

Nov. 30, 1965

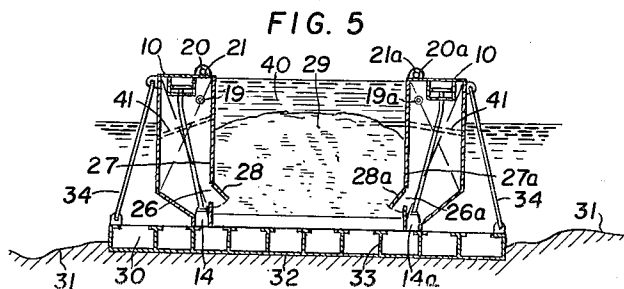
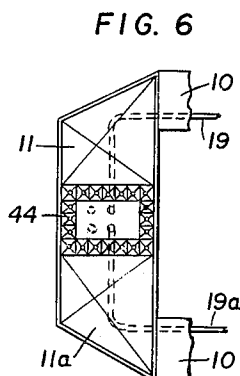
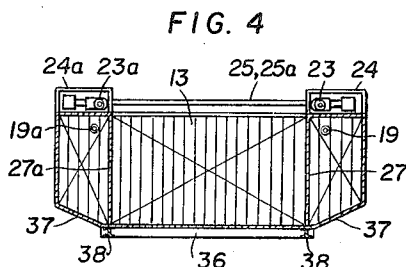
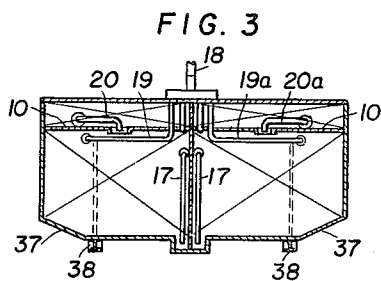
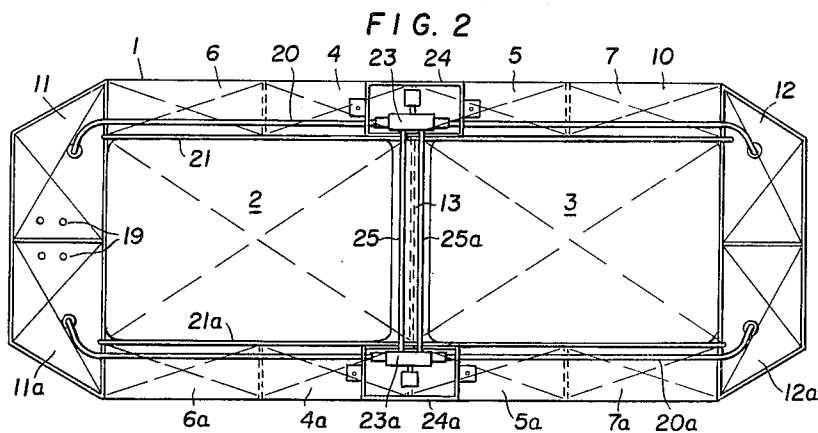
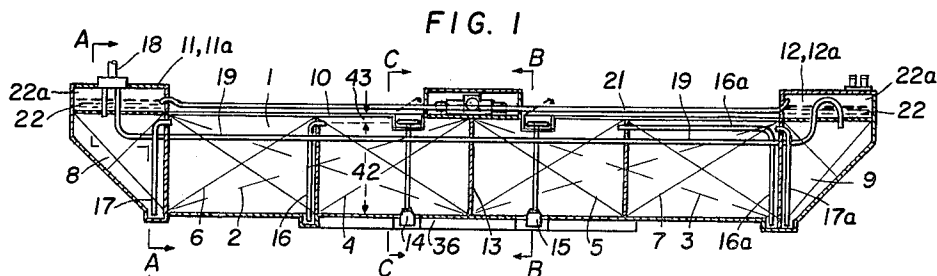
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3,220,372

