Oct. 21, 1958

J. G. BAKER

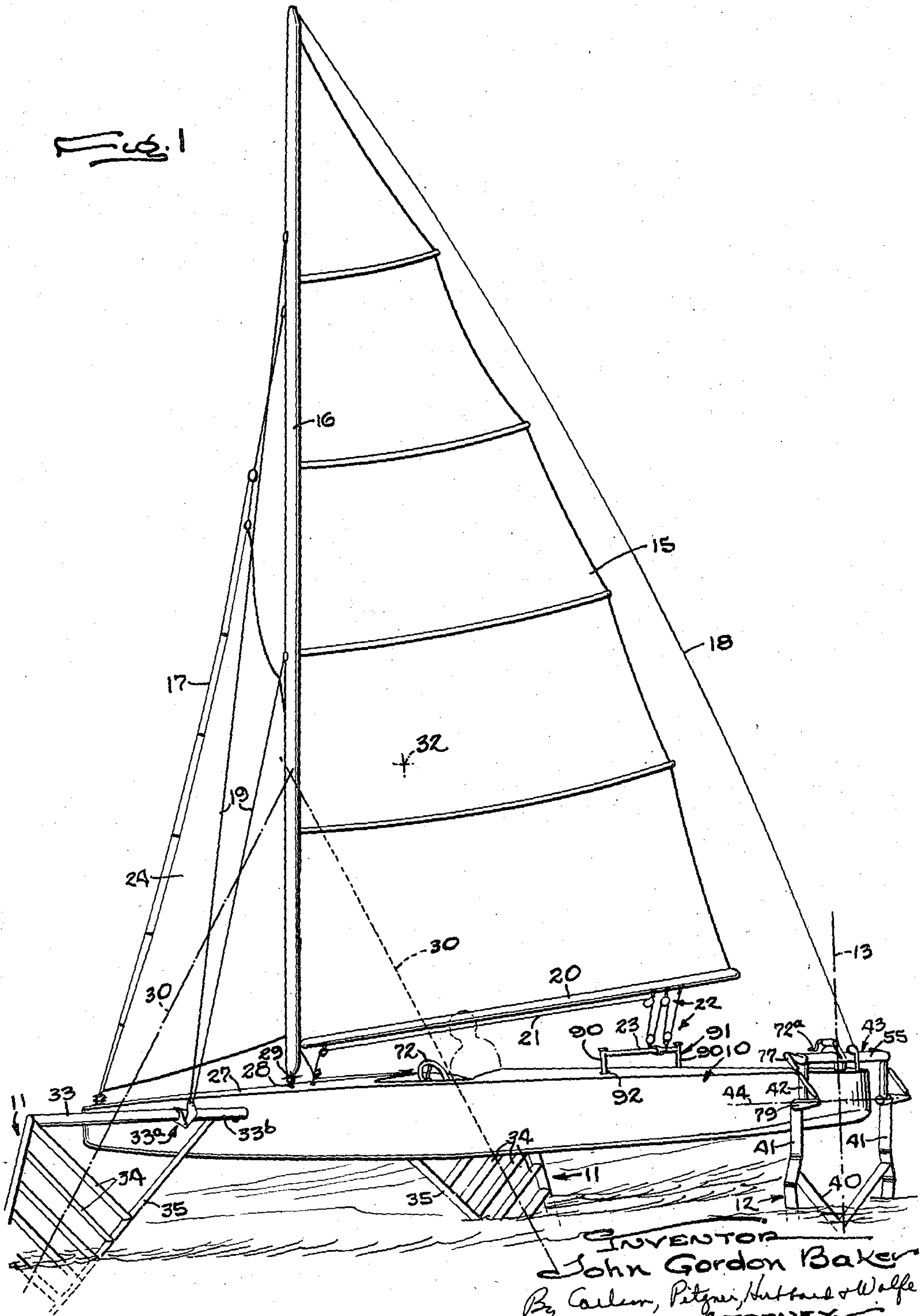
2,856,879

HYDROFOIL SYSTEM FOR BOATS

Filed Sept. 13, 1956

10 Sheets-Sheet 1

FIG. 1



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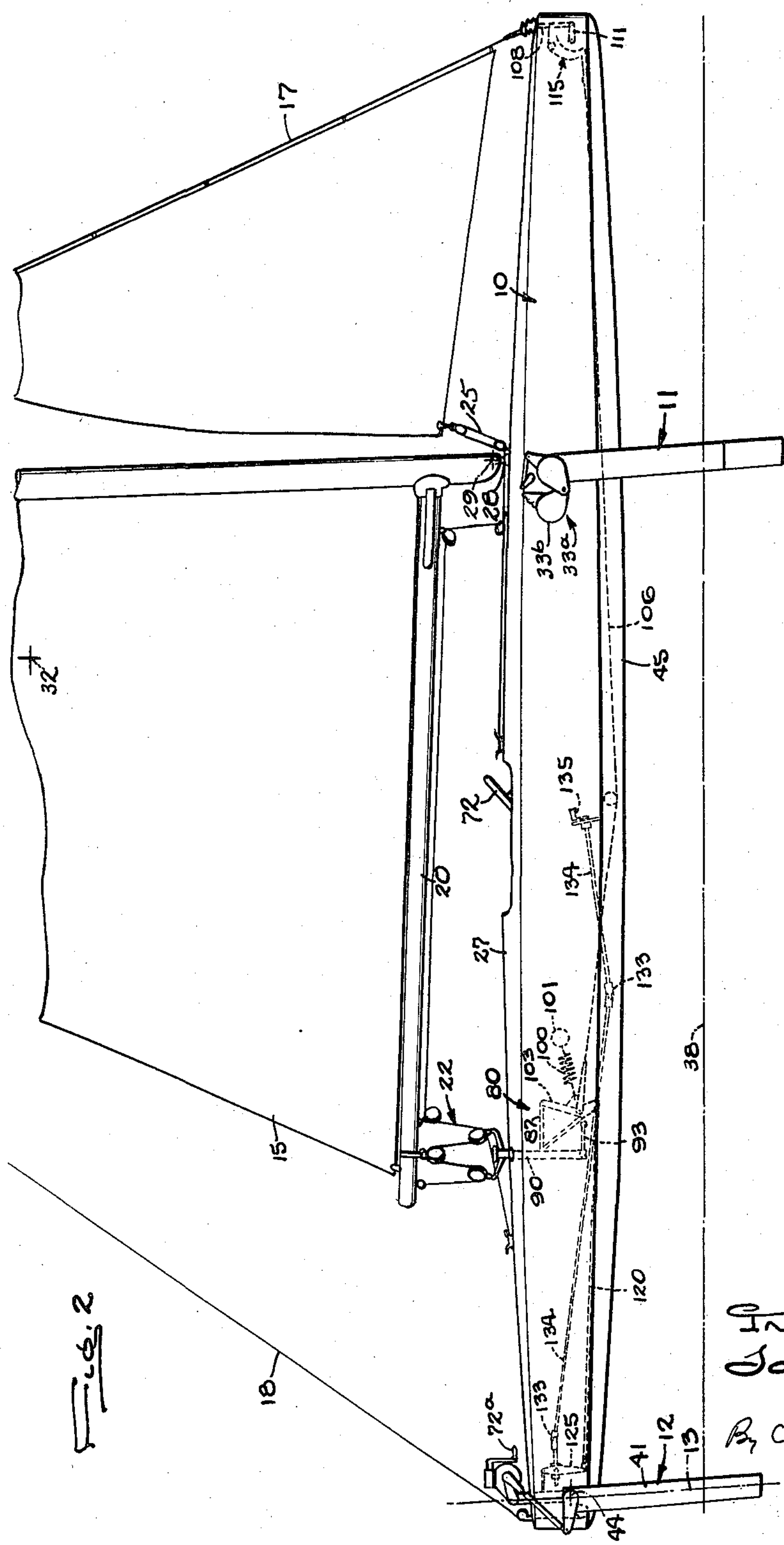

