April 3, 1962 R. W. PRIEST 3,027,860

ANTI-FRICTION HULL

Filed Oct. 15, 1959 2 Sheets-Sheet 1

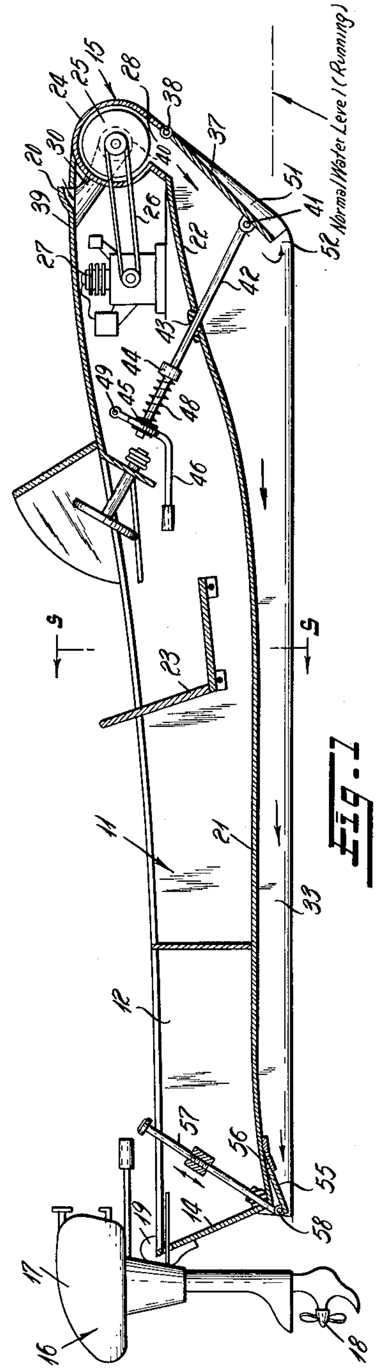

FIG. 1

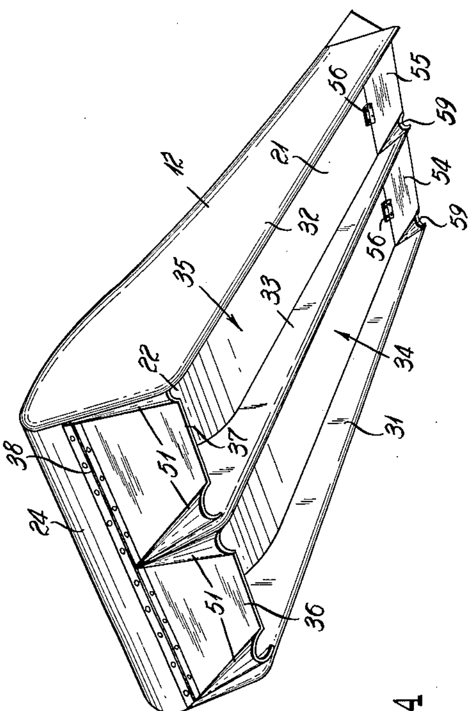

FIG. 2

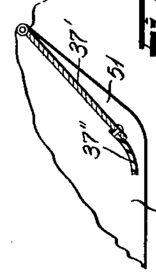

FIG. 1A

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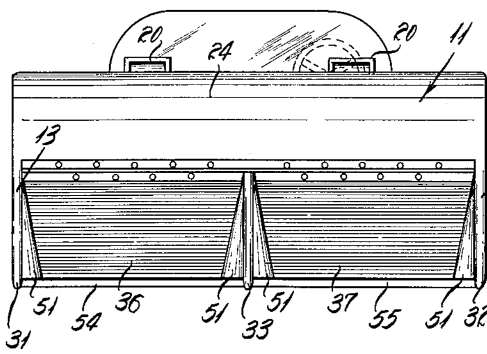


