SLURRY CARRYING VESSEL

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Filed: Jan. 30, 1973
Appl. No.: 328,013

U.S. Cl.................... 210/242, 210/537, 214/14, 302/16
Int. Cl.......................... B01D 21/24
Field of Search........ 210/242, DIG. 21, 533, 210/537, 302/16, 214/14, 15 B

Vessel for carrying slurries and means for draining slurry water from the ship's hold.

17 Claims, 48 Drawing Figures
SLURRY CARRYING VESSEL

The present invention relates to a slurry carrying vessel, and more particularly it relates to means for draining slurry water from ship’s holds.

In the case of transporting powdery or granular materials such as iron sand, powdery ore, chips, coal and gravel by carrying vessels, a system has been thought of wherein these cargoes are converted into a slurry form and fed into the ship’s holds by pipes. A slurry cargo fed into a hold is quickly separated into a cargo layer which has settled due to the difference in specific gravity, and a free water layer thereabove. Transport with such free water layer still retained in the hold is not only uneconomical but presents a serious problem of safety in view of the force which the swaying free water exerts on the hull.

Further, slurry water also exists in the settling cargo layer. The amount of such settling water varies with the properties of the cargo, but transport with such settling water retained results in an increase in the cost of transport because of the resulting increase in the total weight. Further, it involves inconveniences in that at the time of unloading, the cargo cannot be handled in the same manner as ordinary bulk cargoes.

For these reasons, it would be very convenient in various points of view if upon loading the hold with a slurry cargo, not only the free water on the settling cargo layer but also the settling water in said cargo layer can be discharged into the outside of the ship.

A first object of the present invention is to provide a slurry carrying vessel having a hold construction capable of continuously loading with a slurry cargo up to a predetermined level, quickly discharging the free water on the cargo layer, and discharging the settling water in the cargo layer by utilizing the time during which other holds are being loaded with the cargo or the ship is cruising. Thus, a slurry carrying vessel according to the present invention is characterized in that the hold wall is provided with an overflow drain port located suitably above the predetermined loading level of cargo and an on-off valve-equipped free water drain port located below said overflow drain port but slightly above said predetermined loading level and that the hold bottom is provided with a number of filter-equipped drain ports. According to such arrangement of the invention, after the free water layer separated on the settling cargo layer within the hold as a result of continuous loading with the slurry cargo reaches the level of said overflow drain port, the free water in said free water layer is discharged by overflowing through said overflow drain port, so that the level of the cargo layer alone increases without involving any increase in the level of the free water layer. As the level of the cargo layer reaches the predetermined loading level, loading with the slurry cargo is stopped and the on-off valve for the free water drain port is opened to discharge the free water on the loaded cargo so that there is substantially no free water layer. On the other hand, the settling water in the cargo layer can be gradually discharged through the filter-equipped ports in the hold bottom by utilizing gravity fall. The discharge of the settling water may be effected by utilizing the time during which the other holds are being loaded with cargo or the ship is cruising.

Several embodiments of the invention to be hereinafter described have numerous features, which will be readily understood from the following description with reference to the accompanying drawings. Further, in the following description an example is taken of iron sand slurry, but it is to be understood that other types of slurry cargo may also be similarly handled.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic side view in longitudinal section showing the arrangement of a plurality of holds in a slurry carrying vessel;

FIG. 2 is a schematic plan view in cross-section of the same;

FIG. 3 is an enlarged side view in longitudinal section of the No. 5 hold;

FIG. 4 is a plan view in longitudinal section of said hold;

FIG. 5 is a front view in longitudinal section of said hold;

FIGS. 6A through 6-F are views explanatory of the order in which iron sand slurry is loaded;

FIGS. 7 and 8 are schematic side views in longitudinal section of the principal portions of modifications;

FIG. 9 is a longitudinal section of a drain tunnel having filter-equipped drain ports;

FIG. 10 is a front view of a portion of said drain tunnel;

FIG. 11 is an enlarged longitudinal section of the filter;

FIG. 12 is a partly broken-away front view of said filter;

FIG. 13 is a partly broken-away rear view of said filter;

FIG. 14 is a longitudinal section of a modification of said filter;

FIG. 15 is a partly broken-away view of said modified filter;

FIG. 16 is a longitudinal section of an embodiment showing another form of filter-equipped drain tunnel;

FIG. 17 is a front view in longitudinal section of the filter shown in FIG. 16;

FIG. 18 is a longitudinal section of an embodiment showing still another form of filter-equipped drain port;

FIG. 19 is a partly broken-away front view of the filter shown in FIG. 18;

FIG. 20 is a plan view in cross-section showing means for fixing successive filters shown in FIG. 19;

FIGS. 21, 23, 24 and 26 are longitudinal sections showing different drain tunnel constructions;

FIG. 27 is a longitudinal section showing the relation between the drain tunnel construction and bilge well shown in FIG. 24;

FIG. 27 is a longitudinal section showing an example of the construction of a filter-equipped bottom drain port;

FIG. 28 is a plan view in cross section of the drain port shown in FIG. 27;

FIG. 29 is a longitudinal section of the principal portion of a modification of the construction shown in FIG. 27;

FIG. 30 is a longitudinal section of the principal portion of a flat plate type filter;

FIG. 31 is a plan view of said principal portion;
FIG. 32 is a longitudinal section of the principal portion of a modification of said filter;

FIG. 33 is a schematic front view in longitudinal section of a construction adapted to discharge overflow water directly into the outside of the ship;

FIG. 34 is a side view in longitudinal section of the principal portion of said construction;

FIG. 35 is a side view in longitudinal section showing an example in which a settling tank is provided in a drain passageway;

FIG. 36 is a front view in longitudinal section of the same;

FIG. 37 is a plan view in cross section showing a drain passageway construction making use of a corrugated plate;

FIG. 38 is a perspective view showing an example in which wave breaking means is mounted over an over-flow drain port;

FIG. 39 is a side view in longitudinal section of the same;

FIG. 40 is a plan view in cross section of the same;

FIG. 41 is a perspective view showing a modification thereof;

FIG. 42 is a plan view in cross section of said modification; and

FIG. 43 is a plan view in longitudinal section of said modification.

