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3,154,043

HYDRODYNAMIC TRAVELLING WAVE PROPULSION APPARATUS

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3 Sheets-Sheet 1

FIG. 1.

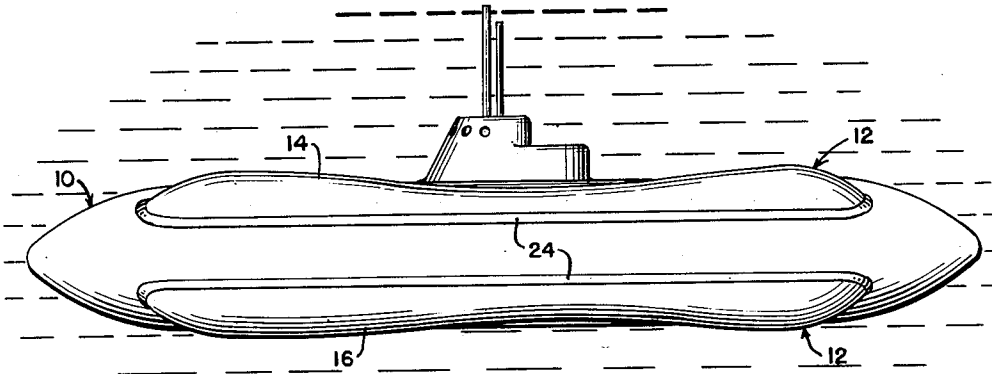


FIG. 2.

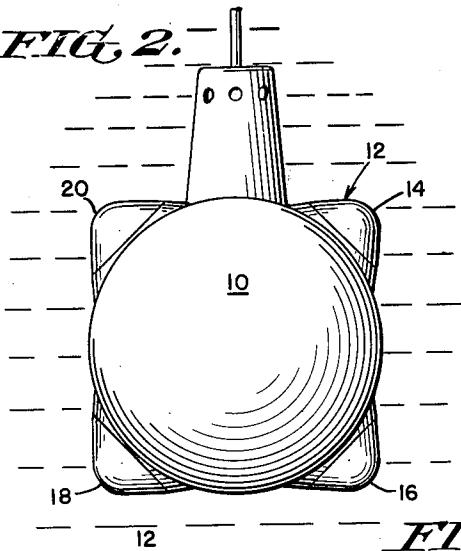


FIG. 10.

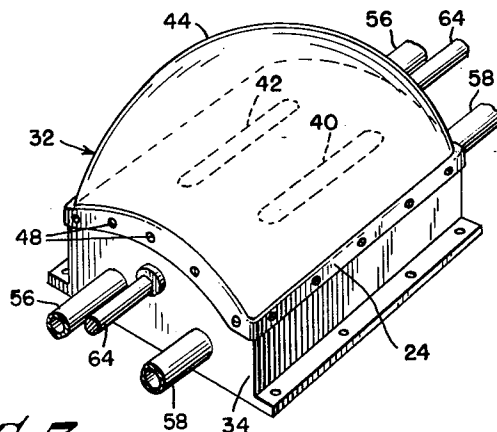
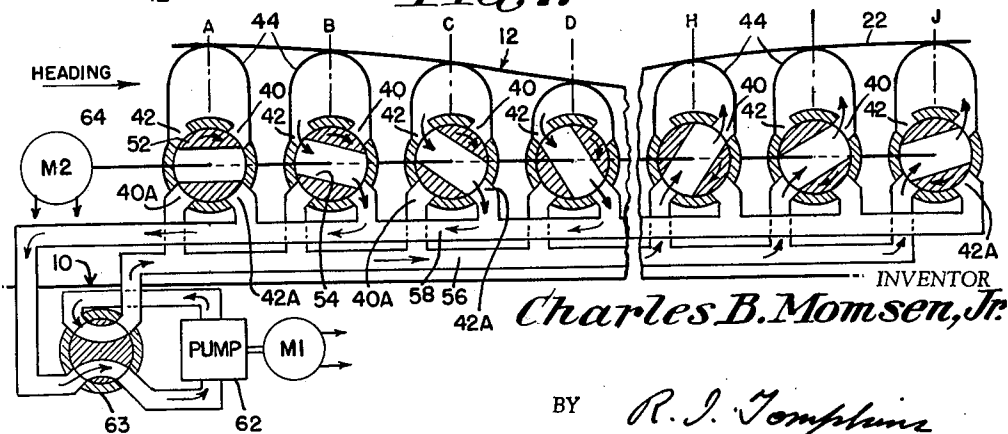


FIG. 7.