Fig. 3

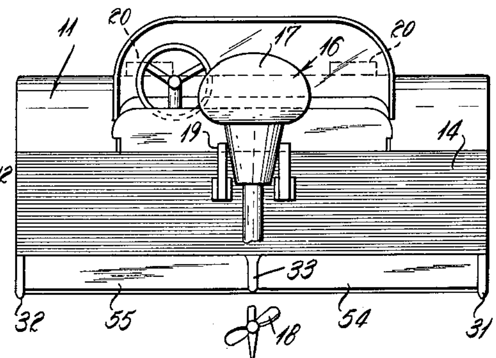


Fig. 4

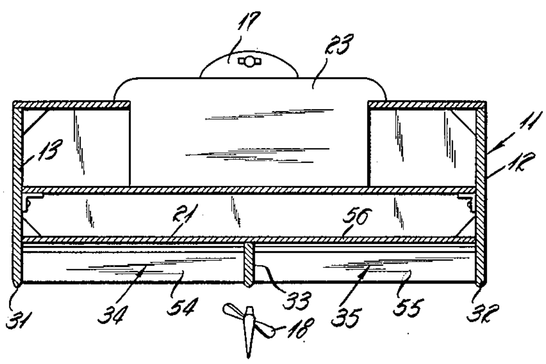


Fig. 5

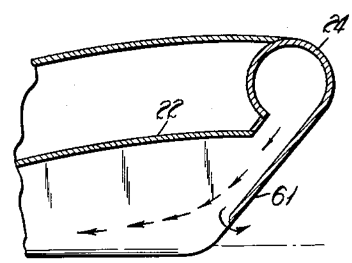


Fig. 6

Fig. 7

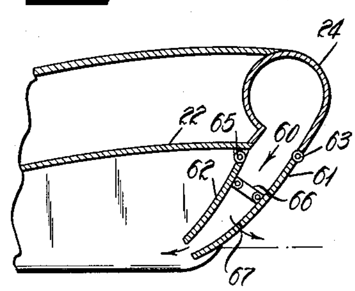
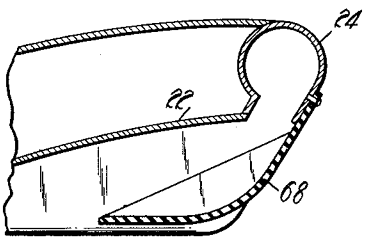


Fig. 8



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ANTI-FRICTION HULL

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The present invention relates to the support and movement of water-borne vehicles and has particular reference to an improved anti-friction hull structure wherein means is provided for continuously maintaining a pressurized layer of air or other gas between the vehicle bottom and the surface of the water.

Several methods of supporting surface vessels are actively employed by naval architects in the design of ships and boats at the present time. These methods and the disadvantages of each are as follows:

A. Buoyant displacement support.—Probably one of man's earliest inventions was a buoyant supported wooden craft. Archimedes first defined the physical laws governing this type of support for men who go to sea and this fundamental principle of support is utilized by all the larger ships. But ships which depend on buoyant displacement for support and the design operating condition require greater propulsion power or develop lower speeds of advance through the water due to high water resistance. In addition, this type of vehicle which carries the greatest amount of cargo tonnage in the world today is subjected to unnecessary motions by many sea conditions with the resulting loss in performance. For acceptable ship design performance, this form of the vessel is all important and certainly majestic but, in many cases, unfortunate from a cargo carrier cost of construction and operational point of view.

B. Planing support.—Planing craft are of a more recent origin and utilize both buoyant-support and hydrodynamic-lift developed on the bottom of the craft due to its swift forward speed through the water. The use of boats and seaplanes designed to take advantage of the planing support principle for reduction of water resistance is quite limited. Practice has shown that only comparatively small swift craft are feasible. Even in the use of planing craft within its proper size and speed category the water resistance is high. The most unfortunate aspect of this type of craft is its slamming and pounding motion in a seaway of only moderate turbulence.

C. Hydrofoil support.—Hydrofoil craft are also of recent origin. This type of supported craft utilizes hydrofoils or small wings extended beneath the vessels into the water. As with the planing support type of craft, the hydrofoil also suffers due to limitation to small size and high speed to facilitate proper support. Also, this type of support has the disadvantages of planing vessel form and the use of mechanical operated structural appendages extended from the hull bottom.

The present invention proposes to overcome most of these inherent difficulties and is directed to a novel means of reducing hydrodynamic resistance of a water-borne vehicle.

The invention also provides a novel craft having higher speed while using less power in stable transit and thereby consuming less fuel than previous water-borne vehicles.

It is a further object of the invention to provide a craft which has efficient cargo handling and stowage capabilities due to a generally box-like shape made possible by novel construction principles used in obtaining improved water support.

Furthermore, it is an object of this invention to provide a water-borne vessel having a very small draft in still water as well as under the operating conditions of

the vessel, wherein a continuous layer of air or the like is maintained between the surface of the water and the bottom of the vessel.