In FIGS. 1 and 2, No. 1 hold 1 to No. 5 hold 5 are defined by opposed longitudinal partition walls 8 cooperating with ship's side boards 6 to define therebetween a number of wing tanks 7 arranged longitudinally of the ship, transverse partition walls 9 dividing said longitudinal partition walls, and a double bottom board 12 cooperating with a ship's bottom outer board 10 to define a space 11 therebetween, each hold having a suitable number of hatchways 13. With the No. 3 hold serving as a void space, the other holds 1, 2, 4 and 5 are used as cargo holds.

The outline of the dehydration construction of each cargo hold will now be described with reference to FIGS. 3-5 by taking the No. 5 hold 5 as an example.

A vertical drain passageway 14 at the stern transverse partition wall 9 of each cargo hold is defined by said transverse partition wall 9 and a channel-shaped member 15 attached thereto, the lower end of said passageway communicating with a water reservoir space 17 which is elongate widthwise of the ship and is disposed at the lower portion of the transverse partition wall 9 and defined by said transverse partition wall 9, inclined plate 16 and double bottom board 12. An overflow drain port 18 establishing communication between the passageway 14 and the cargo hold which is adjacent to the bow side of said passageway 14 is disposed at a predetermined distance above the normal iron sand loading level H in said cargo hold. Further, disposed somewhat above said iron sand loading level H is a free water drain port 19 for drawing the free existing water between said iron sand loading level H and the overflow drain port 18, said free water drain port 19 being provided with an on-off valve 20 so that it can be made to communicate with said drain passageway 14 whenever it is desired to do so. The numeral 21 designates an emergency drain port for draining water from between the double bottom board 12 and the iron sand loading level H into the drain passageway 14, it being provided with an on-off valve 22.

A drain tunnel 23 which is elongate longitudinally of the ship and disposed at a corner of the cargo hold between the opposed longitudinal walls 8 and the double bottom board 21 is defined by portions of said longitudinal partition wall 8 and double bottom board 12, an inclined roof plate 24 extending downwardly from the longitudinal partition plate, and a longitudinal side plate 25, which is provided with a number of filter-equipped drain ports 26 arranged longitudinally of the ship. The said two drain tunnels 23 communicate with said water reservoir space 17 at their stern side ends. The numeral 27 designates a drain pipe having a bell-mouth 28 downwardly opened within said water reservoir space 17, said drain pipe leading to an overflow drain pump (not shown) and used mainly for drainage of overflow water. The numeral 29 designates a drain pipe having a bell-mouth 31 downwardly opened within a bilge well 30, said drain pipe being used mainly for drainage of settling water and similarly leading to an overflow drain pump (not shown). While said bilge well 30 is shown opening to the water reservoir space 17, they may be separated from each other, with the drain tunnels 23 communicating with the bilge well 30, so that free water and overflow water rich in mud and dirt, i.e., the drain water from the drain passageways 14 may be discharged outside the ship in a course separate from that for the relatively clean drain water from the drain tunnels 23. A suitable number of filter-equipped bottom drain ports 32 to compensate for the drain water are disposed adjacent the longitudinal partition walls 8 of the double bottom board 12 in the cargo hold and communicate with said bilge well 30 through respective conduits 33.

FIG. 6 shows hydration methods. In FIG. 6-A, an artificial pond 34 provided on a shore rich in iron sand has a slurry make-up station 35 and a pump station 36 installed therein. The iron sand slurry made up by these facilities is pumped into an Imodco buoy 37 on the sea through a pipeline 38 on the sea-bottom. It is then pumped through an Imodco pipe 40 into a loading pipeline 39 on a slurry carrying vessel moored to said buoy. The iron sand slurry pumped into the loading pipeline 39 is fed to one selected cargo hold through that one of a plurality of loading pipes 41 divided among the cargo holds whose on-off valve 42 is open.

In the cargo hold having the iron sand slurry pumped thereinto, the iron sand settles faster due to the difference in specific gravity, so that the slurry is separated into an iron sand layer 43 and a free-water layer thereabove, their levels gradually rising with a substantial height difference therebetween. As shown in FIG. 6-B, if the on-off valve 20 for the free-water drain port 19 is left closed, the free water, upon reaching the overflow drain port 18, flows into the drain passageway 14 through the overflow drain port 18, so that the level of the iron sand layer 43 alone rises thenceforth. The overflow water which was flowed into the drain passageway 14 then flows down into the water reservoir space 17, wherefrom it passes through the bell-mouth 28 for drainage outside the ship through the drain pipe 27.

When the level of the iron sand slurry reaches the predetermined iron sand loading level H as shown in FIG. 6-C, the front end bent portion 41A of the loading pipe 41 is turned aside to change the slurry loading site in the hold to ensure that the slurry is placed substan-
fully uniformly over the entire area of the hold up to said level H. Upon passage of the time required for the floating iron sand particles in the free-water layer 44 to settle, the on-off valve 20 for the free-water drain port 19 is opened to allow the free water to flow out into the drain passageway 14 through said drain port 19. It is then drained outside the ship from the water reservoir space 17 through the drain pipe 27, as in the case of the overflow water. As a result, almost all of the free water on the iron sand layer disappears, but there still exists water between iron sand particles. This settling water gradually moves down by gravity until it flows out into said drain ports 23 through filter-equipped drain ports 26. Further, said settling water flows out also through the filter-equipped bottom drain ports 32 and guided into the bilge wells 30 through the conduits 33. The settling water extracted in this manner is drained outside the ship along with the overflow water during drainage of such overflow water, and the overflow water and free water pass from the bilge wells 30 through the bell mouth 31 to be discharged outside the ship with a sufficient amount of time taken in such drainage operation. When the natural dehydration operation on settling water by gravity is completed, the iron sand in the cargo hold becomes a suitably wet motionless mass and completely stabilized.

When the iron sand slurry is pumped, the volumetric ratio between the amount of iron sand and the amount of water is as high as, e.g., 1:5, and in the initial stage of pumping operation, such ratio is set at a greater value. Therefore, as shown in FIG. 6-A, there will be a large amount of free water in the initial stage of loading the cargo hold. If the ship violently sways under such condition due to wind and waves, the sway of free water results in a great shock acting on the ship, which becomes a problem in respect of safety. If, therefore, such situation arises, loading with iron sand slurry is stopped as shown in FIG. 6-F and the on-off valve 22 for the emergency drain port 21 is opened to allow said free water to quickly flow out into the drain passageway 14 through said drain port 21. It may then be drained outside the ship as in the case of drainage of overflow water. Thus the aforesaid problem is solved.

