Jan. 14, 1964 H. VON SCHERTEL 3,117,546

AUTOMATIC HYDROFOIL CONTROL SYSTEM FOR WATERCRAFT

Filed Nov. 4, 1960 2 Sheets-Sheet 1

Fig. 1a

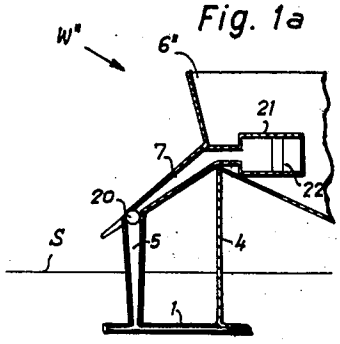


Fig. 1

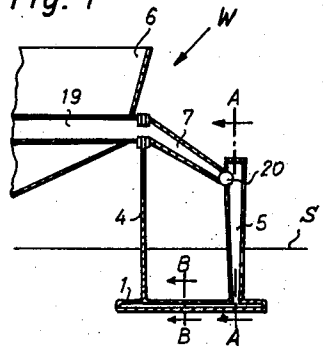


Fig. 2

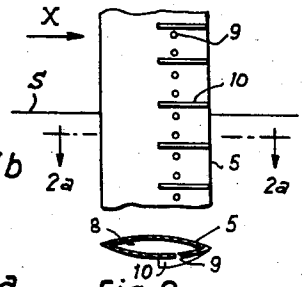


Fig. 2a

Fig. 3

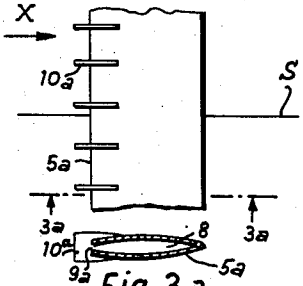


Fig. 3a



Fig. 7b

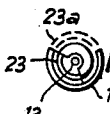


Fig. 7a

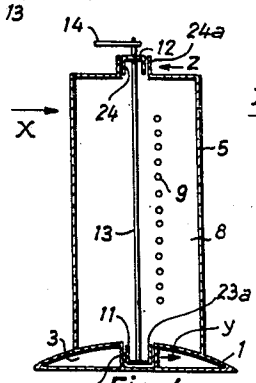


Fig. 4

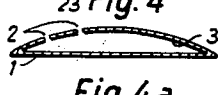


Fig. 4a

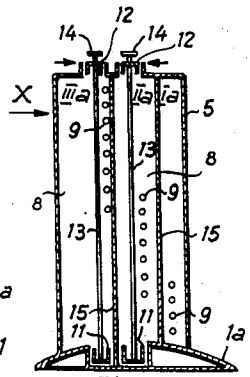


Fig. 5

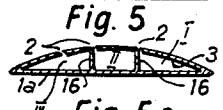


Fig. 5a

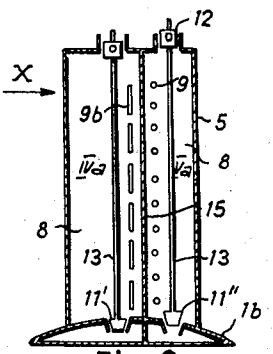


Fig. 6

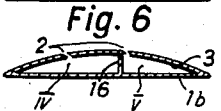


Fig. 6a

INVENTOR:
HANNS VON SCHERTEL

BY Michael S. Striker

his ATTORNEY

Jan. 14, 1964 H. VON SCHERTEL 3,117,546

AUTOMATIC HYDROFOIL CONTROL SYSTEM FOR WATERCRAFT

Filed Nov. 4, 1960 2 Sheets-Sheet 2

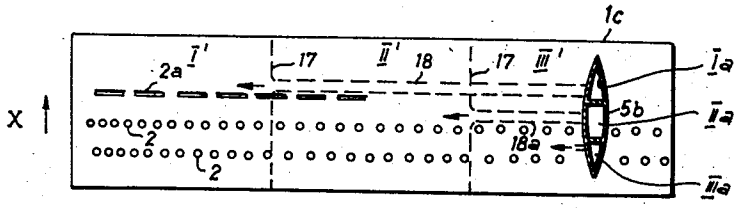


Fig 8

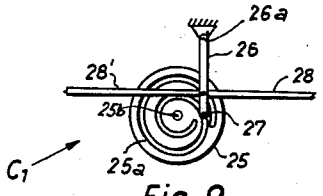


Fig. 9

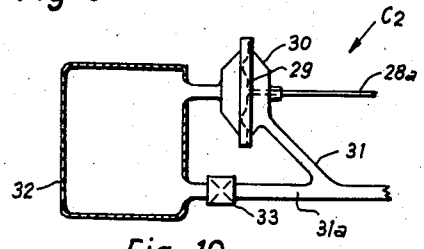
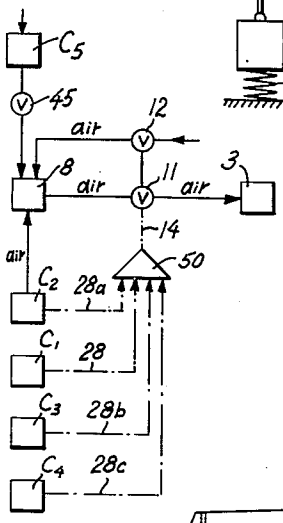


Fig. 10

Fig. 15



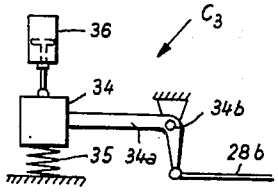


Fig. 11

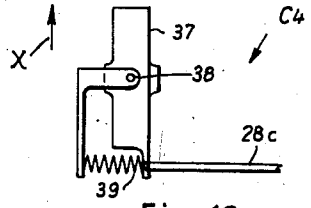


Fig. 12

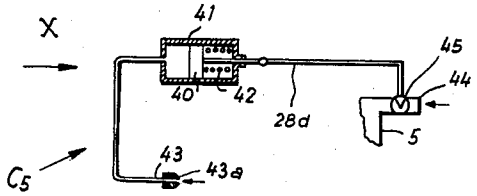


Fig. 13

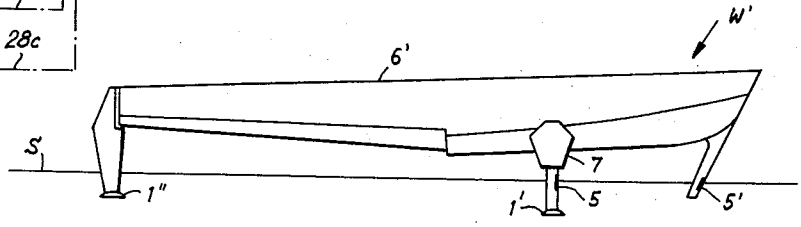


Fig. 14

INVENTOR:
HANNS VON SCHERTEL

BY Michael S. Striker
his ATTORNEY

United States Patent Office 3,117,546 Patented Jan. 14, 1964

3,117,546

AUTOMATIC HYDROFOIL CONTROL SYSTEM FOR WATERCRAFT

Hanns von Schertel, Hergiswil am See, Switzerland

Filed Nov. 4, 1960, Ser. No. 67,189
31 Claims. (Cl. 114—66.5)

The present invention relates to improvements in watercraft of the type comprising one or more cavitating or non-cavitating, preferably fully submerged hydrofoils (hereinafter called "foils") which extend transversely and carry the weight of the hull, and more particularly to an automatic control system which regulates the extent to which the foil or foils are submerged in water when the watercraft is in motion and which also improves the seaworthiness of the water craft.

Fully submerged foils for watercraft of the above outlined character do not possess sufficient stability to retain a given distance from the water surface and, therefore, such foils must be combined with special control systems which regulate the extent to which the foils may sink by changing the lift force whenever the foils descend too far below or rise too close to the water surface. The presently known control systems respond only to changes in optimum distance of the foils from the water surface and, therefore, they are considered satisfactory for use in relatively calm waters, i.e. when the wave formation is rather negligible, but they cannot properly control the foils in turbulent waters. In the latter instance, the control system must be capable of responding to certain other factors, such as the speed at which the foils change their distance from the water surface, the vertical acceleration of the foils, and also the rolling, pitching, heeling or trim of the water craft from its normal position. The above influences or factors become very important and must be given full consideration when a foil-supported watercraft is operated in heavy seas, and the control system utilized under such circumstances must be capable of transmitting corresponding signals to the foils so that the latter will react in time and will change or retain their distance from the water surface as the momentary conditions might require in dependency on one or more of the above factors.

In certain presently known control systems for such purposes, the depth (i.e. the distance from the water surface) of the foils is adjusted by utilizing rockable or swingable foils which, by changing their inclination, affect the lift force, or by providing hingedly connected flaps at the trailing edges of the foils and by adjusting the position of the flaps and hence of the momentarily prevailing lift force by an arrangement comprising depth-sensitive mechanical or electronic commando elements. According to one prior proposal, scanning elements are mounted on elongated forwardly extending arms in such a way as to slide on the water surface and to bring about a change in the inclination of the foils or of their flaps whenever the foils change their distance from the water surface. Such control systems are rather bulky and too delicate for use in turbulent waters.

According to another prior proposal, scanning elements provided with electrical contactors are used, and the contactors are constructed in such a way that they complete an electric circuit whenever the scanning elements are submerged in water to thereby transmit a control signal to the foils or to the flaps. It was further proposed to utilide a sonic altimeter which records the depth of the foils and transmits corresponding signals to the foil adjusting mechanism. Such electronic control systems must include an amplifier and two sources of energy which not only increases the cost but also leads to frequent malfunctioning and reduces the reliability of the control systems so that the latter cannot insure full stability of water craft under all operating conditions.

