

Feb. 5, 1952

A. B. HAZARD
HYDROFOIL BOAT

2,584,347

Filed April 11, 1950

2 SHEETS—SHEET 1

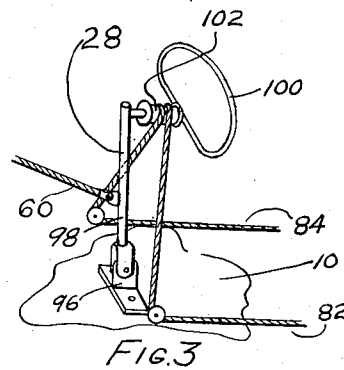
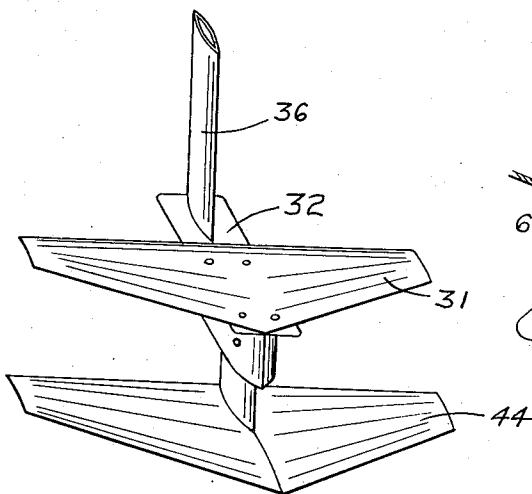
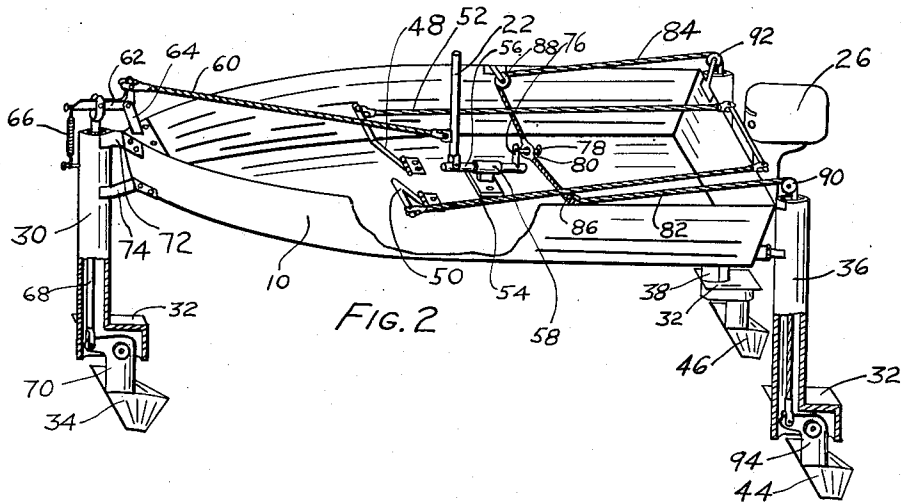
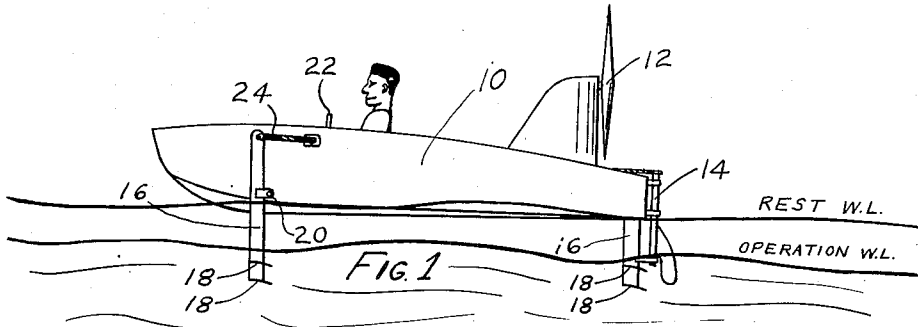


