce water into water receiver 53. It will be noted that the ratio of the height of valved connections 39 and 40 and oil discharge conduit means 37 and 38 above the marine floor to the height of overflow 64 above the marine floor is less than the ratio of water density to oil density. Consequently, by well-known displacement principles, water will pass through water conduit means 58, 59, 60, 61 and 62 to corner compartments 6, 7, 8 and 9 and central compartment 10 respectively, the oil displaced from the volumes or spaces defined by corner compartment 6 and that portion of column 11 lying below bulkhead 22, corner compartment 7 and that portion of column 12 lying below bulkhead 30, corner compartment 8 and column 13, corner compartment 9 and column 14, and central compartment 10, passing through the several oil conduit means to either or both loading stations 35 and 36.

It may be preferred, in the operation of this structure and by the appropriate manipulation of the several valves, to introduce oil from well production into the space or volume represented by corner compartments 6, 7, 8 and 9 and columns 11, 12, 13 and 14 collectively, or into the space or volume represented by central compartment 10 and, depending upon which space or volume is being filled with oil, to discharge oil from the other space or volume into the tanker. This method permits accurate determinations of the amount of oil being produced and of the amount of oil being transferred to the tanker.

The contents of settling tank 16 can be drained to either loading station as part of the preceding operation or as a separate operation through oil conduit means 49 when valve 50 is open.

Water receiver 53 performs a very important function in the preceding operation, viz., displacing oil by water, in that it provides an "air gap" between the water pump and the several oil storage volumes or spaces thus positively preventing overpressure and consequent rupture of the plating of such volumes or spaces or bursting of seams therein. In conventional designs, such overpressure could result from some of the valves in the oil lines being closed inadvertently. The "air gap" provided by the water receiver 53 permits an absolute, predetermined limit to be placed on the amount of internal pressure in the present invention, as water pump 56 is not directly hydraulically coupled to the said apparatus, said predetermined limit being absolutely foolproof and not subject to malfunctioning of any kind.

Water receiver 53 performs another important function in the preceding operation in that it provides a constant hydrostatic head on the body of oil and thereby carry-over of displacing water to the tankers is prevented. In conventional designs, where the water pump is directly hydraulically coupled to the system, surging, turbulenece and eddying of the displacing water in the body of oil to be displaced would result in some of the displacing water passing to the tanker vessel along with the displaced oil.

Prior to refloating the structure to relocate same, oil in the several oil storage volumes or spaces in the hull and columns is displaced by water as described above. Then, these spaces or volumes are deballasted by means of compressed air. This may be done by closing spectacle flanges or equivalent valve means **97, 98** and **101**, and valves **44, 29, 25, 46** and **48**, and by opening compressed air connections **95, 96, 99, 100** and **102** and connecting the same to a source of compressed air. Under the pressure of the compressed air, water from the several oil storage spaces or volumes in the hull and columns will be displaced through the several water conduit means to water receiver **53** and out through overflow **64**. As this process continues, the structure will regain buoyancy and will gradually refloat. It will be evident, to those familiar with the art, that by regulating the flow of compressed air to the several said oil storage spaces or volumes in the hull and columns the rate of ascent and the stability or trim of the structure can be controlled.

Although we have shown and described our invention in considerable detail, we do not wish to be limited to the exact construction shown and described, but may use such substitutions, modifications or equivalents thereof as are embraced within the scope of the invention or as pointed out in the claims.

We claim:

1. Marine oil storage apparatus comprising:
(*a*) a tank adapted to be submerged and stably supported adjacent the marine floor,
(*b*) a compartment elevated above said tank,
(*c*) first conduit means secured to said compartment and communicating with the interior thereof to introduce water into said compartment,
(*d*) baffle means in said compartment,
(*e*) first and second chambers in said compartment defined by said baffle means,
(*f*) oil withdrawal means secured to said compartment and communicating with the upper portion of said first chamber,
(*g*) second conduit means secured to said compartment and communicating between said first chamber and the lower portion of said tank,
(*h*) said first chamber communicating with said second chamber below the level of said oil withdrawal means, and
(*i*) an overflow conduit secured to said compartment and communicating between said second chamber and the atmosphere.

2. Marine oil storage apparatus comprising:
(*a*) a tank adapted to be submerged and stably supported adjacent the marine floor,
(*b*) a compartment elevated above said tank,
(*c*) first conduit means secured to said compartment and communicating with the interior thereof to introduce water into said compartment,
(*d*) baffle means in said compartment,
(*e*) first and second chambers in said compartment defined by said baffle means,
(*f*) oil withdrawal means secured to said compartment and communicating with the upper portion of said first chamber,
(*g*) second conduit means secured to said compartment and communicating between the lower portion of said first chamber and the lower portion of said tank,
(*h*) said first chamber communicating with said second chamber below the level of said oil withdrawal means, and

(*i*) an overflow conduit secured to said compartment and communicating between said second chamber and the atmosphere.