An important object of the present invention is to provide a control system for the foils of foil-supported watercraft which, in its basic form, operates without movable component parts from the point where a control signal is received and all the way to the point where the lift force upon the foil is changed, and which may be readily installed in many types of foil-supported watercraft of presently known design.

Another object of the invention is to provide a control system of the just outlined characteristics which is capable of operating without amplifiers and without separate sources of energy though it can insure full stability of watercraft in calm as well as in turbulent waters.

A further object of the invention is to provide a control system for at least partially submerged foils of a foil-supported watercraft which is of exceptionally rugged and very simple construction, which is sufficiently stable to withstand repeated collisions with driftwood and other partly or fully submerged objects, whose reaction to changes in the position of foils with respect to the water surface is fully automatic, and which consists of a very small number of component parts.

An additional object of the instant invention is to provide a control system of the above described type which is capable of taking into consideration all factors which arise in actual use of a foil-supported watercraft in calm and/or in turbulent waters.

A concomitant object of my invention is to provide a control system for the foils of foil-supported watercraft which is especially suited for use in turbulent waters but which may be readily adapted for use in calmer waters.

Still another object of the invention is to provide a control system of the above outlined characteristics whose main component part simultaneously performs at least one additional function, for example, by serving as a component part of the means for connecting the respective foil with the hull or by constituting the sole connection between the foil and the hull.

An additional object of the invention is to provide a control system for at least partly submerged foils of foil-supported watercraft which may be combined with one or more control devices each automatically responsive to a given factor which may arise in actual operation of the watercraft, e.g. pitching, rolling, listing, heeling, forward acceleration, vertical acceleration and certain other factors.

A further object of my invention is to provide a control system of the above outlined characteristics whose sensitivity may be varied from the pilot stand and which is capable of preventing an overturning of the watercraft in a sharp curve.

With the above objects in view, the invention resides in the provision of a watercraft which is supported in water by one or more at least partially submerged and at least partially hollow foils each of which extends substantially transversely of the hull and is formed at its upper or suction side with air discharge aperture means, the watercraft further comprising a control system for at least one of its foils which is adapted to deliver predetermined quantities of air to the aperture means in dependency on the momentary position of the watercraft with respect to the water surface and preferably also in response to changes in forward speed, vertical speed and/or vertical acceleration of the watercraft. In its basic form, the control system comprises at least one at least partialy hollow control member or sensing member whose internal space communicates with the internal space of the respective foil and which is formed with normally partly exposed and partly submerged air intake

orifice means arranged in the area of the subpressure or suction produced by the water flow at the profile of the control member in such a way that the ratio of the combined cross-sectional area of exposed orifice means to the combined cross-sectional area of submerged orifice means changes with the extent to which the control member is submerged in water. Consequently, whenever a foil descends deeper into water when the watercraft is in motion, the extent to which the control member is immersed in water also increases whereby air admission to the immersed orifice means is cut off by the water flow which produces subpressure at such immersed orifice means, and the momentarily exposed orifice means deliver less air to the aperture means at the suction side of the foil so that the lifting force to which the foil is subjected increases and causes an upward movement of the foil together with the control member. On the other hand, if the control member emerges to a greater extent from the water, the ratio of the combined cross-sectional area of exposed orifice means to the combined cross-sectional area of submerged orifice means increases so that more air is delivered to the suction side of the foil whereby the lifting force decreases and the foil is caused to descend to its normal position at a given distance from the water surface. Thus, the action of the control member is fully automatic in that it controls the delivery of air into the foil and hence the magnitude of the lifting force in dependency on the extent to which it is submerged in water.

Another feature of my invention resides in the provision of control devices, each responsive to a different factor arising when the watercraft is in actual operation, and in the provision of regulating valves which are installed in the control member and are operatively connected with the aforementioned control devices so as to permit entry of additional air into or to reduce the flow of air toward the aperture means which lead to the suction side of a foil in response to impulses received from the respective control device or devices. The control devices may selectively respond to a listing, pitching, heeling or rolling movement of the watercraft, to vertical acceleration of the watercraft, or to changes in vertical speed of the watercraft.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following detailed description of certain specific embodiments when read in connection with the accompanying drawings, in which:

FIG. 1 is a fragmentary transverse sectional view of a watercraft showing one of its fully submerged foils and a control member which forms part of the control system embodying one form of my invention;

FIG. 1*a* is a similar fragmentary transverse sectional view of a watercraft and of a different control system for one of its foils;

FIG. 2 is an enlarged fragmentary side elevational view of a control member forming part of the control system shown in FIG. 1;

FIG. 2*a* is a transverse section through the control member as seen in the direction of arrows from the line 2*a*—2*a* of FIG. 2;

FIG. 3 is an enlarged fragmentary side elevational view of a modified control member;

FIG. 3*a* is a transverse section through the modified control member as seen in the direction of arrows from the line 3*a*—3*a* of FIG. 3;

FIG. 4 is an enlarged central vertical section through the control member and an enlarged transverse section through the associated foil as seen in the direction of arrows from the line A—A of FIG. 1;

FIG. 4*a* is an enlarged transverse section through the foil as seen in the direction of arrows from the line B—B of FIG. 1;

FIG. 5 is a central vertical section through a modified control member and a transverse section through the associated foil;

FIG. 5*a* is another transverse section through the foil associated with the control member of FIG. 5;

FIG. 6 is a further central vertical section through a different control member and a transverse section through the associated foil;

FIG. 6*a* is another transverse section through the foil associated with the control member of FIG. 6;

FIG. 7*a* is an enlarged transverse section through the lower regulating valve which is mounted in the control member of FIG. 4;

FIG. 7*b* is an enlarged transverse section through the upper regulating valve of the control member shown in FIG. 4;

FIG. 8 is an enlarged top plan view of a modified foil and a horizontal section through the associated control member;

FIG. 9 is a schematic plan view of a control device which adjusts the flow of air through the regulating valves in response to changes in the course of the watercraft;

FIG. 10 is a schematic section through a control device which adjusts the flow of air through the regulating valves in response to changes in the speed at which the foil moves toward and away from the water surface;

FIG. 11 is a schematic side elevational view of a control device which is adapted to adjust the flow of air through the regulating valves in response to vertical acceleration of the watercraft;

FIG. 12 is a schematic plan view of a control device which adjusts the position of the regulating valves in response to listing and/or pitching of the watercraft;

FIG. 13 is a schematic partly side elevational and partly sectional view of a control device which adjusts the regulating valves in response to changes in the forward speed of the watercraft;

FIG. 14 is a schematic side elevational view of a watercraft which is supported on two sets of spaced transversely extending foils and whose forward foils are associated with a plurality of control members; and

FIG. 15 is a schematic diagram showing the manner in which the structure of FIG. 4 may be combined with the control devices of FIGS. 9 to 13.

Referring now in greater detail to the drawings, and first to FIG. 1, there is shown a watercraft W which is supported on water by a least one pair of fully immersed, laterally spaced, transversely extending at least partly hollow foils 1 (only one shown), each of these foils being formed with at least one internal space 3 (see FIG. 4*a*) which is bounded at its upper side by a normally concave wall formed with discharge apertures 2 through which air introduced into the space or spaces 3 may be discharged to the upper or suction side of the respective foil 1. The profile of the foils 1 need not always be such as shown in the drawings but may assume a number of other forms. In the embodiment of FIG. 4*a*, the apertures 2 are substantially perpendicular to the general plane of the upper wall which forms part of the foil 1, whereas FIGS. 5*a* and 6*a* respectivley show two foils 1*a*, 1*b* whose apertures are inclined in rearward direction so that the air passing therethrough is discharged substantially tangentially with respect to the suction side of the respective foil. Such formation of the apertures is preferred in the control system of my invention. It is assumed that the apertures 2 in the foils 1, 1*a* and 1*b* are of circular contour though, and as illustrated in FIG. 8, the upper wall of a modified foil 1*c* may be formed with differently configurated and differently arranged apertures. As shown, the apertures may also assume the form of elongated closed slots 2*a* which, together with the circular apertures 2, may but need not extend through the full length of the foil 1*c*. Also, the foil may be formed with elongated apertures 2*a* as well as with circular apertures 2, and these apertures may be disposed

in two or more rows. FIG. 8 further shows that the spacing between the apertures need not be the same, i.e. that the apertures at one end of the foil 1c are closer to each other than the apertures at the other end of the foil. As a further modification which is not illustrated in FIG. 8, the slot shaped apertures 2a may be replaced by a continuous slot of considerable length which, in some instances, may extend all the way between the two longitudinal ends of the foil. The purpose of the arrangement of apertures 2 and 2a as shown in FIG. 8 will be described in greater detail hereinafter. In all embodiments, the apertures 2 and/or 2a are preferably disposed in rows which are perpendicular to the direction in which the watercraft moves when in actual operation. Wherever applied, the arrow X indicates the direction in which the watercraft advances.

Referring back to FIG. 1, the hull 6 of the watercraft W is connected with a laterally extending auxiliary outrigger or wing 7 which supports two vertical struts 4, 5, the lower ends of these struts being secured to the foil 1. In the embodiment of FIG. 1, the hull 6 is assumed to be supported by two spaced transversely aligned horizontal foils 1 each of which is disposed at one lateral side of the hull; however, it is equally possible to support the watercraft W on a single transversely extending foil which may be inclined with reference to a horizontal plane or which may be shaped in the form of a letter V.