It is still a further object that such a vessel is easily stabilized in pitch or roll.

It is a further object of the invention to provide a novel vessel wherein pressurized air is continuously introduced into a space between the bottom of the vessel and the surface of the water and special air directional and confining structure is provided for optimum efficiency and stability.

Another object of the invention is to provide a novel vessel structure wherein a generally flat bottom is formed with longitudinal rails defining one or more laterally spaced open-ended cells into which pressurized air is forced, and special control flap or like arrangements are provided at least for the forward ends of such spaces so that during movement on the surface of the water the vessel is supported essentially on a continuous directionally controlled stream of pressurized air.

In its preferred embodiment the invention will be disclosed as applied to a vessel having longitudinal airspace defining rails on its bottom, with a blower for forcing air under superatmospheric pressure into the forward ends of such spaces, and with control flaps extending over the ends of such spaces.

Further objects of the invention will appear as the description proceeds in connection with the appended claims and the annexed drawings wherein:

FIGURE 1 is a somewhat diagrammatic longitudinal cross-sectional view of one type of water craft incorporating the principles and construction of this invention;

FIGURE 1A shows an alternative form of flap structure;

FIGURE 2 is a generally perspective front view of the forward end and the underside of the craft of FIGURE 1 showing the longitudinal air spaces;

FIGURES 3 and 4 are front and rear views respectively of the vessel of FIGURE 1;

FIGURE 5 is a transverse cross-section through the center of the hull of FIGURE 1; and

FIGURES 6, 7 and 8 illustrate various modifications in the configuration of bow structures that may be used in this invention.

Referring to FIGURES 1–5, the vessel is shown as generally box-like and rectangular in plan view with a hull **11** having opposite side walls **12** and **13**, a stern **14** and a bow section indicated at **15**. In this form the vessel is propelled along the surface of the water by a conventional outboard motor assembly **16** comprising essentially a gasoline engine **17** and propeller **18** with the usual controls for driving and steering, secured to stern **14** as by the clamp **19**.

The bottom wall **21** of the vessel slopes upwardly at **22** forwardly of the operator's seat **23**. At the bow a plenum **24** contains a blower in the form of a squirrel cage type rotor **25** that is belt driven at **26** from a gasoline engine **27** having the usual controls, although preferably it has a fixed normal operating speed for producing a desired air pressure at plenum outlet **28**. Wall section **22** joins to the plenum outlet so that the bottom wall of the vessel may form the top of an air space extending longitudinally beneath the vessel. A suitable air intake scoop **29** is provided at the top of the hull connected by conduit **30** to the intake **40** of the blower.

A plurality of parallel rails **31**, **32** and **33** extend longitudinally of the vessel, outer rails **31** and **32** preferably being downward extensions of the hull side walls, and rail **33** being centered laterally. These flat-sided rails are just in contact with the water surface or extend only slightly beneath the water surface in normal operation and form side walls of the longitudinal air spaces. These longitudinal air spaces or cells are indicated at 34 and 35.

If desired other transversely intermediate rails may be used to provide more longitudinal air spaces, or in some cases rail 33 may be omitted so that only one air space is present.

At the bow similar transverse flaps 36 and 37 are flexibly mounted or hinged along a pivot section 38. It will be noted that the upper transverse hull wall 39 here curves down to form part of the plenum 24, and that the pivot section 38 extends along the lower edge of the latter. In this embodiment the flaps 36 and 37 are rigid plates of metal, wood or plastic. As shown in FIGURE 1A, the flaps could be combinations of rigid sections 37', with flexible bottom edge sections 37" for improving the air seal.

Each flap 36 and 37 has pivoted thereto at 41 a rod 42 that extends through a flexible seal 43 in the bottom wall and has an enlarged portion 44. A spring 48 surrounds the rod 42 with one end fixed to portion 44 and the other end secured to a slidable collar 45 which in turn is operatively connected to a control lever 46 pivoted at 49 on the hull. Suitable means is provided for holding lever 46 in any adjusted position.

With air under pressure being delivered into spaces 34, 35 from the plenum the flaps 36, 37 are displaced to the position shown in FIGURE 1. Depending on the sea or wave conditions, or the hull weight distribution, independent adjustments are made by control levers 46 to vary the strengths of springs 48 to obtain optimum water and air flow conditions at the flaps 36, 37. Adjustment of lever 46 shifts collar 49 along the rod 42 and changes the compression (or tension) of the spring 48 until a balanced condition is attained.