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FIG. 6.

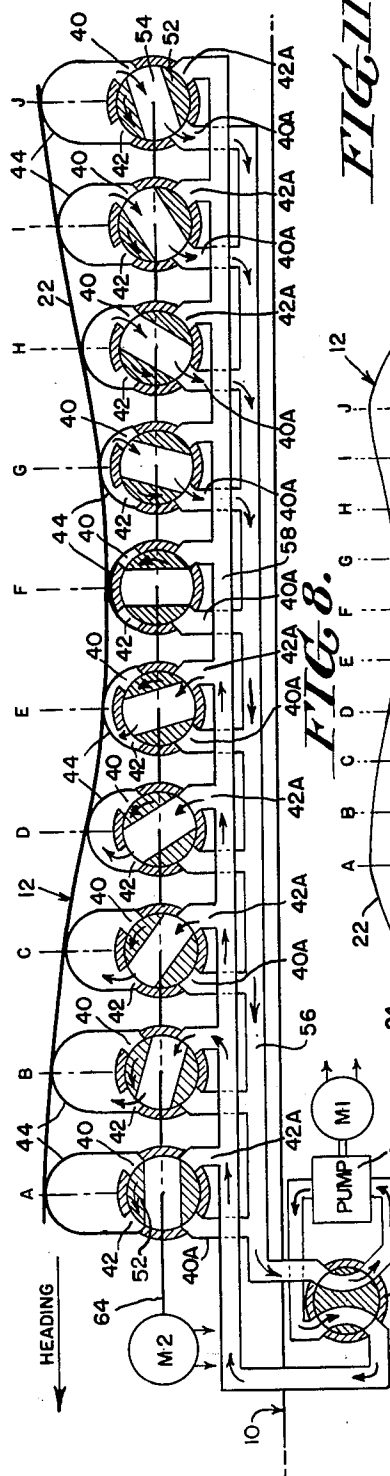


FIG. 7.

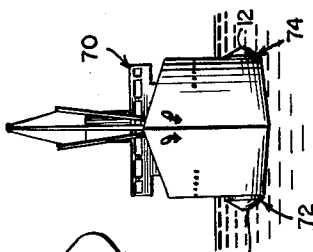


FIG. 8.

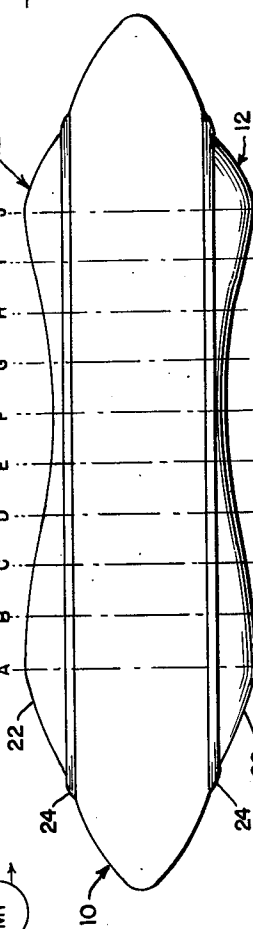
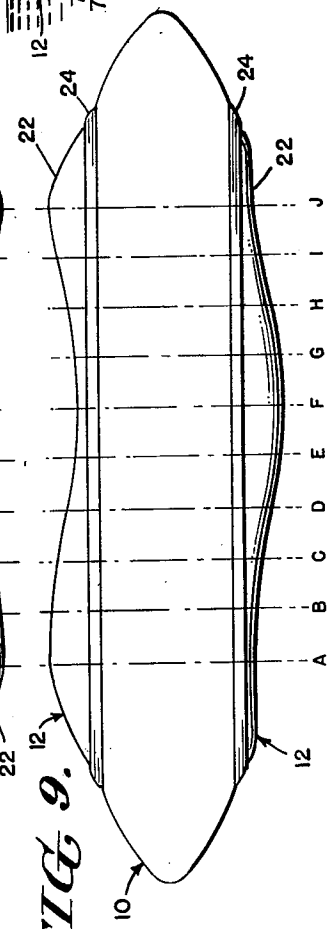


FIG. 9.