The outer strut 5 constitutes a control member or sensing member and forms part of the control system which determines and regulates the distance between the ideal water level or surface S and the foil 1. As can be observed in FIG. 2a, the control member 5 is of streamlined shape and is formed with an internal space 8 which communicates with the surrounding atmosphere through one or more groups of vertically spaced orifices 9. These orifices may be provided in the area of the subpressure produced by the water flow at the profile of the control member, e.g., in the central portion, but the orifices are preferably somewhat closer to the leading edge of the control member 9 and, when the watercraft W is in motion, the orifices 9 are normally located partly above and partly below the water surface. It is assumed in FIGS. 2 and 2a that the watercraft moves in a direction from the left to the right as is indicated by the arrow X. As is known, a subpressure or suction area develops along that portion of the control member 5, as viewed in FIG. 2, which is formed with the orifices 9 when the watercraft is in motion and the member 5 descends below the water surface S.

The internal space 8 of the control member 5 communicates with the internal space 3 of the foil 1 so that, when the watercraft W is in motion, the low-pressure area developing at the suction side of the foil 1 causes an inflow of air through those orifices 9 which are momentarily located above the water surface S, the air then flowing through the spaces 8, 3 and being discharged through the apertures 2. Thus, the flow of air through the apertures 2 is brought about in a fully automatic way owing to the development of the low-pressure area at the upper side of the foil 1 when the watercraft is in motion.

The control system shown in FIGS. 1, 2 and 4a operates as follows:

When the foil 1 increases its distance from the water surface S to such an extent that all orifices 9 are submerged, the supply of air to the upper side of the foil is shut off which results in an increased lift force so that the foil rapidly rises to its normal position. Such lifting action takes place whenever the number of submerged orifices increases with respect to the number of exposed orifices, i.e., whenever the ratio of combined cross-sectional area of exposed orifices 9 to the combined cross-sectional area of submerged orifices decreases while the watercraft is in motion. Alternately, when the foil 1 rises closer to the water surface, the combined cross-sectional area of exposed orifices 9 increases so that more air is drawn through the apertures 2 to thereby bring about a fully automatic descent of the foil in a direction away from the water surface by causing a reduction in the lift force. In other words, the lift force acting upon the foil decreases proportionally with an increase in the quantity of air delivered through the apertures 2 to the suction side of the foil.

As is shown in FIG. 3a, the modified control member 5a of FIG. 3 is formed with air intake orifices 9a which are provided in its trailing edge. In order to prevent atmospheric air from penetrating into the momentarily submerged orifices 9a by flowing downwardly along the trailing edge of the control member 5a when the watercraft is in motion, the adjacent vertically spaced orifices 9a are preferably separated by plate-like substantially horizontal fins (fences) 10a which extend to a given extent rearwardly and beyond the trailing edge of the member 5a. Similar fins 10 are preferably provided between the orifices 9 of the control member 5 shown in FIGS. 2 and 2a. It will be noted that the fins 10 are provided only at that side of the control member 5 which is formed with the orifices 9. In their preferred form, the fins 10 and 10a are disposed in planes which are substantially perpendicular to the general plane of the respective control member.

Though the orifices 9, 9a are normally of circular shape (see FIGS. 2, 4 and 5), it is equally possible to provide the control members with orifices 9b in the form of elongated vertically aligned slots as is shown in FIG. 6. Furthermore, it is also possible to provide at least one or all control members with one or more substantially vertical slots of such length that each thereof replaces an entire row of orifices 9, 9a or 9b. For example, the orifices 9a of FIG. 3a may form such a continuous slot which extends along the entire trailing edge of the control member 5a and which is interrupted by the horizontal fins 10a.

The manner in which the position of the foil or foils is controlled is not changed if each foil is associated with two or more control members. In fact, it is not absolutely necessary that a control member be actually connected with the associated foil so as to constitute a supporting means therefor in a manner as shown in FIG. 1. For example, and as shown in FIG. 14, the watercraft W' is provided with a forward set of foils 1' and with a rear set of foils 1''. The rear foils 1'' are not associated with a control system; however, each forward foil 1' is associated with two control members 5, 5' the latter of which is disposed at the bow of the hull 6'. The control member 5' communicates with the respective hollow foil 1' by conduit means (not shown) extending through or along the hull 6', while the control member 5 actually supports the respective foil 1' and constitutes a rigid connection between the outrigger or wing 7 and the foil. On the other hand, it is equally possible to utilize only the forward control member 5' for delivering controlled quantities of air to the respective foil 1' while the member 5 then merely constitutes a strut for the foil.

When the control system for a single foil 1' includes two or more control members (e.g. the members 5, 5' of FIG. 14), the quantity of air delivered to the apertures of the foil 1' depends on the ratio of combined cross-sectional area of exposed orifices to the combined cross-sectional area of submerged orifices in all control members.

The airflow establishing connection between the internal space or spaces of a control member and the internal space or spaces of the associated foil may be brought about in a number of ways. Thus, the system of FIG. 1 utilizes a control member 5 which is formed with a single internal space 8 (see FIG. 2a), this internal space 8 in turn communicating with a single internal space 3 of the associated foil 1 (FIGS. 4 and 4a). The communicative connection between the spaces 8 and 3 is established through a regulating valve 11, shown in FIGS. 4 and 7a, which may

assume the form of a common rotary slide valve. The valve 11 distributes air in the space 3 so that incoming air is uniformly divided between the apertures 2. As is clearly shown in FIG. 4*a*, the apertures 2 are provided in two rows which are adjacent to the trailing edge of the foil 1, whereas the valve 11 admits air in a direction toward the leading edge of the foil (see the arrow Y in FIG. 4) or parallel to the leading edge.

In the embodiment of FIG. 5, the internal space of the modified control member 5*b* is divided into three zones I*a*, II*a*, III*a*, by a pair of spaced vertical partitions or walls 15 which are disposed in two parallel planes located between the leading and trailing edges of the streamlined control member 5*b* and perpendicular to the direction in which the watercraft advances (arrow X). Each of these zones I*a*–III*a* receives air through a different set of vertically spaced or staggered intake orifices 9. It will be seen that the lowermost or foremost (right-hand) set of orifices 9 leading into the zone I*a* extends slightly above the level of the lowermost orifice 9 in the second or median set of orifices which communicates with the zone IIa, and that the uppermost orifice 9 in the median set is located above the level of the lowermost orifice in the uppermost or rearmost (left-hand) set of orifices which communicates with the zone III*a*. In other words, the three vertical sets or rows of orifices 9 are staggered with respect to each other but at least one orifice in at least one of these rows becomes either exposed or submerged whenever the control member 5*b* changes its vertical position with respect to the water surface.

The foil 1*a* (see FIGS. 5 and 5*a*) which is associated with the control member 5*b* is provided with vertical partitions or walls 16 which are parallel with the partitions 15 by extending between the leading and trailing edges of the foil and divide the internal space 3 into three zones I, II, III each of which communicates only with the respective zone I*a*, II*a*, III*a* of the space 8 in the control member 5*b*. It is preferred to arrange the orifices in such a way that the uppermost set or row of orifices (9 in FIG. 5) communicates with the zone III*a* of the space 8 which is communicatively connected with the rearmost zone III of the space 3 in the associated foil 1*a*, i.e. with that zone which is closest to the trailing edge of the foil 1*a*. The zone I*a* of the space 8 which communicates with the lowermost set of orifices 9 is connected with the foremost zone I*a* of the space 3, namely with that zone which is closest to the leading edge of the foil. Thus, when the control member 5*b* of FIG. 5 is immersed to such an extent that its lowermost and median rows of orifices 9 are submerged below the water surface, only the rearmost zone III of the space 3 in the foil 1*a* of FIG. 5*a* will receive a continuous supply of air, the air being drawn through the apertures 2 located closest to the trailing or left-hand edge of the foil 1*a*. As the control member 5*b* begins to rise, the median zone II and finally the foremost zone I of the space 3 in the foil 1*a* will also receive a supply of air from the respective zones II*a*, I*a* of the space 8.

The arrangement of FIG. 8 is analogous to the construction shown in FIGS. 5 and 5*a*. The internal space of the foil 1*c* is subdivided into three zones I', II', III' by two partitions or walls 17 which are parallel with the direction of forward movement (arrow X). In other words, the partitions 17 are perpendicular to the partitions 16 shown in FIG. 5*a* and to the leading and trailing edges of the foil 1*c*. The leftmost zone I' of the space in the foil 1*c* communicates with a conduit or duct 18 leading to the foremost zone I*a* of the space in the control member 5*b*. The median zone II' communicates with the median zone II*a* of the space in the control member 5*b* through a second conduit or duct 18*a*, and the rightmost zone III' communicates directly with the rearmost zone III*a*. This zone III' is more distant from the longitudinal axis of the hull than the zones I' and II' (compare with FIG. 1). The hull is assumed to be at the left-hand side of the foil 1*c* shown in FIG. 8. The orifices leading to the zone III*a* which communicates with the most distant zone III' are disposed at a level above the orifices leading to the zones I*a* and II*a* in the internal space of the control member 5*b*.

