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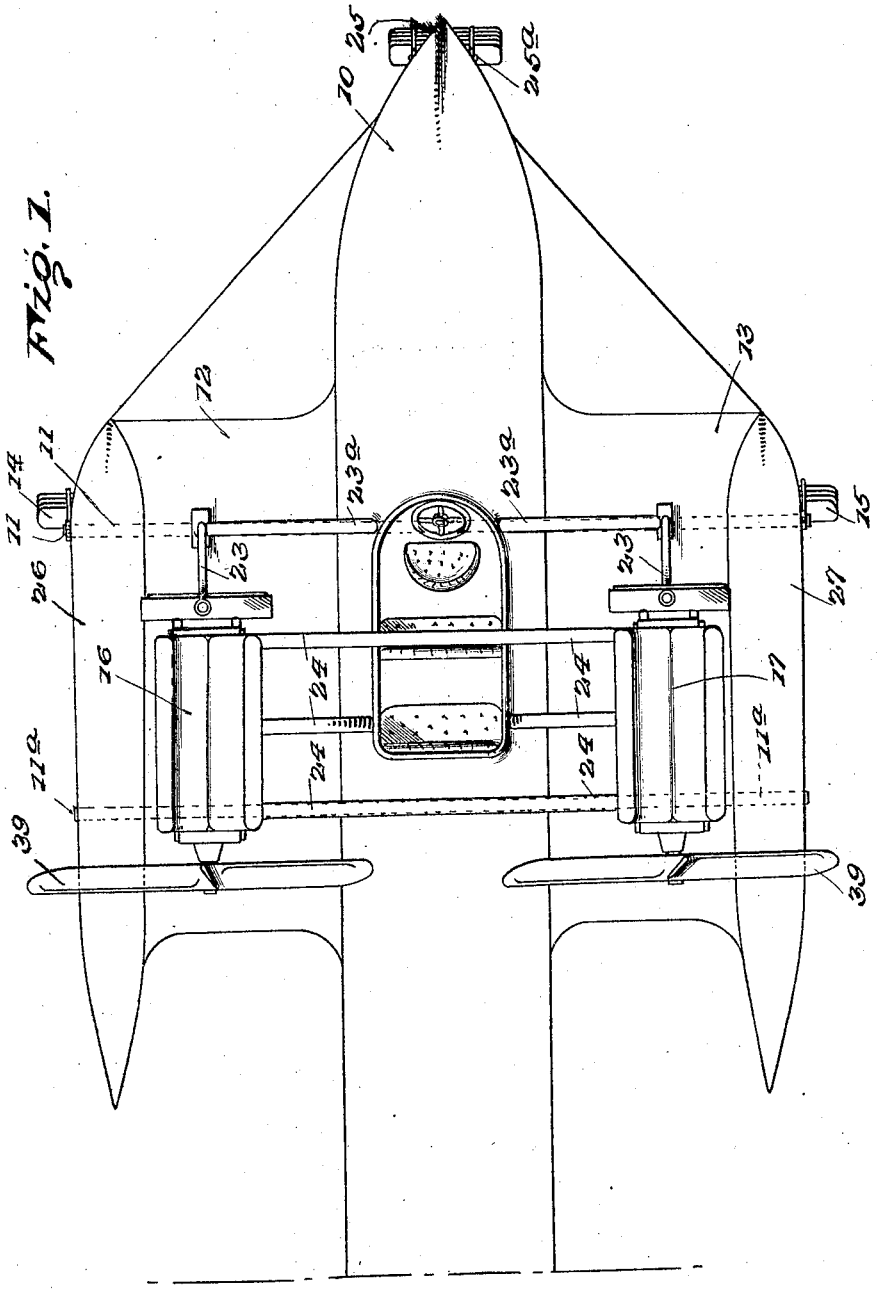
HYDRODROME, HYDROAEROPLANE, AND THE LIKE.

APPLICATION FILED MAY 7, 1920.

1,410,874. Patented Mar. 28, 1922.

4 SHEETS—SHEET 1.

Fig. 1.



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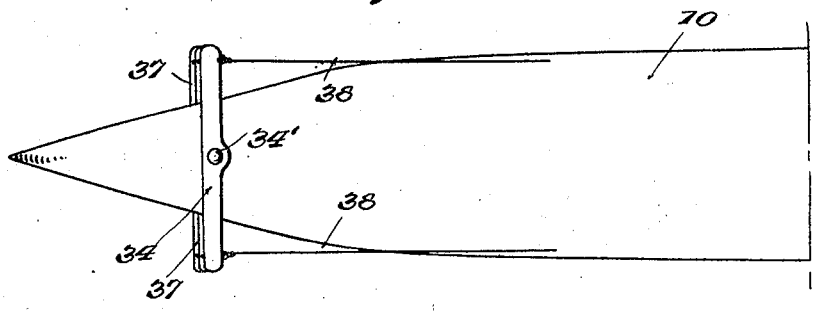
4 SHEETS—SHEET 2.

