Nov. 18, 1969 H. M. COMBS 3,478,711

SUBMERSIBLE SEA TRAIN

Filed July 30, 1968 3 Sheets-Sheet 1

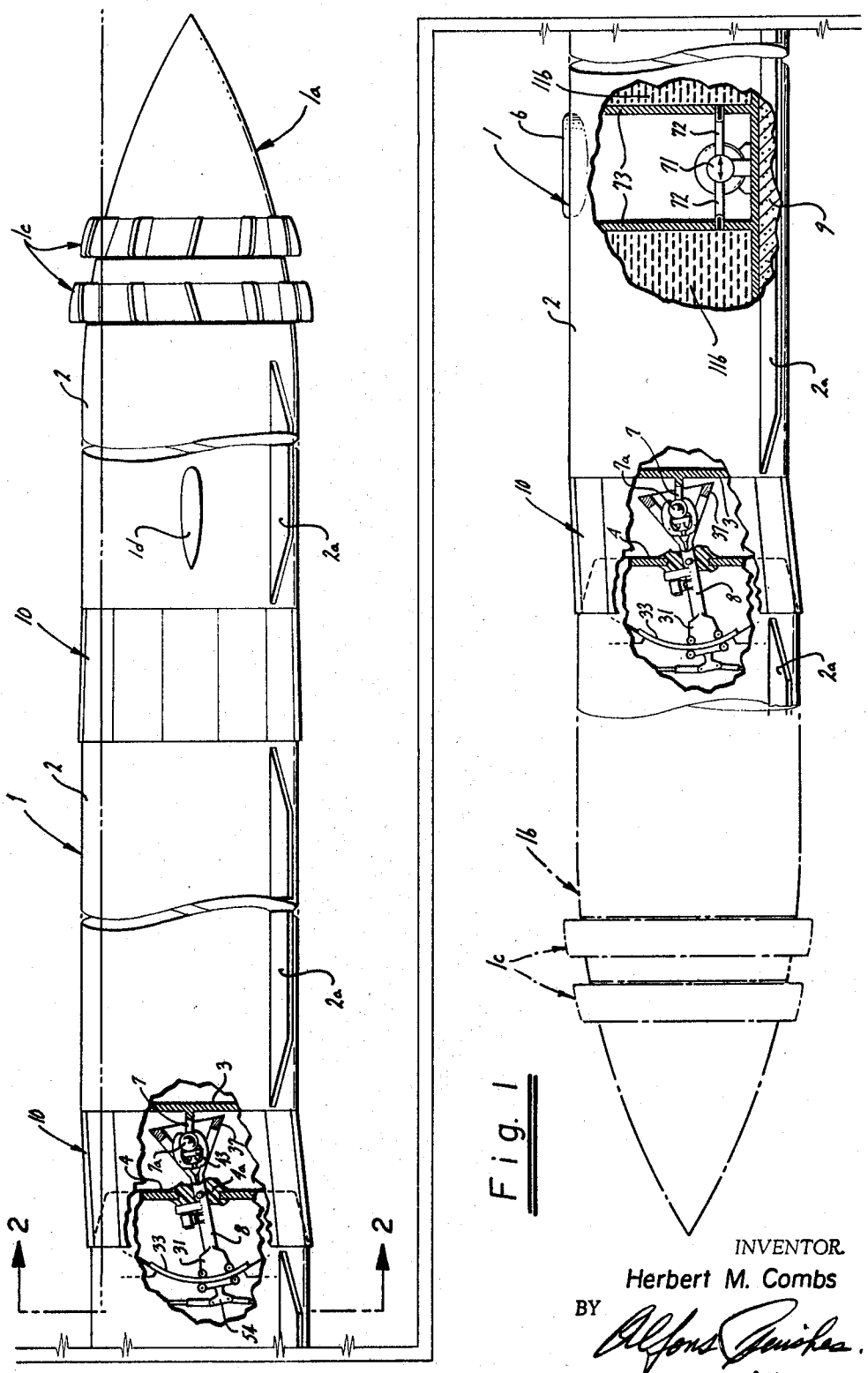


Fig. 1