Referring to FIGURE 2, a series of flexible waterproof edge seals or curtains 51 are provided between the side edges of flaps 36 and 37 and the rails. These seals are preferably rubber or plastic sheet strips that prevent water from entering the spaces 34 and 35 as well as retaining the compressed air flowing therein, and they permit adjustment and other flap movement.

Referring to FIGURE 1, the blower at 25 delivers air under the desired high pressure through throat 28 and the diverging passages provided by wall 22, flaps 36, 37 and the rails into the longitudinal spaces or cells 34 and 35, air flow being in the direction of the arrows. Some air exits below the edges of flaps 36, 37 at 52 to provide an effective forward air seal for the pressurized spaces, and some air exits beneath the rear flaps 54, 55. Thus there is provided between the bottom of the vessel and the water surface a continuously flowing pressurized body of air which effectively supports the vessel with only the rails 31, 32, 33 touching the water.

As the vessel moves along the water surface there is impact of water, usually waves, upon the flaps, tending to swing them clockwise in FIGURE 1. This will be called the hydrodynamic force acting on the flaps. This is resisted essentially by air pressure, adjustable springs 48 and the inertia of the flaps due to their weight. Thus for normal hydrodynamic forces the flaps 36 and 37 operate normally, but they are free to swing when encountering abnormal hydrodynamic forces such as large waves, or when striking inert objects on the water such as floating wood, etc.

During advance of the vessel, the hydrodynamic force of the water tends to swing flaps 36, 37 inwardly, clockwise in FIGURE 1. The air pressure is developed in spaces 34 and 35 in such fashion that the vessel effectively is lifted by the air stream above the surface of the water and the air stream is exhausted beneath the bow and stern flaps.

At the stern are preferably provided a pair of stern flaps 54 and 55 extending across the ends of spaces 34, 35 and pivoted at 56. These flaps extend angularly rear-

wardly and downwardly from their pivots with their lower edges terminating a slight distance above the lower edges of the rails 31—33. Adjustment of flaps 54, 55 is effected by a threaded rod 57 universally connected at 58, so that rotation of rod 57 shifts the flap angle. Suitable water and air tight seals are also provided here, between the lateral edges of the flaps and the rails as at 59, and at the pivot structure, to confine the compressed air support layer as much as possible. Rods 57 prevent clockwise swinging of flaps 54, 55 due to hydrodynamic action, and they provide a means of adjusting the stern flaps to adjust the trim of the vessel, the rate of exhaust of compressed air, etc.

The vessel may be started in the usual manner and once under way blower 25 is started to build up pressure in spaces 34, 35. Preferably a predetermined pressure build-up is developed, and by careful adjustment of both front and rear flaps the air exhaust is controlled and the vertical dimension of the supporting compressed air layer determined for optimum operation, taking into account the load and water conditions. For optimum results the air pressure in the spaces 34 and 35 should be at least equal to the head of water equivalent to the draft of the vessel.

FIGURE 6 illustrates a possible bow variation for certain conditions wherein each flap 61 is a rigid extension of the plenum wall and terminates sufficiently above the normal water level during operation to permit forward exhaust of compressed air.

FIGURE 7 illustrates another bow embodiment wherein effectively a swingable nozzle 60 is provided at the plenum discharge. Here front flap 61 is hinged at 63, an associated flap 62 is hinged at 65, and the flaps are connected to swing together as by linkage 66. In this embodiment, during vessel movement the end of the nozzle is actually located below water level and a slot or like aperture 67 is provided in each front flap for forwardly exhausting part of the air supplied by the blower to provide an air seal at the lower end of flap 61. A suitable adjustment for changing the angle of the nozzle comprising a rod and spring assembly like that used to adjust flap 37 in FIGURE 1 can be used here.

FIGURE 8 illustrates another possible form of bow construction wherein flexible rubber or plastic sheet flaps 68 are secured along their upper and side edges with their lower edges trailing within the spaces 34, 35. In this embodiment the air pressure within essentially maintains flaps 68 in relatively distended condition where they function like rigid flaps, but they are sufficiently flexible to give under abnormal hydrodynamic forces.

In all embodiments of the invention the blower 25 may be a unit to supply the same pressure air to all longitudinal air passages, or it may comprise arrangements, as by adjustable dampers, for supplying independently adjustable pressures to the several air passages. This latter is a useful feature for stabilization as during turning of the vessel.