The loading operation where there is a plurality of cargo holds as shown in FIGS. 1 and 2 is carried out in turns with respect to various cargo holds, for example, in such a manner that with the No. 3 cargo hold serving as a void space the No. 2 cargo hold is first loaded, followed by the No. 5 cargo hold, No. 1 cargo hold and No. 4 cargo hold. The loading which takes place in this particular order is effected by controlling the opening and closing of the on-off valve 42 and other on-off valves placed in the loading pipelines 39 shown in FIG. 6-A. When such loading method is to be employed, as shown in FIGS. 1 and 2, it is desirable that the hold 4 to be loaded last be so constructed that it has a smaller volume and a larger drain area per volume than the other holds. To this end, the hold 4 may have a larger number of drain ports 26 and 32 than other holds or if there is no problem in point of strength it may have the same number of drain ports each having a larger drain area. Alternatively, the drain ports 26 alone may be increased in number or the various drain ports in one hold may all be increased in number.

The arrangement described above provides the following merits.

The time needed from the time the loading of the last loading hold with iron sand slurry is completed until the drainage of settling water is completed can be greatly decreased as compared with the other holds (it is possible to make the two period of time nearly equal to each other). If, therefore, the volumes and total drain area of the holds except the last loading hold are such that the drainage in the holds whose loading has been completed at least prior to the completion of loading of the last loading hold is completed, then it is possible to set sail almost as soon as the loading of the last loading hold is completed. For example, in the case where there is a large amount of residual water in the holds at the time of completion of the loading of the last loading hold, since the draft of is calculated on the basis of the weight of the cargo alone, the actual draft would be above the safety draft upon completion of loading, so that the departure of the ship has to be delayed until the dehydration is completed in order for the draft to attain the safety level, thus greatly decreasing the loading efficiency. However, such situation can be avoided if the arrangement described above is employed.

As for the other holds, since it is only necessary to complete drainage before the completion of the loading of the last loading hold, the total drain area thereof may be small. Therefore, as compared with the case where the total drain area of all holds is increased, the construction costs can be made low and other desirable effects obtained in the field of maintenance.

In addition, although filter-equipped bottom drain ports 32 have been provided in order to compensate the drainage of settling water to be effected from the drain ports 26 through the drain tunnels, the same purpose may also be attained by providing filter-equipped auxiliary drain ports 45 in direct communication with the drain passageways 14 and water reservoir space 17, as shown in FIG. 7. As shown in FIG. 8, at a position below the iron sand loading level H, auxiliary drain ports 46 are provided in one or more stages to allow free water produced during iron sand loading operation to flow out into the drain passageways 14. Each of said drain ports 46 may be provided with an on-off valve 47. With such arrangement, those auxiliary drain ports which are above the surface level of an iron sand layer 43 may be opened during iron sand loading operation to allow free water to be drained as soon as possible before the free water level reaches the overflow drain ports 18, and the auxiliary drain ports 46 may then be successively closed slightly before the iron sand layer 43 reaches said overflow drain ports 18. Therefore, safety and efficiency in iron sand slurry loading operation can be further improved.

It is desirable that those drain ports which are provided with on-off valves, such as free water drain ports 19, emergency drain ports 21 and auxiliary drain ports 46, be equipped with filters so that the opening and closing of the on-off valves may not be adversely affected by iron sand which flows in.

Next, a concrete example of the construction of the filter-equipped drain port 26 provided in a drain tunnel 23 will now be described with reference to FIGS. 9 through 13.

As shown, an inclined roof-shaped plate member 24 extends inwardly beyond a vertical lateral plate 25. Protecting members 48 of T-shaped (or V-shaped) cross-section project from the outer side of said vertical lateral plate 25 and are arranged at regular intervals.
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longitudinally of the ship. Disposed at positions opposed to said protecting members 48 are reinforcing plates 49 of the shape allowing passage of workers and water. The vertical lateral plate 25 is provided with dehydration ports 50 arranged at regular intervals longitudinally of the ship. Such a dehydration port 50 is equipped with a flat plate-like filter 51. The filter 51 comprises an inner perforated plate 53 having a number of small apertures 52, an outer perforated plate 55 having a number of small apertures 54, a metal screen 56 consisting of a plurality of filter layers, and annular spacers 58 defining a suitable space 57 between the outer perforated plate 55 and the screen 56. The filter 51 is united in such a manner that the filter 51 is held between the inner and outer perforated plates 53 and 55 by a plurality of bolts 59 extending through suitable places on the periphery with nuts 60 threadedly fitted thereon. In this united condition the filter is removably fitted to the vertical lateral wall 25 by another plurality of bolts 61 and nuts 62 threadedly fitted thereon, thereby closing said dehydration port 50. As shown in FIG. 11, it is desirable that the small apertures 52 in the inner perforated plate 53 be in staggered relation to the small apertures 54 in the outer perforated plate 55 since such arrangement makes it possible to weaken the forces acting on places on the screen 56 opposed to the small apertures 52 and to spread iron sand flowing in from the space 57 over the entire region of the space 57 thereby to improve the filtration function of the screen 56.

The annular spacers 58 are welded to the outer aper- tured plate 55 in advance, and the bolts 61 used to secure the filter 51 to the vertical lateral plate 25 extend through said spacers 58.

If at least the lower region of the space 57 is left open between the spacers 55, iron sand which has flowed into the space 57 and remained therein will spontaneously fall and flow out of said space during unloading of the iron sand in the hold, thus assuring a satisfactory filtration effect lasting for a long time without the need to carry out cleaning operation by manually removing iron sand in the space in the screen 57.

In addition, the numeral 63 designates a rubber pack- ing covering both surfaces of the screen 56 and the num- eral 64 designates a rubber packing bonded to the periphery of the inner surface of the inner perforated plate 53. The numeral 65 designates a pair of handle and reinforcing members secured to and projecting from the outer perforated plate 55, each being formed with an opening 66 of the size allowing insertion of the fingers therein for easy handling in mounting and dis- mounting the filter 51. The provision of the protecting members 48 projecting from the outer side of the verti- cal lateral plate 25 to which the filters 51 are fitted makes it possible to protect the filters 51. That is, in unloading operation, the usual practice is to use a bull- dozer to collect a cargo remaining on the bottom of a hold after substantial unloading is effected by a grab bucket. In such collecting operation by a bulldozer, said protecting members prevent the scraper from hitt- ing or contacting the filters 51. Further, the same merit is attained by the provision of the roof-shaped member 24 projecting beyond the vertical lateral mem- ber 25. Further, the screen 56 may be fitted to the inner side of the inner perforated plate 53.