The lift characteristics of the foil (i.e. the increase in the lift force when the foil descends further below the water surface) are determined by the magnitude and spacing of the orifices 9, 9*a* and/or 9*b*. In the embodiment of FIG. 6, such characteristics may be varied at the will of the pilot so that the watercraft may be adapted to different seawaves. The space in the control member 5*c* of FIG. 6 is divided by a partition 15 into a pair of zones IV*a*, V*a* adapted to communicate with the respective zones IV, V of the internal space 3 in the foil 1*b* of FIG. 6*a*. The passage between the zones IV, IV*a* is controlled by an axially shiftable regulating valve 11', and a similar regulating valve 11'' controls the passage between the zones V, V*a*. It is assumed in FIG. 6 that only the forward regulating valve 1'' is open so that air drawn through the widely spaced orifices 9 of comparatively small cross-sectional area may be delivered into the forward zone V of the internal space 3 in the foil 1*b*. The rear zone IV*a* communicates with closely adjacent orifices 9*b* of much larger cross-sectional area so that vertical movements of the foil 1*b* will be affected much more effectively if the valve 11' is open. Since the spacing between the orifices 9 leading into the zone V*a* is much larger than the spacing between the orifices 9*b*, the movement of the regulating valve 11'' into its open position will cause only slight changes in the lifting action so that the foil 1*b* is then particularly suited for use in calm waters because it does not follow the configuration of short waves. However, when the rear regulating valve 11' is moved to its open position, the foil 1*b* responds more rapidly and will follow the configuration of higher waves which is very desirable when the watercraft is operated in turbulent waters. Thus, when the orifices 9*b* are rapidly submerged while the control member 5*c* emerges from a wave trough and enters a wave crest, the supply of air to the rear zone IV and to the rear apertures 2 of the foil 1*b* is reduced very rapidly so that a substantial lifting action develops which causes the foil to ride the wave rather than to retain its vertical position. The lifting action is reduced when the control member 5*c* emerges from a wave crest to enter into a wave trough, it being assumed that the regulating valve 11' is in open position.

It will be readily understood that, under certain circumstances, the control system may embody a control member which embodies selected or even all features described in connection with FIGS. 2 to 6, and that the foil associated with such a modified control member may also embody certain features described in connection with FIGS. 4*a*–6*a* and 8. For example, in order to render the control system less sensitive in calm waters and to thereby eliminate or reduce the influence of short waves, the internal space of the control member communicating directly with the orifices 9, 9*a* or 9*b* may be enlarged in a manner as shown in FIG. 1. In this embodiment of my invention, the means for enlarging the space into which air is drawn through the orifices of the control member comprises the outrigger or wing 7 which is made hollow and whose internal space communicates with the internal space 8 of the control member 5 through a throttle valve 20. Furthermore, the internal space of the outrigger 7 communicates with the interior of a tubular carrier 19 which is secured to the hull 6 so that air entering through the momentarily exposed orifices 9 of the control member 5 must change the pressure of air contained in a comparatively large chamber consisting of the internal space 8 in the control member 5, of the internal space in the outrigger 7 and of the internal space in the carrier 19. The connection between the interior of the outrigger 7 and of the carrier 19 on the one hand, and the internal

space 8 on the other hand may be regulated by the aforementioned throttle valve 20 which is preferably adjustable from the pilot stand by a remote control device (not shown) in the form of a Bowden wire or the like. Of course, the means which communicates with the internal space of the control member need not necessarily assume the form of an outrigger but may consist of another structural component of the watercraft as well as of a part which is provided solely for the purpose of enlarging the space with which the orifices of the control member communicate.

FIG. 1*a* illustrates a modified watercraft W'' whose inner strut 4 is directly connected with the hull 6''. The internal space of the control member 5 communicates with the internal space of an outrigger or wing 7 by means of a throttle valve 20, and the internal space of the outrigger 7 in turn communicates with a cylinder 21 reciprocably receiving a piston 22, the latter serving as a means for varying the volume of the composite chamber which communicates with the air intake orifices of the control member 5. This composite chamber includes the internal spaces of the control member 5 and of the outrigger 7 as well as that portion of the space in the cylinder 21 which is located at the left-hand side of the piston 22. It will be readily understood that the control system of FIG. 1*a* is less sensitive if the piston 22 is displaced in a direction to the right and/or if the throttle valve is in its fully open position. The piston 22 also serves as a means for varying the useful volume of the cylinder 21 in such a way that the frequency of periods at which the watercraft meets the waves is different from the characteristic frequency of the watercraft.

In its form as described hereinabove, the control system can adjust the quantities of admitted air solely in dependency on the changes in distance between a foil and the water surface. This is known as the immersion depth control. However, it is normally desirable to control the quantity of air admitted to the discharge apertures of the foil by factors other than the distance between the foil and the water surface, particularly when the watercraft is operated in turbulent waters. To that end, the control system preferably comprises at least one pair of aforementioned regulating valves 11, 12 which, in one of their forms, are shown in FIGS. 4, 7*a* and 7*b*. The valves 11, 12 are coupled to each other by a connecting rod or shaft 13 so that they may be adjusted in unison by a handgrip member 14, by remote control means (not shown) from the pilot stand, or by one, two or more control devices which will be described in greater detail in connection with FIGS. 9 to 13. The regulating valves 11, 12 are shown in the form of common rotary slide valves, i.e. a rotary movement of the shaft 13 is necessary to adjust the position of these valves in order to admit controlled quantities of air into the internal spaces 8 and 3 (valve 12) in addition to the air drawn through the orifices 9, or to throttle or completely seal the passage between the spaces 3 and 8 (valve 11).

In FIGS. 7*a* and 7*b*, the valves 11, 12 are respectively shown in their neutral positions, i.e. the rotary valve member 23 of the lower regulating valve 11 completely exposes the air discharge opening 23*a* which connects the space 3 with the space 8, and the rotary valve member 24 of the upper regulating valve 12 completely seals the air intake opening 24*a* provided at the top of the control member 5 to connect the space 8 with the surrounding atmosphere. Thus, the flow of additional air through the opening 24*a* (arrow Z in FIG. 4) is prevented, whereas the air drawn through the momentarily exposed orifices 9 is free to pass through the opening 23*a* toward the apertures 2 of the foil 1. Consequently the lifting action of the control system depends solely on the distance between the foil 1 and the water surface S.

When the connecting shaft 13 is rotated in a clockwise direction, as viewed in FIGS. 7*a* and 7*b*, the lower regulating valve 11 will begin to throttle the flow of air through the opening 23*a* while the upper valve 12 remains in its closed position whereas, when the shaft 13 is turned in anticlockwise direction, the upper valve 12 will begin to admit additional air through the opening 24*a* while the lower valve 11 remains in its open position so that the air drawn through the opening 24*a* may flow to the apertures 2 to thereby exert additional influence on the lifting action.

The control member 5 of FIG. 5 embodies two pairs of regulating valves 11, 12. The left-hand valve 11 controls the flow of air from the rearmost zone III*a* of the space 8 to the rearmost zone III of the internal space 3, and the right-hand valve 11 controls in similar manner the flow of air between the zone II*a* and the median zone II of the space 3 in the foil 1*a*. The foremost zone I*a* is in continuous communication with the foremost zone I of the space 3. The upper regulating valves 12 which are shown in their closed positions in FIG. 5 serve to admit additional air to the zones II*a*, III*a* while the zone I*a* receives air solely through the momentarily exposed lowermost set of orifices 9.

The construction of the regulating valves shown in FIG. 6 is different insofar as the lower regulating valves 11', 11'' comprise conical valve members which control the respective openings between the zones IV, IV*a* and V, V*a* in response to axial displacements of the shafts 13. The upper regulating valves 12 comprise slide valve members which may be adjusted upon further displacements of the respective shafts 13. However, the ultimate effect is the same regardless of the exact construction of the regulating valves. It will be readily understood that valves of a design other than shown in FIGS. 4–6 and 7*a*, 7*b* may be utilized in my control members without departing from the scope of this invention.

I will now describe various control devices which may be operatively connected with the regulating valves 11, 12 in order to improve the seaworthiness and stability of a foil-supported watercraft by automatically adjusting the supply of air to the internal space of the foil or foils whenever the circumstances should so require.

It is well known that a watercraft with only slightly keeled and fully submerged foils tends to list in outward direction when caused to move in an arcuate path because the centrifugal force generates a pair of oppositely directed forces one of which passes through the center of gravity and the other of which passes through the lateral supporting means, these forces tending to overturn the watercraft in outward direction whenever the watercraft moves in a curve. In order to counteract such forces and to bring about an inwardly oriented listing or tilting movement of the watercraft, I provide a control device C_1 which automatically admits additional air to the foil or foil portion located at the inner side of the curve by opening the upper regulating valve or valves 12, and which simultaneously throttles the flow of air into the foil portion located at the outer side of the curve by shutting off or by at least partially closing the lower regulating valve or valves 11.

The control device C_1 is shown in greater detail in FIG. 9. It comprises a rotary drum or disc 25 which is rotatably mounted on a shaft 25*b* and is operatively connected with or forms part of the steering or directional control mechanism of the watercraft. The drum 25 is formed with a preferably helical cam groove 25*a* adapted to receive and to guide a follower 27. This follower is mounted at one end of a lever 26 whose other end is pivotable about a fixed axis 26*a* by being secured to a stationary component part of the watercraft. The lever 26 is articulately connected with the ends of two actuating members 28, 28' the former of which is assumed to be operatively connected with the shaft 13 or with the handgrip means 14 of the interconnected regulating valves 11, 12 shown in FIG. 4, i.e. with the regulating valves of the control member 5 shown in FIG. 1. The other actuating member 28' is then connected with the common

shaft of the regulating valves in the left-hand control member of the watercraft W, not shown in FIG. 1. The configuration of the cam groove 25*a* in the drum or disc 25 is such that the actuating member 28 turns the connecting shaft 13 in a direction to admit additional air to the foil 1 of FIG. 1 if the watercraft W travels in such an arcuate path that its right-hand or starboard control member 5 is at the inner side of a curve so that the starboard foil will rapidly descend to a lower level and will thereby insure that the watercraft will be inclined sufficiently to prevent an overturning of the hull. At the same time, the regulating valves 11, 12 in the port control member 5 which is assumed to be at the outer side of the curve will be adjusted by the left-hand actuating member 28' in such a way that the lower valve 11 will reduce the flow of air to the internal space of the left-hand foil so that the latter will be subjected to a stronger lift force which will counteract the tendency of the hull to overturn in a right-hand curve.