Fig. 2

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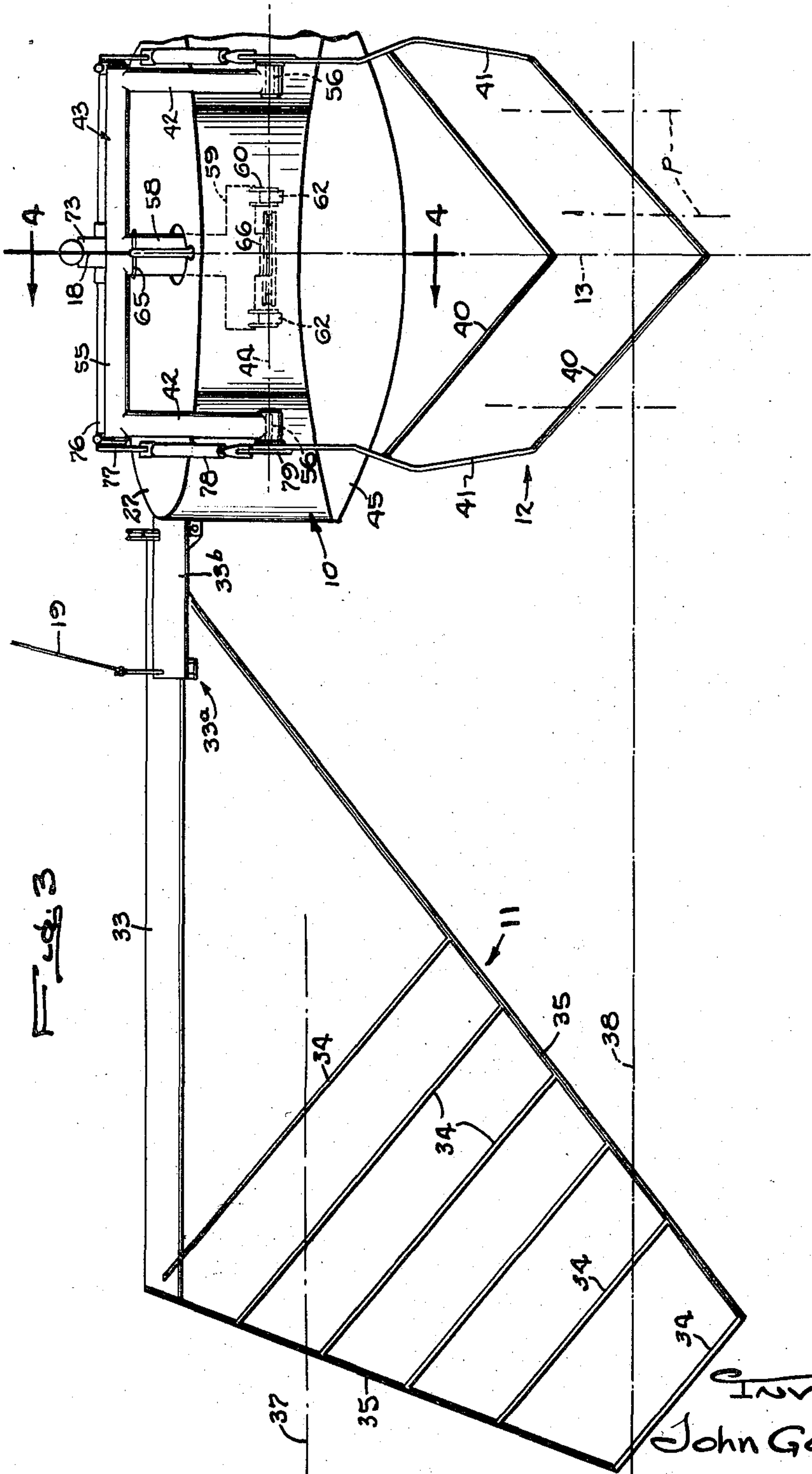

Fig. 3

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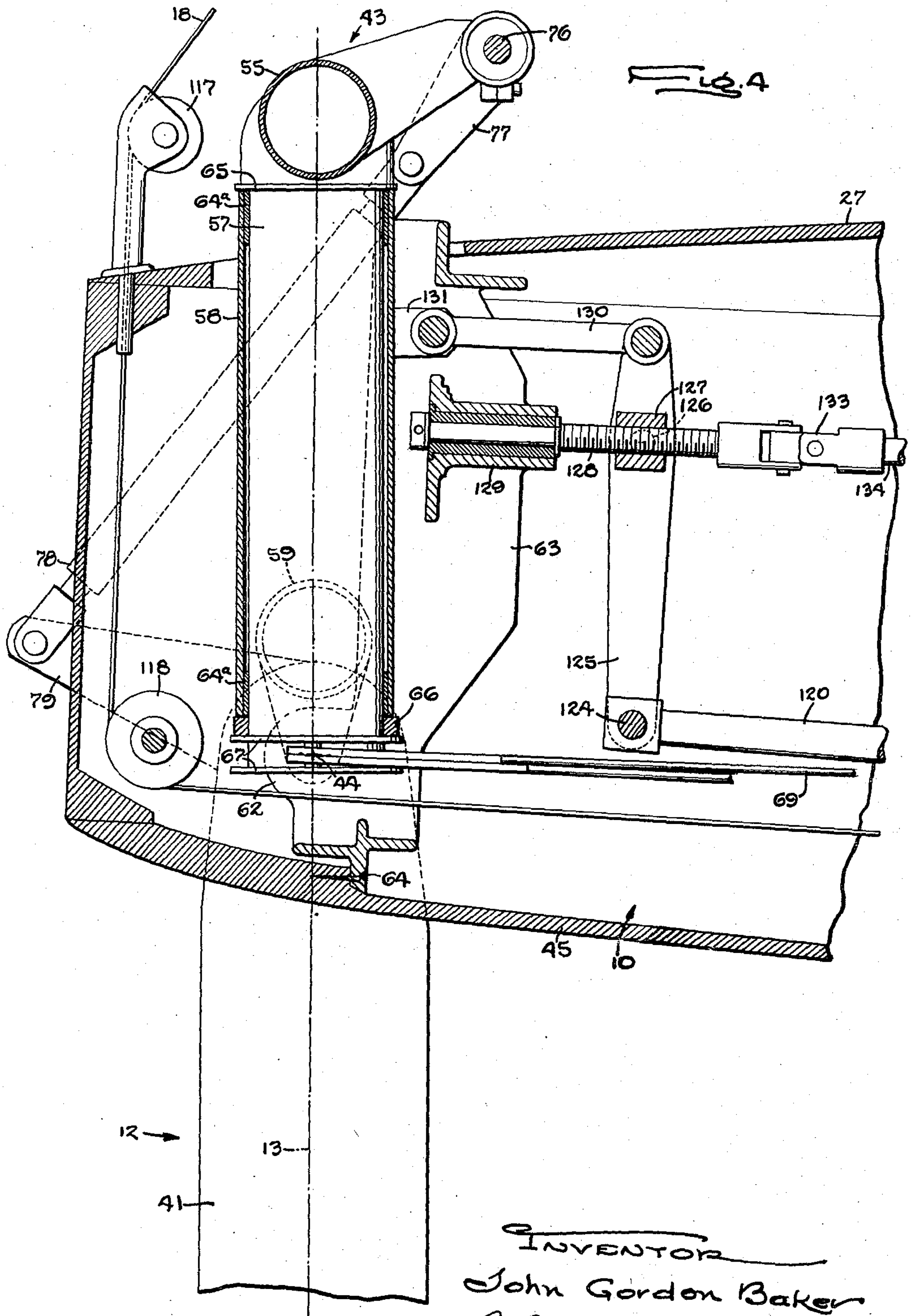
Fig. 4



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HYDROFOIL SYSTEM FOR BOATS

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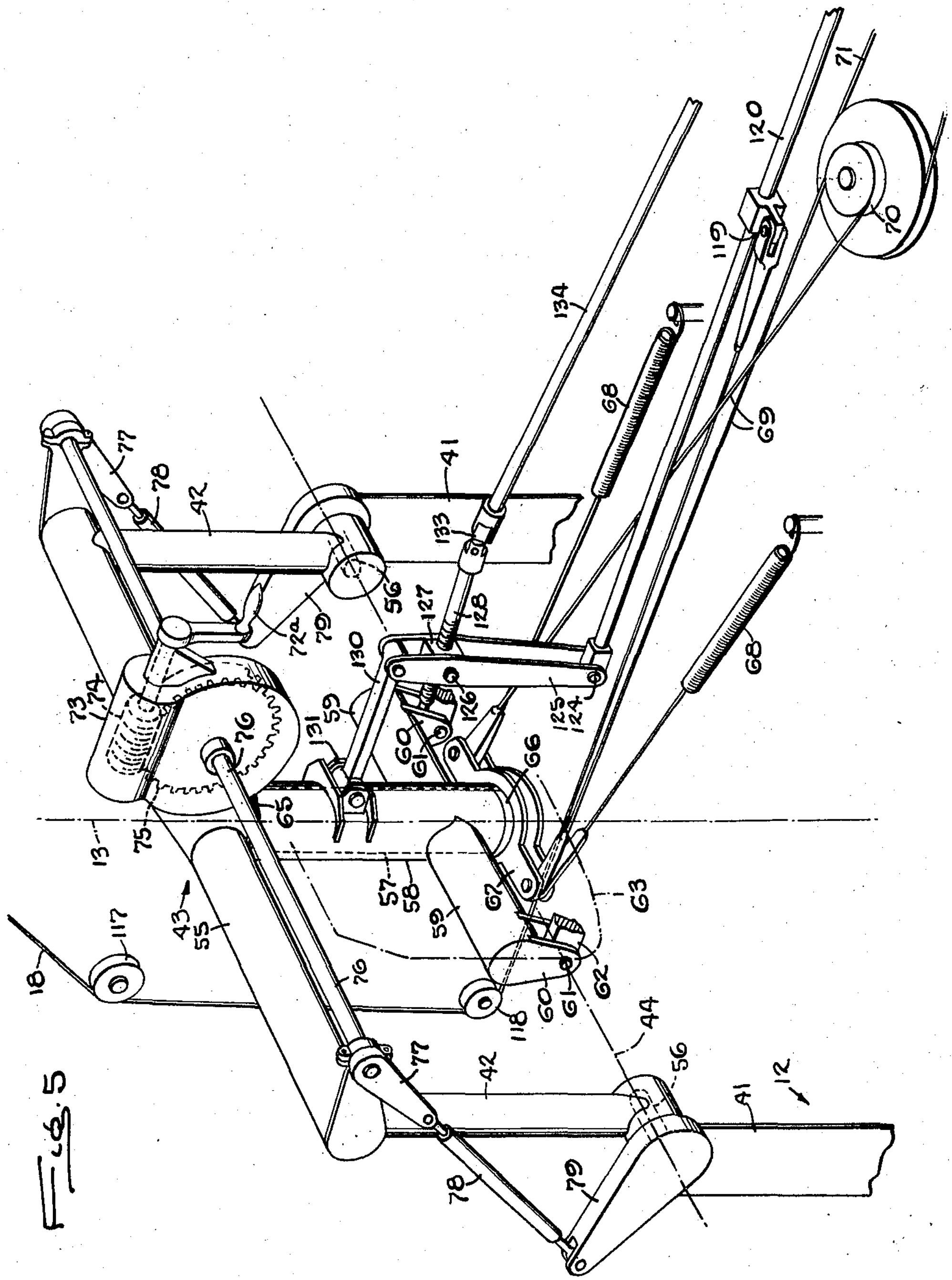