FIGS. 14 and 15 illustrate an example in which a filter member 67 made of fiber is applied to the surface of said metal screen 56. The filter member 67 may be in the form of a knitted or woven fabric of polyester yarn. It may also be fitted to the back of the metal screen 56.

In general, a filter made of stainless steel is used as said metal screen, but stainless steel is relatively less re- sistant to humidity variations. When such metal screen is repeatedly subjected to great humidity variations as in the case where it is soaked in water during loading of iron sand and left to dry in the air after unloading and until next loading of iron sand slurry, its durability is decreased to the extent that it will soon become deteriorated. However, the fiber filter member fitted to the metal screen as described above will retain moisture for a long time, which means that said moisture keeps the metal screen moistened even when there is no slurry cargo, thereby prolonging the useful life of said metal screen.

FIGS. 16 and 17 illustrate another embodiment of the filter-equipped drain port. In this embodiment, a vertical lateral plate 25 forming a drain tunnel 23 is provided with a cylindrical recessed portion 70 projecting into the drain tunnel, said recessed portion removable receiving therein a bottomed cylindrical body 72 having a cylindrical projection 71 at the middle of the bottom. The bottomed cylindrical body 72 has a flange 73 around the periphery of the opening, which flange is secured to the vertical lateral plate 25 at the periph- ery of the recessed portion 70 by bolts 74. Within the bottomed cylindrical body 72, there are defined by the cylindrical projection 71 an outer annular space 75 opening to the hold side and a middle space 76 disposed inwardly of said space 75 and opening in the opposite direction. The middle space 76 communicates with a drain tunnel 23 through an opening 77 formed in the bottom of the recessed portion 70, and the outer annular space 75 communicates with said central space 76 through a number of small apertures 78 formed in the peripheral wall of the cylindrical projection 71 and also communicates with the drain tunnel 23 through a member of small apertures 79 formed in the peripheral wall of the bottomed cylindrical body 72 and through openings 80 formed in the peripheral wall of the re- cessed portion 70. The numeral 81 designates an O-ring placed between the flange 73 and the vertical lateral plate 25. A filter screen 82 is fitted on the inner peripher- al surface of said outer annular space 75 so as to cover the small apertures 78 and 79. The screen 82 has its inner and outer peripheral edges fixed to the peripheral portion of the opening in the bottomed cylindrical body 72 and to the front end periphery of the cylindri- cal projection 71. Such fixing may be effected by an ad- hesive, metal bracers 83, set-screws or other means.

The bottomed cylindrical body 72 may be formed of F. R. P. or steel plate coated with synthetic resin. The numeral 84 designates a reinforcing plate disposed in the drain tunnel 23 and having a worker passage opening 85 and water passage openings 86.

According to the filter-equipped drain port constructed in the manner described above, settling water in the iron sand layer passes through the filter screen 82, small apertures 78, middle space 76 and then through opening 77 or small apertures 79 and openings 80 and flows into the drain tunnel. The filter screen 82 which covers the small apertures is installed in a dou- ble-wall annular form, so that its surface area is much larger than the inlet opening area of the recessed por-
tion 70. Therefore, even if the inlet opening in the re- cessed portion 70 is small, it is possible to secure a suf- ficient area for filtration and carry out efficient drain- age of settling water.

Further, since the filter screen 82 is positioned sub- stantially at right angles to the vertical lateral plate 25, there is no possibility that a load acting on said vertical lateral plate 25 at right angles thereto will act directly on said screen, so that a satisfactory filtration effect can be assured for a long time without the danger of the screen becoming clogged or damaged. Further, the bot- tomed cylindrical body 72 and filter screen 82 can be integrally removed from the recessed portion 70, thus assuring easy inspection and repair.

FIGS. 18 through 20 illustrate still another embodi- ment of the filter-equipped drain port. The numeral 90 designates a passageway defined by cutting off the lower portion of a vertical lateral plate 25. The numeral 91 designates a filter assembly installed in a drain tunnel 23 and inclined in such a manner as to define a space 92 of triangular cross-section inside said passageway 90 with said passageway 90 forming one side of the triangle. The angle of inclination of the filter assembly 91 is equal to or greater than the angle of repose of iron sand. The filter assembly comprises a rectangular frame 93, bracing frame 94, a screen support plate 95 and filter screen 96 having their peripheral portions clamped between said rectangular frame 93 and brac- ing frame 94, and a plurality of bolts 97 for putting them together, said screen support plate 95 having a plurality of transversely arranged rectangular openings 98, said filter 96 having a rubber packing 99 fitted around the peripheral edge. The numeral 100 designates an inclined fixed frame to which the filter assem- bly 91 is secured, said frame having filter support rods 101 projecting from the lower portion and clamp bolts 102 pivoted on the upper portion thereof. The rect- angular frame 93 of said filter assembly 91 is provided with bifurcated projections 103 adapted to engage said support rods 101 and bifurcated projections to receive said clamp bolts 102. The filter assembly 91 is secured in position in the following manner.

First, the filter assembly 91 is inserted into the space 92 through the passageway 90 and the lower bifurcated projections 103 are engaged with the support rods 101. With a rubber packing 105 sandwiched between the rectangular frame 93 and the fixed frame 100, the filter assembly 91 is turned upwardly around the axes of the support rods 101, and with the clamp bolts 102 fitted in the upper bifurcated projections 104, thumb nuts 106 threaded fitting on said clamp bolts are then tighten- ed. As a result, the hold communicates with the drain tunnel 23 only through the passageway 90, space 92, filter screen 96, rectangular openings 98, and opening 107 in the fixed frame 100. Therefore, it follows that the settling water in the iron sand layer flows into the drain channel only after being filtered through said filter screen 96. In addition, the filter assembly 91, as shown in FIGS. 19 and 20, is also fixed by a metal bracer 108 at the longitudinal end thereof. The metal bracer 108 is tightened by a bolt 110 threaded fitting in a nut-like body 109 fixed to the fixed frame 100 between adjunc- cent filter assemblies 91, with the opposite free end portions of the metal bracer being simultaneously fitted in a recess 111 formed in the rectangular frame 93 of each of the two adjacent filter assemblies 91. Thus, by tightening the bolt 110, the adjacent ends of the two fil- ter assemblies are simultaneously clamped.