By suitable changes in the configuration of the cam groove 25*a*, any desired transmission ratio between the rotary movement of the rotary member 25 and the rotary movement of the regulating valves 11, 12 (shaft 13) may be achieved. It is preferred to provide adjustable connections between the actuating members 28, 28' and the lever 26 in order to enable an operator to adjust the extent to which the one or the other foil will be submerged in a curve. Of course, the actuating members 28, 28' may simultaneously control two (FIG. 5) or more interconnected regulating valves or, when coupled with the regulating valves shown in FIG. 6, they may bring about axial displacement of the shaft or shafts 13.

FIG. 10 illustrates a control device C_2 which is automatically responsive to the immersion speed or to upward speed (emersion speed) of a control member in a seaway and which is operatively connected with the regulating valves 11, 12 in such a way as to selectively admit additional air or to at least partly shut off the flow of air to the internal chamber of the foil in response to such speeds. For example, when the foil rapidly emerges from a high wave, the change in quantity of air delivered to the internal space of the control member and consequently the change in lift force acting upon the foil will be much greater than if the watercraft travels over comparatively short waves. The purpose of the control device C_2 is to assist the basic control system in such situations by regulating the admission of air through the upper valve 12 and/or through the lower valve 11. In other words, the device C_2 acts as an auxiliary control means to thereby improve the seaworthiness of the watercraft.

The control device C_2 comprises a flexible diaphragm 29 which is received in a tightly sealed housing 30 to divide the latter's interior into a left-hand compartment and into a right-hand compartment. The right-hand compartment communicates directly with the internal space 8 of the associated control member 5 through a conduit 31. The left-hand compartment of the housing 30 communicates with an air chamber or accumulator 32, the latter being connected with the space 8 of the control member 5 by a second conduit 31*a* which contains an adjustable throttle valve 33. The actuating member 28*a* is secured to the diaphragm 29 and is operatively connected with the handgrip means 14 or with the connecting shaft 13 of the regulating valves 11, 12.

The control device C_2 operates as follows:

When the control member 5 rapidly emerges from a wave crest to enter a wave trough, the pressure of air in its internal space 8 increases very rapidly and is conveyed to the right-hand side of the diaphragm 29 through the conduit 31 so that the diaphragm 29 is deflected in a direction to the left and entrains the actuating member 28*a* in the same direction so as to adjust the position of the regulating valves 11, 12 in a sense to admit additional air through the valve 12 whereby the lift force acting on the associated foil decreases and the latter descends rapidly from the water surface in the wave trough. The pressure at the left-hand side of the diaphragm 29 develops more slowly because the air must pass the throtlte valve 33 and must fill the chamber 32.

When the situation is reversed, i.e. when the control member 5 rapidly enters a wave crest, a large number of its orifices 9 is immersed in water so that the pressure in its internal space 8 drops very rapidly. Such drop in pressure is immediately communicated to the right-hand side of the diaphragm 29 through the conduit 31*a*, whereas the pressure at the left-hand side of the diaphragm drops more slowly, this being due to the throttling action of the valve 33 and also to the presence of large quantities of air in the chamber 32. The diaphragm 29 is then deflected in a direction to the right and shifts the actuating member 28*a* in a sense to admit less air through the valves 11, 12 so that the lifting action upon the foil increases and the latter rises in a direction toward the water surface of the wave crest.

The control device C_3 of FIG. 11 is automatically responsive to vertical acceleration of the watercraft and comprises a weight or mass 34 which is mounted on a bell crank lever 34*a*, the latter being rockable about a fixed axis 34*b* so that the mass 34 may move in a substantially vertical plane. A resilient element in the form of a compressed helical spring 35 maintains the mass 34 in a state of equilibrium, and the latter is connected with a damping means in the form of a dashpot 36. The free end of the bell crank lever 34*a* is articulately coupled with an actuating member 28*b* which, in turn, is operatively connected with the common shaft of the regulating valves 11, 12 in the control member 5. The control device C_3 adjusts the regulating valves 11, 12 in a sense that the valves throttle the flow of air to the foil when the control member is accelerated in downward direction, i.e. when the mass 34 moves upwardly, and that the valves 11, 12 admit more air into the internal space of the foil when the control member is accelerated in upward direction so that the mass 34 moves downwardly i.e. an increased lifting action develops when the vertical acceleration is in downward direction and the lifting action decreases when the control device is accelerated in upward direction.

The control device C_4 of FIG. 12 is automatically responsive to rolling or, pitching speed of the watercraft and adjusts the regulating valves 11, 12 in such a way that the lift force counteracts the tendency of the hull to be inclined from its proper position. This control device comprises a rate gyroscope which is mounted in a housing or casing 37, the latter being pivotable about the axis of a vertical shaft 38 and being normally held in a neutral position by resilient means in the form of a spring 39. The casing 37 is articulately coupled with an actuating member 28*c* which is operatively connected with the common shaft of the regulating valves 11, 12 in such a way as to reduce the flow of air to the internal space of that control member which is momentarily dropping. When the watercraft is caused to roll in heavy seas, the housing 37 of the gyroscope performs precision angular movements about the axis of its vertical shaft 38' and thereby shifts the actuating member 28*c* at a rate proportional with the angular speed of rolling. Thus, when the control member whose regulating valves are operatively connected with the actuating member 28*c* rises, additional air is admitted to its internal space whereas, when the control member sinks owing to a rolling movement of the watercraft, the actuating member 28*c* will cause the regulating valves to reduce the supply of air to the internal space of the foil so that the latter is caused to rise toward the water surface and to thereby return the watercraft to its normal position with respect to the lonigtudinal axis of the hull.

If it is desired to counteract pitching movements of the watercraft, i.e. to prevent a tilting about an axis which is perpendicular to the longitudinal axis of the hull, the

control device C_4 comprises at least one gyroscope which is turned through 90 degrees with respect to the gyroscope of FIG. 12. Though it is considered that the watercraft is sufficiently stabilized if it includes a control device of the type shown in FIG. 12 which is responsive to angular speed of the control members, it is equally possible to provide a modified control device which utilizes a so-called gyroscopic horizon capable of responding to all inclinations of the watercraft. In such instances, a single gyroscope is sufficient to adjust the regulating valves in response to listing movements about the longitudinal axis of the hull and also in response to pitching of the watercraft about an axis which is perpendicular to the longitudinal axis of the hull.

It will be readily understood that, if desired, each of the control devices shown in FIGS. 9–12 may control a separate set of regulating valves in the control member or members of the control system for a foil-supported watercraft, or that two, three or all such control devices may be operatively connected with a single set of regulating valves. In the latter instance, the connection **50** (see FIG. 15) between the control device C_1–C_4 and the single set of regulating valves **11**, **12** comprises suitable mechanical or hydraulic mixer elements of known design which insure that only a selected control device will affect the position of the regulating valves in a given situation, i.e. that say the control device C_1 of FIG. 9 will adjust the valves **11**, **12** when the watercraft is guided in an arcuate path while the other control devices do not affect the position of the regulating valves unless there is simultaneous pitching, listing or other undesirable fringe movement of the hull such as must be eliminated to insure full seaworthiness and stability of the watercraft and safety of its occupants.

A very important advantage of the above described control devices is that the actuating members **28**, **28'**, **28***a*, **28***b* or **28***c* may be coupled directly with the common shaft or shafts of the regulating valves without any amplifiers therebetween. This is possible because the forces necessary for adjusting the position of the regulating valves **11**, **12** are extremely small so that the valves will readily respond even to minimal displacements of the corresponding actuating members, e.g. to a minimal vertical displacement of the mass **34** shown in FIG. 11. Such construction of the control devices and their connections with the regulating valves insure that the control system is more reliable because it is much simpler than the conventional control systems described in the introductory part of this specification.

A further very important advantage of my invention is that the basic control system as described in connection with FIGS. 1, 2 and 4, but without the regulating valves **11**, **12**, is capable by itself to insure a high degree of stability for the watercraft in calm as well as in turbulent waters. Thus, and since the control devices of FIGS. 9 to 12 are always combined with the basic control system including at least one at least partially hollow foil, at least one at least partially hollow control member, the air discharging apertures at the suction side of the foil and the air intake orifices in the control member, the watercraft can be safely operated in turbulent waters even if the one or the other of the control devices C_1–C_4 should become inoperative in actual operation of the watercraft. In order to insure that an inoperative control device cannot affect the controls of the watercraft, it is preferred to construct the control devices in such a way that their actuating members permit the regulating valves to return to their respective neutral positions whenever a control device is out of order.

Finally, it is often desirable to provide the watercraft with a control device which automatically adjusts an additional air valve in response to increasing forward speed in order to prevent the foil or foils from ascending closer to the water surface as a result of increased forward speed. This tendency of foils to rise toward the water surface in response to increased forward speed is normally observable in watercraft of the type to which my present invention pertains.

The control device C_5 of FIG. 13 is constructed in such a way that it regulates a valve **45** in a sense to admit more air into the internal space of the associated foil or foils whenever the forward speed of the watercraft increases. To this end, the device C_5 comprises a cylinder **41** which receives a reciprocable piston **40**, the latter being permanently biased in a direction to the left by a resilient element in the form of a coil spring **42** which is housed in the cylinder **40** at the right-hand side of the piston. The left-hand side of the cylinder communicates with a conduit **43** whose free end is submerged in water and is provided with a water intake nozzle **43***a* so that the dynamic pressure of water entering through the nozzle **43***a* and flowing through the conduit **43** shifts the piston **40** counter to the bias of the spring **42** whenever the forward speed in the direction indicated by the arrow X increases. The control member **5** is formed with an air intake pipe **44** which contains the adjustable control valve **45**, the latter being adjustable by an actuating means in the form of a link train **28***d* in a sense to admit more air into the internal space of the control member **5** and hence into the internal space of the associated foil whenever the forward speed of the watercraft increases. The air then tends to counteract the lift force acting upon the foil so that the latter retains its optimum distance from the water surface.