FIG. 4

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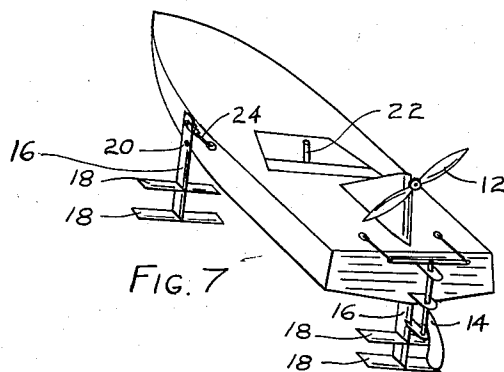
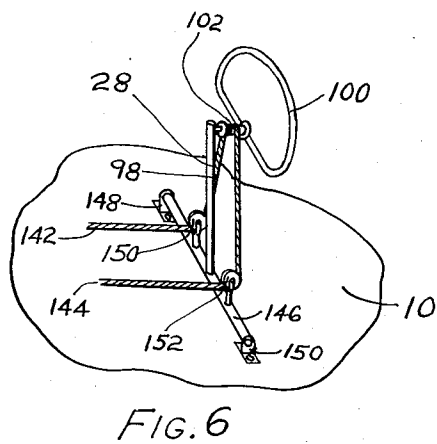
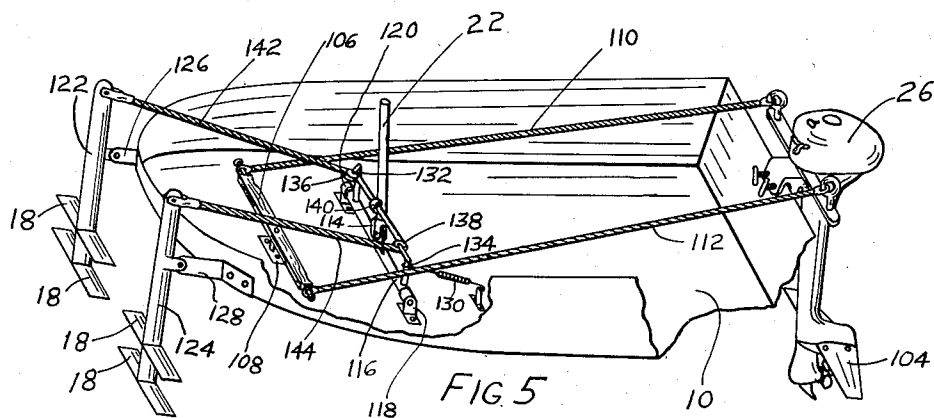
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HYDROFOIL BOAT

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2 SHEETS—SHEET 2



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HYDROFOIL BOAT

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5 Claims. (Cl. 114—66.5)

1

The present invention relates to water craft such as boats etc. and pertains more particularly to boats of the type in which the hull of the boat emerges in its entirety from the water when the craft passes from the position of rest to that of speed while the elements of support remain at least partially immersed in the water.

One object then of the present invention is to provide a water craft of new and novel design which is capable of high speeds and which may be easily, quickly and surely maneuvered.

Another object of this invention is to provide a new and highly efficient water craft, simple in construction and economical to manufacture.

Still another object of this invention is to provide means for accomplishing the above objects which may be quickly and easily attached to present-day boats of conventional design.

Other and further objects and advantages will become apparent as this description proceeds. The invention then consists in the novel construction, combination and arrangement of parts, as hereinafter more specifically set forth, claimed and shown in the accompanying drawings which form a part of this application for Letters Patent.

In the accompanying drawings I have illustrated several preferred and practical embodiments of my invention, it being understood, however, that the drawings are merely illustrative and that my inventive-concept is susceptible of other embodiments and utilizations, and that the illustrated embodiments likewise are susceptible of a wide range of variation and modification without departing from the spirit of my invention or the scope of the appended claims.

In these drawings which accompany and form a part of this specification, and in which like reference numerals have been used to designate the same or like parts throughout the several figures:

Figure 1 is a side elevation of one form of the hydrofoil boat of my invention having an air drive and a water rudder. Operational and rest waterlines are indicated.

Figure 2 is a perspective view partially broken away and partially in section showing the hydrofoil boat of my invention, the boat having an outboard motor drive;

Figure 3 is a view in perspective of a control wheel system adapted for use in place of the stick control shown in Figure 2;

Figure 4 is a perspective view of one of the struts of the hydrofoil boat shown in Figure 2; illustrating one possible arrangement of fixed and movable hydrofoils;

2

Figure 5 is a perspective view partially broken away of the hydrofoil boat of my invention showing a different type of control system than that utilized in the boat shown in Figure 2;

Figure 6 is a view in perspective of a control wheel system adapted for use in place of the stick control shown in Figure 5; and,

Figure 7 is an end view in perspective of the boat shown in Figure 1.