The bow configuration shown in FIGURES 1–5, 7 and 8 all have the important feature of being adjustable or flexible. As the craft moves through the waves and proceeds through the water, the bow yields to the oncoming waves and always keeps the enclosed pressure chamber under the water craft.

The principles involved in this invention are shown as applied to a water craft but an efficient amphibious craft can also use the basic construction. One of the possible modifications for amphibious craft would be to suitably mount the longitudinal rails to fold or move up in any convenient manner. Wheels operated in a conventional way could be provided to thereby move the vehicle over solid terrain with the longitudinal rails moved down in place whenever a water obstacle is encountered. Forward and rear flaps would also move up out of the way since they have already been described as adjustable.

It will be apparent from the foregoing that the essential objective of the construction involved in this invention is to cause air under pressure and confining control to flow beneath the vehicle to effectively lift the hull bottom out of the water so that the longitudinal rails are just about in contact with the water. As a result, the vehicle is suspended on air under pressure enclosed by the rails and the flaps. The hydrodynamic resistance of the vehicle when moving forward is thereby materially minimized and stems only from two sources. Frictional resistance results from the slight contact of the longitudinal rails and the water, and wave making resistance results from the depression in the water surface under the hull. Small additional resistance may be due to the tips of the flaps planing over the water. Since the wetter surface consists mainly of the rail surface, the frictional resistance is minimized by the novel construction. The shallow depression in the water's surface under the hull forms an ideal planing form, thereby also minimizing the wave-making resistance.

A further advantage lies in the longitudinal stability resulting from changes of the air flow caused by pitching of the vehicle and transverse stability which is assured by the separation of air enclosures between the rails. Additional longitudinal stability, if desired, may readily be obtained by the installation of a third set of flaps mounted across the middle of the vehicle.

The vessel of the invention thus rides over the surface of the water with essentially no water to hull friction surface contact, so that power of the driving motor is used much more effectively. Furthermore, the power required to supply the air cushions between the bottom of the hull and the water surface is very small and much less than that saved for propulsion so that the net power utilized is materially smaller. The vessel, as disclosed, can dispense with expensive design curves and streamlining, and can be simple, box-like and easy and inexpensive to build, with larger load capacity.

From the foregoing, varied application of the novel aspects of the invention will occur to those skilled in the art, and variations in matters of detail will be apparent and therefore it is appropriate that the appended claims be accorded a latitude of interpretation consistent with the spirit and scope of the invention.

I claim:

1. In a vessel for moving over a water surface, a hull, a power plant supported on said hull and having variable speed means for propelling said vessel along the water surface, means providing at least one longitudinal air space along the entire length and under the bottom of said hull, movable flap means swingably depending from the bow portion of said hull on an axis transversely of said hull and extending transversely of said space, means at the extreme forward end of said hull defining a passage constituting the forward end of said air space, said flap means defining a front wall section of said passage, and means independent of said propelling means for blowing air under pressure only into said passage and against substantially the entire rear surface of said flap means for developing and continuously maintaining within said space a rearwardly moving layer of air under controlled optimum superatmospheric pressure effective and sufficient during vessel movement by said propelling means to raise and support said hull out of effective frictional surface contact with the water, said layer of air being continuously exhausted at the rear end of said air space, the power supplied to maintain said layer of air under pressure being materially less than the propulsive power of said power plant, and said flap means being substantially entirely backed by said pressurized air to oppose rearward swinging of said flap means due to hydrodynamic forces acting on said flap means as the vessel moves along the water.

2. In the vessel defined in claim 1, said flap means comprising a relatively stiff plate hinged along its upper edge

to said hull and a flexible member secured along and extending from the lower edge of said plate.

3. In a vessel for moving over a water surface, a hull, transversely spaced rails depending from the bottom of the hull and defining a longitudinal space below said hull bottom substantially from one end of the hull to the other, flap means flexibly swinging about an axis transversely of said hull extending transversely across the front end of said space, means at the extreme front end of said hull defining an air inlet passage constituting the front end of said space with said flap means providing a front wall section of said passage, variable speed power means on said hull for propelling said vessel over the surface of the water, and means for blowing air under pressure only into said passage and against substantially the entire rear surface of said flap means for developing and continuously maintaining within said space a rearwardly flowing hull raising and supporting layer of air under selected controlled optimum superatmospheric pressure, said air layer at its forward end substantially fully backing said flap means to oppose rearward swinging of the flap means due to hydrodynamic forces acting on said flap means during forward movement of the vessel through the water, and the lower edge of said flap means being not lower than the adjacent lower front edges of said rails, said layer of air being continuously exhausted at the rear end of said longitudinal space, the power required to maintain said air layer being appreciably less than that required to propel the vessel along the water surface at operational speeds, and the air pressure in said layer being at least equal to a head of water approximately equivalent to the draft of said vessel at operational speeds.