Fig. 1a



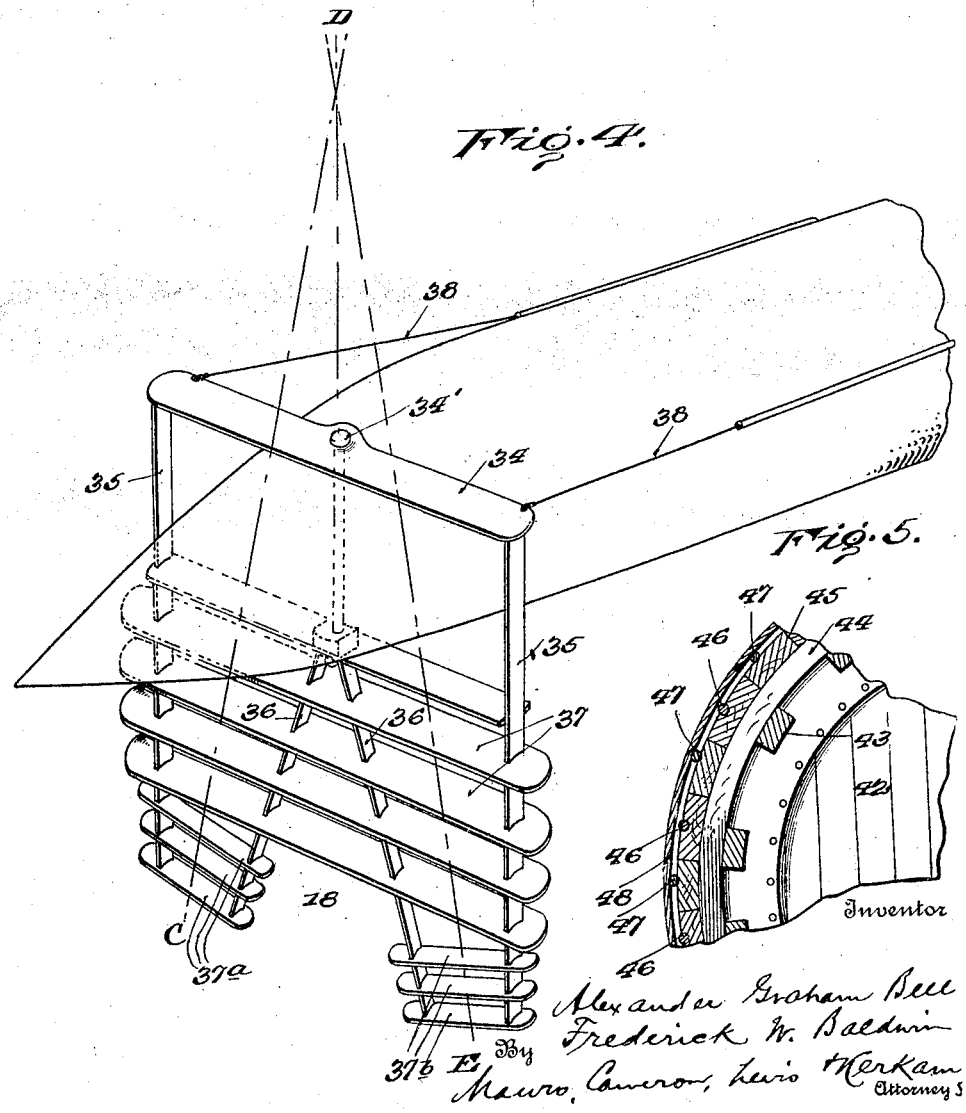


Fig. 4.

Fig. 5.

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4 SHEETS—SHEET 3.

Fig. 2.

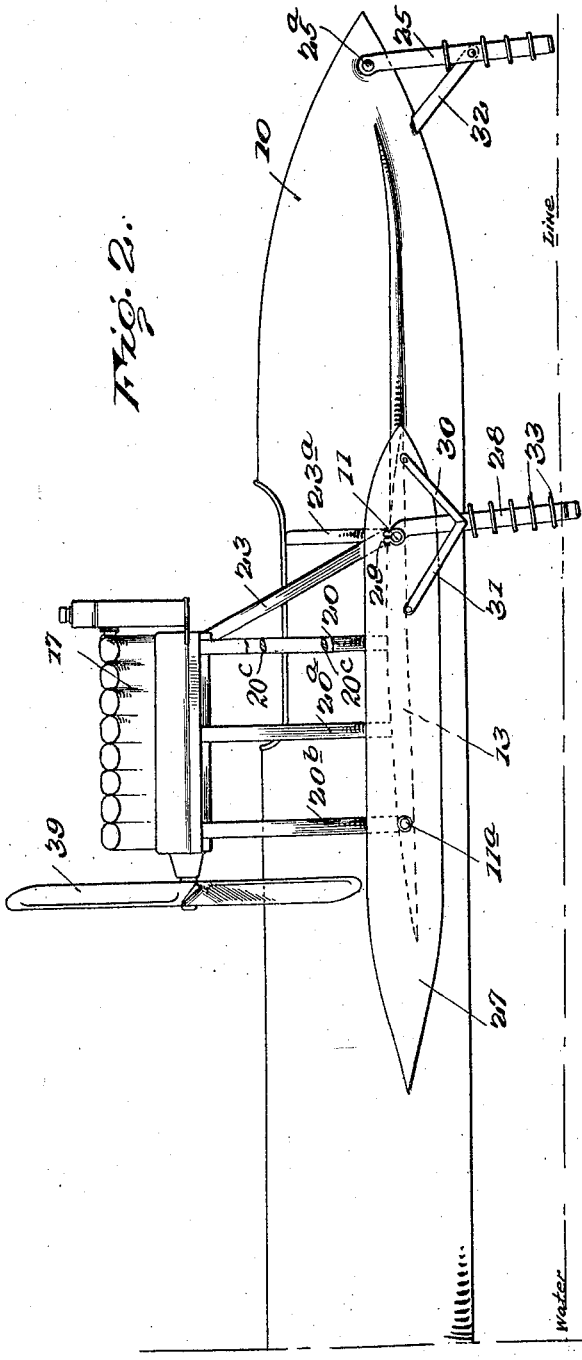
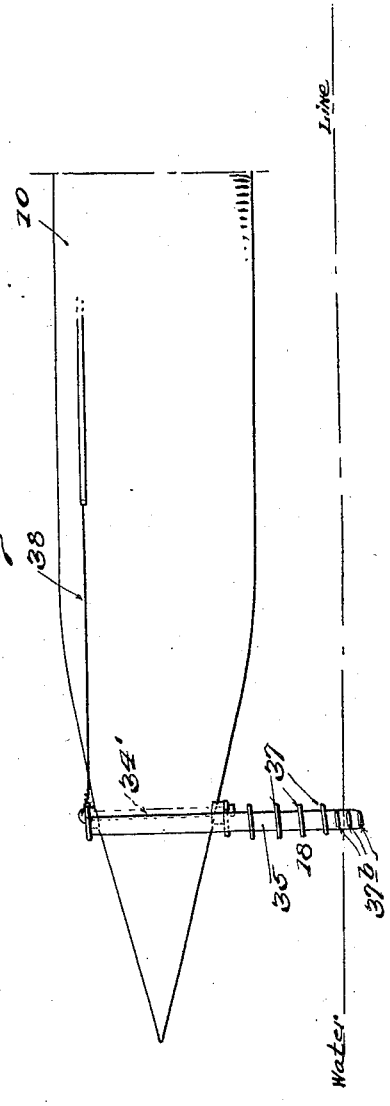


Fig. 2a.



