tank emptying operation. Since a pump generally has an optimum operating condition at a specific combination of the flow rate and pressure, the aforesaid change in the water flow is generally undesired.

Additionally, during load altering operations of the marine structure, such as multiple ballast operations and/or oil refueling, which occur simultaneously as a ballast tank emptying operation, there may be a need for controlling the rate at which the ballast tank is emptied in order to maintain a balance in the marine structure. Moreover, when a ballast tank is almost emptied of water, it may be desirable to have a low flow rate of the water leaving the ballast tank in order to at least limit the amount of air in the water entering the pump.

Pumping ballast water usually requires relatively high capacity pumps while when pumping bilge water, generally low capacity pumps are required. The difference in requirements of the pumps tends to be burdensome for the manufacturer of the marine structure as it demands two different pumps, each specifically adapted for the operating condition required for the specific purpose of the pump. Further, if the marine structure is damaged, it remains vital that the ballast pumps and bilge water pumps are operational, even if the hull is breached or the space at which the pumps are positioned is flooded. Today, this is often solved by having a plurality of pump rooms at different locations; this ensures that always one ballast pump or bilge water pump remains operational.

In view, of the above, it may be realized that there is a need for improvements in the field of moving fluids.

SUMMARY OF THE ~~INVENTION~~DISCLOSURE

The above mentioned drawbacks are at least partly solved or at least partly reduced by a tank arrangement according to the present ~~invention~~disclosure and more specifically, a tank arrangement for temporarily hold bilge fluid and/or ballast fluid in a marine structure. The tank arrangement comprises a storage space defined by at least one tank wall, at least one fluid inlet for introducing the bilge fluid and/or ballast fluid in the storage space, and at least one fluid outlet for permitting removal of at least parts of the bilge fluid and/or ballast fluid from the storage space. The at least one fluid outlet is at least partly formed by a caisson adapted for receiving a submersible pump at a submersible pump position in the storage space. The submersible pump comprises a high side and a low side. The caisson

comprises at least one circulation conduit having an inlet and an outlet, adapted to enable circulation of at least parts of the bilge fluid and/or ballast fluid in the caisson from the high side of the submersible pump to the low side of the submersible pump, when the submersible pump is in the submersible pump position.

The present ~~invention~~disclosure provides for a tank arrangement which can be utilized with a submersible pump. The tank arrangement enables a submersible pump for pumping e.g. bilge water or ballast water while being constantly submerged in water, thereby removing the risk of failure during start up due to air in the pump, or insufficient pump fluid. By having a tank arrangement which is adapted for a submersible pump, and by using a submersible pump, the tank arrangement is less susceptible for the risks involved when pump rooms are flooded, e.g. during a hull breach. Thus, bilge water and/or ballast water pumping becomes less exposed for failure due to flooding of the pump. The tank arrangement can be operated to separate air entering the storage space together with the incoming liquid, to be a temporarily storage chamber for circulation liquid and to maintain the a predetermined minimum level of liquid in the storage space, enabling the submersible pump to be substantially constantly submerged.

According to an aspect of the present ~~invention~~disclosure, the at least one circulation conduit comprises at least one circulation flow valve for regulating the flow at the outlet of the circulation conduit. The circulation flow valve enables a controlled flow which in turn enables different operating conditions for the submersible pump so that the operating conditions can be adapted for a specific purpose, e.g. for pumping bilge water or ballast water. The outlet of the circulation conduit can advantageously be arranged in the proximity of the submersible pump position. Optionally, the outlet of the circulation conduit can be arranged at the low side of the submersible pump, when the submersible pump is arranged in the submersible pump position. The circulated water can thereby be directly propelled onto the low side of the submersible pump.

According to an embodiment of the present ~~invention~~disclosure, the circulation conduit extends through the at least one tank wall into the storage space. As such the inlet of the circulation conduit is arranged to the caisson outside of the storage space, defined by the tank walls, and thereafter extends into the storage space. This enables e.g. a circulation flow valve to be positioned outside of the storage space while still permitting the advantages of the circulation conduit as mentioned above. In an embodiment according to

the present ~~invention~~disclosure, the inlet of the circulation conduit can be arranged within the tank wall defining the storage space, the circulation conduit can thereafter be arranged to extend outside of the storage space, to thereafter return into the storage space. There are several advantages with this which will be explained in greater detail below.