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SUBMERSIBLE SEA TRAIN

Filed July 30, 1968 3 Sheets-Sheet 2

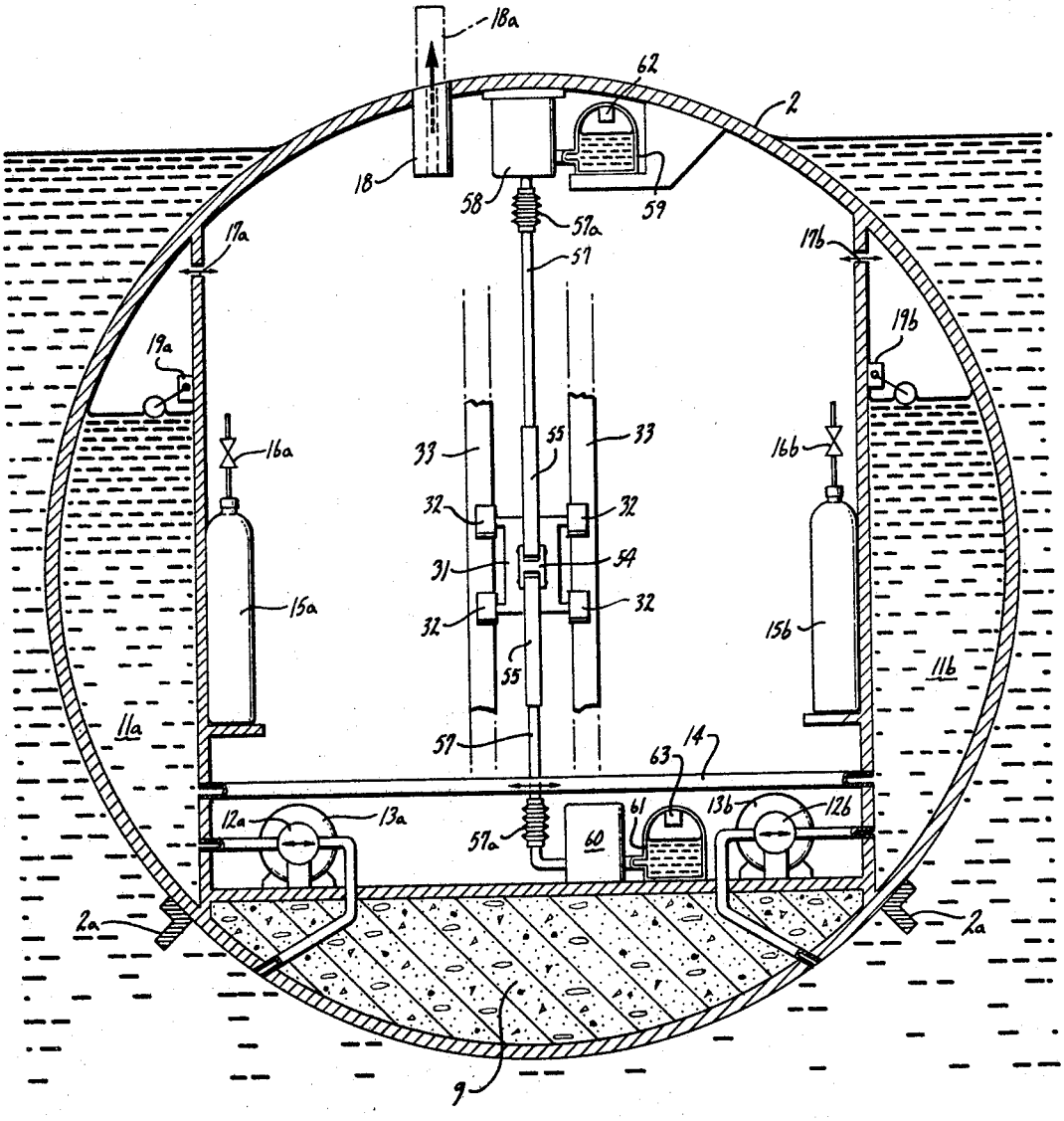


Fig. 2