SUBMERSIBLE MINING, LIFTING AND TOWING BARGE

Filed Sept. 6, 1961

2 Sheets-Sheet 1



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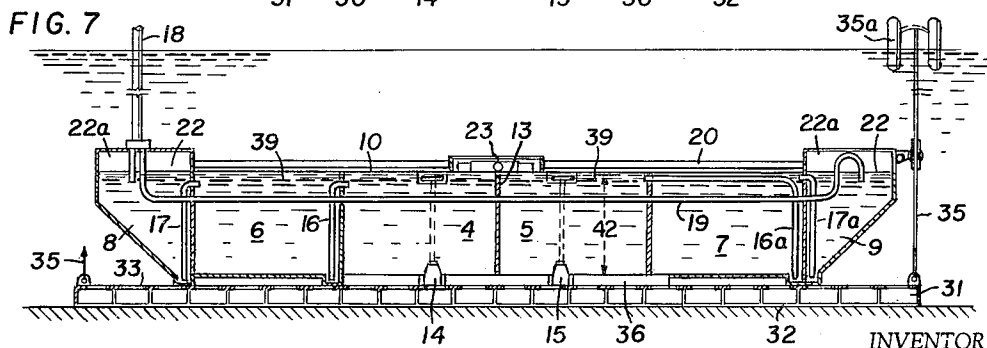
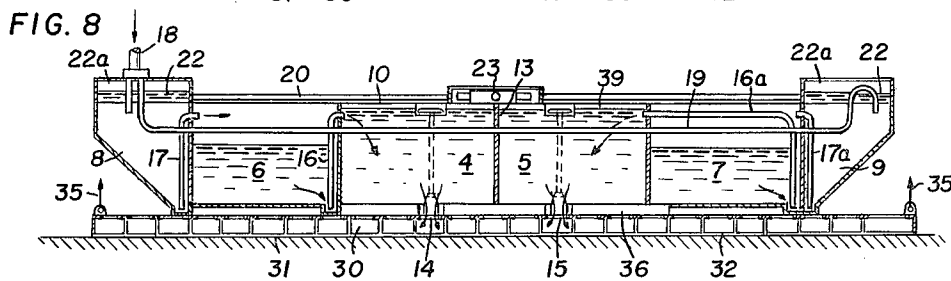
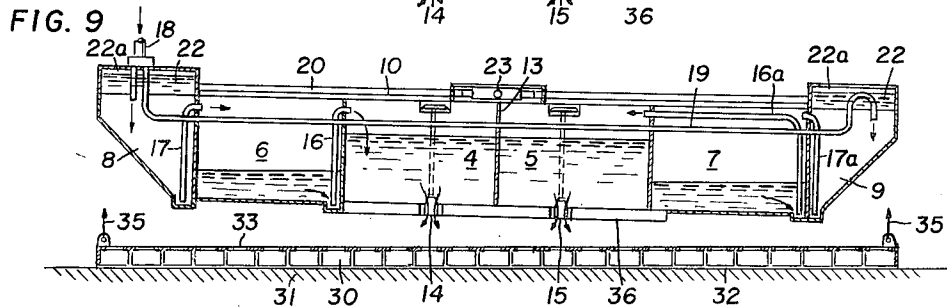
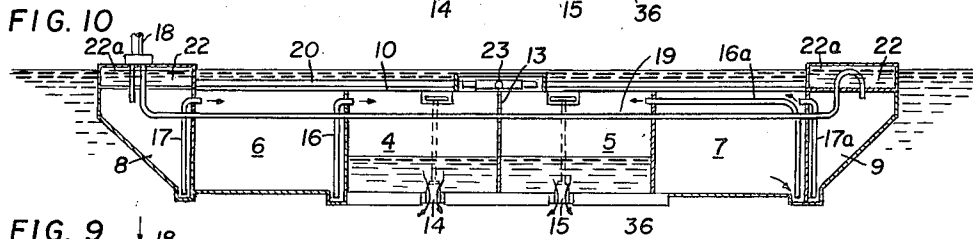
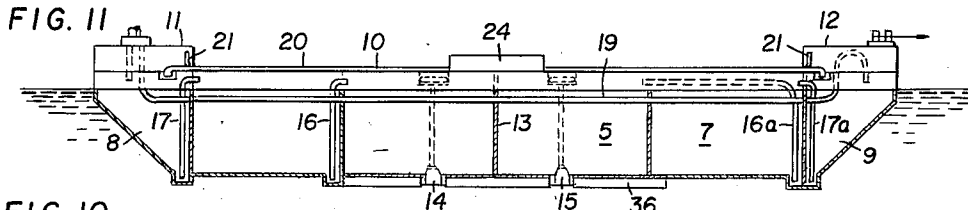
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SUBMERSIBLE MINING, LIFTING AND TOWING BARGE