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**HYDRODYNAMIC TRAVELLING WAVE
PROPULSION APPARATUS**Charles B. Momsen, Jr., 4202 12th Road S.,
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2 Claims. (Cl. 115—5)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of royalties thereon or therefor.

The present invention relates to marine propulsion and more particularly to a propulsion and steering apparatus wherein flexible elastic membranes mounted exteriorly of the hull and along the length of a vessel are hydraulically expanded and contracted to form travelling sine waves simulating the undulating motion made by the body of a swimming fish. The travelling wave form of propulsion of the present invention is highly efficient and provides active propulsion along substantially the entire length of the vessel in contradistinction to the conventional screw propeller where propulsive forces are only at the stern.

Apparatus for accomplishing the foregoing result and forming the subject matter of the present invention comprises a plurality of flexible elastic membranes mounted on a vessel and having means enclosed within the membranes and exteriorly of the hull of the vessel for providing undulating motion to the membranes, thus causing propulsion of the vessel. The operating means comprises a plurality of hydraulically expandable members or cells, the expansion and contraction of each cell being controlled by a valve driven by a variable-speed motor. A motor-driven pump within the hull circulates and maintains pressure on a fluid, preferably a substantially non-compressible liquid, which communicates with each of the control valves. Each valve permits expansion and contraction of the cell individual thereto, in timed relation to the other cells, thus each cell expands and contracts a portion of the membrane during each revolution of the valve. The timing of the valves is such that each cell becomes fully expanded and contracted in timed consecutive order from bow to stern for forward motion of the vessel, and from stern to bow for reverse motion of the vessel. In this manner, one cell may be fully expanded and another cell may be fully contracted, while between these two extremes are other cells in various stages of expansion or contraction. Thus, the membrane under the influence of the cells is manipulated substantially in the shape of a travelling sine wave, the wave travelling along the length of the membrane in continuous repetition as long as the mechanism is operated. This motion provides propulsive forces to the vessel. When the membranes on one side of the vessel are operated while those on the other side are not, the vessel will be steered laterally. When the top membranes are operated the vessel is steered downwardly, while when the bottom membranes are operated the vessel is steered upwardly.

The primary object of the invention is to provide a novel form of propulsion for vessels.

Another object of the invention is to provide a propulsion mechanism for a vessel which is quiet in operation, thereby to avoid detection in time of war.

Still another object is to provide a propulsion mechanism for a vessel which is highly efficient in operation.

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A further object is to provide a propulsion mechanism for a vessel wherein no moving shafts project through the hull of the vessel thereby avoiding leaks.

Still a further object is to provide a propulsion and steering mechanism for a vessel wherein the vessel is capable of being steered horizontally by the propulsion mechanism.

An additional further object is to provide a propulsion and control mechanism wherein a vessel of the submarine type is maneuverable in both vertical and horizontal directions entirely by use of the propulsion mechanism.

Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawing wherein:

FIG. 1 is a side elevation of a submarine showing the devices of the present invention installed thereon;

FIG. 2 is a bow on view of the submarine;

FIG. 3 is a sectional view along the length of one of the propulsion devices and showing the expansion elements in elevation;

FIG. 4 is a sectional view through one of the expansion elements;

FIG. 5 is a view at right angles to FIG. 4 and showing the expansion element partly in elevation and partly broken away;

FIG. 6 is a diagrammatic view showing the timing of the plurality of expansion elements and the valves therefor as adjusted for forward propulsion;

FIG. 7 is a view similar to FIG. 6 and showing the system adjusted for propulsion to the rear;

FIG. 8 is a plan view of the submarine showing a pair of the propulsion devices mounted on opposite sides thereof and operating in unison;

FIG. 9 is a view similar to FIG. 8 and showing the propulsion devices operating in staggered relation to each other;

FIG. 10 is a perspective view of one of the expansion elements, and

FIG. 11 shows a surface vessel equipped by a pair of the propulsion and steering devices of the present invention.