According to the arrangement described above, since the angle of inclination of the filter assembly 91 dis- posed inside the passageway 90 to define the space 92 of triangular cross-section is equal to or greater than the angle of repose of iron sand, the iron sand flowing into the space 92 through the space 92 will not directly press said filter assembly 91. Therefore, the danger of the filter assembly 91 becoming clogged or damaged is minimized and since there is no need for the filter as- sembly to have a high strength, its construction can be simplified. Further, since the filter assembly 91 can be erected adjacent the double bottom board 12, settling water can be completely drained. Further, the mount- ing and dismounting of the filter assembly 91 is easy.

Several concrete examples of the construction of the filter-equipped drain port 26 installed in the drain tun- nel have been described so far, but instead of providing the drain tunnels along the longitudinal partition walls 8 as shown in FIGS. 3 through 5, they may be provided along the transverse partition walls 9 or along both lon- gitudinal and transverse partition walls. In the case of providing drain tunnels along the transverse partition walls 9, the water reservoir space 17 can be used as a drain tunnel. Further, the drain tunnel 23, water reser- voir space 17 and drain passageway 14 may be adapted to allow entrance and exit of a worker for removal of incoming iron sand. As for such gateway, the drain port may be utilized for this purpose, or a separate closable manhole may be provided.

The method of constructing a drain tunnel 23 pro- jecting into the hold by utilizing a corner on the hold side between a partition wall and the double bottom board as described above is desirable particularly in the case of remodeling the holds of a conventional bulk cargo carrying vessel into ones adapted to carry slurry loads. However, in the case of newly making a carrying vessel, a drain tunnel may be provided outside the hold and this tunnel may then be made to communicate with the hold through a filter-equipped drain port, thereby making it possible not only to avoid reduction of the hold volume but also to facilitate the operation of collect- ing residual iron sand after unloading.

FIGS. 21 through 26 illustrate some embodiments wherein there is provided a drain tunnel recessed out- wardly of a partition wall and double bottom board, as described above.

FIGS. 21 and 22 illustrate an embodiment in which an obliquely downwardly recessed drain tunnel is formed at a corner of the hold by interconnecting the longitudinal partition wall 8 and the double bottom board 12 by a curved plate 112 of substantially semi- cylindrical cross-section projecting outwardly of the hold and there is provided a drain port 115 having a fil- ter assembly 114 mounted on an inclined filter support plate 113 interconnecting the opposite ends of said curved plate 112. The numeral 116 designates a sup- port plate reinforcing and filter protecting member projecting from that surface of the filter support plate 113 which is on the hold side, said member 116 being positioned between adjacent filter assemblies 114. The numeral 117 designates a rib plate reinforcing the dou- ble bottom plate 12, and the numeral 118 designates a rib plate reinforcing the longitudinal partition wall 8. In addition, the settling water which has flowed through the filter assembly 114 into the drain tunnel 23 sur-
rounded with the curved plate 112 and filter support plate 113 can be introduced directly into the bilge well 30, for example, through an opening 119 provided in the lower end side of said drain tunnel 23, i.e., the lower end side of the curved plate.

With the above arrangement employed, since the degree of concentration of bending moment stresses at the corner in connection with transverse strength is decreased as compared with the case where the longitudinal partition wall 8 and double bottom plate 12 are connected together at right angles to each other, there is involved no problem of strength despite the presence of the drain tunnel recessed in said corner. However, it is necessary to increase the thickness of the curved plate 112 since it is necessary for the curved plate to have the same amount of 1/20 as the other sections. As for shear strength at the time of loading, if the area of the rib plate immediately below the curved plate as indicated by the line X — X in FIG. 21 is made larger than the cross-sectional area of other region of the rib plate, e.g., at a position indicated by the line Y — Y, the shear stresses in the drain tunnel position will never exceed the shear stresses in the other positions. Further, the length indicated by 1 in FIG. 22 tends to change due to strains produced at the time of loading. If, therefore, the upper and lower edges of the curved plate 112 are rigidly connected together by the filter support plate 113, there is the danger of said support plate 113 breaking or buckling. Therefore, it is desirable that as shown in FIG. 22, for example, only one end of the filter support plate 113 be rigidly connected to the curved plate and the other end be mounted so as to allow relative movement in the direction of the length 1 by means of a hole and bolt and nut means 121.

Since the drain tunnel construction described above is cylindrical, there is no need to reinforce it by small ribs against internal and external pressures. Moreover, since there is no member projecting into the drain tunnel, if some selected filter assemblies are removed at the time of cleaning of the drain tunnel, it is possible to use a long bar-like cleaner and insert it into the tunnel for cleaning purposes, thereby making it unnecessary for a worker to crawl into the tunnel. As a result, the drain tunnel may be small in diameter just enough to match with the filter assemblies.

FIG. 23 illustrates an example in which a curved plate 122 of semi-cylindrical cross-section is used to form a recessed drain tunnel 23 in the double bottom board 12 at a position nearer to the ship's side. The numeral 123 designates a filter support plate and the numeral 124 designates a drain port equipped with a filter assembly 125. In this embodiment also, the end portion of said drain tunnel 23 may be directed into the upper region of the bilge well 30 to allow drain water to flow directly into the bilge well 30 through an opening 126 formed in the curved plate 122. In the case of the FIG. 23 embodiment, there is no problem if the same measure as in the embodiment shown in FIGS. 21 and 22 is taken with respect to bending moment and shear strength in connection with the transverse strength of the hull. As for reinforcement of ribs, a thickness-increasing plate 128 may be attached to a rib plate 117 below the drain tunnel in order to increase thickness, or an opening 127 in the rib plate 117 below the double bottom board may be shifted to a position shown at 127' in phantom lines to increase the cross-sectional area of the rib. Such measures will be sufficient for shear strength. With the opening 127 shifted to the position shown at 127', it is possible to neglect the strains of the curved plate 122. Therefore, there is no need to arrange the support plate 123 in the manner shown in FIG. 22 and the opposite ends may be welded directly to the curved plate 122.