Filed Sept. 6, 1961

2 Sheets-Sheet 2



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3,220,372

SUBMERSIBLE MINING, LIFTING AND TOWING BARGE

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9 Claims. (Cl. 114-16)

The present invention relates to a barge specially designed for mining operations at the sea bottom.

Mining operations at the sea bottom are usually performed by dredging work up to moderate water depths. At greater water depths, as for instance in gold mining operations off the Mexican coast, small quantities of sand are suctioned by way of a hose into a small submerged container for later processing at the surface.

In order to avoid repeated lifting of a great number of small quantities of minerals or other desirable materials from the sea bottom where the water depth makes direct dredging prohibitive, it is proposed in accordance with this invention to use a submersible barge which is capable of lifting great quantities of material from the sea bottom to the surface, and then to tow the barge from the site of mining operation to the site of processing.

Loading of the barge while resting on the sea bottom will be performed by special equipment like suction hoses or similar apparatus which are directly or remotely controlled underwater devices as developed elsewhere.

Upon completion of loading, the barge is raised to the surface and then towed to a plant ashore or to a floating plant for processing of the minerals or other material from the sea bottom. Employing a submersible barge as described hereinafter makes possible hauls of large quantities of minerals in a single operation, thus avoiding otherwise repeated hauls of small quantities which operation requires a greater time per ton material hauled, particularly at the presence of great water depths. By using a mining barge of the present invention, underwater mining operations can be brought to a higher economical level.

In case of emergency a barge according to this invention may also be used for ready available underwater storage of ammunition and military equipment in watertight containers and for emergency foodstuff.

A barge intended to be lowered to the sea bottom and to be raised from the sea bottom to the surface in loaded condition has to be designed in such a way that said operation can be conducted safely and efficiently. Positive stability and level trim have to be assured in all phases of operation, i.e. during submersion, while raising the barge from the sea bottom and when the barge is at the surface. In particular during the critical phase of leaving the surface while submerging, surface stability should still be present when gravity stability develops gradually by raising the center of buoyancy and vice versa. Special devices have to be employed for keeping the barge on even trim during submerging and raising in loaded or empty condition. While the barge is resting on the sea bottom, special devices have to be provided which release the barge from the water pressure which otherwise would pin-point the barge on the sea bottom. It is generally known that such forces, usually referred to as adhesion forces, are of great magnitude and increase with the water depth sometimes to such an extent that separating a structure from the sea bottom is a difficult operation.

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In order to solve the aforementioned technical problems an underwater mining, lifting and towing barge is designed and constructed according to the present invention in the following manner.

The barge consists of one or more open cargo cells and is equipped with wing tanks for ballasting and producing buoyancy. The buoyancy or wing tanks are so arranged and shaped that the buoyancy center is all the time above the weight center of the entire system while the barge is in submerged condition. For providing sufficient overcrossing of surface and weight stability and further to raise the center of buoyancy versus the cargo space center, special tanks are provided on deck at the fore and aft end of the barge. When the deck is just below the waterline during raising and the buoyancy center is about to pass the weight center, there is already a certain waterplane inertia present by virtue of the aforementioned end tanks on deck. In this way, a small surface stability is present when the gravity stability diminishes. When the barge is emerging further, a great waterplane inertia develops as soon as the deck touches the surface. The present problem is similar to that of floating docks with regard to the critical stability phase at water levels between the ship's bottom and the pontoon deck of a floating dock.