Referring back to FIG. 8, the foil **1***c* shown in this illustration is provided with several rows of apertures **2**, **2***a* which are arranged in such a way as to insure uniform distribution of air over the entire suction side of the foil. It is assumed that the internal space of the foil **1***c* receives air from a single source, i.e. only from the control member **5***b*. It will be noted that the spacing between the adjacent apertures **2** in the two lower rows is reduced proportionately with the distance from the source of air, namely, from the control member **5**. Of course, it is equally possible to obtain uniform distribution of air by spacing the apertures **2** and/or **2***a* at equal intervals but by increasing the area of the orifices in a direction away from the control member **5**. It can be said that the combined cross-sectional area of apertures per unit surface of the suction side should increase in a direction away from the control member, either by varying the spacing between the orifices of equal areas, or by varying the areas of the orifices.

In the watercraft W' of FIG. 14, only the forward foil or foils **1'** are combined with a control system in a manner as described above, i.e. each foil **1'** is associated with two control members **5**, **5'**. The rear foil or foils **1''** need not always be combined with a control system because they will automatically retain a desired distance from the water surface S owing to angular displacements about a transverse axis of the front foil whenever the rear foils change their distance from the water surface. Such construction insures that the rear foil or foils will automatically rise toward the water surface when their angle of incidence increases as a result of a pivotal movement performed by the rear foils about the forward foils. It will be readily understood that the lift force on the rear foils will increase if their angle of incidence increases.

Of course, the novel control system is equally useful in connection with less stable foil or foils of the type which are only partly submerged when the watercraft is in motion.

It will be seen that I provide a control system which operates on the heretofore unemployed principle that the lift force which acts upon a hollow foil may be varied by changing the influx of air into the foil, i.e. by admixing variable quantities of air into the flow or into the cavitation bubble at the upper side of the foil. The air discharged through the apertures of the foil brings about

a weakening of the low-pressure area which develops at the upper side of the foil when the watercraft is in motion, i.e. this low-pressure area becomes less pronounced proportionally with an increase in the quantity of air discharged through the apertures and to the suction side of the foil. Such extremely simple and efficient regulation of the lift force is of considerable advantage because the foil may be rigidly secured to the hull, i.e. it need not pivot about a transverse axis as in certain conventional types of foil-supported watercraft, and the trailing edge of the foil need not be provided with flaps so that the watercraft may operate without bulky, complicated and expensive motion transmitting arrangements which are normally utilized for imparting pivotal movements of the flaps.

Furthermore, the improved control system is capable of preventing cavitation by introducing selected quantities of air into the stream at the suction side of the foil. This is of considerable advantage because it is now possible to utilize foils with a profile of greater thickness which, particularly in watercraft constructed for operation at extremely high speeds, brings about considerable reduction in statical stresses. In the event of partial cavitation, particularly at the leading edge of the foil, the air which is discharged at points rearwardly spaced from the leading edge prevents a collapse of bubbles in the high-pressure zone so that no erosion of the material of which the foil consists can take place. In fully cavitating foils in which the vapor bubbles collapse only at a point rearwardly of the trailing edge, the low-pressure area is weakened and the lift force influenced in the same way as in non-cavitating foils, i.e. in dependency on the quantity of air discharged through the apertures in the upper wall of the foil. Finally, it is possible to regulate the discharge of air along the upper side of the foil in a manner that the lift force is controlled all the way as the forward speed of the watercraft increases while the foil passes from the stage of non-cavitation to the stage of full cavitation.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic and specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. In a watercraft of the type whose hull is supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal axis of the hull, in combination, at least one foil having a suction side and defining therewithin at least one internal space, said foil formed with air discharge aperture means between said suction side and said internal space; and a control system for automatically adjusting the distance between the foil and the water surface, said system comprising at least one control member defining therewithin at least one internal space in communication with the internal space of said foil, said control member formed with air intake orifice means disposed in the area of subpressure produced by the water flow at the profile of the control member and located in part above and in part below the normal level of the water surface when the watercraft is in motion, the low-pressure area developing at the suction side of said foil causing the air entering through the orifice means disposed above the water surface to flow from the internal space of said control member into the internal space of said foil and to be discharged through said aperture means, the ratio of combined cross-sectional area of orifices above the water surface to the combined cross-sectional area of orifices below the water surface determining the extent to which the air discharged through said aperture means affects the lift force upon said foil.

2. In a watercraft of the type whose hull is supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal axis of the hull, in combination, at least one foil having a suction side and defining therewithin at least one internal space, said foil formed with air discharge aperture means between said suction side and said internal space; and a plurality of spaced control members for automatically adjusting the distance between the foil and the water surface when the watercraft is in motion, each control member defining therewithin at least one internal space in communication with the internal space of said foil and each formed with air intake orifice means disposed in the area of the subpressure produced by the water flow at the profile of the control member and located in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering through the orifice means disposed above the water surface being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion.

3. In a watercraft of the type whose hull is supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal axis of the hull, in combination, at least one foil having a leading edge, a trailing edge, a suction side and defining therewithin at least one internal space, said foil comprising at least one internal partition extending intermediate said edges for dividing said internal space into a plurality of zones and said foil formed with a plurality of aperture means for connecting each of said zones with said suction side; and at least one control member for automatically adjusting the distance between said foil and the water surface when the watercraft is in motion, said control member having a leading edge, a trailing edge, defining therewithin at least one internal space and comprising at least one internal partition extending between said last mentioned edges for dividing said last mentioned internal space into a plurality of zones each of which communicates with one of said first mentioned zones, said control member formed with a plurality of sets of vertically spaced air intake orifice means, each of said sets of orifice means communicating with one of said last mentioned zones and said orifice means disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering through the orifice means disposed above the water surface being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion, the uppermost set of said orifice means communicating with that zone of the internal space in said control member which communicates with the zone of said first mentioned internal space closest to the trailing edge of said foil, and the lowermost set of said orifice means communicating with that zone of the internal space in said control member which communicates with the zone of said first mentioned internal space closest to the leading edge of said foil.

4. In a watercraft of the type whose hull is supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal axis of the hull, in combination, at least one foil having a leading edge, a trailing edge, a suction side and defining therewithin at least one internal space, said foil comprising at least one internal partition extending substantially at right angles to said edges for dividing said internal space into a plurality of zones and said foil formed with a plurality of aperture means for connecting each of said zones with said suction side; and at least one control member for automatically adjusting the distance between said foil and the water surface when the watercraft is in motion, said control member having a leading edge, a trailing edge, defining therewithin at least one internal

space and comprising at least one internal partition extending between said last mentioned edges for dividing said last mentioned internal space into a plurality of zones, said foil comprising duct means for communicatively connecting each of said last mentioned zones with one of said first mentioned zones, said control member formed with a plurality of air intake orifice means leading into each of said last mentioned zones and disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering through the orifice means disposed above the water surface being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion.

5. In a watercraft of the type whose hull is supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal axis of the hull, in combination, at least one foil having a suction side and defining therewithin at least one internal space, said foil formed with aperture means for connecting said space with said suction side; and at least one control member for automatically adjusting the distance between said foil and the water surface when the watercraft is in motion, said control member having a leading edge, a trailing edge, defining therewithin at least one internal space and comprising at least one internal partition extending between said edges for dividing said last mentioned internal space into a plurality of zones each of which communicates with said first mentioned internal space, said control member formed with a plurality of sets of air intake orifice means each leading into one of said zones, said orifice means disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering through the orifice means disposed above the water surface being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion, each of said sets comprising a plurality of substantially vertically spaced orifice means and the spacing between the orifice means in at least one of said sets being different from the spacing of orifice means in each other set.

6. In a watercraft of the type whose hull is supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal axis of the hull, in combination, at least one foil having a suction side and defining therewithin at least one internal space, said foil formed with aperture means for connecting said space with said suction side; at least one control member for automatically adjusting the distance between said foil and the water surface when the watercraft is in motion, said control member defining therewithin at least one internal space and formed with air intake orifice means disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering through the orifice means disposed above the water surface being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion; cylinder means defining an internal space communicating with the internal space of said control member; valve means provided between said cylinder means and said control member for regulating the flow of air between the internal spaces of said control member and said cylinder means; and piston means reciprocably received in said cylinder means for varying the useful volume of the internal space in said cylinder means.

7. In a watercraft of the type whose hull is supported by at least one at least partially water-submerged foil transversely to the longitudinal direction of the hull, in combination, at least one foil having a suction side and defining therewithin at least one internal space, said foil formed with air discharge aperture means between said suction side and said internal space; at least one control member for automaticaly adjusting the distance between the foil and the water surface when the watercraft is in motion, said control member defining therewithin at least one internal space in communication with the internal space of said foil and formed with air intake orifice means communicating with said last mentioned internal space and disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering through the orifice means disposed above the water surface being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion; first regulating valve means mounted in said control member for selectively admitting additional air into said last mentioned internal space; second regulating valve means mounted in said control member for controlling the flow of air between said internal spaces; means for connecting said valve means with each other in such a way that said first valve means is closed when said second valve means is fully open; and means for simultaneously adjusting the position of said valve means, said adjusting means operable in a first direction for admitting additional air through said first valve means and in a second direction for throttling the flow of air through said second valve means.