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SUBMERSIBLE SEA TRAIN

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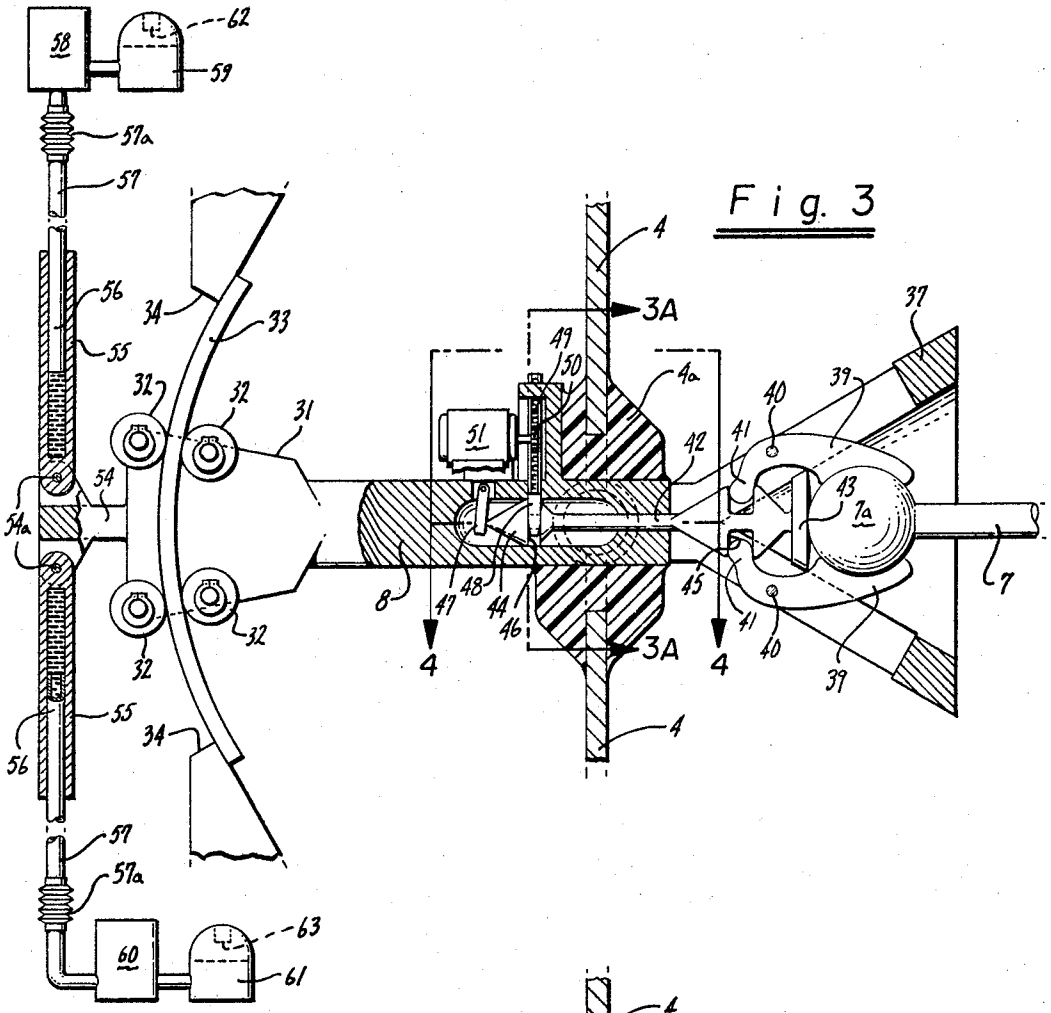