Referring now in detail to the drawings and first advertg to that form of the invention shown in Figures 1 and 7, the reference numeral 10 has been used to designate generally a water craft of conventional design, having an air propeller drive 12 and a rudder 14 for steering. The reference numeral 16 has been used to designate generally a strut member having hydrofoils 18 mounted thereon. In this particular form of the invention there are two struts 16 at the front of the boat 10 and one strut 16 near the stern of the boat. The struts 16 are pivotally mounted to the boat 10 by pivot means 20 so that they may be moved forward or backward by means of a control stick or wheel which controls the movements of the struts 16 by the rope or cable 24 connecting the upper end of the strut 16 to the control stick 22. The lift on a hydrofoil is proportional to the square of the velocity with which it is moved through the water and to the angle of attack or pitch. Thus, if the control stick 22 is pulled backwards it causes the upper part of the struts 16 to move backward and the lower part of the struts, carrying the hydrofoils 18, to move forward, about the pivot point 20, thus causing the hydrofoils 18 carried by the strut 16 to increase their angle of attack or pitch which increases the lift at the front end of the boat 10 and the pitch of the boat 10 and the lift of all hydrofoils 18, causing it to rise from the surface of the water, as is explained in greater detail hereafter. Conversely, if the control stick 22 is pushed forward, the upper part of the struts 16 is also moved forward while the lower part of the struts 16 carrying the hydrofoils 18 is moved backward about the pivot point 20, thus decreasing the angle of attack or pitch of the hydrofoils, which in turn decreases the lift of the hydrofoils and causes the boat to move downwardly toward the surface of the water. The boat 10 may be steered in a conventional manner by means such as the rudder assembly 14, which, if desired may also be connected to the control stick 22.

Figure 2 shows a modified form of the watercraft of my invention. The reference numeral 10 has again been used to generally designate a

3

boat, shown in Figure 2 as a conventional type. The boat 10 has been shown as being driven by a conventional outboard motor 26, although it is to be understood that the principles of my invention may be readily adapted for use on any type watercraft driven by any type propelling means such as inboard motors, air drives etc. without departing from the spirit of my invention or the scope of the subjoined claims. In Figure 2 I have also illustrated a control stick 22 used to control the movements of the boat 10 on the water, although a wheel control shown in Figure 3 and designated generally by the reference numeral 28 may be equally well used. The stick 22 or the control wheel 28 are of a type previously used in controlling the movements of airplanes through the air. A strut 30 carrying a flat plate 32 which may have a fixed hydrofoil 31 secured thereto and a movable hydrofoil 34, as shown most clearly in Figure 4 is secured to the front of the boat 10, and two struts designated by the reference numerals 36 and 38 are pivotally secured to the rear of the boat on opposite sides thereof as is shown most clearly in Figure 2. The struts 36 and 38 also have flat plates 32, which may also have fixed hydrofoils 31 secured thereto and movable hydrofoils 44 and 46 respectively mounted thereon. The details of the construction of these struts 30, 36 and 38 is shown most clearly in Figures 2 and 4. While I have illustrated the strut members as carrying one fixed and one movable hydrofoil for the sake of simplicity, it is to be understood that any number of fixed and movable hydrofoils may be carried by the struts. Attached to the outboard motor 26 are rudder pedals 48 and 50 shown pivotally mounted on the floor of the boat 10. The rudder pedals may be attached to either side of the outboard motor 26 by means of the ropes or cables 52 and 54 respectively. Thus, when the operator puts pressure on the right rudder pedal, the rudder or outboard motor will be moved in such a direction as to cause the boat to turn to the right and vice versa. A hand throttle (not shown) is placed within easy reach of the operator to control the speed of the watercraft. It should be noted at this point that all control cables or ropes may have some means for tightening and adjusting the same such as turnbuckles or the like. The stick 22 is pivotally connected to a round bar member 56 which goes through and is held in place by a collar member 58 secured to the floor of the boat 10. This arrangement permits the stick 22 to be moved backward or forward and also turned from side to side as is shown most clearly in Figure 2. A rope or cable 60 runs from the front of the stick 22 to a pivotally mounted L-shaped lever arm pivoted to a support member 64 at the bow of the boat 10. The lever arm 62 may be spring biased by a spring 66, as shown in Figure 2 and a control rod 68 extends from the long arm of the L-shaped lever arm 62 to a second pivotally mounted lever 70 at the lower part of the strut 30, said lever 70 carrying the movable hydrofoil 34. The strut 30 may be secured to the bow of the boat 10 by means of the brackets 72 and 74 as is shown most clearly in Figure 2. The bar 56 of the stick 22 has an upwardly extending lever arm 76 at the rear end thereof which moves from side to side as the stick 22 is moved from side to side. A bolt 78 extends from the lever arm 76 through a collar member 80. Control ropes or cables 82 and 84 are attached to the collar 80 and run laterally, one to each side of the boat 10