Referring more particularly to the drawings, wherein like numerals indicate like parts throughout the several views, 10 indicates generally a marine vessel which is shown as being a submarine. A plurality of propulsion devices of the present invention, indicated generally at 12, are mounted on the hull of the submarine 10, as shown in FIG. 1. It is, of course, understood that members 12 may be used with equal facility on a surface vessel, the members 12 being located below the water line, as shown in FIG. 11.

As shown in FIG. 2 the devices 12 are mounted equidistantly around the circumference of the submarine 10 as at 14, 16, 18 and 20. Each of the propulsion devices 12 comprises an outer membrane 22 secured to the hull of the submarine 10 by a frame 24 and bolts 26. In order that pressure inside the membrane is equalized with the ambient pressure, a plurality of ports are provided at 28 for the passage of water into and out of the chamber 30 formed by the membrane 22.

A plurality of expansion elements 32 are mounted in chamber 30 along the length thereof which coincides with the length of the vessel. Each element 32 comprises a rectangular housing 34 which is bolted to the exterior of the hull of vessel 10 by bolts 36. The housing 34 is provided with an arched cover 38 having ports 40 and 42 therein.

Secured at the periphery of each housing 34, in fluid-tight relation therewith, is an elastic diaphragm 44. The securing means comprises a frame 46 and screws 48. Ports 40 and 42 communicate with a valve chamber 50 containing a rotary valve member 52. A passage 54 is formed in member 52. Extensions 40A and 42A positioned diametrically opposite to ports 40 and 42, respectively, communicate with manifolds 56 and 58, respectively.

Manifolds or headers 56 and 58 accommodate either intake or exhaust of the hydraulic fluid, depending on the direction of flow of the fluid, and are common to all of the expansion elements 32, as shown in FIG. 3, extending along the length of and exteriorly of the hull of vessel 10.

Manifolds or headers 56 and 58 pass through the hull of vessel 10 having fluid-tight connection therewith as by welding 60. The manifolds are connected through a reversing valve 63 to a pump 62, mounted interiorly of vessel 10. Pump 62 is driven preferably by an electric motor M1, or any suitable power source. Pump 62 circulates a liquid through manifolds 56 and 58 at sufficient pressure to expand the diaphragms 44 of elements 32 against the ambient pressure of the water surrounding the vessel 10. The rotary valve members 52 of elements 32 are driven by connecting shafts 64, one of which is connected to an electric motor M2 capable of operation within a fluid medium.

Motors M1 and M2 are of the variable speed type whereby the speed of rotation of the valve members 52 and the pump 62 is controlled. By varying the speed of the valve members and the pump, in order to maintain adequate pressure, the speed of the vessel is controlled. The vessel may also be steered by stopping or slowing the propulsion devices 14 and 16 and permitting propulsion devices 18 and 20 to continue propulsion at a cruising speed. A sharper turn may be had by reversing the action of propulsion devices 14 and 16, while propulsion devices 18 and 20 remain in the ahead condition. It is, of course, understood that a turn in the opposite direction is had by stopping, slowing, or reversing devices 18 and 20 and permitting devices 14 and 16 to operate at forward speed. The foregoing steering system is applicable to either surface vessels or submarines.

If it is desired to propel a submarine toward the surface, devices 14 and 20 are slowed, stopped, or reversed, while devices 16 and 18 continue, for example, at cruising speed. To propel the submarine toward the bottom devices 16 and 18 are slowed, stopped, or reversed and devices 14 and 20 remain at cruising speed. Thus, it is apparent that a submarine or surface ship equipped with the propulsion devices of the present invention may be propelled by a difference in speed of opposite propulsion devices in forward or reverse directions or steered to port or starboard on a horizontal plane. It is also clear that a submarine so equipped may be steered additionally either toward the surface or toward the bottom. All of the foregoing is accomplished without the use of the usual rudders, vanes or other such apparatus.