Fig. 3

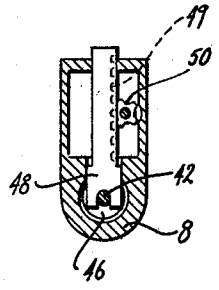


Fig. 3A

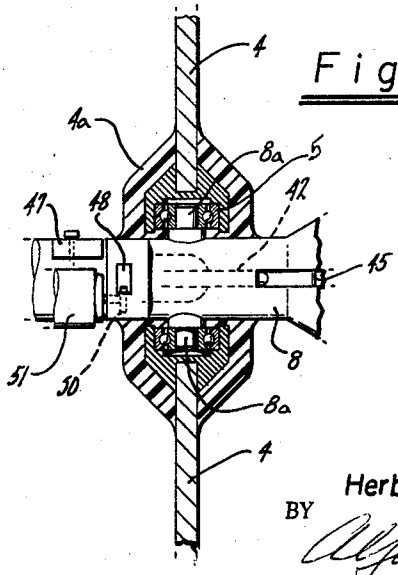


Fig. 4

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3,478,711

SUBMERSIBLE SEA TRAIN

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Filed July 30, 1968, Ser. No. 748,832
Int. Cl. B63b 3/13; B63g 8/22
U.S. Cl. 114—16 5 Claims

ABSTRACT OF THE DISCLOSURE

A number of submersible cargo vessels are coupled together and to a towing means after the manner of a string of freight cars and a locomotive. Novel means of coupling and uncoupling units together with an automatic means for maintaining proper relative buoyancy and submergence under varying conditions of operation make possible such an articulated combination.

BACKGROUND OF THE INVENTION

A well known fact among engineers is that no two non-compressible objects can occupy the same place at the same time. Taking cognizance of this fact, it becomes obvious that the great obstacle to the rapid movement of any vessel or object through water is the displacing or removing of the necessary water to permit the object or vessel to pass. Note the very small resistance offered to a common sewing needle dropped point first into a barrel of water. Research and study of the fastest swimming fish revealed one striking design feature in common: a long needle nose. The swordfish has been clocked at 71 miles per hour; the sailfish at 70 miles per hour; and the marlin at 60 miles per hour. Although the barracuda with its long sleek body had a top speed considerably above other fish, it did not approximate these three.

The advantages of submersible or submarine cargo vessels from the standpoint of greater hydrodynamic efficiency and greater safety during war time conditions has been realized for some time. The use of self-propelled vessels of this type has been curtailed by limitations in overall size and further by the amount of space available for cargo after providing for propelling machinery, crews, etc. Use of towed vessels of this type besides the size limitation presents the problem of maintaining proper buoyancy and hence submergence under varying conditions of sea, speed, and cargo sizes. The use of a number of vessels coupled together to overcome the size limitations and provide greater flexibility has not been heretofore feasible because of the mechanical problems of coupling and uncoupling such units, aggravated by the increased problem of maintaining proper relative buoyancy and reducing the water drag due to absence of streamlining between adjacent units.

The problem was partly solved by my invention covered by Patent No. 2,727,485, to which further reference will be made herein.

It is therefore a general object of my invention to provide a submersible cargo vessel or vessels which will have relatively few limitations as to size and number of vessels.

It is another object of my invention to provide a submersible cargo vessel which will have automatic means of maintaining proper relative buoyancy and submergence.

It is a more specific object of my invention to provide a submersible cargo vessel or vessels comprising a series of units coupled together in the form of a train.

It is still another more specific object of my invention to provide a satisfactory means of readily coupling and uncoupling units of such a train.

Finally it is an object of my invention to reduce water

resistance to a minimum by providing a maximum of streamlining of individual units, as well as overall.

SUMMARY

The sea train is a new revolutionary means of transportation across waterways. It follows the pattern of the railroad train in that it is made up of a great number of units connected in tandem and pulled by an engine or tractor unit at the bow. It differs from the railroad train in that it floats instead of having wheels rolling upon rails.