4

where they pass over pulleys 86 and 88 respectively and then run rearwardly along the sides of the boat 10 over pulleys 90 and 92 respectively as is shown most clearly in Figure 2. The control ropes or cables 82 and 84 pass down through the strut members 36 and 38 respectively and are attached at the bottom of said strut members to pivoted levers such as that indicated by the reference numeral 94, the said levers being attached to the movable hydrofoils 44 and 46 as is shown in Figure 2. If a control wheel 28 such as that shown in Figure 3 is used, the operation is quite similar. The control wheel 28 comprises a rod portion 98 pivotally mounted to a bracket member 96 secured to the floor of the boat 10 so that it is free to move backwards and forwards. The control rope or cable 60 is attached to the front end of the rod portion 98. A wheel member which I have designated by the reference numeral is rotatably secured to the rod portion 98 and the control ropes or cables 82 and 84 are secured to a drum 102 mounted on the shaft of said wheel portion 100, so that when the wheel 100 is rotated the control ropes 82 and 84 move with it as is shown most clearly in Figure 3.

It will thus be seen that I have introduced three types of control systems in this new and novel watercraft of my invention. The rudder pedals 48 and 50 control the direction of the boat 10 about the yaw axis. The control stick 22 or 98 if moved forward or backwards controls the pitch of the whole boat 10, and if the control stick 22 is moved in a sideways direction, or if the control wheel 100 is turned the roll of the boat 10 is controlled. The operation then of the craft is rather simple. If the control stick 22 or 98 is pulled back it will move the control rope or cable 60 backwards too which in turn will move the movable hydrofoil 34 forward and thus increase its angle of attack or pitch. This means as heretofore explained that there is more lift generated by the front hydrofoil which introduces a pitching moment about the pitch axis of the craft which causes the front end of the boat to rise. When the bow of the boat rises the pitch of the whole boat 10 is increased which means that the pitch of all of the hydrofoils will be increased with the increased pitch of the boat which in turn means that the lift of all of the hydrofoils will be increased and therefore the boat will climb upwards, away from the surface of the water. If the stick 22 or 98 is pushed forward there is a reverse effect, i. e. the movement of the stick forward moves the control rope or cable 60 forward and the spring member 66 or the water forces on the hydrofoil 34 causes the angle of attack or pitch on the movable hydrofoil 34 to be decreased, there is therefore less lift in front, the bow of the boat 10 drops the pitch of the craft 10 and the pitch of all of the hydrofoils is decreased, the lift is decreased and the boat descends toward the surface of the water.

To control the craft about the roll axis, the stick 22 is moved sideways or the wheel member 100 is turned in the desired direction. To illustrate, if it is desired to bank the boat 10 to the right, the control stick 22 is moved to the right, or the control wheel 100 is turned to the right, and as previously explained this will cause the angle of attack or pitch of the movable hydrofoil 46, on the right side of the boat 10, to decrease, and at the same time the pitch of the movable hydrofoil 44 on the left hand side of the boat is increased. This then produces a rolling moment about the longitudinal axis of the boat

5

10 by increasing the lift forces on the left side and decreasing the lift forces on the right side so that the right side of the boat 10 becomes lower than the left side. Opposite movement of the control stick 22 or the wheel member 100 will produce opposite results.

When the right rudder pedal 48 is pushed forward the control rope or cable 52 will move forward and turn the rudder 14 or outboard motor 26 in such a direction as to cause the bow of the boat 10 to turn to the right. Pressure by the operator on the left rudder pedal 50 will cause the bow of the boat 10 to turn to the left.