3. Marine oil storage apparatus comprising:
(*a*) a tank adapted to be submerged and stably supported adjacent the marine floor,
(*b*) a compartment elevated above said tank,
(*c*) first conduit means secured to said compartment and communicating with the interior thereof to introduce water into said compartment,
(*d*) baffle means in said compartment,
(*e*) first and second chambers in said compartment defined by said baffle means,
(*f*) oil withdrawal means secured to said compartment and communicating with the upper portion of said first chamber,
(*g*) second conduit means secured to said compartment and communicating between the lower portion of said first chamber and the lower portion of said tank,
(*h*) said first chamber communicating with said second chamber below the level of said oil withdrawal means and only through a liquid column,
(*i*) an overflow conduit secured to said compartment and communicating between said second chamber and the atmosphere, and
(*j*) a pressure-vacuum relief valve operatively interposed between said first chamber and the atmosphere.

4. Marine oil storage apparatus comprising:
(*a*) a tank adapted to be submerged and stably supported adjacent the marine floor,
(*b*) a compartment elevated above said tank,
(*c*) first conduit means secured to said compartment and communicating with the interior thereof to introduce water into said compartment,
(*d*) a plurality of spaced baffles in said compartment,
(*e*) first, second and third chambers in said compartment defined by said baffles,
(*f*) oil withdrawal means secured to said compartment and communicating with the upper portion of said first chamber,
(*g*) second conduit means secured to said compartment and communicating between said first chamber and the lower portion of said tank,
(*h*) said first chamber communicating with said second chamber below the level of said oil withdrawal means,
(*i*) said second chamber communicating with said third chamber adjacent the lower portion of said compartment, and
(*j*) an overflow conduit secured to said compartment and communicating between said third chamber and the atmosphere.

5. Marine oil storage apparatus comprising:
(*a*) a tank adapted to be submerged and stably supported adjacent the marine floor,
(*b*) a compartment elevated above said tank,
(*c*) first conduit means secured to said compartment and communicating with the interior thereof to introduce water into said compartment,
(*d*) a plurality of spaced baffles in said compartment,
(*e*) first, second and third chambers in said compartment defined by said baffles,
(*f*) oil withdrawal means secured to said compartment and communicating with the upper portion of said first chamber,
(*g*) second conduit means secured to said compartment and communicating between the lower portion of said first chamber and the lower portion of said tank,
(*h*) said first chamber communicating with said second chamber below the level of said oil withdrawal means,
(*i*) said second chamber communicating with said third chamber adjacent the lower portion of said compartment,

(*j*) an overflow conduit secured to said compartment and communicating between said third chamber and the atmosphere, and

(*k*) a pressure-vacuum relief valve operatively interposed between said first chamber and the atmosphere.

6. Marine oil storage apparatus comprising:

(*a*) a tank adapted to be submerged in a body of water,

(*b*) a column secured to said tank and extending above the surface of the water, the interiors of said tank and said column being in communication with each other,

(*c*) a compartment secured to said column above the surface of the water,

(*d*) first conduit means secured to said compartment and communicating with the interior thereof to introduce water into said compartment,

(*e*) baffle means in said compartment,

(*f*) first and second chambers in said compartment defined by said baffle means,

(*g*) oil withdrawal means secured to said compartment and communicating with the upper portion of said first chamber,

(*h*) second conduit means secured to said compartment and communicating between said first chamber and the lower portion of said tank,

(*i*) said first chamber communicating with said second chamber below the level of said oil withdrawal means, and

(*j*) an overflow conduit secured to said compartment and communicating between said second chamber and the atmosphere.

7. Marine oil storage apparatus comprising:

(*a*) a tank adapted to be submerged in a body of water,

(*b*) a column secured to said tank and extending above the surface of the water, the interiors of said tank and said column being in communication with each other,

(*c*) a compartment secured to said column above the surface of the water,

(*d*) first conduit means secured to said compartment and communicating with the interior thereof to introduce water into said compartment,

(*e*) baffle means in said compartment,

(*f*) first and second chambers in said compartment defined by said baffle means,

(*g*) oil withdrawal means secured to said compartment and communicating with the upper portion of said first chamber,

(*h*) second conduit means secured to said compartment and communicating between the lower portion of said first chamber and the lower portion of said tank,

(*i*) said first chamber communicating with said second chamber below the level of said oil withdrawal means and only through a liquid column,

(*j*) an overflow conduit secured to the upper portion of said compartment and communicating between said second chamber and the atmosphere, and

(*k*) a pressure-vacuum relief valve operatively interposed between said first chamber and the atmosphere.

8. Marine oil storage apparatus comprising:

(*a*) a tank adapted to be submerged in a body of water,

(*b*) a column secured to said tank and extending above the surface of the water, the interiors of said tank and said column being in communication with each other,

(*c*) a compartment secured to said column above the surface of the water,

(*d*) first conduit means secured to said compartment and communicating with the interior thereof to introduce water into said compartment,

(*e*) a plurality of horizontally spaced vertically disposed baffles in said compartment,

(*f*) first, second and third chambers in said compartment defined by said baffles,

(*g*) oil withdrawal means secured to said compartment and communicating with the upper portion of said first chamber,

(*h*) second conduit means secured to said compartment and communicating between the lower portion of said first chamber and the lower portion of said tank,

(*i*) said first chamber communicating with said second chamber below the level of said oil withdrawal means,

(*j*) said second chamber communicating with said third chamber adjacent the lower portion of said compartment, and

(*k*) an overflow conduit secured to the upper portion of said compartment and communicating between said third chamber and the atmosphere.