Each unit is cylindrical in shape and has a connecting means which gives it a universal tilting movement, permitting each unit to tilt in any given direction relative to the adjacent unit. Rigidly attached to the rear end of each unit is a cylindrical, flexible collar or sleeve on which inner surface are a number of stiffening ribs which taper backward until they blend in with the thin rear edge of the collar. The rear inner surface of the collar has a sliding engagement with the front end of the following section which itself is somewhat rounded on the front end to permit the collar to remain undistorted as the angle of the adjacent units differ. This arrangement enhances the overall streamlined effect and consequently the efficiency of my invention described more particularly in my Patent No. 2,727,485 mentioned above.

Each unit is watertight except when in port loading and unloading. An automatic mechanism or a remote electrical control at the bow or stern end of the sea train controls the water entering or being expelled from the ballast tanks of one or more units until the desired buoyancy is attained. When underway across a body of water, the sea train will be floating by approximately one to three percent of its volume, but not limited as a buoyancy or displacement, whereas when approaching a harbor the ballast tanks may be pumped up to establish a float of 20 to 30 percent. The floor on the inside of each unit is covered by a layer of concrete to provide ballast and stability.

The coupling means between the units which comprise an important part of my invention, comprises a spherical ball affixed to a concentric bar which in turn is positioned at the stern end of each unit and an automatically closing jaw type clamp affixed to a bar which rides in pivot bearings at the bow end of each unit. This combination permits the two coupled units to articulate in a horizontal plane and to move relative to one another in a vertical plane. The latter movement is controlled by a novel hydraulic system which responds to movements of the tow bar in a vertical plane and in turn energizes the circuit which supplies the ballast tank pumps. In this manner excessive vertical movement of adjacent units is prevented and stability of the entire train assured.

Fore and aft trim of individual units is controlled by a fore and aft trim pump which shifts water from forward to after ballast tanks and vice-versa as needed in response to mercury level control switches.

An auxiliary air supply and venting system insures proper operation of the ballast tanks as these are being pumped or emptied of ballast in response to the operation of the control system mentioned above.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic longitudinal view of the train of my invention showing the cargo and traction units and method of coupling, with partial cut-aways.

FIG. 2 is a cross-section through the forward end of one of the units along line 2—2 showing the general schematic arrangement and relative location of the principal pieces of ballast control equipment.

FIG. 3 is a longitudinal section through a pair of tow

bars showing partially schematically their method of operation.

FIG. 3*a* is a side elevation of the locking yoke of FIG. 3.

FIG. 4 is a partial section of a forward bulkhead along the line 4—4 of FIG. 3 showing the method of pivoting and water sealing the forward tow bar.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to the figures and particulary first to FIG. 1, there are seen the cargo units **1** of my vessel. These are coupled together and in turn coupled to the forward traction unit **1***a* and the after traction unit **1***b*. The latter two units are similar to those described in my Patent No. 2,727,485 and the method of propulsion may be any conventional type and will not be described in any detail since it forms as such no important part of the invention. It should be noted that these latter units are of needle nose construction for the reasons previously pointed out and are equipped with propulsion or retarding units **1***c* and adjustable diving plane **1***d*. The latter may be manually or automatically controlled and in general perform the same function as do the planes of conventional submarines.

Each unit is equipped with a pressure hull **2** which is of cylindrical construction and bilge keels **2***a*, the latter to provide stability. Each pressure hull is equipped with an after end **3** and a forward end **4**. Each forward end is equipped with a special flexible water seal **4***a*, shown for fully on FIG. 4 and described in greater detail below. A pressure tight hatch **6** may be of more or less conventional design to provide access and egress from the unit and is constructed to provide a minimum of obstruction to the movement of the vessel when submerged.

On each after end wall there is fixedly positioned a concentric tow bar **7** which has a spherically shaped end **7***a*. Each forward end wall is equipped with a forward tow bar **8** disposed for rotation in a vertical plane around pivots **8***a* which will also be described in greater detail below.

Referring now to FIG. 2 as well as FIG. 1, there is seen a concrete ballast **9** positioned in the bottom of each unit to insure greater stability, particularly when the unit is empty of cargo. Adjoining each unit there is the connecting collar or sleeve **10** more fully described in my Patent No. 2,727,485. This will not be described in great detail here except to point out that the forward end of the sleeve is fixedly positioned on the after end of each unit and overlaps the outside periphery of the forward end of the succeeding unit, thus preserving the streamlining or protection against resistance to the movement through the water while permitting the relative vertical or horizontal movement between successive units.