The fore and aft tanks provided above the deck of the present barge fulfill a second purpose as trim stabilizer. The deck tanks are half filled with water and are connected to each other by an air and water pipe. Fore and aft tanks form a closed circuit. In instances where cargo produces a trim moment, a pumping device, preferably a screw pump, is pumping water ballast from one deck tank to the other and thus eliminates the trim moment. The air above the water within the partially filled water tanks and the ballast water are exchanged from one end to the other end of the barge as per trim requirements.

Ballasting of the barge for submersion and raising of the barge is done by conventional sea valves and air pressure. However, a special arrangement of overflow pipes and flaps has to be provided in order to make the underwater mining barge workable. To accomplish this, one or more customary sea valves are installed in the midship wing tanks. When the sea valves are opened in order to start submersion of the barge, midship wing tanks on port and starboard are first filled with ballast water. Air escapes through air pipes which are carried from top to bottom of the adjacent and each following wing tank in the direction toward the end compartments. The end compartments, which form the fore and aft peak tanks respectively, are connected to each other by a special air pipe for supplying air to both end compartments from one end of the barge and furthermore to provide an air escape simultaneously from both end compartments and consequently from all other wing tanks of the forward and aft group.

The height of the overflow from the first midship ballast wing tank to the adjacent tank is determined by the freeboard which has been reached when the midship wing tanks are gradually filling with water ballast. Since the then reached inside water level of the midship wing tanks provides trapped air in consideration of the height of the overflow pipe, the capacity of the midship wing tanks and adjacent wing tanks and the height of the overflow of each tank has to be designed in such a manner that with a fully submerged barge, the trapped air produces

a not destroyable buoyancy of the desired quantity at a certain depth which will partly compensate the weight of the barge while resting on the sea bottom. Such relief of weight is sometimes desirable when mining operations have to be conducted at sea bottoms of insufficient supporting capacity.

Since the end compartments are connected by an air pipe, only one air supply hose is required. During raising, air pressure is blowing water ballast from the end compartments first and then successively from adjacent and following compartments in the direction of the midship wing tanks from where the water ballast of all group compartments is pressed to the outside through the open sea valves. It should be appreciated that during the entire operation from submerging through loading and raising of the barge, the sea valves are permanently open. When the barge has reached the sea level they will be closed for the towing trip. Surplus compressed air, if any, is then released from all tanks.

The open cargo space is made floodable by openings at the longitudinal wing tank bulkheads. The openings are closed by spring-loaded flaps with a slight pressure of the flap against the coaming of the opening on the cargo space side. When water ballast enters the wing tanks, the water pressure opens the flap slightly against the spring force of the flap and water enters the cargo space from the wing tanks. When the barge is filled with minerals or other material from the sea bottom, the flap is firmly pressed by the weight of the cargo and is then tightly closed against air pressure from the wing tanks when raising of the barge is started.

Instead of using air pressure through a hose from a special tender, it is the preferred procedure to employ chemicals which produce pressure gas when they come in contact with sea water as described in my patent application Serial Number 816,806, now Patent No. 3,080,844.

The barge should not rest directly on the sea bottom but rather on a specially built grid. The grid consists of a heavy bottom plate and preferably T-shaped girders on which the barge is resting in the manner of a ship docked in a floating dock. In this way, the bottom of the barge is exposed to water pressure from underneath and only a small percentage of the barge bottom area is covered by flanges of the T-girders. This will greatly reduce the adhesion force which otherwise would pin-point the barge on the sea bottom.