Referring more particularly to the valve mechanism and the expansion elements, as shown in the timing diagram of FIG. 6, ten valves and expansion elements are employed to form a complete wave although more or less may be used, if desired. Position A shows the first expansion element fully expanded and the membrane 22 extended fully. The valve is shown fully closed. Position B shows the second expansion element in the last phase of the intake cycle with the valve nearly closed. The valves are open but in various stages of closing through positions C, D, and E. Thus B, C, D and E are in different phases of the intake cycle. F shows an expansion element fully collapsed and the valve therefor fully closed. G shows the valve nearly closed at the end of the exhaust cycle, and the expansion element nearly

empty, while H, I, and J show the valves in various stages of permitting fluid to exhaust and empty the expansion elements. It is, of course, understood that each valve, as shown in FIG. 4 of the drawings, runs through an intake cycle during one half of a revolution and an exhaust cycle for the other half of the revolution, and the bores 54 of the valves, where ten are employed, are angularly spaced rotatively 36° apart. Thus the bore in valve member 52 of the expansion element at position B is at an angle of 36° ahead of the valve bore in A, and the valve bore in C is at an angle of 36° ahead of the valve bore in B and so on through the complete line of valves, as clearly shown in FIG 6.

As shown in FIG. 8, two of the propulsion devices 12 are attached to opposite sides of a vessel 10. Both of the devices 12 are operating in unison. In other words, the high point of the sine wave of membrane 22 of one of the devices 12 is at the moment at position A on both sides and each of the valves at the other positions is at the same angle with respect to its mate in the other device 12, as shown.

FIG. 9 shows a vessel 10 having a pair of propulsion devices 12 which are out of phase. The high point of the sine wave of membrane 22 being at position A of propulsion device 12 on one side, while the high point of propulsion device 12 on the other side is at position F and opposite to the low point on the first side.

As each of the propulsion devices is individually controlled as to speed and stopping and starting, it is obvious from the foregoing description that complete steering and propulsion control of a surface ship or a submarine may be accomplished by varying the speed, or stopping, or reversing certain of the propulsion devices with respect to other such devices, as heretofore described without resorting to the use of rudders, elevators, or other conventional control devices.

The propulsion and steering devices 12 of the present invention are shown as used on a surface vessel 70 in FIG. 11. The devices 12 are attached to opposite sides of the vessel 70 and below the water line as at 72 and 74. It is clear that the pair of devices 12 will operate to propel and steer the vessel in the manner heretofore set forth.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A marine propulsion device for a vessel operating in a fluid medium comprising, a plurality of elongated elastic membranes extending along the length of said vessel and in contact with the fluid medium, means fastening the periphery of said membranes to the sides of said vessel, a plurality of hydraulic expansion members enclosed by said membranes, said membranes being expanded and contracted in the form of a traveling wave by said expansion members, a plurality of valves for controlling the expansion and contraction of said expansion members, pump means connected to said valves for providing hydraulic fluid thereto under pressure, and means for rotating in either direction said valves to permit said hydraulic fluid to enter and leave said expansion members in timed consecutive order and to reverse the direction of travel of the travelling waves.

2. Apparatus for propelling and controlling a vessel in a liquid medium comprising, at least a pair of undulating elastic membranes mounted on opposite sides of and running along the length of said vessel and in contact with said liquid medium, a plurality of hydraulically actuated expansion members enclosed by each of said membranes and operating to shape said membranes in the form of travelling waves, expandable elastic covers for said expansion members in contact with said membranes whereby said expansion members expand and con-

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tract the membranes to form said travelling wave, rotary control valves individual to each expansion member for hydraulically expanding and contracting said covers, driving means for rotating said rotary valves in timed sequential order, a pump individual to each of said membranes for supplying and receiving a hydraulic fluid to and from said expansion members in accordance with the timed sequential order of said valves, and means for individually controlling the speed and direction of the travelling waves of said membranes whereby the speed and direction of travel of the vessel is controlled.

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