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APPLICATION FILED MAY 7, 1920.

1,410,874. Patented Mar. 28, 1922.

4 SHEETS—SHEET 4.

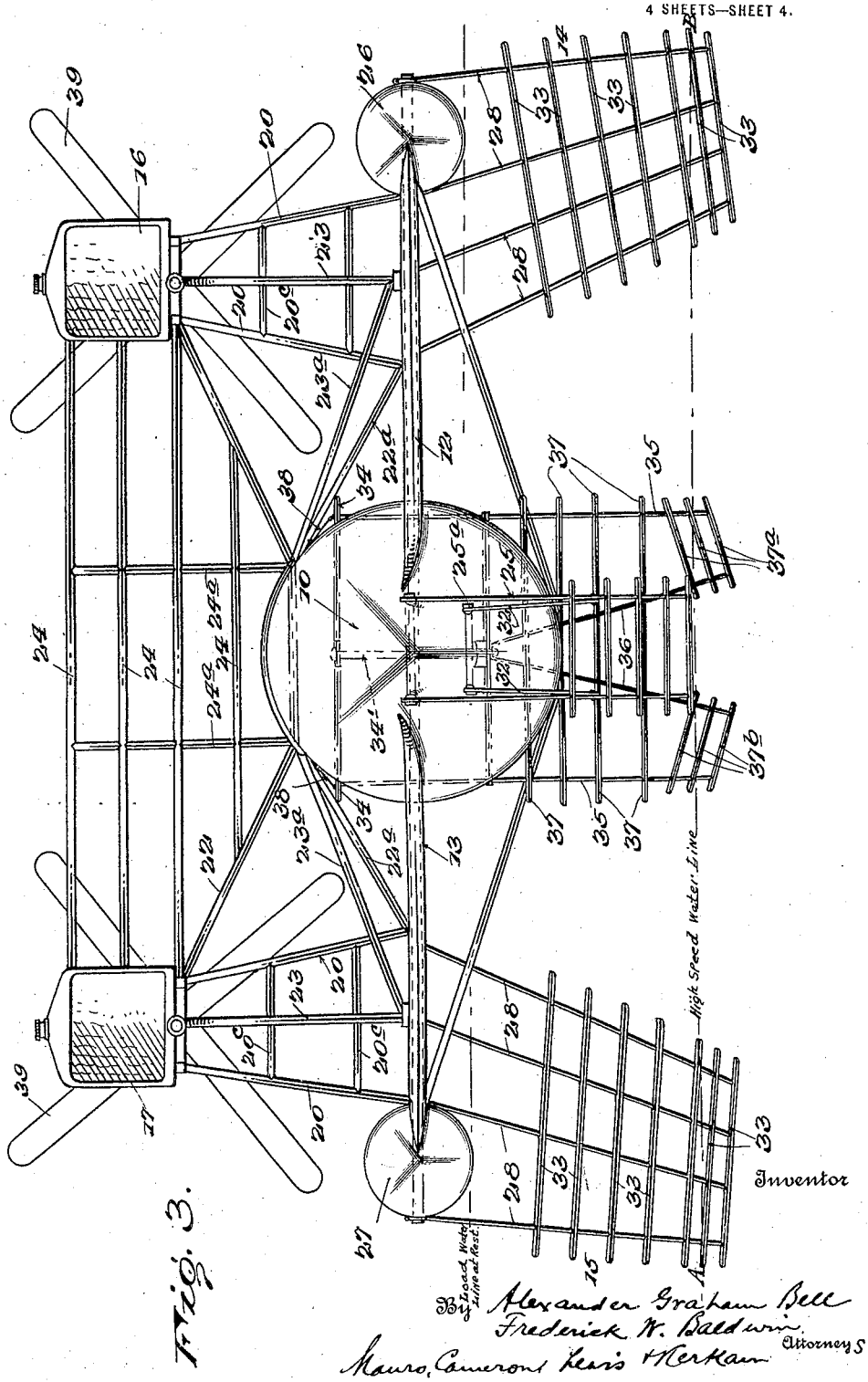

Fig. 3.

UNITED STATES PATENT OFFICE.

ALEXANDER GRAHAM BELL, OF WASHINGTON, DISTRICT OF COLUMBIA, AND FREDERICK W. BALDWIN, OF BADDECK, NOVA SCOTIA, CANADA.

HYDRODROME, HYDROAEROPLANE, AND THE LIKE.

1,410,874. Specification of Letters Patent. Patented Mar. 28, 1922.

Application filed May 7, 1920. Serial No. 379,475.

To all whom it may concern:

Be it known that we, ALEXANDER GRAHAM BELL, a citizen of the United States of America, and a resident of Washington, District of Columbia, and FREDERICK W. BALDWIN, a subject of the King of Great Britain, and a resident of Baddeck, Nova Scotia, Canada, have invented new and useful Improvements in Hydrodromes, Hydroaeroplanes, and the like, which invention is fully set forth in the following specification.

The invention relates to hydroplane boats of the submerged hydrofoil type which, when in motion, are heavier than the water they displace.

Vessels of the submerged hydrofoil type are more comparable to heavier-than-air flying machines than to balloons and are sharply differentiated from displacement vessels by the fact that they are heavier than the water they displace. They have the same sort of advantage over the ordinary displacement vessel (the lighter-than-water craft) that the heavier-than-air flying machine has over the ordinary balloon (the lighter-than-air vessel). Ordinary displacement vessels displace their own weight of the medium through which they move, whereas vessels of the present type weigh a great deal more than the water displaced by the submerged hydrofoils. This gives to the moving vessel the advantage of momentum, and upon this superior momentum depends its power of ploughing through the water at great speed. The greater the weight supported by the submerged hydrofoils and the less the weight of water displaced by these hydrofoils the less the retarding effect of a wave on the whole machine and the greater the possible speed that can be attained.