FIG. 5

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Fig. 6

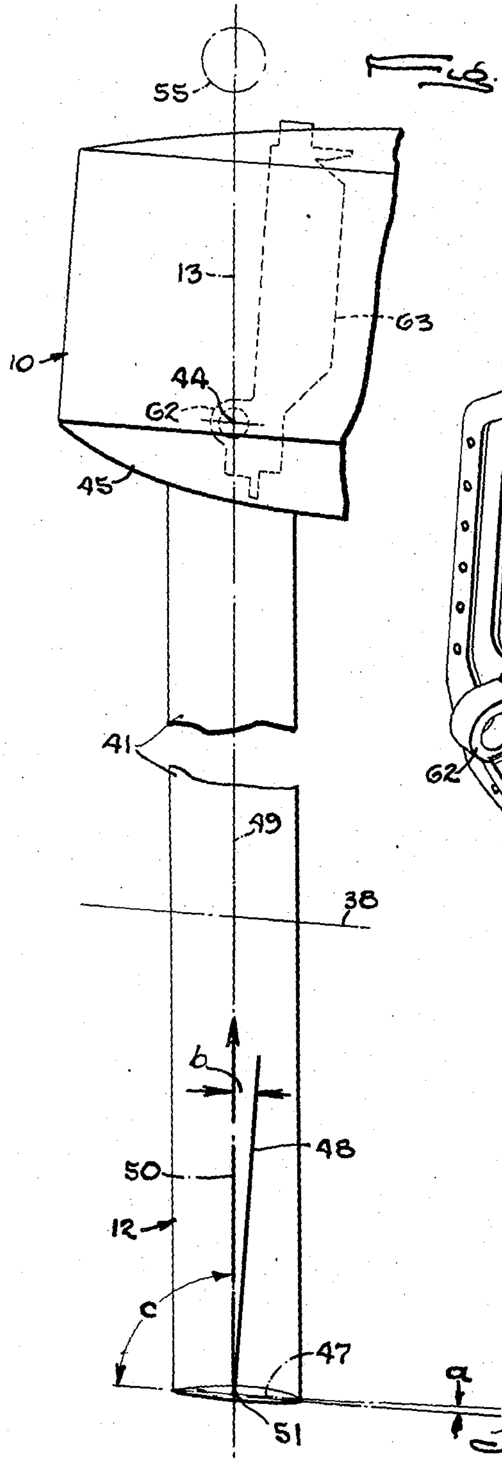

Fig. 7

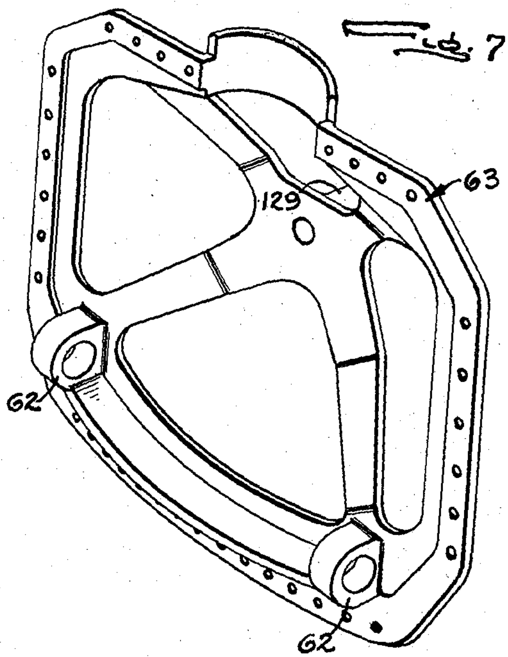

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Fig. 8

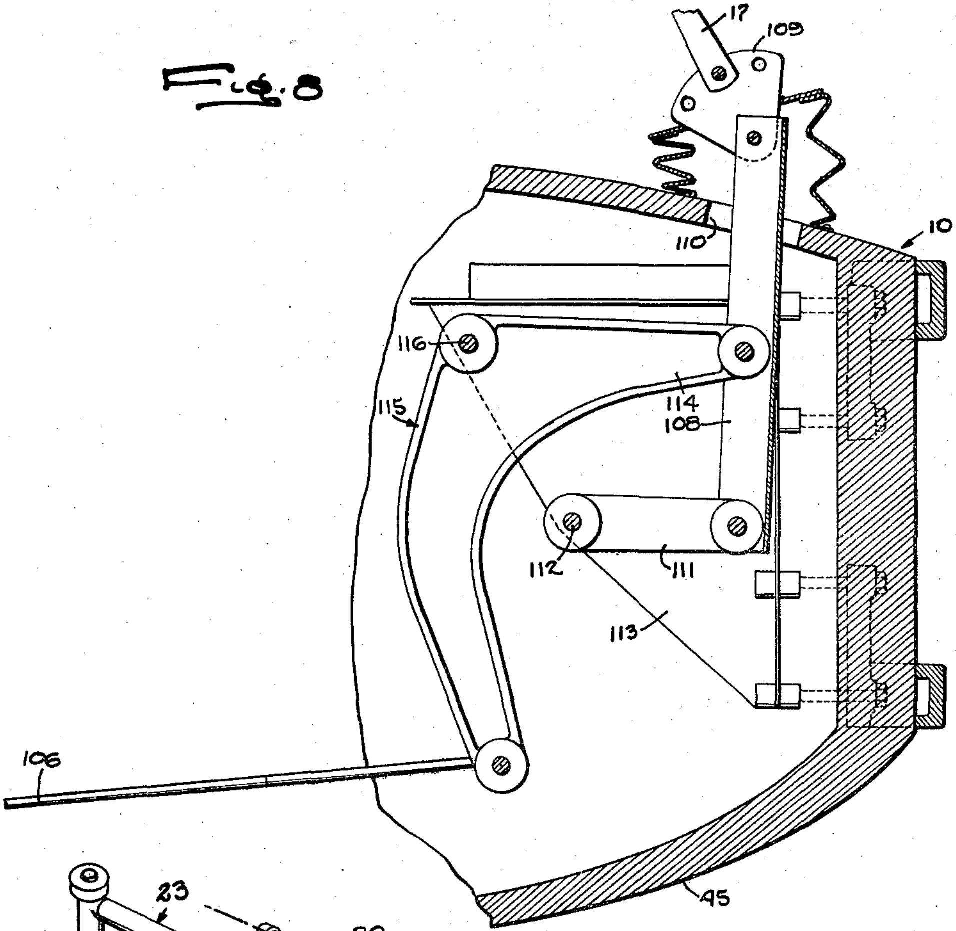

Fig. 9

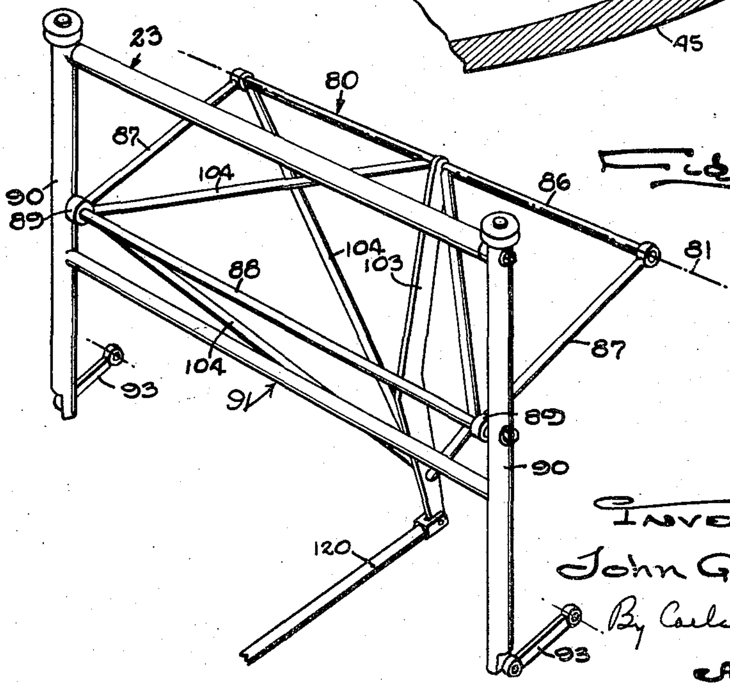