Figure 5 illustrates another modification of the new and novel watercraft of my invention. The reference numeral 10 has again been used to generally designate the boat, and the reference numeral 26 an outboard motor carrying a hydrofoil 104 on the lower drive shaft housing thereof. A rudder bar 106 is pivotally connected to a supporting bracket 108 mounted on the floor of the boat 10. Control ropes or cables 110 and 112 are connected to each end of the rudder bar 106 as is shown most clearly in Figure 5. The opposite ends of the control ropes or cables 110 and 112 are connected to either side of the outboard motor 26 at the stern of the boat 10. A control stick 22 is pivotally connected to a bracket member 114 carried on a rod 116 which turns in pivot mounts 118 and 120 secured to the bottom of the boat 10 as is shown most clearly in Figure 5. At the bow of the boat are two strut members designated by the reference numerals 122 and 124 which carry fixed hydrofoils 18 rigidly secured thereto. The strut members 122 and 124 are pivotally secured to the bow of the boat 10 by means of brackets 126 and 128 respectively. If desired, the strut members 122 and 124 may be spring biased by means of the spring 130 in order to help balance out some of the drag moment introduced into the control system. The rod 116 carries two pulley bracket mounting members 132 and 134 carrying pulleys 136 and 138 respectively. Through an eye member 140 carried on the stick 22 are fastened control ropes or cables 142 and 144 which pass over the pulleys 136 and 138 respectively and the other ends of the control ropes or cables are secured to the upper ends of the strut members 122 and 124 respectively as is shown most clearly in Figure 5. Again tightening means such as turnbuckles are used on all control ropes and cables in order to provide a method of keeping slack out of the control system and providing equal response from all members when the controls are used by the operator of the boat. If desired, a control wheel, designated generally by the reference numeral 28, such as that shown in Figure 6 may be used in place of the control stick 22. A control rod 98 carries a wheel member 100 rotatably mounted thereon, said wheel member 100 having a drum 102 carried on the shaft thereof. The previously described control ropes or cables may be wound around the drum 102 so that turning the wheel 100 will cause movement of the strut members 122 and 124. The control rod 98 is rigidly secured to a bar member 146 which turns in pivot mounts 148 and 150 secured to the floor of the boat 10. The bar member 146 carries two pulleys 152 and 154 over which pass the control ropes or cables 142 and 144 respectively as is shown most clearly in Figure 6.

The control system just described illustrates the principle of rotating the struts and hydrofoils together in order to obtain complete con-

6

trol of the new and novel watercraft of my invention. The rudder bar 106 controls the direction of the boat 10 about the yaw axis. If it is desired to turn the nose of the boat to the left, the operator simply pushes on the left side of the rudder bar 106 which moves the control rope or cable 112 forward and turns the rudder or outboard motor so that the boat turns left. To turn the nose of the boat to the right the operator merely presses on the right side of the rudder bar 106. The speed of the boat may be controlled by a hand throttle (not shown) placed conveniently near the operator. The control stick 22 or the control wheel 100 if moved backwards or forwards controls the pitch of the whole boat 10. Thus, if the control stick 22 or control wheel 100 is moved backward it pulls the control ropes or cables 142 and 144 backwards, which in turn moves the upper part of the struts 122 and 124 backwards, thus moving the lower part of the struts 122 and 124, which carry the hydrofoils 18, forward, thus increasing the angle of attack or pitch of the hydrofoils 18 and thereby increasing the lift on the front of the boat 10 which introduces a pitching moment about the pitch axis of the boat 10 causing the front end of the boat to rise. When the bow of the boat rises, the pitch of the whole boat is increased which means that the pitch of all of the hydrofoils will be increased which in turn means that the lift of all of the hydrofoils will be increased and therefore the boat will climb upwards, away from the surface of the water. If the stick 22 or the control wheel 100 is moved forwards by the operator there will be a reverse effect, i. e. the control ropes or cables 142 and 144 will move forward as will the upper ends of the struts 122 and 124 which in turn will cause the lower ends of the strut members 122 and 124 to move backward, thus decreasing the pitch of the hydrofoils 18 and consequently their lift so that the bow of the boat 10 drops, and the pitch of the craft and the pitch of all of the hydrofoils is decreased, the lift is thus decreased and the boat descends toward the surface of the water.