The invention has for its object the provision of a construction of this type which will embody the maximum of strength with the minimum of weight; and in which the parts are so constructed, arranged and correlated as to secure a maximum of speed and load-carrying ability with the minimum of applied power. To this end there is preferably provided two sets of hydrofoils projecting downwards on either side of the hull, rigidly connected by a truss, or trusses, or other suitable means. On the central part of this truss the main hull or float structure is supported. Arranged substantially above each hydrofoil set and near the outer ends of the transverse truss or trusses are placed motor supports, thus carrying the weight of the motors and taking the thrust of the propellers at the most advantageous point. Below the motor supports, we prefer to provide a pair of substantially horizontal float structures or pontoons, placed on either side of the hull to balance the whole structure when at rest or in motion below planing speed.

A further and most important object of the invention is to provide steering means which can be operated, when the boat is travelling at high speed—say 60 miles per hour—with the minimum of power. To this end, a third hydrofoil set is mounted on a vertical axis in the medial line of the structure and at the rear of the boat. This set is provided with substantially vertical strut members to which are secured the hydrofoil blades, as hereinafter described. By these means it has been found possible to turn the boat on a very sharp turning radius and at a very high speed, with practically as little steering effort as is required with an automobile and without perceptible heeling of the boat when the turn is being made. This absence of heeling, that is to say the ability to maintain the boat on an "even keel", so to speak, when making a sharp turn at such a speed—and the ease with which this is effected by the operator—are matters of great importance, as will be readily appreciated.

This feature of the invention will be more fully appreciated from a consideration of the prior art, as represented in such patents as Hewitt No. 1,084,578 and Forlanini No. 1,112,405, wherein rudder 42^a (Hewitt, Fig. 2) and rudder T (Forlanini, Fig. 1) are employed in association with the rear hydrofoil sets for the purpose of steering. In these devices the hydrofoil sets are fixed, so far as any steering function is concerned, the steering being effected by the use of the conventional rudders referred to, against the great resistance to turning movement presented by the blades and struts of the hydrofoils. Accordingly, in such devices the turn had to be made on a large radius and through the application of great power.

Further, as hereinafter more fully described, the pivoted set of hydrofoils in our device is preferably provided with blades

or planes arranged at a dihedral angle with the vertex downward and with the upper lateral extremity of a lower blade intersecting a horizontal plane passing through the lower extremity of the next higher blade. This is of importance because, in turning at high speed, centrifugal force tends to list the craft outward away from the center about which the turn is being made. With this dihedral arrangement of blades, the reaction of the blades on the water is directed to a point above the center of gravity of the craft, thus preventing the outward listing thereof and permitting a very sharp turn, say in 180 feet, at very high speed (the turn being started at say 50 m. p. h.) to be made on practically an even keel. This feature has an important bearing on the comfort and safety of the passengers, to say nothing of the striking and important advantage of turning on a short radius.

Further, this particular arrangement of hydrofoils prevents any vertical oscillation or porpoise-like movement of the rear of the craft, which was such a noticeable objection in the prior art structures.

A feature of importance that contributes largely to the high speed of travel which has been attained with this construction is the fact that the propellers are mounted exterior of the hull and rotated by direct-drive; it having been experienced that indirect drive (such as employed in the Hewitt and Forlanini structures referred to), when the engines or motors are carried in the hull and their power transmitted to the propellers, is much less efficient. Furthermore, by mounting the motors exterior of the hull, danger from fire is lessened and the space in the hull can be utilized for other important purposes. In addition, the mounting of the motors substantially above the hydrofoil sets, which constitute the supports during normal operation, is justified and fortified by the technical considerations that thereby the weight and strains are applied to the frame at the most advantageous points.

A further object of the invention is to eliminate vertical or porpoise-like oscillations of the boat and to insure a smooth and even movement of the craft when supported on the hydrofoils. This has been effected by inclining the hydrofoil blades of the main or forward hydrofoil sets and preferably also the blades of the steering set, as heretofore stated, obliquely upward in the lateral direction so that the upper lateral extremity of a lower blade intersects a horizontal plane passing through the lower lateral extremity of the next higher blade. With a construction of this type it has been experienced that, at high speeds of sixty miles per hour and upwards, the forward movement of the craft is even and comfortable even when passing over a surface broken by high waves.

Other objects and advantages, dealing with the construction and mounting of the hull, the hydrofoil sets, and other parts of the device will hereinafter appear.

The invention will be better understood by reference to the accompanying drawings, illustrating one expression of the inventive idea and wherein—

Figures 1 and 1ª are a plan view of a device embodying the invention;

Figures 2 and 2ª are a side view;

Figure 3 is a front elevation;

Figure 4 is a detail perspective showing the rear or steering set of hydrofoils; and

Figure 5 is a detail showing the construction of the hull.

Referring to the drawings, wherein like reference numerals indicate like parts, 10 indicates the main central float structure or hull, 11 indicates a beam or girder extending through the hull and carrying same when planing; 12 and 13 indicate a pair of substantially horizontal deck structures extending from each side of said hull; 14 and 15 indicate hydrofoil sets projecting downwardly into the water from said beam or girder; 16 and 17 indicate a pair of motor casings one mounted on each end of said beam; and 18 indicates a third hydrofoil set mounted on a vertical axis in the medial line of the structure and to the rear of said first-named sets. This hydrofoil set 18 is utilized for steering and disposes of the necessity of a rudder.

The hull 10 is of an elongated cylindrical shape with tapering ends and its greatest diameter is preferably approximately one-tenth of its length. It is provided with the usual cock-pit for the accommodation of the crew, and also provides storage space for supplies and the accessories employed in such craft. Mounted on decks 12 and 13 are uprights 20, 20ª and 20ᵇ that support the motor casings 16 and 17. The beam or girder 11 passes through the hull and the decks 12 and 13. Braces 22 extend from each casing from the upper ends of the uprights 20, 20ª and 20ᵇ, and braces 22ª extend from the lower ends of said uprights to the hull. A brace 23 extends forwardly and downwardly from each casing to a point above the beam or girder 11 and a transverse brace 23ª extends from this point to the hull. The uprights 20 are connected by cross members 20ᶜ and the motors 16 and 17 are united by cross-pieces 24. The latter are preferably braced by uprights 24ª. These various members complete a truss construction that connects the hydrofoil sets and the hull.