The bottom of the grid is a full plate, preferably without holes in order to produce a great adhesion force. A firm adhesion of the grid on the bottom of the sea is desirable for two reasons. First, the grid serves so to say as a docking place for the barge; second, guidance ropes attached to buoys on the surface and to the grid intended as guidance means for the barge during submersion may exert great forces on the guidance ropes by currents and swaying of the barge. A full plate of the grid ensures the maximum of adhesion force for proper anchoring of the system under prevailing circumstances. The grid may be lowered to the bottom of the sea at the first submersion of the mining barge whereby the barge itself serves as a vehicle for lowering the grid and the entire system. The grid remains on the sea bottom during the mining expedition and may later be pulled to the surface separately or may be considered as lost investment after mining at this particular site is abandoned.

The above and other features of the invention become more apparent and will be more fully described in the following detailed description of a preferred embodiment, taken in conjunction with the accompanying drawing wherein.

FIG. 1 is an inboard profile of one embodiment of the barge according to the invention;

FIG. 2 is a plan view of FIG. 1 in deck level;

FIG. 3 is a cross section of FIG. 1 at A—A;

FIG. 4 is a cross section of FIG. 1 at B—B;

FIG. 5 is a cross section of FIG. 1 at C—C;

FIG. 6 is a modification of the pressure gas supply installation;

FIG. 7 shows the barge on the sea bottom with flooded tanks;

FIG. 8 shows the barge on the sea bottom at the beginning of discharge of ballast water by air pressure;

FIG. 9 shows the barge while leaving the sea bottom and raising to the surface at a slight trim;

FIG. 10 shows the barge just below the surface with deck-tanks partly emerging;

FIG. 11 shows the barge in fully raised condition at the surface ready for towing.

A barge 1 with open cargo spaces 2, 3 has on port and starboard side wing tanks 4, 5, 6, 7 and 4a, 5a, 6a, 7a and end compartments 8, 9. Above the deck 10 of the barge 1 and above end compartments 8, 9 there are independent buoyancy, stability and trim tanks 11, 12 and 11a, 12a. A transverse bulkhead 13 subdivides the cargo space, wing tanks and end compartments in two groups fore and aft. Midship wing tanks 4, 5, 4a, 5a are equipped with bottom sea valves 14, 15. Overflow pipes 16, 17 and 16a, 17a are arranged in such way that the lower opening of the pipe is in a recess at the bottom of each tank and the upper opening of the pipes below the tank top with opening in direction to the adjacent tank and in a direction from the barge ends to the midship wing tanks. Employing this arrangement of overflow pipes, water ballast is blown simultaneously from both ends and successively from tank to tank toward the midship wing tanks 4, 5 and 4a, 5a where the ballast water of all compartments escape through the open sea valves 14, 15, as best shown in FIGS. 8 and 9. Air pressure is supplied via a hose 18 at only on end of the barge with direct access to one end compartment and connected by a pipe 19 to the other end compartment.

Deck tanks 11, 12, 11a, 12a are connected by water pipes 20, 20a and air pipes 21, 21a and are permanently filled at about half the height of the tank with water 22 and air 22a. Screw pumps 23, 23a activated by a levelling contact (not shown) are pumping ballast water in either direction from one deck tank to the other deck tank as per trim requirements. Screw pumps 23, 23a are housed in a watertight structure 24, 24a.

Openings 26, 26a are provided at the lower portion of the longitudinal bulkheads 27, 27a and are closed by flaps 28, 28a which are slightly pressed by a spring-loaded hinge from the cargo space side against the coaming of the opening 26, 26a. When the barge is loaded with minerals 29, FIG. 5, the weight of the cargo load, in addition to the spring load of the hinge, is pressing the flaps 28, 28a against the openings 26, 26a. In this way, openings 26, 26a are tight against water and air pressure when the ballast water is blown out from the wing tanks.