8. In a watercraft of the type whose hull is supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal direction of the hull, in combination, at least one foil having a suction side and defining therewithin at least one internal space, said foil formed with air discharge aperture means between said suction side and said internal space; at least one control member for automatically adjusting the distance between the foil and the water surface when the watercraft is in motion, said control member defining therewithin at least one internal space in communication with the internal space of said foil and formed with air intake orifice means communicating with said last mentioned internal space and disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering through the orifice means disposed above the water surface being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion; first regulating valve means comprising at least one rotary slide valve member mounted in said control member for selectively admitting additional air into said last mentioned internal space; second regulating valve means comprising at least one rotary slide valve member mounted in said control member for controlling the flow of air between said internal spaces; and means for connecting said valve means with each other in such a way that said first valve means is closed when said second valve means is fully open.

9. In a watercraft of the type whose hull is supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal direction of the hull, in combination, at least one foil having a suction side and defining therewithin at least one internal space, said foil formed with air discharge aperture means between said suction side and said internal space; at least one control member for automatically adjusting the distance between the foil and the water surface when the watercraft is in motion, said control member defining therewithin at least one internal space in communication with the internal space of said foil and formed with air intake orifice means communicating with said last mentioned internal space and disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering through the orifice means disposed above the water surface being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion; first regulating valve means comprising at least one slide valve member mounted in said control member for selectively admitting additional air into said last mentioned internal space; second regulating valve means comprising at least one axially reciprocable conical

valve member mounted in said control member for controlling the flow of air between said internal spaces; and means for connecting said valve means with each other in such a way that said first valve means is closed when said second valve means is fully open.

10. In a watercraft having a directional control mechanism and a hull supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal direction of the hull, in combination, at least one foil disposed laterally of the hull, having a suction side and defining therewithin at least one internal space, said foil formed with air discharge aperture means between said suction side and said space; at least one control member for automatically adjusting the distance between the foil and the water surface when the watercraft is in motion, said control member defining therewithin at least one internal space in communication with the space of said foil and formed with air intake orifice means communicating with said last mentioned space and disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering through the orifice means disposed above the water level being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion; first regulating valve means mounted in said control member for selectively admitting additional air into said last mentioned space; second regulating valve means mounted in said control member for controlling the flow of air between said spaces; and a control device operatively connected with said directional control mechanism and with said valve means for admitting additional air into said last mentioned space and into said first mentioned space when the watercraft is moved in an arcuate path and said foil is located at the inner side of the path, and for throttling the flow of air from said last mentioned space to said first mentioned space when the watercraft is moved in an arcuate path and the foil is located at the outer side of the path.

11. In a watercraft of the type having a hull supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal direction of the hull, in combination, at least one foil having a suction side and defining therewithin at least one internal space, said foil formed with air discharge aperture means between said suction side and said space; at least one control member for automatically adjusting the distance between the foil and the water surface when the watercraft is in motion, said control member defining therewithin at least one internal space in communication with the space of said foil and formed with air intake orifice means communicating with said last mentioned space and disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering through the orifice means disposed above the water surface being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion; first regulating valve means mounted in said control member for selectively admitting additional air into said last mentioned space; second regulating valve means mounted in said control member for controlling the flow of air between said spaces; and a control device automatically responsive to immersion speed and to emersion speed of said control member, said control device operatively connected with said valve means for adjusting the flow of air in a sense to admit additional air to said last mentioned space and to permit the flow of additional air into said first mentioned space in response to emersion speed of said control member, and to throttle the flow of air from said last mentioned space into said first mentioned space in response to immersion speed of said control member.

12. In a watercraft of the type having a hull supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal direction of the hull, in combination, at least one foil having a suction side and defining therewithin at least one internal space, said foil formed with air discharge aperture means between said suction side and said space; at least one control member for automatically adjusting the distance between the foil and the water surface when the watercraft is in motion, said control member defining therewithin at least one internal space in communication with the space of said foil and formed with air intake orifice means communicating with said last mentioned space and disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering through the orifice means disposed above the water surface being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion; first regulating valve means mounted in said control member for selectively admitting additional air into said last mentioned space; second regulating valve means mounted in said control member for controlling the flow of air between said spaces; and a control device automatically responsive to immersion speed and to emersion speed of said control member, said control device operatively connected with said valve means for adjusting the flow of air in a sense to admit additional air to said first mentioned space in response to emersion speed of said control member, and to throttle the flow of air from said last mentioned space into said first mentioned space in response to immersion speed of said control member, said control device comprising a closed housing, a flexible diaphragm in said housing for dividing the latter into a first and a second compartment, first conduit means for connecting said first compartment with said last mentioned space, an air chamber communicating with said second compartment, second conduit means for connecting said air chamber with said last mentioned space, adjustable valve means mounted in said second conduit means for throttling the flow of air between said air chamber and said last mentioned space, and actuating means connected with said diaphragm and with said regulating valve means.

13. In a watercraft of the type having a hull supported by at least one at least partially water-submerged foil extending substantialy transversely to the longitudinally direction of the hull, in combination, at least one foil having a suction side and defining therewithin at least one internal space, said foil formed with air discharge aperture means between said suction side and said space; at least one control member for automatically adjusting the distance between the foil and the water surface when the watercraft is in motion, said control member defining therewithin at least one internal space in communication with the space of said foil and formed with air intake orifice means communicating with said last mentioned space and disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering through the orifice means disposed above the water surface being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion; first regulating valve means mounted in said control member for selectively admitting additional air into said last mentioned space; second regulating valve means mounted in said control member for controlling the flow of air between said spaces; and a control device automatically responsive to vertical accelerations of the watercraft, said control device operatively connected with said valve means for adjusting the flow of air in a sense to admit additional air to said last mentioned space in response to upward acceleration of the watercraft, and to throttle the flow of air from said last mentioned space into said first mentioned space in response to downward acceleration of the watercraft.

14. In a watercraft of the type comprising a hull supported by at least one at least partialy submerged foil extending substantially transversely to the longitudinal di-

rection of the hull, in combination, at least one foil disposed at least in part laterally of the hull, said foil having a suction side, formed with at least one internal space and having air discharge aperture means between said suction side and said space; at least one control member for automatically adjusting the distance betwen the foil and the water surface when the watercraft is in motion, said control member defining therewithin at least one internal space in communication with the space of said foil and formed with air intake orifice means communicating with said last mentioned space and disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering through the orifice means disposed above the water surface being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion; first regulating valve means mounted in said control member for selectively admitting additional air to said last mentioned space; second regulating valve means connected with said first valve means and adapted to control the flow of air between said spaces; and a control device operatively connected with said valve means for automatically admitting additional air into said last mentioned space and into said first mentioned space when the watercraft rolls about the longitudinal axis of the hull in a direction to move the foil toward the water surface and for throttling the flow of air from said last mentioned space into said first mentioned space when the watercraft rolls in a direction to move the foil away from the water surface.

15. In a watercraft of the type comprising a hull supported by at least one at least partially submerged foil extending substantially transversely to the longitudinal direction of the hull, in combination, at least one foil disposed at least in part laterally of the hull, said foil having a suction side, formed with at least one internal space and having air discharge aperture means between said suction side and said space; at least one control member for automatically adjusting the distance between the foil and the water surface when the watercraft is in motion, said control member defining therewithin at least one internal space in communication with the space of said foil and formed with air intake orifice means communicating with said last mentioned space and disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering through the orifice means disposed above the water surface being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion; first regulating valve means mounted in said control member for selectively admitting additional air to said last mentioned space; second regulating valve means connected with said first valve means and adapted to control the flow of air between said spaces; and a control device operatively connected with said valve means for automatically admitting additional air into said last mentioned space and into said first mentioned space when the watercraft pitches in a direction to move the foil toward the water surface and for throttling the flow of air from said last mentioned space into said first mentioned space when the watercraft pitches in a direction to move the foil away from the water surface.

16. In a watercraft of the type comprising a hull supported by at least one at least partially submerged foil extending substantially transversely to the longitudinal direction of the hull, in combination, at least one foil disposed at least in part laterally of the hull, said foil having a suction side, formed with at least one internal space and having air discharge aperture means between said suction side and said space; at least one control member for automatically adjusting the distance between the foil and the water surface when the watercraft is in motion, said control member defining therewithin at least one internal space in communication with the space of said foil and formed with air intake orifice means communicating with said last mentioned space and disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering through the orifice means disposed above the water surface being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion; first regulating valve means mounted in said control member for selectively admitting additional air to said last mentioned space; second regulating valve means connected with said first valve means and adapted to control the flow of air between said spaces; and a control device operatively connected with said valve means for automatically admitting additional air into said last mentioned space and into said first mentioned space when the watercraft pitches and rolls in a direction to move the foil toward the water surface and for throttling the flow of air from said last mentioned space into said first mentioned space when the watercraft pitches and rolls in a direction to move the foil away from the water surface, said control device comprising at least one rate gyroscope means including a housing mounted for pivotal movements about a substantially vertical axis, resilient means for maintaining said rate gyroscope means in a state of equilibrium, and actuating means connected with said housing and operatively coupled with said valve means for adjusting the latter in response to angular displacements of said rate gyroscope means about said vertical axis.