The main hydrofoil sets 14 and 15, as heretofore stated, are mounted on said beam or girder 11 and extend downwardly therefrom. It is sometimes desired to employ a plurality of said truss connections, and as

here shown an additional beam or girder 11ª forms the base of a second truss construction, the other elements of which are above set forth.

A preventer set or sets of hydrofoils are preferably suitably mounted at or near the bow of the craft, as more fully set forth hereinafter. In the present embodiment of the inventive idea, a preventer set 25 is pivoted on the hull at 25ª.

Horizontal floats or pontoons 26 and 27 are positioned on either side of the main hull. These pontoons carry but little weight and rest lightly on the water when the craft is in its position of rest and before high speed has been attained, and by their offset position they serve principally to stabilize the floating craft. They are secured in position by any desired means, being connected in the embodiment illustrated to the marginal extremities of the decks 12 and 13.

The decks 12 and 13 may have a cambered top and substantially flat bottoms to form aerofoils, if desired; and are preferably made as small as convenient to minimize the retarding action that is caused by the slapping of the waves when the craft is travelling on its hydrofoils through rough water. The combined structure of the hull, pontoons and decks is designed to offer as little resistance as is possible to the propulsion of the craft through the air when riding on the hydrofoils. It may be stated here that all parts of the craft, where it is practical to do so, are given stream-line formations to lessen air-resistance as much as is possible when the craft is under way, and that all transverse members, such as 20ᵉ and 24, are preferably shaped to constitute aerofoil surfaces.

The planing surfaces that travel through the water to elevate the craft are preferably embodied in three sets of superposed hydrofoils, as heretofore stated. This tripod arrangement has been found to be the most satisfactory as it does not have the twisting action to the same extent as does the four-point system of support.

Mounted on each end of the beam or girder 11 is a series of downwardly projecting struts 28 of comparatively thin metal arranged edgewise in the direction of the travel of the craft. The opposite sides of each strut are cambered to offer as little resistance as possible to the passage of the strut through the water or air during the progress of the craft. These struts are so mounted that the lower extremities thereof are slightly in advance of a vertical plane passing through the center of the supporting beam 11, the resultant tendency of the hydrofoil set being therefore to move forward rather than backward. This is due to the fact that the lift on the blades is greater than the drift, this forward and upward tendency neutralizing the backward tendency, thus relieving the strut of all strain. Preferably, each strut is secured to the beam by a clamping collar 29, the connection being such that the vertical axial line of the strut is eccentric to and in advance of the horizontal axis of the beam. Each strut is held against fore and aft movement by a series of braces, the braces 30 extending forwardly and connected to the pontoons being compression members and the braces 31 extending rearwardly and connected to the pontoons being tension members. Similar tension braces 32 extend rearwardly from the struts of the preventer set to the hull.

Extending across the series of struts 28 is a series of superposed substantially parallel hydrofoils or planing blades 33 preferably increasing gradually in length from the lowermost to the uppermost.

The term "superposed" is herein meant to cover any arrangement of the blades in different horizontal planes whether they are directly above one another or offset in different vertical planes. Preferably, also, the upper blades have the same width and the lower blades have a less width, with the lower three blades spaced somewhat closer together than the remaining upper ones.

The hydrofoils and struts are preferably formed of high grade steel ground to shape and all are preferably welded together to form a unitary whole. Each hydrofoil has a substantially flat under surface and a cambered upper surface, which formation has been found to be most efficient in planing effect. Also each hydrofoil is slightly inclined upward toward its front edge to give the required upward thrust, the angle of incidence being determined by the load and speed factors. Each hydrofoil is laterally inclined obliquely upwards from the vertical axial plane of the hull about 5° from the horizontal so that the downward thrust of the blade will be directed outwardly to some extent from said plane. Furthermore, this lateral inclination will cause the hydrofoil to leave and enter the water obliquely, and thereby avoid the shock or vertical oscillation produced when a horizontal blade as a whole suddenly enters and leaves the water. Also the lower three hydrofoils are so arranged and spaced that the lower end of an upper blade impinges the same horizontal plane (see A—B, Fig. 3) that passes through the upper end of the blade next below. In consequence of this vertical overlapping there is a continuity of action between the two blades; that is, the overlapping ends simultaneously enter and leave the water and thereby avoid the shock that would occur should there be an interval between the action of the two blades in entering and leaving the water.

The sets of hydrofoils positioned on the ends of the beam 11 are duplicates of each other. The corresponding laterally inclined hydrofoils of the two sets, if continued inwardly, would intersect to form a shallow obtuse dihedral angle of but a few degrees —about 10°—less than a straight angle. This slight obliquity of the opposite hydrofoils in the two sets, taken in connection with their offset from the main hull, has been found to be sufficient to effect an inward thrust that imparts great stability to the craft, particularly when it is travelling at a high rate of speed and is riding on its lower or lowermost hydrofoils.

The beams 11 and 11ª preferably have a length equal to little more than one-fourth the length of the main hull and cross the main hull about one-fourth of the hull's length from the bow. These beams carry considerably more than two-thirds of the total weight of the craft and transmit this load to the two attached sets of hydrofoils when the latter carry the craft above the surface of the water.

In order to get the craft under way with the minimum of resistance, the struts 28 are preferably mounted on beam 11 so that they may be readily swung by any suitable means, as a worm and gear connection (not shown) to a vertical position, thus moving the hydrofoils from a positive angle of incidence to a zero angle. As the speed of the craft picks up, the struts are swung forward, moving the hydrofoils to the desired angle of incidence, and the struts fixed in this position.