The caisson can be a long caisson, e.g. extending between the tank arrangement and the deck of the marine structure, or e.g. an intermediate caisson extending to a level substantially in the plane of the centre of balance of the marine structure, or optionally a short caisson, extending just past the tank wall defining the storage space. The caisson generally comprises a first and a second end. According to an embodiment of the present ~~invention~~disclosure, the second end of the caisson is arranged to form the submersible pump position. The submersible pump position is adapted to receive the submersible pump enabling the submersible pump to operate with at least a first and a second operating condition. The submersible pump position can be adapted to seal around the submersible pump, preventing liquid or air leakage between the submersible pump and the caisson. Optionally the submersible pump itself can be equipped with means for sealing around the submersible pump, or a combination thereof is of course possible.

A closeable lid can advantageously be arranged at the first end of the caisson, this is especially advantageous when the caisson is a short caisson or not more than a recess in the into the storage space. The closeable lid can be arranged with means for permitting power and/or control cables to extend through the lid or to permit cables to be connected to the lid for power and/or control management of the submersible pump. Optionally the submersible pump itself can be provided with means of sealing the first end of the caisson. Advantageously this can be a circumferential seal flange extending around the periphery of the submersible pump. The submersible pump can thus be fixed to the caisson preventing the submersible pump from torque imparted by the flow of liquid or via e.g. rotating blades of the submersible pump, during operation. Additionally, any cables can be attached to the submersible pump at the dry side of the submersible pump, while permitting the wet side of the submersible pump extend down into the storage space of the tank arrangement. Thus the power cord/cables does not need to be constantly submerged, however, the benefits of a submerged pump, as described above and below are still achieved.

In an embodiment of the present ~~invention~~disclosure, the caisson extends through the at least one tank wall into the storage space. The caisson can be arranged to extend in a substantially vertical direction, thereby permitting the submersible pump to be introduced into the storage space in a vertical direction. Optionally, the caisson can be arranged to extend in a substantially horizontal direction, thereby permitting the submersible pump to be introduced into the storage space in a horizontal direction. A combination of the above is possible, e.g. in a diagonal direction.

The caisson can be arranged to extend a distance D at least past the at least one tank wall, and away from the storage space of the tank arrangement. The distance D is about the range of 0,1-50 meters. For a short caisson the distance D is about 0,1- 8 meters, preferably about 0,1-5 meters, more preferably about 0,2-2, even more preferably 0,2-1 meters. This permits a tank arrangement to which a submersible pump can be easily replaced, removed or serviced.

In an embodiment of the present ~~invention~~disclosure, the tank arrangement comprises means for removing air, or excess air, from the storage space. This will prevent air from entering the submersible pump in an undesired manner. It may however permit air to be circulated back to the submersible pump and especially to the low side of the submersible pump. The means for removing the air from the storage space is advantageously arranged to the circulation conduit. In such an embodiment, the means for removing the air from the storage space comprises a priming ejector. The storage space can be adapted to enable air to raise to the top of the storage space, e.g. by having a dome or spherical formed structure of parts of a tank wall or arranged to the tank wall.

The priming ejector is advantageously promoting the air to be removed by means of the circulated liquid as motive power. This reduces the need for separate power sources for the individual functions. The priming ejector can be in fluid communication with an air discharge conduit, which in turn is arranged to discharge the air outside of the storage space, e.g. outside of the marine structure. This embodiment is a simple yet effective way of discharging the air.

However, optionally or even additionally, the priming ejector can be in fluid communication with an air discharge conduit which is arranged to discharge air inside the storage space. This solution enables the submersible pump to finally discharge the air from the storage

space out through the outlet of the tank arrangement. Nevertheless, the priming ejector can be arranged with an ejector outlet for ejecting at least air. The ejector outlet of the priming ejector is in an embodiment arranged in the storage space and in the proximity of the submersible pump position to enable the submersible pump to remove the air. The means for removing the air is arranged to operate by means of the circulating flow in the circulation conduit as motive power.

The present ~~invention~~disclosure further relates to a tank arrangement and submersible pump assembly. The assembly comprises a tank arrangement according to the accompanying claims, or optionally as described above, and a submersible pump. The submersible pump can advantageously be arranged with means for sealing the caisson. This submersible pump can be connected with cables at a dry side of the submersible pump, as this side is outside of the storage space. The cable and the connection still needs to be adapted for withstanding water, as this part of the marine structure could be flooded in case of an accident. Optionally, if the caisson comprises a lid, the submersible pump comprises a power and/or control cable with a sufficient length for removing the submersible pump from the submersible pump position without disconnecting the power and/or control cable.

The present ~~invention~~disclosure provides for a tank arrangement which can be integrated in a conduit system of e.g. a ballast system, generally because it can be made within a generally confined space. It further has a high reliability of operation and service and can keep the submersible pump submerged at all times. The present ~~invention~~disclosure can further provide a one-way flow into the tank arrangement, circulating parts of the water, and provide a one way out from the tank arrangement for the water.