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Fig. 10

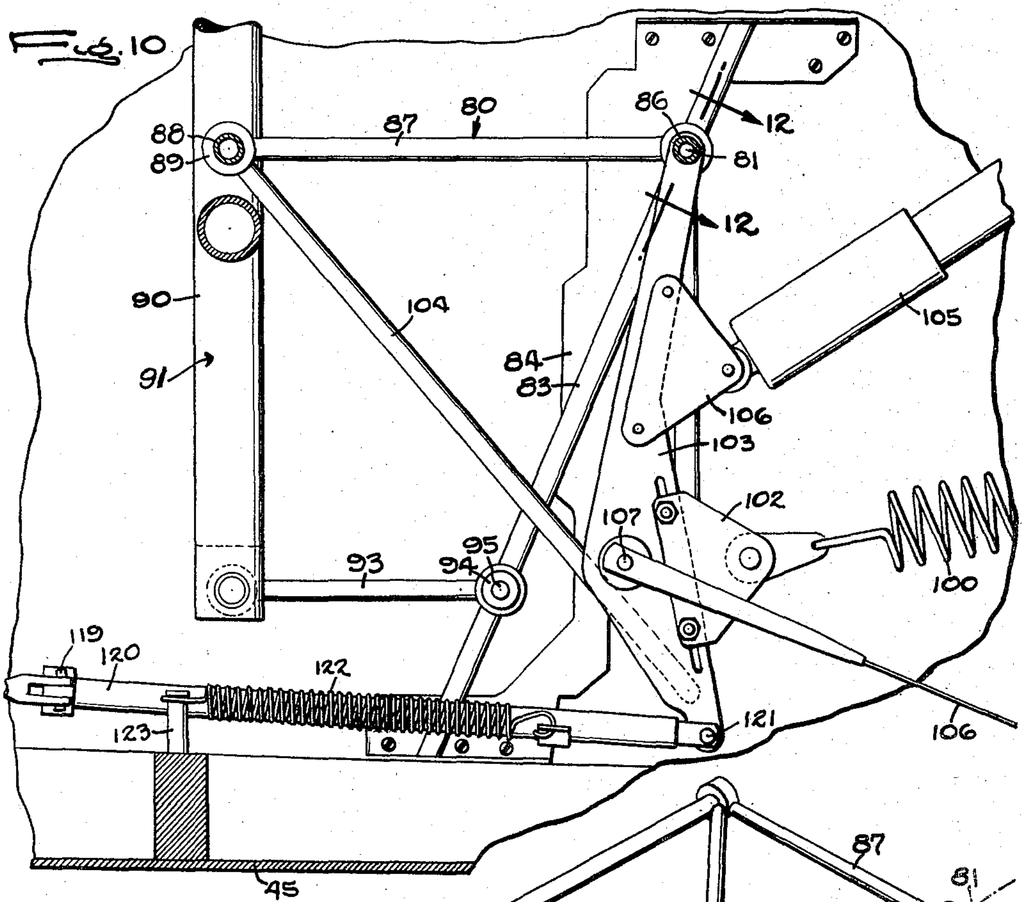


Fig. 11

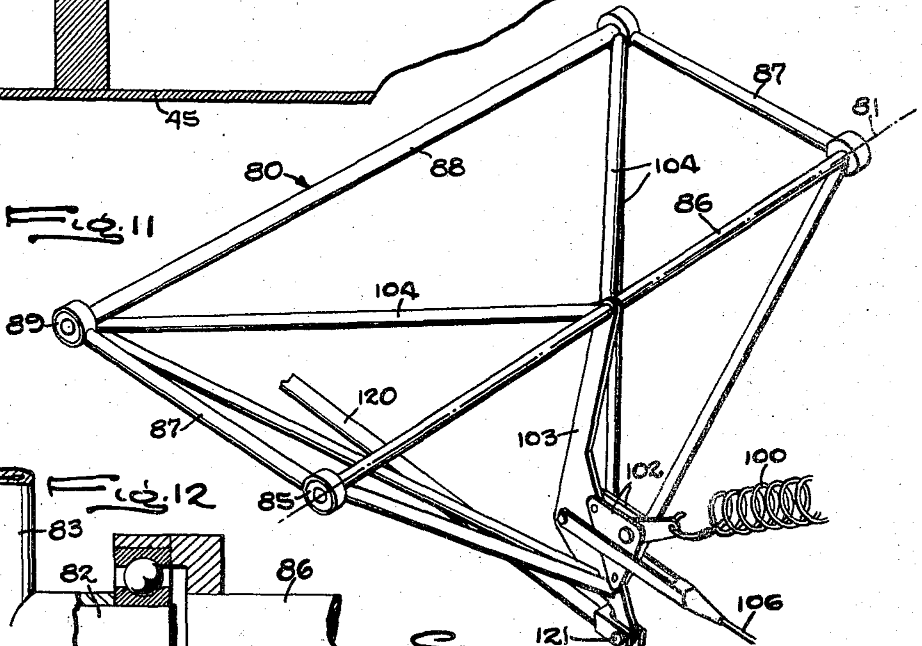
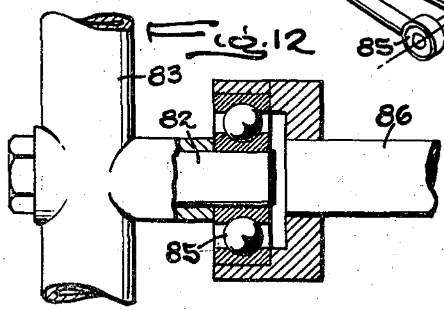


Fig. 12



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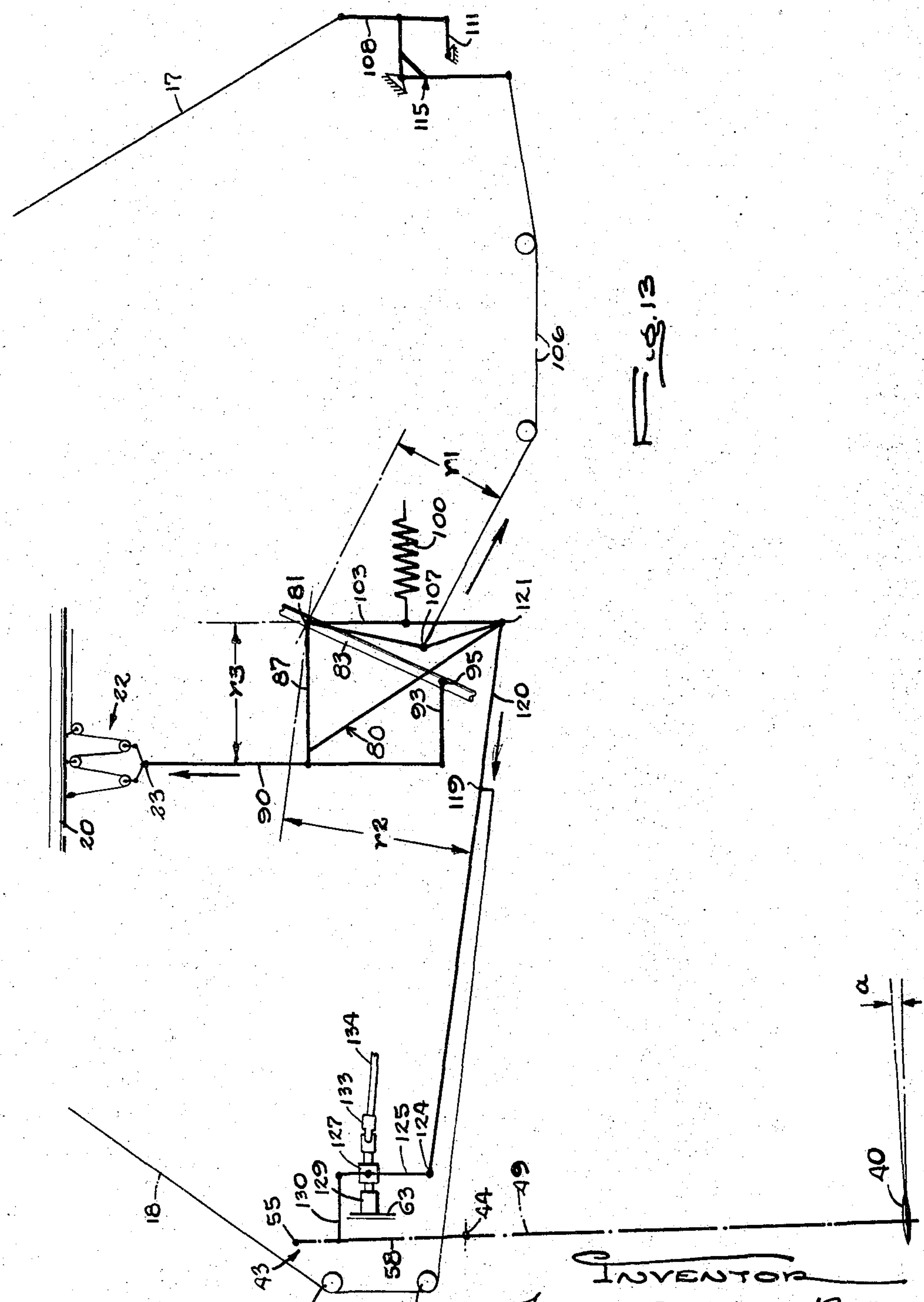