Each unit is equipped with port ballast tanks **11***a* and starboard ballast tanks **11***b*, somewhat after the manner of conventional submarines. These ballast tanks communicate with the exterior or the sea through port ballast control pump **12***a* and starboard ballast control pump **12***b* respectively. These pumps are of the positive displacement type and are disposed to operate in either direction of rotation by means of port ballast pump motor **13***a* and starboard ballast pump motor **13***b*. In this manner these pumps may be used either to pump ballast into or out of the tanks as needed in the operation. Equalizer line **14** running port to starboard between the ballast tanks serves to insure the level in both tanks to be substantially equal at all times.

Port air banks **15***a* and starboard air banks **15***b* comprise a series of bottles of compressed air manifolded together and supported in the interior in any convenient manner, as is done in conventional submarines. The air banks are equipped with automatic air outlet valves **16***a* and **16***b* arranged to supply air to the interior of the vessel at a predetermined rate and pressure in order to maintain the pressure of the atmosphere within the unit to be substantially constant and permit proper functioning of the ballast control. This is further facilitated by port inboard ballast vents **17***a* and starboard inboard ballast vents **17***b* which permit communication between the interior or cargo space and the air space above the ballast water as shown. An outboard vent **18**, which is of a check valve type, permits the blowing of air to the outer atmosphere when the pressure becomes excessive on the interior. A high level extension of vent **18** is seen at **18***a* which permits proper operation of this vent when the vessel is entirely submerged. A port ballast tank float switch **19***a* and a starboard tank float switch **19***b* serve to prevent excessive water level in these ballast tanks. These are connected to the circuit supplying input to ballast pump motors **13***a* and **13***b* and interlocked with the other control equipment described below in a conventional manner and will not be described in greater detail here.

It is evident that single units of all of the above components would be sufficient for proper operation, but I provide these in duplicate for safety reasons to insure proper operation of the vessel in the event of failure of one of the components.

Referring now more particularly to FIG. 3, there is seen first the carriage end **31** of tow bar **8** on which are positioned rollers **32** which ride on rails **33** equipped with limit stops **34**. There is also seen the funnel end **37** of tow bar **8**. The latter performs the multiple functions of guiding ball end of after tow bar **7***a* into proper position for coupling of the units and for supporting the gripping jaws **39**. The latter are supported on the funnel end **37** by means of pins **40** and are equipped with lever ends **41**. Actuating rod **42** is positioned concentric with tow bar **8** and in sliding relation thereto. Actuating rod **42** is equipped with a bumper end **43** disposed to make contact with ball end **7***a* and with control end **44** located in a cavity inside tow bar **8** as shown. Slot **45** in actuating rod **42** is disposed to engage gripping jaw levers **41** of gripping jaws **39**. Slot **46** at the control end of actuating rod **42** is disposed to receive locking yoke **48**. Control end **44** is further disposed to operate limit switch **47**.

Locking yoke **48** is better seen on FIG. 3*a* and is equipped with a rack **49** and a pinion **50** which is driven by motor **51** positioned on the top of tow bar **8**.

The operation of the locking features of my tow bars should now be evident to those skilled in the art. When the units are in an uncoupled position, gripping jaws **39** are wide open and actuating rod **42** is in a position to the far right in FIG. 3. As one of the units **1** of FIG. 1 is maneuvered into position for coupling with an adjacent unit, ball end **7***a* is guided by funnel end **37** so that it strikes bumper end **43**. This causes actuating rod **42** to move to the left, thereby closing jaws **39** and clamping them around ball **7***a*. At the same time control end **44** strikes limit switch **47** which is connected to a source of power not shown, and to motor **51**. This starts motor **51** driving pinion **50** and lowering rack **49**, thereby positioning yoke **48** into slot **46**, thus providing a positive lock for the coupling mechanism. When uncoupling the units, motor **51** is started in an opposite direction from an outside power source and switch (not shown), thereby raising yoke **48** permitting actuating rod **42** to move to the right, opening jaws **39** and releasing ball **7***a*.