FIG. 24 illustrates an example in which a tunnel forming plate 129 is installed outside the longitudinal partition wall 8 and adjacent the double bottom board 12 to define a drain tunnel 23 between it and the longitudinal partition wall 8. The numeral 130 designates a filter support plate and the numeral 131 designates a drain port equipped with a filter assembly 132. In addition, as shown, the lower edge of the drain port 131 is substantially flush with the double bottom board 12 and the bottom of the drain tunnel 23 is below the level of the double bottom board 12, thereby facilitating drainage of settling water.

In this embodiment, since a reinforcing plate 133 for supporting loads on the longitudinal partition wall is required in the drain tunnel 23, the cleaning of the drain tunnel 23 has to be done by a worker crawling thereinto. Therefore, the size of the drain tunnel 23 must be such that it allows entrance and exit of a person.

In the embodiment described above, as shown in FIGS. 25, since the bilge well 30 provided below the double bottom board 12 and said drain tunnel are transversely offset, it is necessary to establish communication between one end bottom of the tunnel forming plate 129 and the lateral portion of the bilge well 30 by piping 134. In this case, if the interior of the bilge well 30 is divided by a partition wall 138 into a chamber 135 to which the piping 134 opens and a chamber 137 to which a drain pipe 136 opens so that drain water may overflow from the chamber 135 into the chamber 137, then the chamber 135 serves as a settling tank for the iron sand which has passed through the filter assembly, whereby it is possible to prevent the iron sand from being discharged outside the ship along with the drain water and eliminate troubles otherwise caused by iron sand flowing into the pump.

FIG. 26 illustrates a modification of the FIG. 23 embodiment. A tunnel forming plate 141 of L-shaped cross-section is provided to define a drain tunnel 23 between the double bottom board 12 and the portion of the longitudinal partition wall 8 below the level of the double bottom board 12, and a drain port 143 equipped with a filter 142 is provided in the portion of the double bottom board directed into said drain tunnel 23. The numeral 144 designates a reinforcing plate installed in the upper region of the drain tunnel 23.

Concrete examples of the filter-equipped bottom drain port 32 shown in FIGS. 3 through 5 will now be described.

In FIGS. 27 and 28, the numeral 145 designates a recess formed by a bottomed cylindrical body 146 installed under the double bottom board 12. A bottomed cylindrical body 148 which is frusto-conical and whose small diameter end is closed is concentrically erected on an intermediate partition plate 149 in the recess 145 with said small end 147 upwardly directed. The numeral 150 designates a rubber packing placed between the intermediate partition plate 149 and the peripheral flange 151 around the opening in the bottomed cylindrical body 148. The numeral 152 designates a bolt for fixing the bottomed cylindrical body 148. The height of said bottomed cylindrical body 148 is such that it is re-
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The peripheral wall has a number of small apertures 153 and a filter screen 154 wrapped therearound to cover said small apertures 153.

As a result of this arrangement, the interior of the recess 145 is divided into an annular space 155 surrounding the bottomed cylindrical body 148, a central space 156 within the bottomed cylindrical body 148 and a bottom space 157 below the partition plate 149, said central space 156 and bottom space 157 communicating with each other through an opening 158 formed in the partition wall 149, said bottom space 157 having a conduit 33 extending therefrom to the previously mentioned bilge well 30.

Therefore, the iron sand slurry also enters said annular space 155 and from this annular space 155 the settling water passes through the screen 154 and small apertures 153 into the central space 156, wherefrom it flows down into the bottom space 157 and passes through the conduit 33 into the bilge well 30.

It is desirable that the screen 154 be fixed to the bottomed cylindrical body 148 by any suitable method so that along with the bottomed cylindrical body 148 it may be removably received in the recess 145. Further, the partition wall 149 may be removably received in the inlet portion of the recess 145 so as to position the bottomed cylindrical body 148 under the partition plate 149. In that case, the iron sand slurry enters the central space 156 through the opening 158, while the settling water flows down from the annular space 155 to the bottom of the recess 145, wherefrom it is introduced into the bilge well 30 by the conduit 33. In this connection it is desirable that the screen 154 be mounted on the inner surface of the peripheral wall of the bottomed cylindrical body 148.

Further, as shown in phantom lines, in order to protect the screen 154 it is also possible to provide a perforated cylindrical body 159 holding the screen 154 between it and the bottomed cylindrical body 148.

The features of this construction reside in this, that the screen is immune from direct loads during loading and that the filtration area can be made sufficiently greater than the area of the opening in the recess 145.

FIG. 29 illustrates an improvement of the embodiment shown in FIGS. 27 and 28. The numeral 160 designates a removable cover plate to close the inlet portion of said recess 145, said cover plate being formed with a plurality of openings 161 positioned immediately above the annular space 155. The peripheral portion of the cover plate 160 removably receives the peripheral portion of a filter screen 162 which is flexible and whose size is such that it covers the central bottomed cylindrical body 148 and the bottom and outer peripheral wall surfaces of the annular space 155. Thus, once the cover plate 160 is set in position, the depending screen 162 covers the bottomed cylindrical body 148.

According to such arrangement, the mounting and demounting of the screen is very easy and it is possible to decrease the load on the screen 162. Further, it is possible to increase the filtration area by additionally providing small apertures 163 in the upper end of the bottomed cylindrical body 148.

In addition, the mounting of the bottomed cylindrical body 148 on the partition plate 149 may be by a threaded engagement structure 164.

FIGS. 30 and 31 illustrate another concrete example of the filter assembly. This filter assembly is characterized by comprising an inner perforated plate 166 forming part of a hold wall 165, an outer perforated plate 167 with a suitably clean S defined between it and said inner perforated plate 166, a filter screen 168 attached to the outer side of said outer perforated plate 167, the positions of the apertures 169 and 170 in said two plates being offset from each other (see FIG. 31). The inner plate 166 is secured to a reinforcing and receiving seat frame 172 by bolt and nut means 173, said frame being attached to the inner peripheral side of an opening 171 formed in the hold wall 165. A rubber packing 174 maintains water-tightness. The two plates 166 and 167 are connected together through an annular member 175 and a reinforcing connecting member 176 in such a manner as to maintain said clearance S. The screen 168 comprises, for example, a stack of a plurality of wire gauzes and has its peripheral edge united by a metal frame 178 having a rubber packing 177 attached thereto and is fitted from outside with respect to said outer plate 167 and annular member 175. Further, in order that materials (load) other than water may, in principle, not pass through the screen 168, a wire gauze of finest mesh, e.g., 300-mesh is placed on the side of the outer plate 167 and a wire gauze of coarse mesh, e.g., 50-mesh, which also serves to reinforce the first-mentioned wire gauze, is stacked thereon, on which is then stacked a wire gauze of fine mesh, e.g., 300-mesh, on which is finally stacked a wire gauze of coarse mesh, e.g., 50-mesh. The first wire gauze of fine mesh facing toward the interior of the hold assures prevention of the passage of loads and the second wire gauze of fine mesh serves as a spare to said wire gauze. The screen 168 is secured to said inner plate 166 by a frame body 180 and a bolt 181.