Fig. 13

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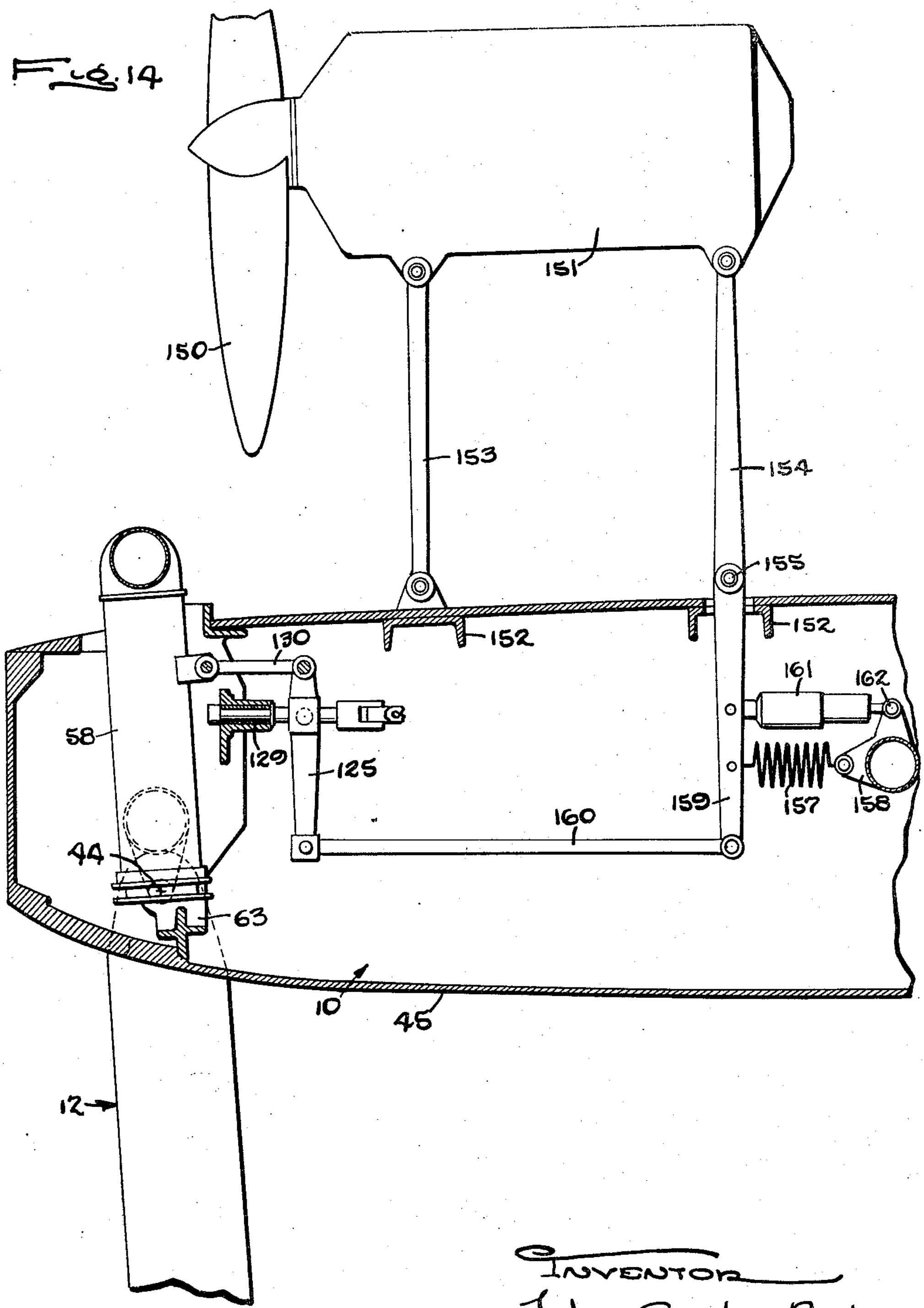
Fig. 14



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United States Patent Office

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HYDROFOIL SYSTEM FOR BOATS

John Gordon Baker, Evansville, Wis.

Application September 13, 1956, Serial No. 609,613

18 Claims. (Cl. 114—66.5)

This invention relates to a system of hydrofoils attached to the hull of a boat and adapted upon forward motion of the boat produced by a horizontally directed thrust to raise the boat and maintain the same above the water during continuance of the propelling thrust. In certain of its aspects, the invention is more particularly concerned with a system in which the boat is supported at the bow by two overhanging hydrofoils and at the stern by a single hydrofoil.

One object is to provide a hydrofoil boat of the above character in which the front hydrofoils are arranged in a novel manner such as to minimize the overall width of the hydrofoil boat.

A second object is to adapt the rear hydrofoil for steering and incidence angle adjustment by a mounting disposed wholly within the boat hull.

A third object is to provide a novel mounting which permits the incidence angle of one of the hydrofoils to be adjusted by a force which is relatively small over a wide range of the incidence adjustment.

A fourth object is to provide a system for adjusting the incidence angle of a hydrofoil automatically to compensate for changes in the externally applied thrusts which tend to disturb the trim of the boat hull.

A fifth object is to balance the externally applied thrust forces against a spring and utilize the displacement of the latter to effect the incidence angle adjustment.

A sixth object is to provide an incidence angle adjusting system which is adaptable for practical use on sailboats.

A seventh object is to provide a hydrofoil sailboat in which the rigging is arranged in a novel manner such as to minimize the number of thrust forces required to be combined in effecting the automatic incidence adjustment of the incidence angle.

An eighth object is to effect the incidence angle adjustment in response to changes in the tension of the rigging of the boat sail.

The invention also resides in the novel manner of weighing and combining a plurality of different thrust forces and utilizing their resultant to effect the incidence angle adjustment.

Other objects and advantages of the invention will become apparent from the following detailed description taken in connection with the accompanying drawings, in which

Figure 1 is a perspective view of a sailboat in operation with a hydrofoil system embodying the novel features of the present invention.

Fig. 2 is a fragmentary side elevational view.

Fig. 3 is a fragmentary rear end view.

Fig. 4 is a fragmentary section taken along the line 4—4 of Fig. 3.

Fig. 5 is a fragmentary perspective view of the mechanism shown in Fig. 4.

Fig. 6 is an enlarged fragmentary side view of a boat

stern with one of the rear hydrofoils broken and shown in section along the water plane of the boat.

Fig. 7 is a perspective view of the rear hydrofoil mounting bracket.

Fig. 8 is a fragmentary longitudinal section through the bow of the sailboat.

Fig. 9 is a fragmentary perspective view of a part of the incidence angle adjusting mechanism.

Fig. 10 is a fragmentary sectional view of the incidence adjusting mechanism taken along the center line of the boat.

Fig. 11 is a fragmentary perspective view of part of the incidence adjusting mechanism.

Fig. 12 is a fragmentary section taken along the line 12—12 of Fig. 10.

Fig. 13 is a schematic view of the incidence angle adjusting mechanism.

Fig. 14 is a fragmentary schematic view illustrating the manner of incorporating the incidence adjustment in a boat driven by an air propeller.

For purposes of illustration, the invention in its various aspects is shown in Figs. 1 to 13 of the drawings incorporated in a sailboat having an elongated hull **10** adapted to float on the water but also adapted to be supported above and out of contact with the water by a hydrofoil system comprising two front hydrofoils **11** overhanging opposite sides of the hull and a rear hydrofoil **12** straddling the longitudinal center line of the boat at the stern and adjustable about an upright axis **13** to steer the boat.

The main sail **15** is attached in the usual way to a mast **16** braced by a fore, back and side stays **17**, **18** and **19** and carrying a boom **20** whose angle is controlled by a sheet **21** extending around pulleys **22** movable along a traveler **23**. The usual jib **24** attached to the forestay **17** is adjusted by the jib sheet **25** extending around a sheave **26** attached to the deck **27** close to the lower end of the mast. The latter is supported on the deck through a ball joint **28** for universal swiveling of the mast about a multiplicity of axes including a transverse axis **29** disposed in the plane determined by the lines **30** to be described below.

In accordance with one aspect of the present invention, the front hydrofoils **11** are constructed and arranged to exert forces which are directed upwardly and inwardly and intersect substantially at the level of the thrust center **32** (Fig. 1) of the sails. In this location, the resultant forces derived from the action of the hydrofoils **11** provide the necessary reaction to the side force of the sail. As a result, neither the usual heavy keel or a center board as used on conventional sailboats is necessary. Moreover, this arrangement permits location of the hydrofoils closer to the sides of the boat than would be possible with V-shaped front hydrofoils for example. The overall width of the boat is thus reduced to a minimum for a given top speed and wind velocity.