Referring now again to FIG. 2, as well as FIG. 3, there is seen also on these figures the control system which I utilize to maintain proper relative buoyancy for submergence between adjacent units on my train. This comprises essentially a combination of a hydraulic and electrical control system. The hydraulic components are utilized in order to produce a dampening effect which may be needed in the case of rapid changes in submergence as by pitching, etc., of the units, while the electrical components, many of which are not shown since they are of a conventional type, are utilized to energize the ballast pump motors.

Hydraulic system actuating lever **54** is fixedly posi-

tioned on the end of the tow bar **8** and connects with hydraulic system actuating cylinders **55** through pins **54***a*. Stationary hollow pistons **56** which are positioned to be in slideable relation with movable cylinders **55** are connected to hydraulic system pipes **57**. Flexible joints which may be of the bellows or similar type **57***a* are inserted in the pipe lines **57** to compensate for the bending action which the lines **57** will be subjected to by the motion of the cylinders **55**. Hydraulic pipes **57** connect with upper hydraulic main tank **58** and lower hydraulic main tank **60** respectively. These tanks in turn connect with lower hydraulic surge tank **61** and upper hydraulic surge tank **62** respectively. All four tanks are disposed to maintain an air space in their upper portions which permits for compression and expansion of the air as the hydraulic fluid changes in level. Switches **62** and **63** are positioned in the upper and lower surge tanks respectively and are connected in the circuit supplying the ballast tank pump motors **13***a* and **13***b*.

The operation of this system is now readily evident to those skilled in the art. Whenever tow bar **8** is caused to rise in position along rails **33** due to the forward end of the unit being higher in the water than the after end of the next preceding unit, hydraulic system actuating lever **54** will cause cylinders **55** to move, thus forcing hydraulic fluid which fills the system to move into one surge tank and out of the other, thus actuating switches **62** and **63**. Since these are connected through appropriate circuitry (not shown) to the motors **13***a* and **13***b*, it will cause pumps **12** and **12***b* to operate in the appropriate direction to pump sea water into the ballast tanks **11***a* and **11***b*, until a proper relative buoyancy between adjacent units is re-established, whereupon the tow bar **8** assumes its horizontal position again, the level of the hydraulic fluid changes and switches **62** and **63** de-energize the motors. I use two independent systems in this manner to provide duplicate power control systems and consequently greater reliability, as I have mentioned previously in connection with other components and elements of my invention. Of course, switches **62** and **63** are so arranged that when the level of the hydraulic fluid rises in tank **59** and correspondingly lowers in tank **61**, the pumps **12***a* and **12***b* will rotate in the proper direction to pump ballast from the sea to the tanks. Conversely, when the level in tank **59** drops and that in tank **61** rises simultaneously, which means that the unit is dropping below the one preceding it, the pumps will operate in the opposite direction and pump ballast from the tanks out to sea.

This change in volume of the ballast in the tanks will, of course, be accompanied by a displacement of the air above the surface of the water which in turn will cause a flow of air into and out of the main compartment through the vents **17***a* and **17***b*. Air required for displacement of the water being pumped out of the ballast tanks will be supplied from the air banks **15***a* and **15***b* through automatic valves **16***a* and **16***b* as described previously. Excess air caused by a rise in the level of the water in the ballast tanks will be vented out through vent **18**. Float switches **19***a* and **19***b* prevent water in the ballast tanks from rising too high and pouring out of vents **17***a* and **17***b*. These switches are interconnected with the ballast pump motors (wiring not shown) in the manner described above.