According to the filter assembly described above, as shown in FIG. 30, the greater part of the pressure P exerted on the filter assembly is received by the surface of the inner plate 166, and the remaining pressure P' passing through the apertures 169 are received by the surface of the outer plate 167, so that little pressure acts on the screen 168. As shown in broken lines W, the drain water passes through the apertures 169, 170, screen 168 and apertures 179 into the outside of the hold.

FIG. 32 illustrates an example in which a frame body 180 which hold a screen 168 between it and an outer apertured plate 167 is fixed directly to said plate 167 by bolts 181.

The filter assemblies described above may be used with the filter-equipped drain ports 26 attached to the drain tunnels 23 and the filter-equipped bottom drain ports 32, or the filter-equipped auxiliary drain ports 45 shown in FIG. 7.

FIGS. 33 and 34 illustrate an example in which there is provided an overflow drain pipe 182 which extends through a wing tank 7 and whose inner end opens to the hold and outer end opens to the outside of the ship. The numeral 183 designates a compartment surrounding said drain pipe 182 and defined by a pair of partition plates 184 and 185 disposed on the bow and stern sides, a bottom partition plate 186, longitudinal partition walls 8, ship's side board 6, and deck 187. Within said compartment 183, the overflow drain pipe 182 is provided with two on-off valves 188 and 189. Further, a manhole 190 is formed in the deck 187 for entrance to
and exit from the compartment 183. As for said on-off valves, the provision of at least one such valve suffices.

According to the above arrangement, since the overflow water at the time of loading with iron sand slurry can be discharged directly into the outside of the ship through the drain pipe, it becomes unnecessary to install pump equipment and moreover the efficiency of loading operation can be increased. This arrangement may be used in place of the overflow drain port 18 and drain manifold attached thereto shown in FIG. 3. Alternatively, it may be additionally provided and it may be used in such a manner that the on-off valves 188 and 189 are opened in emergency only. Further, as shown in FIG. 3, the overflow drain port 18 opening to the hold may be adapted to communicate with an outlet formed in the ship's outer side board 6 through piping. Further, it may also be so arranged that upon completion of loading, the on-off valves are opened to discharge the free water above the iron sand layer directly into the outside of the ship.

It often occurs that during loading with iron sand slurry, the ship sways due to the wind and waves in the harbor. In that case, if the free water above the iron sand layer in the hold sways at a speed above a certain limit in synchronism with the period of sway of the ship, the iron sand particles in said free water move with the free water. Thus, if said iron sand particles dash against the wall, they are disturbed along with the free water and flow into the overflow drain port. As a result, the iron sand particles flow into the drain pipe, causing troubles to pump operation, and carried away into the sea; which is uneconomical.

The embodiment shown in FIGS. 35 and 36 is adapted to assure that the iron sand particles which have flowed into the overflow drain port as described above are separated before they reach the drain pipe. The numeral 191 designates a settling tank disposed adjacent the drain passageways 14. The upper portion of the settling tank 191 if provided with an overflow drain port 18 opening to the cargo hold and overflow openings 192 on a level equal to or slightly above the level of the drain port 18 to provide for overflow from the settling tank 191 to the drain passageways 14. The numeral 193 designates a communication port to allow the drain passageway 14 to communicate with the water reservoir space 17. The lower end of the settling tank 191 is closed by a partition plate 197 above the water reservoir space 17. The lower end side of the settling tank 191 has an opening 195 communicating with the interior of the cargo hold.

According to the above arrangement, the overflow water from the cargo hold first flows into the settling tank 191, where the energy of the overflow water is greatly decreased so that the iron sand particles contained in the overflow water settle and the slurry water alone overflows into the drain passageways 14 through the openings 192 and passes through the water reservoir space 17 into the outside of the ship, as previously described. With the drainage of the settling water in the iron sand layer within the cargo hold, the settling water present among the iron sand particles which collect in the settling tank 191 move into the cargo hold through the opening 195 and is drained along with said settling water. The iron sand which collects in the settling tank 191 will flow out by gravity into the cargo hold through the opening 195 when the iron sand level in the cargo hold becomes lower than said opening 195 as the unloading of the iron sand from the cargo hold proceeds.

A manhole may be provided so that a person may go in and out of the settling tank 191. Further, it is only necessary that the level of the bottom of the settling tank 191 and hence the level of the opening 195 are above the level of the bottom of the cargo hold. Thus, there is no need for said level to be above the water reservoir space 17.

In the example shown, drain passageways 14 communicating with the settling tank 191 through openings 192 have been provided on both sides of the settling tank, but such opening may be provided on one side alone. Further, any suitable number of sets of drain passageways 14 and settling tank may be provided for a single cargo hold.

When the transverse partition wall 9 is constituted by a corrugated plate 196 as shown in FIG. 37, drain passageways 14 and settling tanks 191 may be formed by closing the recesses of the corrugated plate 196 instead of using channel-shaped members as shown in FIGS. 4 and 5.

The settling tank, which is used in order for iron sand particles contained in overflow water to settle and separate, may be installed in other suitable place instead of being positioned side by side with drain passageways, with communication established between said settling tank and the overflow drain port 18 by piping. Further, suitable one of the wing tanks or the No. 3 hold 3 which serves as a void space shown in FIGS. 1 and 2 may be utilized as a settling tank.

FIGS. 38 through 43 illustrate examples in which an overflow drain port 18 is provided with wave breaking means 198 or 199. The wave breaking means 198 shown in FIGS. 38 through 40 is adapted for use where the overflow drain port 18 opens transversely (in the direction of the transverse partition wall). A casing 200 surrounding said drain port 18 has a side plate 201 opposite to said drain port 18, said side plate being provided with a drain water inlet 203 equipped with lower boards 202. Laterally of the bottom, the casing 200 is provided with an opening 204 for removal of the iron sand which collects therein. The bottom plate 205 of the casing 200 is inclined so as to direct the incoming iron sand toward the opening 204.