In addition and for a purpose to appear later, the foils **11** are located so as to dispose the lines **30** of action of their forces in an upright plane which includes an axis **29** extending transversely of the center of the ball joint **28**. To these several ends, the foils **11** are mounted on horizontal tubular bars **33** detachably coupled through suitable connections **33**^{a} with the outward ends of a tube **33**^{b} extending transversely through the hull below the deck **27** and projecting a short distance (Fig. 3) beyond opposite sides of the hull. The side stays **19** may be anchored on the outer ends of the tube **33**^{b}.

To provide adequate lifting forces with foil elements of small chord for efficient high speed operation, each of the foils **11** is of the ladder type comprising a plurality of vertically spaced parallel lifting elements in the form of straight bars 34 spanning inner and outer streamlined struts 35 to which the ends of the lifting elements are welded. The elements 34 are of well known foil cross section (Fig. 6) and inclined upwardly and outwardly at angles such as to derive forces directed along the line 30 when the elements disposed at a proper incidence angle are advanced edgewise through the water.

It will be observed that each of the ladder elements 34 exerts a separate lifting force so that the total lifting force exerted at any time increases with the degree of submergence of the elements. When the boat is floating on the water, the water surface rises to the line 37 (Fig. 3). When the hull is foil borne (Fig. 1), that is, sustained above the water by the hydrofoils, the water surface intersects the foil elements along the line 38 (Fig. 3).

The rear hydrofoil 12 is constructed to serve as a rudder for steering the boat while the latter is floating on the water. To this end, it preferably is of the ladder type comprising two elements 40 of V-shape vertically spaced from each other and rigidly joined at their ends to substantially parallel struts 41 of streamlined cross section. The latter straddle the stern of the boat and are normally rigid with and suspended from depending arms 42 of a rigid frame 43 which, in accordance with one aspect of the present invention, is supported within the boat hull 10 to turn about the upright steering axis 13 and also about a horizontal axis 44 (Figs. 4 and 5) extending transversely of and disposed near but above the bottom 45 of the hull and spaced ahead of the boat stern. Both foils 40 are disposed below the water line 37 when the boat is floating but only a portion of the lower foil 40 is submerged below the water line 38 (Fig. 3) when the boat is foil borne at top speed.

At all points along the active portions of the hydrofoil elements 40, the cross section taken in any vertical plane *p* (Fig. 3) is of a standard shape best shown in Fig. 6. The chord line 47 of each section is disposed in a novel angular relation with respect to the pivot axis 44 so that the resultant of the forces exerted by the water action produces very little moment about the axis 44 in order to minimize the effort required to adjust the incidence angle *a* and therefore the lifting effect of the foil. All of the hydrodynamic forces on the foil 12 produce a resultant force 50 (Fig. 6) which may be considered as intersecting approximately at the center 51 of the chord line 47. By placing the cross section centers all along the lengths of the foil elements 40 in a common plane 49; by properly inclining the foil section chord lines 47 relative to the plane 49; and by setting the entire foil unit 12 so that the plane 49 is at the proper angle with the vertical 48 when the thrust on the boat is just adequate to maintain the foil borne speed of the boat constant, the resultant hydrodynamic force 50 may be disposed approximately in the plane 49. To this end, the plane 49 is tilted backwardly from the vertical 48 through an angle *b* of about 4.75 degrees at the constant speed above referred to. In this position, the plane 49 of the resultant force 50 makes an included angle *c* of about 85 degrees with the rear end portion of the chord lines 47. By locating the foil angle adjusting axis 44 and the foil steering axis 13 in the plane 49, the line of action of the resultant hydrodynamic force 50 on the foil unit 12 at any foil borne constant speed of the boat will substantially intersect both the incidence angle adjustment axis 44 and the steering axis 13. Thus the moment on the foil 12 will be substantially zero at any speed.

Furthermore, under conditions of acceleration with this arrangement, it has been found that the moments on the foil about either the incidence adjusting axis 44 or the steering axis 13 are either small or roughly proportional to the corresponding angular rotation of the foil unit so that they can be roughly compensated for in the selection of the scale of the balancing spring to be described later. Thus either incidence adjustment or steering can be carried out with little effort.

Referring now to Figs. 4 and 5, the frame 43 includes a horizontal tube 55 disposed above and extending transversely across the stern portion of the boat and rigid at opposite ends with the arms 42 which project downwardly along opposite sides of the hull and are pivotally joined by pins 56 to the upper ends of the hydrofoil legs 41. Midway between its ends, the tube is welded or otherwise secured rigidly to the upper end of a shaft 57 extending through and journaled in a tube 58 having alined tubular projections 59 welded thereto near its lower end and paralleling the tube 55. Short arms 60 depend rigidly from the outer ends of the projections 59 and are joined by pivot pins 61 to ears 62 on a bracket 63 (Fig. 7) secured as by screws 64 to the bottom and side walls of the boat hull inside of the latter. The pivot pins 61 are alined with each other.

As shown in Fig. 4, the shaft 57 is journaled in bearings 64ª within the tube 58 and flanges 65 and 66 abut against opposite ends of the tube which thus sustains the weight on the rear hydrofoil 12. Rigid with the lower end of the shaft 57 are arms 67 projecting in opposite directions transversely of the boat and yieldingly held in a straight froward position by springs 68 (Fig. 5) but adapted to be swung back and forth to turn the frame 43 and the hydrofoil 12 about the upright axis 13 for steering the boat to the right or left. For this purpose, the free ends of the arms 67 are connected to the ends of a crossed cable 69 extending around a drum 70 journaled on the hull and adapted to be rotated in opposite directions by a cable 71 movable back and forth by turning a steering wheel 72 located in a convenient position within the boat.

To provide for manual folding or lowering and raising of the rear or steering hydrofoil 12 into and out of the water, the foil struts 41 are adapted to be turned about the pivots 56 as by turning a hand crank 72ª (Fig. 5) carried by the frame 43. This crank is on a shaft journaled in a housing 73 and carrying a worm 74 meshing with a worm wheel 75 on a shaft 76 disposed alongside the tube 55 and carrying depending crank arms 77. The latter are coupled through adjustable links 78 with similar crank arms 79 fast on the pivot pins 56 and the legs 41 of the hydrofoil 12.

In accordance with a primary feature of the present invention, means is provided for sensing and weighing the different and varying external thrusts on the sail rigging tending to vary the pitch or trim of the boat and utilizing the resultant of such thrusts to automatically adjust the angle of incidence of one or more of the hydrofoils to oppose and actually compensate for the effect of such thrust changes on the trim of the boat. It can be shown that this condition of proper trimming is achieved when the summation of all of the moments of the externally applied forces about the axis 29 is zero provided this axis is approximately at the level of the center of gravity of the boat which is the case in the present instance. Since the lines of action 30 of the resultant forces derived from the front hydrofoils, the forces due to tensioning the jib sheet 25, and the load of the mast on the ball joint 28 all intersect at the axis 29, these forces may be disregarded in determining the trimming moment about the axis 29. The remaining forces to be considered in a sailboat are those exerted at the other connections between the sail rig and the boat hull. Of these forces, the components which affect the trim of the hull at any time may be determined by the tension in the fore and back stays 17 and 18 and the lift exerted on the traveler 23.

The means for selecting and weighing the values of these force components and computing the direction and the extent of the incidence adjustment to compensate therefor includes in the present instance a frame 80 (Figs. 9 to 11) pivotally mounted within the boat hull and coupled preferably mechanically with the back and forestays and the traveler. The resultant of these force components thus applied to the computer frame are balanced against the force of a spring **100** so that the resulting displacement of the frame is at all times a measure of the change in the incidence angle of the rear hydrofoil which will offset and compensate for the change in the trimming moment exerted on the boat by the sail rig and tending to detrim the same.

In the present instance the frame **80** is spaced a short distance from the operator's position behind the steering wheel and comprises a plurality of tubes rigidly joined into a box-like truss structure suspended to swing about an axis **81** extending transversely of the boat hull. This axis is defined by studs **82** (Fig. 12) projecting inwardly from bars **83** which are secured to plates **84** attached to the side walls of the hull. The studs **82** support bearings **85** on the ends of a tube **86** joined by side tubes **87** to a cross tube **88** having bearings **89** similarly journaled on the upright tubes **90** of a generally H-shaped frame **91**. The uprights **90** project up through openings **92** in the deck and are joined at their upper ends by the traveler **23** journaled at its ends on the frame **91**. At their lower ends, the uprights are pivoted on the free ends of links **93** whose opposite ends carry bearings **94** journaled on studs **95** projecting from the bars **83**. The uprights **90** and the traveler tube **23** are thus guided for upright movement and therefore adapted to select the proper component of the force applied to the traveler by the sheet **21**. This force component tends to swing the frame **80** clockwise as viewed in Fig. 10.