17. In a watercraft of the type comprising a hull supported by at least one at least partially submerged foil extending substantially transversely to the longitudinal direction of the hull, in combination, at least one foil having a suction side, formed with at least one internal space and having air discharge aperture means between said suction side and said space; at least one control member for automatically adjusting the distance between the foil and the water surface when the watercraft is in motion, said control member defining therewithin at least one internal space in communication with the space of said foil and formed with air intake orifice means communicating with said last mentioned space and disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering said first mentioned space being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion; an additional air intake pipe equipped with a control valve and connected with the last mentioned space; and a control device for automatically adjusting said valve means in response to changes in forward speed of the watercraft by admitting additional air into said last and first mentioned spaces in response to increasing forward speed of the watercraft, said control device comprising cylinder means, piston means reciprocably received in said cylinder means, resilient means for permanently biasing said piston means in a given direction, actuating means operatively connected with said piston means and with said valve means, and conduit means communicating with said cylinder means and comprising water-submerged nozzle means for introducing water into said cylinder means whereby the dynamic pressure of water counteracts the bias of said resilient means when the watercraft is in motion, said actuating means adjusting said valve means in a sense to admit more air to said first and last mentioned spaces in response to increasing dynamic pressure of water upon said piston means.

18. In a watercraft of the type comprising a hull supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal direction of the hull, in combination, at least one foil having a suction side, formed with at least one internal space and having a plurality of air discharge apertures between said suction side and said space, said foil comprising a trailing edge and at least some of said apertures being inclined rearwardly in a direction toward said trail-

ing edge; and at least one control member for automatically adjusting the distance between the foil and the water surface when the watercraft is in motion, said control member defining there within at least one internal space in communication with the space of said foil and formed with air intake orifice means communicating with said last mentioned space and disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering through the orifice means disposed above the water surface being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion.

19. In a watercraft of the type comprising a hull supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal direction of the hull, in combination, at least one foil having a suction side, formed with at least one internal space and having a plurality of air discharge apertures between said suction side and said space; and at least one control member connected with said foil for automatically adjusting the distance between the foil and the water surface when the watercraft is in motion, said control member defining therewithin at least one internal space in communication with the space of said foil and formed with air intake orifice means communicating with said last mentioned space and disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering said first mentioned space being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion, the combined cross-sectional area of apertures per unit area of said foil increasing in a direction away from the point of connection between said foil and said control member.

20. In a watercraft of the type comprising a hull supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal direction of the hull, in combination, at least one foil having a suction side, formed with at least one internal space and having a plurality of elongated slot shaped air discharge apertures between said suction side of said space; and at least one control member for automatically adjusting the distance between the foil and the water surface when the watercraft is in motion, said control member defining therewithin at least one internal space in communication with the space of said foil and formed with air intake orifice means communicating with said last mentioned space and disposed in the area of the subpressure produced by the water flow at the profile of the control member and located in part above and in part below the normal level of the water surface when the watercraft is in motion, the air entering through the orifice means disposed above the water surface being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion.

21. A combination as set forth in claim 1, wherein said control member is of streamlined profile and constitutes a supporting strut for said foil, said strut connected to said hull.

22. A combination as set forth in claim 1, wherein said control member has a leading edge and said orifice means are provided in the proximity of said leading edge.

23. A combination as set forth in claim 10, further comprising shaft means for connecting said first and second valve means to each other, said control device comprising a rotary member connected with said directional control mechanism and having substantially helical cam groove means, lever means mounted for pivotal movement about a fixed axis, follower means connected with said lever means and extending into said cam groove means, and actuating means connected with said lever means and operatively coupled with said shaft means for adjusting the position of said valve means proportionally with pivotal movement of said lever means in response to angular displacement of said rotary member.

24. A combination as set forth in claim 13, wherein said control device comprises a mass, resilient means for maintaining said mass in a state of equilibrium, and actuating means operatively connected with said mass and with said valve means, said actuating means responsive to upward movement of said mass in response to downward acceleration of the watercraft and to downward movement of the mass in response to upward acceleration of the watercraft.

25. A combination as set forth in claim 24, further comprising damping means connected with said mass.

26. In a watercraft of the type whose hull is supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal axis of the hull, in combination, at least one foil having a suction side and defining therewithin at least one internal space, said foil being provided with aperture means for connecting said space with said suction side; at least one control member for automatically adjusting the distance between said foil and the water surface when the watercraft is in motion, said control member defining therewithin at least one internal space and having air intake orifice means disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air which enters through the orifice means disposed above the water surface being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion; at least one at least partially hollow member having an internal space in communication with the internal space of said control member; and valve means disposed between said control member and said hollow member for regulating the flow of air from the internal space of said control member to the internal space of said hollow member.

27. In a watercraft of the type comprising a hull supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal axis of the hull, in combination, at least one foil disposed at least in part laterally of the hull, said foil having a suction side, defining at least one internal space and having air discharge aperture means provided between said suction side and said internal space; at least one control member for automatically adjusting the distance between the foil and the water surface when the watercraft is in motion, said control member defining therewithin at least one internal space in communication with the internal space of said foil and having air intake orifice means communicating with the internal space thereof and disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the air which enters through the orifice means disposed above the water surface being drawn to the suction side of said foil to thereby affect the lift force upon said foil when the watercraft is in motion; first regulating valve means mounted in said control member for selectively admitting additional air into the internal space of said control member; second regulating valve means connected with said first valve means and adapted to control the flow of air between said internal spaces; and a control device operatively connected with said valve means for automatically admitting additional air into said internal spaces when the watercraft is inclined in a direction to move the foil toward the water surface and for throttling the flow of air from the internal space of said control member to the internal space of said foil when the watercraft is inclined in a direction to move the foil from the water surface, said control device comprising a gyroscopic horizon and actuating means operatively connected with said gyroscopic horizon and with said valve means for adjusting the valve means in response to impulses received from said gyroscopic horizon.

28. In a watercraft of the type whose hull is supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal axis

of the hull, in combination, a foil having a suction side and defining therewithin an internal space, said foil having air discharging aperture means provided between said suction side and said internal space; a control system for automatically adjusting the distance between the foil and the water surface, said system comprising a control member defining therewithin an internal space in communication with the internal space of said foil, said control member having air intake orifice means disposed in part above and in part below the normal level of the water surface when the watercraft is in motion, the low-pressure area developing at the suction side of said foil causing the air entering through the orifice means disposed above the water surface to flow from the internal space of said control member into the internal space of said foil and to be discharged through said aperture means whereby the ratio of combined cross-sectional area of orifices above the water surface to the combined cross-sectional area of orifices below the water surface determines the extent to which the air discharged through said aperture means affects the lift force upon said foil; first regulating valve means mounted in said control member above the normal level of the water surface for selectively admitting additional air to the internal space of said control member; and second regulating valve means mounted in said control member for adjusting the flow of air from the internal space of said control member to the internal space of said foil.

29. In a watercraft of the type whose hull is supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal axis of the hull, in combination, a foil having a suction side and defining therewithin an internal space, said foil having air discharging aperture means provided between said suction side and said internal space; and a control system for automatically adjusting the distance between the foil and the water surface, said system comprising a control member defining therewithin an internal space in communication with the internal space of said foil, said control member having a leading edge, a trailing edge and air intake orifice means disposed substantially midway between said edges in part above and in part below the normal level of the water surface when the watercraft is in motion, the low-pressure area developing at the suction side of said foil causing the air entering through the orifice means disposed above the water surface to flow from the internal space of said control member into the internal space of said foil and to be discharged through said aperture means, whereby the ratio of combined cross-sectional area of orifices above the water surface to the combined cross-sectional area of orifices below the water surface determines the extent to which the air discharged through said aperture means affects the lift force upon said foil.

30. In a watercraft of the type whose hull is supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal axis of the hull, in combination, a foil having a suction side and defining therewithin an internal space, said foil having air discharging aperture means provided between said suction side and said internal space; and a control system for automatically adjusting the distance between the foil and the water surface, said system comprising a control member defining therewithin an internal space in communication with the internal space of said foil, said control member having a leading edge, a trailing edge and air intake orifice means disposed in said trailing edge in part above and in part below the normal level of the water surface when the watercraft is in motion, the low-pressure area developing at the suction side of said foil causing the air entering through the orifice means disposed above the water surface to flow from the internal space of said control member into the internal space of said foil and to be discharged through said aperture means, whereby the ratio of combined cross-sectional area of orifices above the water surface to the combined cross-sectional area of orifices below the water surface determines the extent to which the air discharged through said aperture means affects the lift force upon said foil.

31. In a watercraft of the type whose hull is supported by at least one at least partially water-submerged foil extending substantially transversely to the longitudinal axis of the hull, in combination, a foil having a suction side and defining therewithin an internal space, said foil having air discharging aperture means provided between said suction side and said internal space; and a control system for automatically adjusting the distance between the foil and the water surface, said system comprising a control member defining therewithin an internal space in communication with the internal space of said foil, said control member having a plurality of orifice means vertically spaced from each other and disposed in part above and in part below the normal level of the water surface when the watercraft is in motion and said control member further comprising a plurality of fin means each disposed between a pair of adjacent orifice means, the low-pressure area developing at the suction side of said foil causing the air entering through the orifice means disposed above the water surface to flow from the internal space of said control member into the internal space of said foil and to be discharged through said aperture means, whereby the ratio of combined cross-sectional area of orifices above the water surface to the combined cross-sectional area of orifices below the water surface determines the extent to which the air discharged through said aperture means affects the lift force upon said foil.

References Cited in the file of this patent

UNITED STATES PATENTS

2,257,406	Burtenbach	Sept. 30, 1941
2,709,979	Bush et al.	June 7, 1955
2,771,051	Schertel	Nov. 20, 1956
3,006,307	Johnson	Oct. 31, 1961

FOREIGN PATENTS

715,880	Great Britain	Sept. 22, 1954
774,854	Great Britain	May 15, 1957
549,266	Italy	Oct. 9, 1956