On the stern of the hull is mounted the third set of hydrofoils 18 that cooperate with the two beam sets to elevate the propelled craft above the surface of the water. This third set of hydrofoils is also utilized for steering purposes. Preferably, a frame 34 is pivoted to the stern of the hull, a short distance from its extremity, by the pin 34′. This pivot is in front of the center of pressure of said set so that the latter will automatically assume a neutral position. The hull projects through the frame and the latter is somewhat extended laterally to permit the turning of the frame on its pivot for steering purposes. The vertical sides of the frame extend downward to form the struts 35. Inclined struts 36 are also provided and these diverge outwardly toward their lower ends. These struts 35 and 36 carry a series of parallel hydrofoils or planing blades 37, and preferably two additional duplicate sets 37ª and 37ᵇ spaced beneath the lateral marginal extremities of blades 37. The hydrofoils of each set preferably increase in length from the lowermost to the uppermost, and the blades 37ª and 37ᵇ preferably have less width than the upper blades 37. The struts and the horizontal members of the frame are cambered on opposite sides to present as little resistance as possible to the water through which they are edgewise propelled. The struts have considerable fore and aft area to provide lateral thrust for steering. These hydrofoils preferably have flat under surfaces and cambered upper surfaces to obtain the maximum planing effect, and they are inclined upwardly toward their front edges to give the required upward thrust in the planing action. The hydrofoils 37ª and 37ᵇ, which are preferably employed, have a lateral upward inclination about 10° from the horizontal, which is greater than in the beam sets, so that the obtuse dihedral angle that would be formed by the continuation of the corresponding blades in the opposite sets would be considerably less, about 20°, than a straight angle.

As the hydrofoils 37ª and 37ᵇ of the stern set have considerably less area than those of the beam sets and are positioned much closer together than are the beam sets, if the lateral inclination of the hydrofoils was the same as in the beam sets, their stabilizing effect would not be proportionally sufficient. To offset this, the lateral inclination of the stern hydrofoils is increased to give a greater outward thrust per unit of surface and with a resulting increase in the stabilizing effect. This upward inclination of the stern hydrofoils also gives a lateral resistance in both directions that is utilized in steering. The frame 33 is provided with the usual yoke-lines 38 leading to the cock-pit.

At the bow of the mail hull is mounted the preventer set of hydrofoils 25, as heretofore described. If desired, a plurality of preventer sets might be employed. The hydrofoil blades are of any suitable number, preferably with the lowest two of less area, being narrower, than the upper members. These blades and struts are formed of the same material and are shaped as in the other sets; and are preferably interspaced with the blades of the main sets so as to make the vertical movements of the craft smoother and easier. The principal purpose of these preventer sets is to prevent diving after the craft reaches its highest elevation, the preventer set then travelling clear of the water. Before the craft reaches its extreme elevation, the blades of the preventer sets, being more or less immersed, have a planing effect to assist in the elevation of the craft. After the craft has reached its highest elevation, should it tend to dive or plunge, the blades of the preventer sets would submerge more or less and thereby offset or dampen the diving or plunging tendency.

In the present embodiment of the inventive idea, the craft is driven by air-propellers 39 mounted on opposite sides of the

main hull and exterior thereto. Each propeller is carried by one of the shafts of the motor unit, either the crank shaft or a shaft geared thereto in the unit. Any desired number of motors may be employed. A speed of more than 70 miles per hour has been attained with a 60 foot structure weighing 10,000 pounds and employing two low-pressure Liberty motors such as herein indicated. As heretofore described, these motor casings 16 and 17 are supported by the beams or girders 11 and 11ª, uprights 20 and braces 22 and 23, constituting truss constructions that hold the motors and their associated parts rigidly and firmly in place. These motor casings are preferably shaped to interpose the minimum air resistance.

In this connection, attention is directed to the relative positions of the air-propellers and motors and the beam sets of hydrofoils. The normal center of gravity of the craft is almost directly below said air-propellers and, as the beam sets of hydrofoils are but a short distance in advance of the center of gravity, they are in a position to carry most of the dead weight when the craft is under way and elevated by the hydrofoils. As the air-propellers are mounted a considerable distance above the horizontal plane of the lowermost hydrofoils of the three sets, their line of thrust is similarly elevated. When said air-propellers are driven at their maximum speed and the craft is travelling on the lowermost hydrofoils, then the propelling effort is directed to a point between the normal center of gravity and the transverse plane of the two beam sets of hydrofoils. As the beam sets of hydrofoils are situated but a short distance in advance of the normal center of gravity and the center of propulsive effect, they are most effectively positioned to carry the load formed by the dead weight and the propelling thrust and to perform at the same time their planing function.

The supports and braces are formed of wood or metal of stream-line section so as to offer as little resistance as possible to the air during the forward movement of the craft. The deck and other substantially horizontal members preferably constitute aerofoils and act as dampeners to sudden vertical movements of the craft when travelling in disturbed water, the horizontal surfaces cushioning on the air acting to absorb the shock of wave-impact on the hydrofoils.

The main hull 10 of the craft not only serves the usual purpose of providing flotation, giving accommodation to the crew and providing storage room for the accessories, fuel and other supplies, but also constitutes a longitudinal connection between the transverse truss 11, carrying the beam hydrofoils, and the frame of the stern hydrofoils. To constitute such a connection or frame, the hull must have sufficient longitudinal strength and stiffness to form an efficient bridge to withstand the strain and to support the load when the hull is elevated above the surface of the water by the planing action of the hydrofoils. In one form which has been found efficient (Fig. 5), the hull is built around a plurality of transverse bulkheads 42, several of which are preferably watertight. Fore and aft stringers 43 are notched into the bulkheads and around these stringers are spirally wound timbers 44 in as long lengths as possible, and where joints are necessary the connection is preferably made by long scarfs. Planking 45 is laid fore and aft on the timbers 44. Outside the planking a series of steel wires 46 is laid fore and aft and preferably embedded in the planking to resist bending. In order to resist torsional stresses caused by any tendency of the hull to twist in a seaway, two sets of steel wires 47 are spirally wound, one set in one direction and the other set in the opposite direction. These rods and wires are placed under tension to stiffen the hull as much as possible. The outside skin of the hull is preferably of canvas 48 laid in marine glue and wrapped in a spiral direction opposite to that of the timbers 44. In this way a hull is produced with the required strength and stiffness and can be given sufficient displacement for flotation and capacity purposes without excessive weight. The pontoons 26 and 27 are preferably of similar construction, but of lighter material, as they are intended to carry but little weight on flotation, their principal purpose being to float lightly on the water to balance the craft when at rest.