The counterbalancing spring **100** is stretched between a point **101** (Fig. 2) of anchorage on the hull and a link on a bracket **102** adjustably secured to an arm **103** depending from the bar **86** and forming part of the frame **80** by virtue of its rigid connection with the lower ends of bracing tubes **104** converging downwardly from the bearings at the four upper corners of the frame. Oscillation of the latter in service use is reduced by a hydraulic dampening device **105** (Fig. 10) attached to a bracket **106** intermediate the ends of the depending arm **103**.

The tension of the forestay representing one of the components determining the trimming moment exerted by the sail on the boat hull is applied to the computer frame **80** through a cable **106** attached at **107** to the frame and extending forwardly into the bow of the boat as shown in Fig. 8 where it is connected to a rod **108** which is guided vertically so as to select the proper component of the forestay tension. For this purpose, the lower end of the forestay is pivotally connected through a segment **109** to the end of the bar **108** which projects upwardly through a hole **110** in the deck. At its lower end, the bar **108** is pivoted on the free end of a link **111** pivoted at **112** on a bracket **113** bolted to the bow of the hull. At a point spaced above the link **111** the bar is pivotally joined to an arm **114** of a bell crank **115** which is pivoted on the bracket **113** at **116** spaced behind the point **112** so that the arm **114** is somewhat longer than the link **111**. A still longer arm **115** of the bell crank projects downwardly from the pivot **116** and is connected at its lower end to the cable **106**. Thus the bar **108** is guided by the link **111** and **114** for upright movement which is applied to the computer frame **80** in a generally horizontal direction as shown in Fig. 10. In this way the component of the tension in the forestay which contributes to the trimming moment on the hull is applied to the computer frame **80** in a direction to turn the latter counterclockwise as viewed in Fig. 10.

The tension in the backstay **18** which contributes to the trimming moment on the hull is applied to the computer frame **80** in a reverse direction. This is effected by extending the cable of the backstay around a pulley **117** at the stern of the boat downwardly around a pulley **118** on the hull frame and then forwardly to a point **119** of connection to a link **120** (Figs. 4 and 5). The latter extends along the bottom of the boat and is connected at **121** (Figs. 10 and 11) to the extreme lower end of the depending arm **103** on the computer frame. The link is urged rearwardly by a tension spring **122** anchored at **123** on the bottom of the boat and stressed to exert on the frame **80** a substantially lesser force than the spring **100** to maintain the computer linkage system under tension at all times.

The displacement of the computer frame **80** is transmitted to the mounting of the rear hydrofoil **12** to adjust the incidence angle *a* of this foil and thereby compensate for changes in the trimming moment due to changes in the forces of the sail rig producing the displacement of the computer frame. Such transmission is effected in the present instance simply by extending the link **120** rearwardly as shown in Fig. 5 and connecting the same at **124** to the lower end of a lever **125** fulcrumed at **126** on a block **127** forming the nut of a screw **128**. The latter is journaled in a boss **129** on the frame casting **63** (Fig. 7). The upper short end of the lever **125** is pivotally joined by a link **130** to lugs **131** formed on the tube **58** near the upper end of the latter.

In the normally fixed position of the fulcrum **126**, it will be apparent that a forward displacement of the link **120** by the computer will tip the supporting frame **43** of the rear hydrofoil rearwardly about the axis **44** and thereby correspondingly increase the incidence angle *a* of the foil. Conversely, this angle will be decreased in response to a clockwise displacement of the computer frame **80**.

It will be apparent that the different forces contributing to the trimming moment on the hull, with the exception of that of the rear hydrofoil, are applied to the frame **80** and directed along lines indicated by the arrows in Fig. 13. The points **107**, **121** and **23** of application of these forces are located with respect to the pivotal axis **81** of the frame **80** so that the forces act at moment arms $r1$, $r2$ and $r3$. These arms are of such length as to produce moments which are respectively proportional to the corresponding moments acting on the hull.

It will be remembered from the description above that the force required to adjust the rear hydrofoil **12** about the axis **44** and thereby vary its angle of incidence *a* is very small due to the location above described of the plane **49** (Fig. 6). As a result of this and the ratio selected for the lever **125**, the force transmitted back to the computer frame **80** through this lever and the link **120** is negligible in the moment it applies to the frame **80** except for a small moment proportional to the angular movement of the hydrofoil **12** which is compensated for by properly scaling the spring **100**. It follows therefore that the resultant moment on the frame **80** is proportional to the resultant trimming moment on the hull less the trimming moment due to the rear hydrofoil. The angular displacement of the frame **80** about its pivotal axis **81** is likewise proportional to the moment on the hull because of the linear load deflection characteristic of the spring **100**.

The scale of the spring **100** is chosen to properly relate the trimming moment of the forces acting on the hull and the angle of incidence of the foil and therefore the ultimate lifting force thereof.

Independent manual adjustment of the incidence angle may be effected by turning the screw **128** to thereby swing the lever **125** about its lower end **124** as a fulcrum. For this purpose the screw shaft is coupled through a universal joint **133** with a shaft **134** extended forwardly to the operator's position and adapted to be turned by a hand crank **135** (Fig. 2).

Fig. 14 shows another type of hydrofoil boat in which the incidence angle adjusting mechanism may be used to advantage. In this boat, variations in the pitching moment exerted on the boat hull **10** result from changes in the propelling thrust produced by a propeller **150** supported above the hull and driven at different selected speeds by an engine **151**. To facilitate sensing the thrust changes, the engine is mounted on crossbars **152** through the medium of upright truss members **153** and **154** hinged at 155 on the bars and at their upper ends pivotally joined to the engine casing. A parallelogram linkage is thus formed permitting fore and aft movement of the power unit.

The backwardly directed thrust exerted by the propeller is balanced against a contractile spring 157 anchored at 158 and connected to the lower end of a depending arm 159 forming an extension of the link 154. The engine and the drum are thus restrained against movement except in the fore and aft direction in which the movement of the lever 154, 159 is proportioned accurately in accordance with changes in the propeller thrust due to changes in the engine speed. Through a link 160, the motion of the arm is communicated to the lower end of the lever 125 above described and thus utilized to adjust the incidence angle of the rear hydrofoil 12 automatically. By correlating the ratios of the elements of the motion transmitting connections, the incidence angle may be changed in direction and amount so as to produce a change in lift which just counterbalances each change in the pitching moment applied to the boat hull. Vibration of the transmission linkage may be avoided by interposing a suitable shock absorber 161 between the arm 159 and a point 162 of anchorage on the boat hull.

I claim as my invention:

1. In a hydrofoil boat, the combination of, a hull, an upright tube within said hull having projections rigid with opposite sides of the tube and extending transversely of the hull, means rigid with said hull and supporting said projections for turning of said tube about a horizontal axis disposed near the bottom of the hull, a shaft journaled in and extending through said tube, a crossbar rigid with the upper end of said shaft and extending substantially horizontally and transversely of the hull above the deck thereof, a hydrofoil unit having side legs rigidly suspended from the ends of said crossbar for adjustment with said crossbar and tube about said horizontal axis, and means connected to said tube for rocking the same back and forth about said axis whereby to adjust the effective angle of incidence of said hydrofoil unit.

2. In a hydrofoil boat, the combination of, a hull, an upright tube within said hull having projections rigid with opposite sides of the tube and extending transversely of the hull, means rigid with said hull and supporting said projections for turning of said tube about a horizontal axis disposed adjacent the bottom of the hull, a shaft journaled in and extending through said tube, a crossbar rigid with the upper end of said shaft and extending substantially horizontally and transversely of the hull above the deck thereof, a hydrofoil unit rigidly suspended from said crossbar for adjustment with said crossbar and tube about said horizontal axis, means connected to said tube within said hull for rocking the same back and forth about said axis whereby to adjust the effective incidence angle of said hydrofoil unit, and means coupled to the lower end of said shaft and operable to turn the shaft and said crossbar about the shaft axis and thereby steer the boat through the medium of said hydrofoil.

3. In a hydrofoil boat, the combination of, a hull, a crossbar disposed above and extending across one end of said hull, a hydrofoil having upright side legs straddling said hull and rigidly joined to and suspended from the overhanging ends of said crossbar, an upright support within said hull rigid with said crossbar intermediate the ends thereof, a member journaled on said support to turn relative thereto about an upright axis, a frame disposed within and rigidly secured to said hull, means pivotally joining said frame and said member for swinging of the latter about a horizontal axis extending transversely of said hull and disposed within the hull near the bottom thereof, and means operable from the interior of said hull for individually swinging said member and said support back and forth about said horizontal and upright axes.

4. In a hydrofoil boat, the combination of, a hull, a crossbar disposed above and extending across one end of said hull, a hydrofoil having upright side legs straddling said hull and rigidly joined to and suspended from the overhanging ends of said crossbar, an upright support within said hull rigid with said crossbar intermediate the ends thereof, a member journaled on said support to turn relative thereto about an upright axis, a frame disposed within and rigidly secured to said hull, means pivotally joining said frame and said member for swinging of the latter about a horizontal axis extending transversely of said hull and disposed within the hull near the bottom thereof, spring means acting on said member to urge the same to a straight ahead position, and means operable from the interior of said hull for individually swinging said member and said support back and forth about said horizontal and upright axes.