9. Marine oil storage apparatus comprising:

(*a*) a tank adapted to be submerged in a body of water,

(*b*) a column secured to said tank and extending above the surface of the water, the interiors of said tank and said column being in communication with each other,

(*c*) a compartment secured to said column above the surface of the water,

(*d*) first conduit means secured to said compartment and communicating with the interior thereof to introduce water into said compartment,

(*e*) a plurality of horizontally spaced vertically disposed baffles in said compartment.

(*f*) first, second and third chambers in said compartment defined by said baffles,

(*g*) oil withdrawal means secured to said compartment and communicating with the upper portion of said first chamber,

(*h*) second conduit means secured to said compartment and communicating between the lower portion of said first chamber and the lower portion of said tank,

(*i*) said first chamber communicating with said second chamber below the level of said oil withdrawal means,

(*j*) said second chamber communicating with said third chamber adjacent the lower portion of said compartment,

(*k*) an overflow conduit secured to the upper portion of said compartment and communicating between said third chamber and the atmosphere, and

(*l*) a pressure-vacuum relief valve operatively interposed between said first chamber and the atmosphere.

10. Apparatus for use with an oil storage structure submerged in a body of water and operated on hydraulic displacement principles in which oil is introduced into or displaced from the upper portion of said structure and water is introduced into or displaced from the lower portion of said structure, said apparatus comprising a compartment; means to introduce water into said compartment; baffle means in said compartment; first and second chambers defined by said baffle means; oil withdrawal means communicating with the upper portion of said first chamber; water conduit means communicating with said first chamber and adapted to communicate with the lower portion of said structure; said first chamber communicating with said second chamber below the level of said oil withdrawal means; and an overflow connection in said compartment; said second chamber communicating with said overflow connection.

11. Apparatus for use with an oil storage structure submerged in a body of water and operated on hydraulic displacement principles in which oil is introduced into or displaced from the upper portion of said structure and water is introduced into or displaced from the lower portion of said structure, said apparatus comprising a compartment; means to introduce water into said compartment; baffle means in said compartment; first and second chambers defined by said baffle means; oil withdrawal means communicating with the upper portion of

said first chamber; water conduit means communicating with the lower portion of said first chamber and adapted to communicate with the lower portion of said structure; said first chamber communicating with said second chamber below the level of said oil withdrawal means; and an overflow connection in the upper portion of said compartment; said second chamber communicating with said overflow connection.

12. Apparatus for use with an oil storage structure comprising a storage tank submerged in a body of water and provided with a communicating column extending above the surface of the water, which oil storage structure is operated on hydraulic displacement principles under which oil is introduced into or displaced from the upper portion of said oil storage structure and water is introduced into or displaced from the lower portion of said oil storage structure, said apparatus comprising a compartment secured to said column above the surface of the water; means to introduce water into said compartment; baffle means in said compartment; first and second chambers defined by said baffle means; oil withdrawal means communicating with the upper portion of said first chamber; water conduit means communicating with said first chamber and adapted to communicate with the lower portion of said storage tank; said first chamber communicating with said second chamber below the level of said oil withdrawal means; and an overflow connection in said compartment; said second chamber communicating with said overflow connection.

13. Apparatus for use with an oil storage structure comprising a storage tank submerged in a body of water and provided with a communicating column extending above the surface of the water, which oil storage structure is operated on hydraulic displacement principles under

which oil is introduced into or displaced from the upper portion of said oil storage structure and water is introduced into or displaced from the lower portion of said oil storage structure, said apparatus comprising a compartment secured to said column above the surface of the water; means to introduce water into said compartment; baffle means in said compartment; first and second chambers defined by said baffle means; oil withdrawal means communicating with the upper portion of said first chamber; water conduit means communicating with the lower portion of said first chamber and adapted to communicate with the lower portion of said storage tank; said first chamber communicating with said second chamber below the level of said oil withdrawal means and only through a liquid column; an overflow connection in the upper portion of said compartment; said second chamber communicating with said overflow connection; and a pressure-vacuum relief valve operatively interposed between said first chamber and the atmosphere.

References Cited in the file of this patent

UNITED STATES PATENTS

1,702,612	Morse	Feb. 19, 1929
2,058,044	Spencer	Oct. 20, 1936
2,594,105	Watts	Apr. 22, 1952
2,748,739	Monti	June 5, 1956
2,826,306	Burns	Mar. 11, 1958
2,844,213	Wilson	July 22, 1958
2,940,594	Binmore	June 14, 1960
2,973,046	McLean	Feb. 28, 1961
3,008,599	Young	Nov. 14, 1961

OTHER REFERENCES

Oil and Gas Journal, Mar. 10, 1958, p. 101.