In a first aspect, there is provided a ballast system for a marine structure, said ballast system comprising a ballast tank which is in fluid communication via a first inlet conduit with a tank arrangement for temporarily holding bilge fluid and/or ballast fluid in a marine structure, said first inlet conduit comprising a valve, wherein said tank arrangement comprises: a closed storage space defined by at least one tank wall; at least one fluid inlet, in fluid communication with said first inlet conduit, for introducing said bilge fluid and/or ballast fluid in said storage space; and at least one fluid outlet permitting removal of at least parts of said bilge fluid and/or ballast fluid from said storage space; said tank arrangement can be operated to separate air entering said storage space together with

said bilge fluid and/or said ballast fluid; wherein said at least one fluid outlet is at least partly formed by a caisson adapted for receiving a submersible pump at a submersible pump position in said storage space, said submersible pump comprising a high side and a low side, said caisson comprises at least one circulation conduit having an inlet and an outlet, adapted to enable circulation of at least parts of said bilge fluid and/or ballast fluid from said high side of said submersible pump, when said semisubmersible pump is in said submersible pump position, to said low side of said submersible pump, when said submersible pump is in said submersible pump position, said tank arrangement comprising means for removing air from said storage space which air removing means is arranged to said circulation conduit, characterized in that said means for removing air from said storage space comprises a priming ejector arranged to operate by means of at least a part of said circulating flow in said circulation conduit as motive power.

In a second aspect, there is provided a marine structure having a ballast system as defined above.

In a third aspect, there is provided a method for pumping ballast and/or bilge fluid using a ballast system as defined above, wherein said method comprises the steps of circulating at least a part of said ballast and/or bilge fluid back from said high side of said submersible pump to said storage space; thereby maintaining a minimum level of fluid in said storage space characterized in that said method further comprises the step of removing air from said storage space by using said circulated fluid as a motive fluid for said priming ejector.

DEFINITIONS

As used herein, the expression "pump" relates to any type of device being adapted to move a fluid (i.e. liquid and/or gas) such that a higher pressure of the fluid is obtained. Moreover, the position of the pump wherein the fluid enters the pump is herein referred to as the "low side" whereas the position of the pump wherein the higher pressure fluid leaves the pump is herein referred to as the "high side".

CLAIMS

1. A ballast system ~~(10)~~ for a marine structure, said ballast system ~~(10)~~ comprising a ballast tank ~~(12)~~ which is in fluid communication via a first inlet conduit ~~(20)~~ with a tank arrangement ~~(100)~~ for temporarily holding bilge fluid and/or ballast fluid in a marine structure, said first inlet conduit ~~(20)~~ comprising a valve ~~(28)~~, wherein
said tank arrangement ~~(100)~~ comprises:
a closed storage space ~~(101)~~ defined by at least one tank wall ~~(102)~~;
at least one fluid inlet ~~(110)~~, in fluid communication with said first inlet conduit ~~(20)~~, for introducing said bilge fluid and/or ballast fluid in said storage space ~~(101)~~;
and at least one fluid outlet ~~(139)~~ permitting removal of at least parts of said bilge fluid and/or ballast fluid from said storage space ~~(101)~~;
said tank arrangement ~~(100)~~ can be operated to separate air entering said storage space ~~(101)~~ together with said bilge fluid and/or said ballast fluid;
wherein said at least one fluid outlet ~~(139)~~ is at least partly formed by a caisson ~~(140, 170)~~ adapted for receiving a submersible pump ~~(130)~~ at a submersible pump position ~~(131)~~ in said storage space ~~(101)~~, said submersible pump ~~(130)~~ comprising a high side ~~(132)~~ and a low side ~~(133)~~,
said caisson ~~(140, 170)~~ comprises at least one circulation conduit ~~(150)~~ having an inlet ~~(152)~~ and an outlet ~~(153)~~, adapted to enable circulation of at least parts of said bilge fluid and/or ballast fluid from said high side ~~(132)~~ of said submersible pump ~~(130)~~, when said semisubmersible pump ~~(130)~~ is in said submersible pump position ~~(131)~~, to said low side ~~(133)~~ of said submersible pump ~~(130)~~, when said submersible pump ~~(130)~~ is in said submersible pump position ~~(131)~~, said tank arrangement ~~(100)~~ comprising means for removing air ~~(160, 200)~~ from said storage space ~~(101)~~ which air removing means is arranged to said circulation conduit ~~(150)~~,
characterized in that
said means for removing air ~~(160, 200)~~ from said storage space ~~(101)~~ comprises a priming ejector ~~(161, 200)~~ arranged to operate by means of at least a part of said circulating flow in said circulation conduit ~~(150)~~ as motive power.