5. In a hydrofoil boat, the combination of, a hull, a crossbar disposed above and extending across the stern of said hull, a hydrofoil having upright side legs straddling said stern and rigidly joined to and suspended from the overhanging ends of said crossbar, an upright support within said hull joined to said crossbar intermediate the ends of the latter, a frame disposed within and secured rigidly to said hull, means pivotally joining said frame and support for swinging of the latter about a horizontal axis extending transversely of said hull and disposed within the hull near the bottom thereof, and means for rocking said support back and forth about said axis.

6. In a hydrofoil boat, the combination of, a hull, an upright tube within said hull having projections rigid with opposite sides of the tube and extending transversely of the hull, means rigid with said hull and supporting said projections for turning of said tube about a horizontal axis disposed adjacent the bottom of the hull, a shaft journaled in and extending through said tube, a cross bar rigid with the upper end of said shaft and extending parallel to said axis and transversely of the hull above the deck thereof, arms rigid with and depending from the outer ends of said crossbar beyond the sides of said hull, a hydrofoil unit having upright side legs suspended from the lower ends of said arms and joined to the latter to swing about horizontal pivots alined with said axis, a second shaft journaled on said crossbar and having crank and link connections coupling the shaft rigidly to said hydrofoil unit, and manually operable means for turning said second shaft and thereby turn said hydrofoil unit about said axis.

7. A hydrofoil sailboat having, in combination, a hull, front and rear hydrofoils thereon for lifting and supporting the hull above the water while in forward motion, a mast having a boom and mounted on said hull for fore and aft swiveling, fore and back stays bracing said mast, means on the bow and stern of said hull guiding the lower ends of said fore and back stays for upright movement relative to the hull, a traveler coupled to said boom by a sheet and mounted on said hull for upright movement, a computer element mounted in said hull to turn about a fixed axis, means transmitting the load of said back stay and said traveler to said element to turn the same in one direction, a spring yieldably restraining said element against such turning, means transmitting the movement of said forestay to said element to turn the same in the opposite direction, and mechanism responsive to the resultant angular displacement of said element and operable to correspondingly adjust one of said hydrofoils in a direction to change the angle of incidence thereof and compensate for the corresponding change in pitching moment applied to said hull by the sail.

8. A hydrofoil sailboat having, in combination, a hull, front and rear hydrofoils thereon for lifting and supporting the hull above the water while in forward motion, a mast, means on said hull mounting the lower end of said mast for fore and aft swiveling of the mast, fore and back stays bracings said mast, means on the bow and stern of said hull guiding the lower ends of said

fore and back stays, a computer element mounted in said hull to turn about a fixed axis, means transmitting the loads of said back and forestays to said element tending to turn the latter in opposite directions, a spring yieldably restraining said element against such turning, and mechanism responsive to the resultant angular displacement of said element and operable to correspondingly adjust one of said hydrofoils in a direction to change the angle of incidence thereof and compensate for each change in pitching moment applied to said hull by the sail.

9. A hydrofoil sailboat having, in combination, a hull, front and rear hydrofoils thereon for lifting and supporting the hull above the water while in forward motion, a mast, means on said hull mounting the lower end of said mast for fore and aft swiveling of the mast, fore and back stays bracing said mast, means on the bow and stern of said hull guiding the lower ends of said fore and back stays for upright movement relative to the hull, a computer element mounted in said hull to turn about a fixed axis, means transmitting the loads of said back and forestays to said element tending to turn the latter in opposite directions, a spring yieldably restraining said element against such turning, and mechanism for communicating the resultant angular displacement of said element directly to said rear hydrofoil in a direction to adjust the angle of incidence and compensate for each change in pitching moment applied to said hull by the sail.

10. A hydrofoil sailboat having, in combination, a hull, front and rear hydrofoils thereon for lifting and supporting the hull above the water while in forward motion, a mast, means coupling the lower end of said mast to said hull for fore and aft swiveling of the mast, means for bracing said mast including a stay, means on said hull guiding the lower end of said back stay for upright movement relative to the hull, a computer element mounted in said hull to turn about a fixed axis, means transmitting the loads of said stay to said element to turn the same in one direction, a spring yieldably restraining said element against such turning, and mechanism for communicating the resultant angular displacement of said element to said rear hydrofoil in a direction to adjust the angle of incidence and compensate for each change in pitching moment applied to said hull by the sail.

11. In a hydrofoil boat, the combination of, a hull, a hydrofoil system mounted on said hull for lifting and supporting the same above the water while in forward motion including at least one hydrofoil having an angle of incidence adjustable to vary its lifting force and thereby trim the hull, means for applying a thrust for propelling the hull forwardly, said thrust being variable in magnitude and directed horizontally along a line spaced above the hull, and means responsive to changes in said thrust and operable to adjust said incidence angle in a direction and by an amount to maintain the trim of the hull while the latter is foil borne.

12. In a hydrofoil boat, the combination of, a hull, fore and aft hydrofoils for lifting and supporting said hull above the water while in forward motion, at least one hydrofoil having an angle of incidence adjustable to vary the lifting force derived thereby, a member mounted on said hull for fore and aft movement, a spring yieldably restraining said movement of said member relative to said hull, means for applying a horizontally directed thrust of variable magnitude to said member to propel the hull forwardly, and means for communicating the fore and aft movements of said member to said adjustable hydrofoil to vary said incidence angle in a direction and by an amount to maintain proper trim of the hull while the latter is foil borne.

13. In a hydrofoil boat, the combination of, a hull, fore and aft hydrofoils for lifting and supporting said hull above the water while in forward motion, at least one hydrofoil having an angle of incidence adjustable to vary the lifting force derived thereby during planing, a member mounted on said hull for fore and aft movement, means for applying a propelling thrust of variable magnitude to said member, means yieldably biasing said member rearwardly relative to said hull whereby the position of said member relative to said hull corresponds to the magnitude of said propelling thrust, and means responsive to the fore and aft movements of said member to correspondingly adjust said adjustable hydrofoil and vary said incidence angle in a direction and by an amount to maintain proper trim of the hull while the latter is foil borne.

14. In a hydrofoil boat, the combination of, a hull, a plurality of hydrofoils attached to said hull and adapted during forward motion of the hull to raise the same out of and maintain the hull above the water surface, said hydrofoils being spaced apart longitudinally of said hull and at least one thereof having an adjustable angle of incidence, a member mounted on said hull and adapted to respond to the thrust for propelling the boat forwardly, means for sensing changes in said thrust, and means responsive to said thrust changes and operable to correspondingly adjust said incidence angle and thereby change the lifting force to compensate for such changes whereby to maintain a trimmed position of said hull.

15. A hydrofoil sailboat having, in combination, a hull, a sail rig including an upstanding mast, means intermediate the ends of said hull supporting said mast to swivel about a horizontal axis extending transversely of the hull, three hydrofoils mounted on said hull and operable to support said hull above the water when under way and provide resistance for overcoming the side force and rolling moment of the sail, one of said hydrofoils being mounted on said hull for adjustment about a transverse horizontal axis to vary its angle of incidence, and means responsive to changes in the trimming moment applied by the sail rig to said hull and operable to adjust the incidence angle of said adjustable hydrofoil in a direction to overcome and compensate for said trimming moment whereby to maintain the trim of said hull in spite of changes in the magnitude of said trimming moment.

16. A hydrofoil sailboat having, in combination, a hull, a sail supported thereon for exerting a propelling thrust directed along a center of pressure spaced above the hull, and a pair of hydrofoils attached to opposite sides of said hull and projecting below the bottom of said hull, said hydrofoils having lifting elements of foil cross section converging downwardly toward the center plane of said hull and acting during forward motion of the hull through the water to exert on the hull resultant lifting forces directed along lines which converge upwardly and intersect said center plane at a point disposed substantially at the level of said center of pressure.

17. In a hydrofoil boat, the combination of, a hull, fore and aft hydrofoils having active portions of foil cross section submerged in the water for lifting and supporting said hull above the water in forward motion thereof, and means on said hull suspending one of said hydrofoils for swiveling about a horizontal axis extending transversely of the hull and spaced above the active portion of such hydrofoil, the cross section of said active portion having a chord line whose rear end portion makes an acute included angle of approximately 85 degrees with an upright plane including said horizontal axis whereby the line of action of the lifting force exerted by said hydrofoil lies substantially in said plane.

18. In a hydrofoil boat, the combination of, a hull, fore and aft hydrofoils having active portions of foil cross section submerged in the water for lifting and supporting said hull above the water while in forward motion, and means on said hull suspending one of said hydrofoils for swiveling about a horizontal axis extending transversely of the hull and spaced above the active portion of such

hydrofoil, the vertical cross sections of said active portion being spaced along the latter and extending longitudinally of the hull and having centers lying in a single upright plane disposed at an acute included angle of approximately 85 degrees with the rear portion of the chord of each of said cross sections whereby the line of action of the lifting force exerted by said hydrofoil is disposed close to said plane and the moment of such force about said axis is correspondingly reduced.

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