To control the craft about the roll axis, the stick 22 is moved sideways or the wheel member 100 is turned in the desired direction. Thus, if it is desired to bank the boat 10 to the right, the control stick 22 is moved to the right, or the control wheel 100 is turned to the right, and as heretofore explained this will cause the angle of attack or pitch of the hydrofoils on the right side of the boat to decrease, and at the same time the pitch of the hydrofoils on the left side of the boat will be increased. This then produces a rolling moment about the longitudinal axis of the boat 10 by increasing the lift forces on the left side and decreasing the lift forces on the right side so that the right side of the boat 10 becomes lower than the left side. Opposite movement of the control stick 22 or the wheel member 100 will produce the opposite result.

From the foregoing description it will be readily apparent that I have produced a watercraft of new and novel design. As the lift of the hydrofoils is increased the boat hull will rise upwards from the surface of the water until it is entirely clear of the water and only the hydrofoils will remain submerged so that there is very little resistance, and very high speeds will be obtained with a comparatively small expenditure of power. In general the motion of the controls by the operator will produce a rotation in the same direction and about the same axis on the boat

as the same movements of the controls in an airplane would produce about the corresponding axis in an airplane. For this reason a hydrofoil boat equipped with airplane type controls as described in this specification would make a very desirable preflight trainer. A flying student could become orientated to the control system of an airplane at much less expense and with much greater safety than by starting to learn in an airplane. If desired, an airplane type automatic pilot system could be adapted for use with watercraft of this type.

It is to be understood that the forms of my invention herein shown and described are to be taken as preferred and practical embodiments of the same, and that various changes may be made in the shape, size and arrangement of parts without departing from the spirit of my invention or the scope of the appended claims. For example, in larger boats it may be found desirable to incorporate booster elements in the control system. However, this would probably only be necessary in extremely large boats since there is a booster system inherently present in the design, since a small increase in lift on one of the foils at the front end of boat will tilt the whole boat thus increasing the angle of pitch and lift of all of the hydrofoils.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. The combination with a boat hull, a tubular strut attached to said hull and projecting downwardly of the bottom of said hull, said strut being open at its lower end, a bell-crank lever pivoted at its angle within the lower open end of said strut, said lever having an upright arm projecting below said strut, a hydrofoil fixed to said upright lever arm, control means within said boat, and an operative connection between said control means and the remaining arm of said lever.

2. The combination with a boat hull, a tubular strut attached to said hull and projecting downwardly of the bottom of said hull, said strut being open at its lower end, a bell-crank lever pivoted at its angle within the lower open end of said strut, said lever having an upright arm projecting below said strut, a hydrofoil fixed to said upright lever arm, an oscillatory control arm within said boat, and an operative connection between said control arm and the remaining arm of said bell-crank lever.

3. The combination with a boat hull, a tubular strut attached to said hull and projecting downwardly of the bottom of said hull, said strut being open at its lower end, a bell-crank lever pivoted at its angle within the lower open end of said strut, said lever having an upright arm projecting below said strut, a hydrofoil fixed to said upright lever arm, an oscillatory control arm

within said boat, a shaft whereeto said control arm is fixed, a rock arm projecting from said shaft, a pulley mounted on the top of said strut, and a cable carried by said rock arm extending over said pulley and connected to the remaining arm of said bell-crank lever.

4. The combination with a boat hull, a tubular strut attached to said hull and projecting downwardly of the bottom of said hull, said strut being open at its lower end, a bell-crank lever pivoted at its angle within the lower open end of said strut, said lever having an upright arm projecting below said strut, a hydrofoil fixed to said upright lever arm, an oscillatory control arm within said boat, a bracket fixed to said boat adjacent the top of said strut, a second bell-crank lever pivoted at its angle to said bracket and having one horizontal arm extending over the top of said strut and its other arm extending upwardly from the bracket, a cable connecting the upwardly extending bell-crank arm and said control arm, and a link connecting said bell-crank levers.

5. The combination with a boat hull, a tubular strut attached to said hull and projecting downwardly of the bottom of said hull, said strut being open at its lower end, a bell-crank lever pivoted at its angle within the lower open end of said strut, said lever having an upright arm projecting below said strut, a hydrofoil fixed to said upright lever arm, an oscillatory control arm within said boat, a bracket fixed to said boat adjacent the top of said strut, a second bell-crank lever pivoted at its angle to said bracket and having one horizontal arm extending over the top of said strut and its other arm extending upwardly from the bracket, a cable connecting the upwardly extending bell-crank arm and said control arm, a link connecting said bell-crank levers, a coiled tension spring connecting said horizontal bell-crank arm and said strut.

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