2. The ballast system (10) according to claim 1, characterized in that said at least one circulation conduit (150) comprises at least one circulation flow valve (151) for regulating the flow at said outlet (153) of said circulation conduit (150).

3. The ballast system (10) according to claim 1 or 2, characterized in that said outlet (153) of said circulation conduit (150) is arranged in the proximity of said submersible pump position (131).

4. The ballast system (10) according to claim 3, characterized in that said outlet (153) of said circulation conduit (150) is arranged at said low side (133) of said submersible pump (130), when said submersible pump (130) is arranged in said submersible pump position (131).

5. The ballast system (10) according to any preceding claims, characterized in that said circulation conduit (150) extends through said at least one tank wall (102) into said storage space (101).

6. The ballast system (10) according to any preceding claims, characterized in that said caisson (140, 170) comprises a first and a second end (141, 142, 171, 174), and in that said second end (142, 174) of said caisson (140, 170) is forming said submersible pump position (131).

7. The ballast system (10) according to any preceding claims, characterized in that said caisson (170) comprises a first and a second end (171, 174), and in that said first end (171) comprises a closable lid (172).

8. The ballast system (10) according to any preceding claims, characterized in that said caisson (140, 170) extends through said at least one tank wall (102) into said storage space (101).

9. The ballast system (10) according to claim 8, characterized in that said caisson (140, 170) extends a distance (D) at least past said at least one tank wall (102) and away from said storage space (101) of said tank arrangement (100).

10. The ballast system (10) according to any preceding claims, characterized in that said priming ejector (200) is in fluid communication with an air discharge conduit (205), and in that said air discharge conduit (205) is arranged to discharge said air outside of said storage space (101).

11. The ballast system (10) according to claim 10, characterized in that said air discharge conduit (205) is arranged to discharge said air outside of said marine structure.

12. The ballast system (10) according to any preceding claims, characterized in that said priming ejector (161) is in fluid communication with an air discharge conduit (162), and in that said air discharge conduit (162) is arranged to discharge said air inside said storage space (101).

13. The ballast system (10) according to claim 12, characterized in that said priming ejector (161) comprises an ejector outlet (163b) for ejecting at least air, said ejector outlet (163b) of said priming ejector (161) is arranged inside of said storage space (101) and in the proximity of said submersible pump position (131) to enable said submersible pump (130) to remove said air.

14. The ballast system (10) according to any preceding claim, characterized in that said tank arrangement (100) is adapted to separate air entering said storage space (101) together with said fluid, from said at least one fluid inlet (110).

15. The ballast system (10) according to any preceding claim, characterized in that said tank arrangement (100) is adapted to maintain, or to be operated to maintain, a minimum level of fluid (min.) in said storage space, to maintain said submersible pump (130) at least partly submerged when said submersible pump (130) is in said submersible pump position (131).

16. The ballast system (10) according to any one of the preceding claims, wherein said ballast system (10) further comprises a submersible pump (130).

17. The ballast system ~~(10)~~ according to claim 16, characterized in that said submersible pump ~~(130)~~ comprises a power and/or control cable ~~(176)~~.

18. The ballast system ~~(10)~~ according to claim 16 or 17, characterized in that said submersible pump ~~(130)~~ is arranged with sealing means adapted to seal against said caisson ~~(170)~~ when said submersible pump ~~(130)~~ is in said submersible pump position ~~(131)~~.

19. The ballast system ~~(10)~~ according to claim 18, characterized in that said sealing means enables a lid function to said caisson ~~(170)~~.

20. The ballast system ~~(10)~~ according to any of claims 16-19, characterized in said power and/or control cable ~~(176)~~ is of sufficient length for removing said submersible pump ~~(130)~~ from said submersible pump position ~~(131)~~ without disconnecting said power and/or control cable ~~(176)~~.

21. A marine structure having a ballast system ~~(10)~~ according to any one of the preceding claims.

22. A method for pumping ballast and/or bilge fluid using a ballast system ~~(10)~~ according to any of claims 16-20, wherein said method comprises the steps of circulating at least a part of said ballast and/or bilge fluid back from said high side ~~(132)~~ of said submersible pump ~~(130)~~ to said storage space ~~(101)~~; thereby maintaining a minimum level ~~(min.)~~ of fluid in said storage space ~~(101)~~ characterized in that
said method further comprises the step of removing air from said storage space ~~(101)~~ by using said circulated fluid as a motive fluid for said priming ejector ~~(161, 200)~~.

23. The method according to claim 22, characterized in that said ballast and/or bilge fluid circulated to a position in the proximity of said low side ~~(133)~~ of said submersible pump ~~(130)~~.

24. The method according to claim 22 or 23, characterized in that said circulated ballast and/or bilge fluid is regulated by a circulation flow valve ~~(151)~~.