According to the above arrangement, when the free water which becomes choppy due to the sway of the ship is passing through the lower boards 202, its energy is greatly decreased. Since in this condition it flows into the casing 200, the iron sand particles contained therein settle within the casing 200 by gravity and the slurry water alone flows into the drain passageway 14 through the drain port 18. Thus, without the need of providing a large settling tank, it is possible to prevent iron sand from mixing with overflow water and flowing out therewith. The iron sand collecting on the bottom of the casing 200 may be scraped out through the opening 204 at the time of unloading. Further, instead of providing the opening 204, the bottom plate 205 may be made capable of being opened and closed, or the casing 200 may be removable mounted.

The wave breaking means 199 shown in FIGS. 41 through 43 is adapted for use where the overflow drain port 18 opens longitudinally of the ship. Both side plates 209 of a casing 206 covering said drain port 18 are provided with drain water inlets 208 each equipped
with louver boards 207. Openings 210 are provided at the lower ends of said side plates 209, and the bottom plate 211 is inclined toward said openings 210.

The wave breaking action is essentially the same as in the embodiment shown in FIGS. 38 through 40, but in this embodiment the slurry water flowing into the casing 206 through the louver boards 207 changes its direction of flow and then flows into the opening 18, whereby the separation of the iron sand particles in the slurry water within the casing 206 is further improved.

I claim:

1. A slurry carrying vessel characterized in that the hold wall is provided with an overflow drain port located suitably above the predetermined loading level of slurry cargo and an on-off valve-equipped free water drain port located below said overflow drain port but slightly above said predetermined loading level and that the hold bottom is provided with a number of filter-equipped drain ports.

2. A slurry carrying vessel as set forth in claim 1, wherein said overflow drain port and free water drain port communicate with a vertical drain passageway and said filter-equipped drain ports are provided in the wall of a drain tunnel horizontally extending along the hold bottom, there being provided a water reservoir space communicating with said drain passageway and drain tunnel, said water reservoir space having a drain pipe extending therefrom.

3. A slurry carrying vessel as set forth in claim 1, wherein said overflow drain port and free water drain port communicate with a vertical drain passageway, and said filter-equipped drain ports are provided in the wall of a drain tunnel horizontally extending along the hold bottom, there being provided separate water reservoir spaces communicating with said drain passageway and said drain tunnel, respectively, each of said water reservoir spaces having a drain pipe extending therefrom.

4. A slurry carrying vessel as set forth in claim 1, wherein an on-off valve-equipped emergency drain port is located at a suitable level between the hold bottom and said free water drain port.

5. A slurry carrying vessel as set forth in claim 1, wherein each of a plurality of holds arranged longitudinally of the ship is provided with said overflow drain port and free water drain port and is provided at the hold bottom with said filter-equipped drain ports, characterized in that the last loading hold has a smaller volume and a greater filter-equipped drain port area per unit volume than the other holds.

6. A slurry carrying vessel as set forth in claim 1, wherein inside a corner between the hold wall and the hold bottom there is a drain tunnel defined by an inclined roof-shaped plate and a longitudinal side plate and extending along said hold wall, and said number of filter-equipped drain ports are provided in said longitudinal side plate.

7. A slurry carrying vessel as set forth in claim 1, wherein there is a drain tunnel extending along the hold wall and defined by said hold wall and an obliquely downwardly projecting curved plate of substantially semi-circular cross-section which interconnects the hold wall and the hold bottom, and said number of filter-equipped drain ports are provided in a partition wall between said drain tunnel and the hold.

8. A slurry carrying vessel as set forth in claim 1, wherein below a position on the hold bottom adjacent to the hold wall there is a drain tunnel defined by a tunnel forming plate extending along said hold wall, and said number of filter-equipped drain ports are provided in a partition wall between said drain tunnel and the hold.

9. A slurry carrying vessel as set forth in claim 1, wherein said filter comprises an inner perforated plate facing toward the hold, an outer perforated plate substantially parallely placed outside said inner perforated plate, and a filter screen applied to said outer perforated plate, there being a space outside said inner perforated plate, the apertures in said inner perforated plate being positioned in staggered relation to the apertures in said outer perforated plate.

10. A slurry carrying vessel as set forth in claim 1, wherein said filter comprises an annular space one end of which opens to the hold side, a central space which is inside said annular space and one end of which opens to the drain passageway side, a number of small apertures provided in a cylindrical wall between said annular space and central space, and a filter screen covering said small apertures.

11. A slurry carrying vessel as set forth in claim 1, wherein said filter comprises an annular space one end of which opens to the hold side, a central space which is inside said annular space and one end of which opens to the drain passageway side, small apertures provided in a peripheral wall on the outside of said annular space and in a cylindrical wall between said annular space and central space, a filter screen covering said small apertures.

12. A slurry carrying vessel as set forth in claim 1, wherein said filter comprises a metal screen and a fiber screen applied to said metal screen.

13. A slurry carrying vessel as set forth in claim 1, wherein said filter is obliquely outwardly inclined from the upper edge of an opening provided in contact with the hold bottom in a longitudinal side plate forming hold wall, so that a space of substantially triangular cross-section is defined outside said opening, the angle of inclination of said filter being smaller than the angle of repose of the cargo.

14. A slurry carrying vessel as set forth in claim 1, wherein there is an overflow drain port communicating directly with the outside of the ship through a drain pipe extending through a wing tank located outside the hold wall, said wing tank having defined therein a partitioned working chamber surrounding said drain pipe, said working chamber containing an on-off valve placed in said drain pipe.

15. A slurry carrying vessel as set forth in claim 1, wherein there is an overflow drain port communicating through a wing tank located outside the hold wall, said wing tank having defined therein a partitioned working chamber surrounding said drain pipe, said working chamber containing an on-off valve placed in said drain pipe.

16. A slurry carrying vessel as set forth in claim 1, wherein there is a settling tank communicating therewith at the upper portion, and the drain water in the settling tank overflows from a position not lower than the overflow drain port communication position of said settling tank and is guided to a drain passageway.

17. A slurry carrying vessel as set forth in claim 1, wherein a casing covering said overflow drain port is located on the hold side and provided with a drain inlet equipped with lower boards for causing the cargo mixed in the drain water to settle in said casing, it being so arranged that the cargo which collects on the bottom of said casing can be withdrawn.

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