The operation of the device is as follows:

When the craft is at rest, it is supported by flotation, the hull floating upon the surface of the water with the several sets of superposed hydrofoils extending downward below the level of the keel. As the craft begins to move forward through the water under the thrust of the propellers, the hydrofoils begin to exert a lift, the force of which increases with the gain in velocity of the craft and results in the hydrofoils themselves successively leaving the water until, at the highest velocity attainable, only the lowermost hydrofoil of each set is submerged.

In the beginning of the forward movement of the craft, the submerged hydrofoils of the bow preventer sets aid to some extent in the elevation of the hull, but when the maximum elevation is reached the preventer sets are clear of the water and have no further effect in the lifting operation.

When the hull reaches its maximum elevation, it is carried by the lowermost hydrofoil in each of the two beam sets and in the two stern sets 37ª and 37ᵇ, and considerably more

than two-thirds of the load is carried by the lowermost hydrofoil in each of the two beam sets.

The utilization of the stern sets of hydrofoils for steering purposes is an important feature. As has been stated, the two stern sets 37^a and 37^b are carried by a frame pivoted to the stern of the craft to be operated by steering lines from the cock-pit. The longitudinal width of the struts and the inclination of the hydrofoils afford sufficient lateral area for steering purposes. As the boat is turned, especially when travelling at high speed, there is a strong tendency to heel outwardly, due to centrifugal force, but with a setting of the hydrofoils as herein shown this action can be balanced by the inwardly heeling effect of the steering set, thus permitting sharp turns to be made at high speed—a most important consideration. As heretofore stated, with the dihedral arrangement of the blades on the water, the reaction is directed to a point above the center of pressure (see dotted lines C—D and E—D, Fig. 4), thus preventing outward listing.

While, for the sake of clearness, one expression of the inventive idea has been herein described and illustrated in considerable detail, it is to be understood that the invention is not limited thereto, but that the inventive idea is susceptible of various expressions within the scope of the appended claims. For example, while the invention has only been illustrated and described in connection with a craft which is supported only by the hydrofoil sets when travelling at high speed, it is to be particularly borne in mind that the invention may be used in connection with aeroplanes or other flying machines, and that the claims hereto appended are to be interpreted as covering the use of the invention with such devices. Further, while the preferred construction of the steering set has been illustrated and described in detail, certain of the broader claims are not limited to this particular construction.

What is claimed is:—

1. In a device of the character described, the combination of a float structure, a truss construction supporting said float structure, the base of said truss passing through said float structure, a hydrofoil set projecting downwards from each end of said truss and a motor supported on each end of said truss and substantially above said hydrofoil sets.

2. In a device of the character described, a float structure, a plurality of hydrofoil sets projecting downward therefrom and supporting said structure during the planing action, one of said hydrofoil sets being mounted to turn on a vertical axis.

3. In a device of the character described, a float structure, a plurality of hydrofoil sets projecting downward therefrom and supporting said structure during the planing action, one of said hydrofoil sets being mounted on a vertical axis said axis being in front of the center of pressure of said set whereby said set will automatically assume a neutral position.

4. In a device of the character described, a float structure, a plurality of hydrofoil sets projecting downward therefrom and supporting said structure during the planing action, one of said hydrofoil sets being mounted on a vertical axis and comprising a plurality of substantially vertical struts and a plurality of substantially horizontal blades or surfaces, and means for turning said set on its axis.

5. In a device of the character described, the combination of a downwardly projecting hydrofoil set, a motor mounted over said hydrofoil set, and an air-propeller driven by said motor.

6. In a device of the character described, the combination of a plurality of downwardly projecting hydrofoil sets, one on each side of the medial line of the structure, a motor over each hydrofoil set, and an air-propeller driven by each motor.

7. In a device of the character described, the combination of a pair of hydrofoil sets mounted one on each side of the medial fore and aft line of the structure, and a hydrofoil set mounted to turn on a vertical axis in the medial line of the structure and to the rear of said first-named sets.

8. In a device of the character described, the combination of a pair of hydrofoil sets mounted one on each side of the medial line of the structure, a motor mounted over each of said hydrofoil sets, two air-propellers one driven by each motor, and a hydrofoil set mounted on a vertical axis in the medial line of the structure, and to the rear of said first-mentioned hydrofoil sets.

9. In a device of the character described, the combination of a support, a motor mounted thereon, an air-propeller driven by said motor, a hydrofoil set projecting downward from said support in the angle between a vertical line passing through the center of gravity of the motor and the line of thrust of the motor.

10. In a device of the character described, the combination of a float structure, hydrofoil sets projecting downwardly therefrom into the water, a vertical support mounted exteriorly of said structure and comprising vertical and horizontal members, said horizontal members being arranged at a positive angle of incidence, a motor mounted on said support, and a propeller mounted directly on the motor shaft.

11. In a device of the character described, the combination of a float structure, hydrofoil sets projecting downwardly into the water, a plurality of vertical supports mounted exteriorly of said float structure and sym-

metrically arranged with respect thereto and each being arranged over a corresponding hydrofoil set, said supports comprising vertical and horizontal members, a motor mounted on each of said supports, and a propeller mounted directly on each motor shaft.

12. In a device of the character described, the combination of a float structure, hydrofoil sets projecting downwardly into the water, a plurality of vertical supports mounted exteriorly of said float structure and symmetrically arranged with respect thereto, a motor mounted on each of said supports, a propeller mounted directly on each motor shaft, and a plurality of members connecting said supports and arranged at a positive angle of incidence.

13. In a device of the character described, the combination of a float structure comprising a hull and a deck projecting laterally from both sides of said hull, hydrofoil sets projecting downwardly into the water, a plurality of vertical supports mounted exteriorly of said hull and symmetrically arranged with respect thereto and each being arranged over a corresponding hydrofoil set, said supports comprising vertical and horizontal members, a motor mounted on each of said supports, and a propeller mounted directly on each motor shaft, said deck being arranged at a positive angle of incidence and constituting an aero surface.