The barge is resting on a grid 30 on the bottom of the sea 31. The lower part of the grid 30 consists of a heavy plate 32 whereas the bottom of the barge 1 is resting on T-shaped girders 33 welded to the bottom plate 32 as best illustrated in FIGS. 5 and 7. The grid is lowered to the bottom of the sea 31 together with the barge 1 at the beginning of the mining operation. Once the grid 30 is properly placed on the ground, cables 34 which hold the grid 30 during lowering are released. Instead, guidance ropes 35 are attached to the grid 30 and to buoys 35a at the surface. The barge 1 while submerging is guided by the ropes 35 to the proper place on the grid 30.

Fixed ballast 36 is attached to the bottom of the barge 1 for equalizing top weights and to produce a slight aft trim for improved sea steadiness of the barge while under tow.

Wing tanks are designed with a great bilge radius or

in the shape of a trapezoid 37 in order to raise the center of buoyancy as high as possible. On the other hand, the cargo space has to be filled with cargo to only 70 to 80 percent of the possible full capacity in order to keep the center of weight below the buoyancy center when the system is in submerged condition.

The barge 1 is resting on the grid 30 mainly with the fixed ballast projection 36. Overhanging wing tanks support of the wings.

Upon loading, the barge 1 is resting on the grid 30 are equipped with longitudinal girders 38 for proper at the bottom of the sea 31 with all tank compartments flooded as shown in FIG. 7. Trapped air 39 standing under a pressure corresponding to the water depth relieves partly the weight of the barge and cargo on the grid 30.

When the barge 1 is going to be raised, air pressure blows the end compartments 8, 9 first, pressing the water ballast of the end compartments through the pipes 17, 17a into the adjacent wing tanks 6, 6a and 7, 7a, further through the pipes 16, 16a into the midship wing tanks 4, 4a and 5, 5a from where the ballast water escapes to the outside through the open valves 14, 15 on port and starboard side. End compartments and wing tanks are in this way successively emptied as shown in FIGS. 8, 9, 10 and 11.

After a certain amount of buoyancy has developed, the barge starts to raise from the grid 30 as illustrated in FIG. 9. It is well possible that the barge starts raising with one end first due to a trim moment produced by unsymmetrical cargo distribution in longitudinal direction. In such cases, screw pumps 23, 23a are shifting ballast water from one deck tank to the other. Upon stabilizing of the trim moment the barge continues to raise at fairly even trim or rather may ascent with a small oscillatory trim motion limited and controlled by the trim ballasting device 11, 12 and 23.

As soon as the barge 1 starts to raise from the grid 30, air supply via the hose 18 is cut. It should be appreciated that only a small surplus of buoyancy against the underwater weight of the system is required for initiating a raising of the barge. From this instant additional air supply is not only not required but even not desirable in so far as the compressed air within the tank system expands while the barge is ascending to water levels of smaller water pressure. In this way, more and more buoyancy develops without additional supply of air and more and more ballast water is blown out of the tanks by the expanding air. It is obvious that, when additional air should be delivered after raising of the barge at the initial phase, buoyancy will then develop even faster resulting in an undesirable vehement raising motion.

After the barge has reached the surface with empty wing tanks and empty end compartments as shown in FIG. 11, sea valves 14, 15 are closed and air pipes 18 and 19 opened for release of any surplus air. Trapped water 40 at the side of the cargo 29 is self-draining through pipes 41 as shown in FIG. 5.

The barge 1 will be submerged by merely opening the bottom sea valves 14, 15 resulting in successive ballasting of the wing tanks, cargo space and end compartments while the air escapes through the pipe system 16, 17, 18. Particular attention has to be paid to the height 42 of the overflow pipes with regard to freeboard, ballast weight, weight of the barge and buoyancy by trapped air 43 in the midship compartment 4, 4a and 5, 5a. If, for instance, the overflow height of the wing tanks 4, 4a and 5, 5a at the overflow pipes 16, 16a is too high and above the meanwhile reached freeboard or draft, respectively, the barge remains floating and does not submerge because additional water ballast can not enter the adjacent wing tanks for further lowering of the barge.

Instead of using compressed air it is suggested to employ chemicals which are generating pressure gas upon contact with seawater. Chemicals may be housed in a special compartment 44 as shown in FIG. 6. Pellets of

chemicals may be activated by remote controlled electronic devices from the surface as described elsewhere.