Rotating motion of tow bar **8** is made possible by the use of a novel flexible water seal **4***a* mentioned above, which may best be seen by reference to FIG. 4. This comprises essentially two truncated cones which may be made from a flexible plastic, elastomeric, or similar material which is bonded to the forward end **4** and to the cylindrical portion of tow bar **8** to provide a water tight seal for the space required for operation of the bar. Since my vessel is never subjected to deep submergence, this seal need not be of very heavy construction since it will never be subjected to very high pressures. The tow bar **8** is equipped with stub shafts **8***a* which may form an integral part thereof. The latter ride in bearings **5** which are fixedly positioned on the end of hull **4**. This facilitates the rotation of the bar or its pivoting in a vertical plane.

Fore and aft stability of an individual unit is maintained by trim pumps best seen on FIG. 1. Shown there is starboard trim pump **71** connected to trim lines **72** which penetrate port and starboard ballast tank partition **73**. Shown in the figure is the starboard pump, a duplicate system being supplied for the port side. Pump rotation in either direction is controlled by a mercury level switch (not shown), whereby ballast may be pumped from the forward to the after tanks and vice-versa to maintain proper fore and aft trim.

A system of control and power supply cables runs between units and connects with the traction units **1***a* and **1***b* which also carry the power supply. The cables are arranged for rapid connecting and disconnecting.

I claim:

1. A submersible sea train comprising a plurality of submersible vessels connected together by coupling means, said coupling means comprising:

a spherical member positioned on the outer end of a rigid horizontal shaft extending axially from the outside of one end wall of each of said vessels;

a horizontal cylindrical member pivotally mounted for rotation in a vertical plane on the opposite end wall of each of said vessels and extending therethrough;

means for effecting a watertight seal between said cylindrical member and said end wall;

movable clamps pivotally mounted on the outer end of said cylindrical member disposed to engage said spherical member of an adjacent one of said vessels of said train;

means for opening and closing said clamps;

a plurality of rollers positioned on the inner end of said cylindrical member;

said rollers being disposed to engage a rail defining an arc of a circle;

said rail being fixedly positioned in each of said vessels;

means for maintaining varying degrees of submergence of said vessels;

means for propelling the vessel at each end of said train through the water.

2. The train of claim **1** in which said vessels are equipped with ballast tanks and communicating electrically driven ballast pumps the improved means for maintaining the degree of submergence of said vessels at a predetermined level comprising:

an actuating lever fixedly positioned on the inner end of said cylindrical member;

a hydraulic cylinder pivotally mounted on said lever;

a hollow hydraulic plunger in slideable relation with said cylinder;

a closed hydraulic main tank;

a closed hydraulic surge tank;

pipe means communicating a hydraulic fluid from said hydraulic cylinder through said hollow plunger to said main tank and from said main tank to said surge tank;

said surge tank disposed to present a variable surface level of said hydraulic fluid;

an air pocket in said surge tank above the surface of said fluid;

a pressure switch positioned in said air pocket;

means for electrically connecting said pressure switch and said electrically driven ballast pumps to a source of electrical power;

whereby motion of said actuating lever will control the operation of said ballast pumps and thereby the amount of ballast in said tanks.

3. The train of claim **2** in which the propelling vessel at each end of said train is equipped with adjustable diving planes positioned on the outside of the hulls of said vessels.

4. The train of claim **3** including cylindrical sleeves positioned between successive vessels said sleeves having

a diameter slightly greater than that of each vessel and a length slightly greater than the distance between the end walls of adjacent vessels, the periphery of one end of said sleeves being fixedly joined to the hull of one vessel whereby resistance to flow of said train through water is reduced while permitting said train to articulate properly.

5. The train of claim 4 including in addition:

forward and after trim tanks positioned in each of said vessels;

electrically driven trim pumps connected between said trim tanks;

electrical means responsive to the inclination of said vessels in a forward and an after direction for energizing said electrically driven trim pumps,

whereby water may be pumped from said forward trim tanks to said after tanks and vice-versa,

thereby maintaining said vessel in a substantially level state.

References Cited

UNITED STATES PATENTS

2,727,485	12/1955	Combs	114—16
3,208,423	9/1965	Endo	114—235

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U.S. Cl. X.R.

114—77, 235