14. In a device of the character described, the combination of a supporting structure, a hydrofoil set projecting downwardly from said structure and comprising vertical strut members and hydrofoils having a positive angle of incidence, and a compression member extending forwardly from said set to said structure.

15. In a device of the character described, the combination of a supporting structure, a hydrofoil set projecting downwardly from said structure and comprising vertical strut members and hydrofoils having a positive angle of incidence, and a compression member extending forwardly from said set to said structure and a tension member extending rearwardly from said set to said structure.

16. In a device of the character described, the combination of a supporting structure, a rigid horizontal member extending therethrough, a hydrofoil set connected to said member and comprising vertical strut members and hydrofoils having a positive angle of incidence, the lower ends of said struts being positioned slightly forward of said point of connection whereby there is created a resultant tendency of the hydrofoil set to move forward rather than backward, and a compression member extending forwardly from said set to said structure.

17. In a device of the character described, the combination of a supporting structure, a rigid horizontal member extending therethrough, a hydrofoil set connected to said member and comprising vertical strut members and hydrofoils having a positive angle of incidence, the lower ends of said struts being positioned slightly forward of said point of connection whereby there is created a resultant tendency of the hydrofoil set to move forward rather than backward, a compression member extending forwardly from said set to said structure, and a tension member extending rearwardly from said set to said structure.

18. In a device of the character described, the combination of a float structure, a plurality of hydrofoil sets projecting downwardly into the water from said structure and each comprising a plurality of vertical strut members and a plurality of hydrofoils connected to said struts, a pivotal mounting for one of said sets, and means for turning said set on its pivot for steering purposes.

19. In a hydrofoil set, the combination of a plurality of substantially horizontal superposed hydrofoils, substantially vertical struts to which said hydrofoils are connected, and additional superposed hydrofoils beneath said parallel hydrofoils and inclined in the lateral direction obliquely upwards.

20. In a hydrofoil set, the combination of a plurality of substantially horizontal superposed hydrofoils, substantially vertical struts to which said hydrofoils are connected, and additional superposed hydrofoils arranged beneath said horizontal hydrofoils and connected to said struts under the marginal extremities of said horizontal hydrofoils and inclined in the lateral direction obliquely upwards.

21. In a hydrofoil set, the combination of a plurality of substantially horizontal superposed hydrofoils, substantially vertical struts to which said hydrofoils are connected, and additional superposed hydrofoils beneath said parallel hydrofoils and inclined in the lateral direction obliquely upwards, and means for turning said set around a vertical axis.

22. In a hydrofoil set, the combination of a plurality of substantially horizontal superposed hydrofoils, substantially vertical struts to which said hydrofoils are connected, and additional superposed hydrofoils arranged beneath said horizontal hydrofoils and connected to said struts under the marginal extremities of said horizontal hydrofoils and inclined in the lateral direction obliquely upwards, and means for turning said set around a vertical axis.

23. In a device of the character described, a steering mechanism or rudder comprising substantially vertical strut members, superposed hydrofoils connected thereto and inclined in the lateral direction obliquely up-

wards, and means for turning said rudder about a vertical axis.

24. In a device of the character described, a steering mechanism or rudder comprising substantially vertical strut members, two sets of superposed hydrofoils connected thereto one set being arranged on each side of the medial fore and aft line of the craft, the blades in each set being inclined in the lateral direction obliquely upwards, and means for turning said rudder about a vertical axis.

25. In a device of the character described, a steering mechanism or rudder comprising substantially vertical strut members, two sets of superposed hydrofoils connected thereto one set being arranged on each side of the medial fore and aft line of the craft, the blades in each set being inclined in the lateral direction obliquely upwards with the upper ends of the under blades intersecting a horizontal plane passing through the lower end of the blade next above, and means for turning said rudder about a vertical axis.

26. In a device of the character described, the combination of a supporting truss, a hull carried by said truss, hydrofoil sets projecting downwardly therefrom on each side of said hull, and an additional set of hydrofoils mounted in front of said first-mentioned sets, the blades of said additional set being interspaced with these associated sets.

27. In a device of the character described, the combination of a supporting structure, a hydrofoil set projecting downwardly from said structure and comprising a vertical strut member and hydrofoil blades carried thereby, the lower end of the strut being positioned forward of the point of connection with said structure, and a compression member projecting forwardly from said strut.

28. In a device of the character described, the combination of a supporting structure, a hydrofoil set projecting downwardly from said structure and comprising a vertical strut member and hydrofoil blades carried thereby, the lower end of the strut being positioned forward of the point of connection with said structure, and a tension member projecting rearward from said strut.

29. In a device of the character described, the combination of a supporting structure, a hydrofoil set projecting downwardly from said structure and comprising a vertical strut member and hydrofoil blades carried thereby, the lower end of the strut being positioned forward of the point of connection with said structure, a compression member projecting forwardly from said strut, and a tension member projecting rearwardly from said strut.

30. In a device of the character described, a float structure, a plurality of hydrofoil sets supporting said structure during the planing action, one of said hydrofoil sets being mounted on a vertical axis and comprising a plurality of substantially horizontal blades or surfaces, and means for turning said set on its axis.

31. In a device of the character described, the combination of a float structure, a plurality of hydrofoil sets each comprising a vertical strut member and a plurality of hydrofoils connected to said strut, a pivotal mounting for one of said sets, and means for turning said set on its pivot for steering purposes.

32. In a device of the character described, the combination of a supporting truss, a hull carried by said truss, forward hydrofoils projecting downwardly therefrom on each side of said hull, a short set of hydrofoils mounted in front of said first-mentioned sets, and adapted to be above water when the device is moving at high speed.

33. In a water craft, a rudder comprising a hydrofoil set mounted on a vertical axis.

34. In a device of the class described, steering means comprising a plurality of hydrofoil blades mounted on a vertical axis.

35. In a water craft, steering means comprising a hydrofoil set mounted on a vertical axis.

36. In a device of the class described, steering means comprising a plurality of hydrofoil blades mounted to turn on an axis fixed in vertical position.

In testimony whereof we have signed this specification.

ALEXANDER GRAHAM BELL.
FREDERICK W. BALDWIN.