4. In a vessel for moving over a water surface, a hull, a power plant supported on said hull and having driven propeller means extending into the water at the rear of said hull for propelling said vessel at variable speed along the water surface, means providing at least one longitudinal air space along and below the entire bottom of said hull, movable flap means swingably depending from the bow portion of said hull on an axis transversely of said hull and extending transversely of said space, means at the extreme forward end of said hull defining an air inlet passage constituting the forward end of said air space, said flap means defining a front wall section of said passage, means independent of said propelling means for blowing air under pressure only into said passage and against substantially the entire rear surface of said flap means for developing and continuously maintaining within said space a rearwardly moving layer of air under controlled optimum superatmospheric pressure effective during vessel movement by said propelling means to raise and support said vessel out of effective frictional surface contact with the water, said layer of air being continuously exhausted at the rear end of said air space, the power supplied to maintain said layer of air under pressure being materially less than the propulsive power of said power plant, and said flap means being substantially entirely backed by the pressurized air of said space to oppose rearward swinging of said flap means due to hydrodynamic forces as the vessel moves along the water, and means providing a positive stop limiting forward swing of said flap means.

5. A vessel for travel over the surface of the water comprising a hull, at least one pair of downwardly projecting narrow rails extending longitudinally substantially all along the bottom of the hull to define at least one longitudinal air space below said hull bottom, a movable flap swingably depending on a transverse axis from the front end of said hull and extending across the forward end of said space, the lower edge of said flap being no lower than the adjacent lower edges of said rails, means at the front end of said hull defining an air inlet passage as a continuation of said space with said flap serving as the

front wall of said passage, a power plant mounted on said hull having a driven propeller assembly extending into the water near the rear of said vessel for propelling the vessel at variable speed along the water surface, and pressure blower means on said hull connected to discharge air under controlled optimum superatmospheric pressure into said passage and against substantially the entire rear surface of said flap to selectively produce and maintain a hull raising and supporting air layer in said space, the air pressure being effective to fully back said flap sufficiently to oppose rearward swing due to hydrodynamic forces acting on said flap at operational speeds, said layer of air being continuously exhausted at the rear end of said air space, and the power required to maintain said air pressure being materially less than that required to propel the vessel along the water surface, and means for selectively actuating said blower means whereby the vessel may be propelled solely by said power plant with its hull bottom in frictional contact with the water and then when the blower means is operated the hull is raised until its bottom surfaces except for the lower portions of said rails are clear of frictional contact with the water to enable said power plant to propel the vessel at increased speed without increasing its power output.

6. A vessel for travel over the surface of the water comprising a hull, a plurality of downwardly projecting narrow rails extending longitudinally along the bottom of the hull to define at least two side by side separated longitudinal air spaces, movable flaps swingably depending on transverse axes from said hull and extending across the forward ends of said spaces, the lower edge of each flap being no lower than the adjacent lower edges of the rails, means at the extreme front end of said hull defining air inlet passages constituting the front ends of said spaces with said flaps forming the front walls of said passages, a power plant mounted on said hull having a driven propeller assembly extending into the water near the rear of said vessel for propelling the vessel at variable speed along the water surface, and pressure blower means on said hull connected to discharge air under controlled superatmospheric pressure only into said passages and against substantially the entire rear surfaces of said flaps to selectively produce a rearwardly moving hull raising and supporting air layer in said spaces, the air pressure being effective to fully back said flaps sufficiently to oppose rearward swing due to hydrodynamic forces at operational speeds, said layer of air being continuously exhausted at the rear ends of said air spaces, and the power required to maintain said air pressure being materially less than that required to propel the vessel along the water surface, and means for selectively actuating said blower means whereby the vessel may be propelled solely by said power plant with its hull in frictional contact with the water and then when the blower means is operated the hull is raised until its bottom surfaces except for the lower portions of the rails are clear of frictional contact with the water to enable said power plant to propel the vessel at increased speed without increasing its power output.

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