While the invention has been described and illustrated in connection with certain preferred embodiments, it will be understood that many variations and modifications may occur to the skilled in the art, particularly after benefiting from the present teaching, without departing from the spirit and scope of this invention as defined in the appended claims.

What I claim is:

1. A system for controlling the trim stability, raising and lowering of a submersible barge having a deck and a cargo space below the deck, which comprises

- (a) at least one pair of portside tanks and at least one pair of starboard tanks, the tanks of each pair extending from a transverse line through the center of gravity of said barge toward the forward and aft peaks of the barge, respectively,
- (b) a forward tank and an aft tank at the forward and aft peaks, respectively,
- (c) a pair of buoyancy tanks atop the forward tank and a pair of buoyancy tanks atop the aft tank, said buoyancy tanks being arranged above the deck plane, one tank of each pair being arranged portside and the other tank starboard,
- (d) an air supply,
- (e) conduit means connecting the air supply to each of the forward and aft peak tanks,
- (f) sea valve means establishing communication between the water and the portside and starboard tanks nearest said transverse line,
- (g) overflow pipe means extending between adjacent ones of said portside and starboard tanks and said forward and aft tanks, respectively, whereby air pressure supplied through said conduit means to said forward and aft peak tanks will simultaneously force water ballast in said tanks to flow from the forward and aft peak tanks toward the midship tanks whence it escapes through the sea valve means, while water admitted through said sea valve means will simultaneously force air in said tanks to flow from the midship tanks toward the forward and aft tanks, respectively,
- (h) ballast water partially filling said buoyancy tanks, the remainder thereof being filled with air,
- (i) pipes interconnecting the ballast water in the portside buoyancy tanks and in the starboard buoyancy tanks, respectively,
- (j) pipes interconnecting the air in the portside buoyancy tanks and in the starboard buoyancy tanks, respectively, and
- (k) pumping means delivering ballast water through the interconnecting pipes between the portside buoyancy tanks and the starboard buoyancy tanks according to the trim requirements.

2. The system of claim 1, wherein two pairs of portside tanks and two pairs of starboard tanks are provided, two midship tanks and two tanks intermediate the midship tanks and the forward and aft tanks, respectively, being provided portside and starboard.

3. The system of claim 1, wherein said air supply consists of a supply of chemical substances capable of evolving air in contact with water.

4. The system of claim 1, wherein each of said overflow pipe means extends from a point near the top of one of said tanks nearer the transverse line to a point near the bottom of the adjacent one of said tanks.

5. The system of claim 1, wherein the ballast water fills the buoyancy tanks to about half their height.

6. The system of claim 1, wherein said air-pressure controlled pumping means consists of screw pumps in the pipes interconnecting the ballast water, and

(1) a water-tight housing is provided for each screw pump.

7. The system of claim 1, further comprising

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- (n) two longitudinally extending bulkheads defining the cargo space and separating the same from said portside and starboard tanks, said bulkheads defining openings near the bottom thereof, and
- (o) spring-loaded flaps for closing said openings. 5
8. The system of claim 1, further comprising
- (p) a fixed ballast attached to the bottom of the barge and producing an aft trim.
9. The system of claim 1, wherein said portside and starboard tanks are of trapezoidal cross section.

8

References Cited by the Examiner

UNITED STATES PATENTS

601,431	3/1898	Cousins	-----	114—45.5
1,043,411	11/1912	Engstrand	-----	114—45.5
2,887,977	5/1959	Piry	-----	114—16.3

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Examiners.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,220,372

November 30, 1965

Guenther W. Lehmann

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 9, strike out "support of the wings." and insert instead -- are equipped with longitudinal girders 38 for proper support of the wings. --; line 11, strike out "are equipped with longitudinal girders 38 for proper".

Signed and sealed this 27th day of December 1966.

(SEAL)

Attest:

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Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents