Feb. 1, 1966 W. A. GRAIG 3,232,261

WATERCRAFT

Filed Feb. 14, 1964 2 Sheets-Sheet 1

FIG. 1

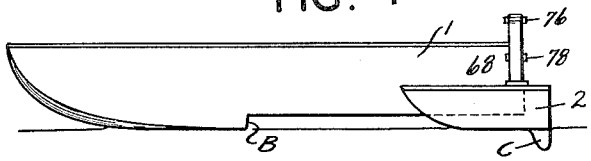


FIG. 2

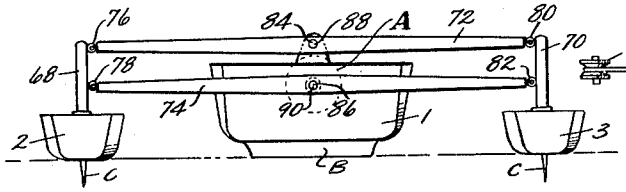
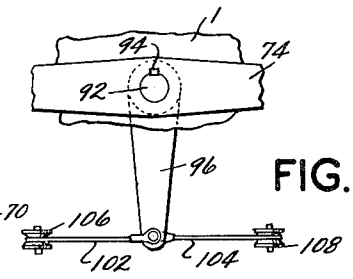


FIG. 4



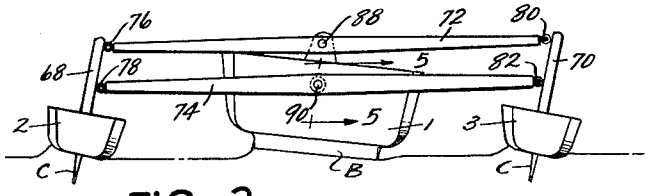


FIG. 3

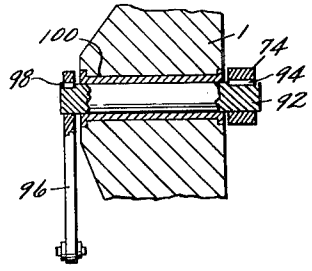
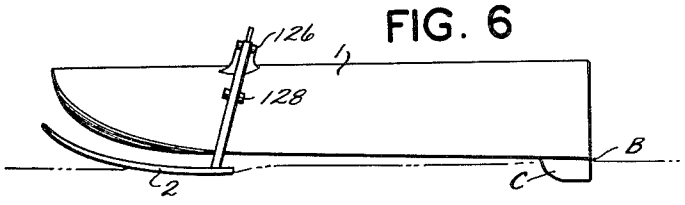


FIG. 5.

FIG. 6



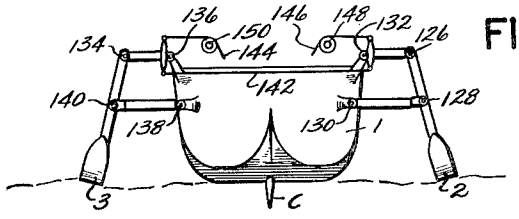


FIG. 7

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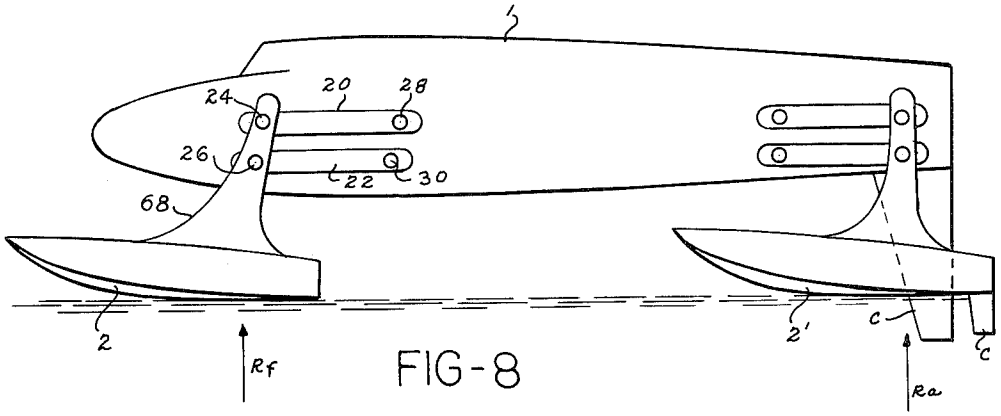


FIG-8

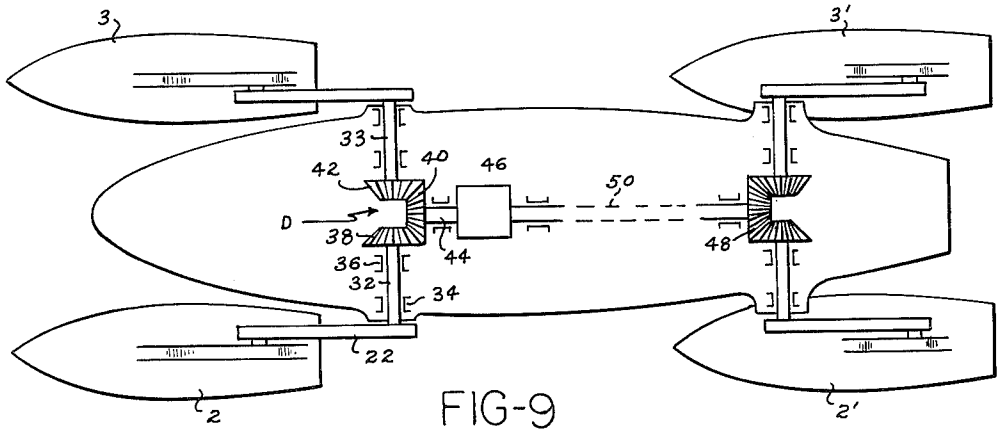


FIG-9

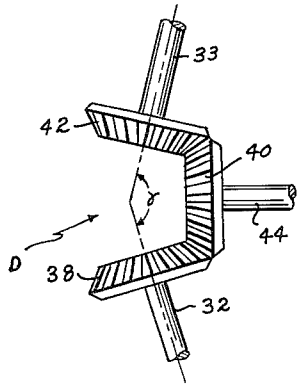


FIG-10

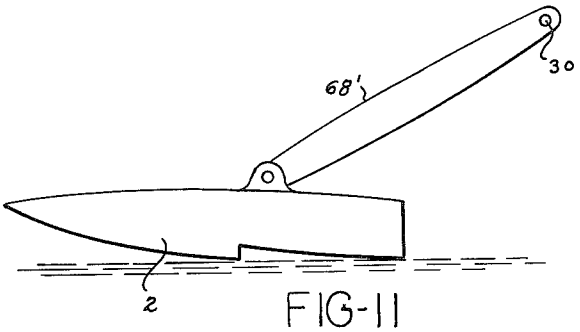


FIG-11

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3,232,261

Patented Feb. 1, 1966

3,232,261

WATERCRAFT

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Filed Feb. 14, 1964, Ser. No. 344,943
13 Claims. (Cl. 114—66.5)

This is a continuation-in-part of application Serial No. 801,793, filed March 25, 1959, now Patent No. 3,124,096.

This invention pertains to surface watercraft that are totally or predominantly supported at sufficient speed by dynamic lift forces and stabilized laterally by hydroplaning elements. The adjective "hydroplaning" denotes here any device operating on the air-water interface and developing dynamic lift forces which grow rapidly as the immersion increases. This class of devices is represented by hydroskis, properly shaped hull bottoms, surface piercing hydrofoils established at relatively shallow angles to the surface, etc.

While any degree of lateral stability can be obtained by providing the craft with port and/or starboard hydroplaning elements spaced sufficiently far apart, this method of stabilization would prevent the craft from banking in a turn. Yet, no satisfactory maneuverability can be obtained without banking the whole craft, or at least its lifting components, such as hydrofoils, fixed or rotary wings, hydroskis, etc. It would seem that the difficulty could be overcome by merely tilting the lifting components, which could be achieved by producing a craft of "deformable" or "variable" geometry, as opposed to the "fixed geometry" configuration. However, a craft's deformations would generally cause a redistribution of the dynamic forces with consequent production of adverse yawing moments or couples. These moments are extremely dangerous, and therefore rob the concept of variable geometry of any practical value.

The purpose of the invention is to overcome this difficulty. The invention provides watercraft of deformable configurations so arranged that their steering is achieved by means of banking the craft's lifting components and that, whether in a straightaway or in a banked turn, the craft retains a satisfactory directional stability. The directional stability is defined as the craft's inherent tendency to head substantially in the direction of its instantaneous velocity (which is coincident with the tangent to the trajectory). A fixed vertical fin (or an equivalent) requiring no manipulation, provides normally such stability, though the invention does not prohibit use of a steerable rudder, as an optional substitute for the fixed fin, or as an accessory to refine of the latter's operation. The steerable rudder will also be used at low speed when, due to the inefficiency of the dynamic lift forces, the watercraft must be steered in the conventional manner.

In order that the above menas—fixed tail fin or equivalent—be sufficient in providing the directional or heading stability as discussed, it is necessary that the yawing moments produced in consequence of the craft's deformation be consistent with the particular water craft's characteristics. Some designs may be best served by producing in this manner yawing couples or moments of a certain, generally small, magnitude acting into the turn; other designs may prefer yawing couples or moments of opposite sign; many craft will operate satisfactorily if the deformation produces no yawing couple or moment at all. The invention provides the means to satisfy any of these conditions, whatever the case may be.

The watercraft of the invention are lifted by at least three supports (also referred to as lift elements, or support elements) developing dynamic forces: one on port, one on starboard, one in front, or back of others. The above described distribution does not preclude a support from performing in a double capacity. For example, if

a support is located in the front left, it serves as a port support and as a fore support at the same time. Thus, the above fore, aft, port, and starboard locations may be fulfilled with less than four supports. It also should be understood that the terms "port" and "starboard" do not necessarily refer to outboard locations but merely indicate, in accordance with frequent practice, the location of the element relative to the centerline of the craft, i.e. on its left or right. The port and starboard supports comprise the hydroplaning elements providing lateral stabilization. The fore and aft supports insure longitudinal stability (i.e., stability in pitch); but the invention is not restricted to any particular system of longitudinal stabilization. It can be achieved by hydroplaning elements; or by a combination of fore hydroplaning supports and aft lifting devices fully immersed in their operating fluid, air or water, as the case may be; or by fully immersed surfaces whose angles of attack are controlled by an automatic pilot; or in any other suitable manner.

Though the lift elements may exceed the number of three, and their arrangement may be varied in many ways, the nature of the invention will be disclosed by reference to the typical case of systems whose lifting elements, limited in numbers to three or four, are essentially symmetrical with respect to the median plane of the craft, and are located in two parallel transverse planes. Not only is such an arrangement consistent with a natural design approach, but also the analysis and solution of its problems points clearly the way in the design of any of its mutations. To fit particular cases, some adaptations may be required; however, the basic approach remains unchanged, and the rules evolved for the presented embodiments are basically the same.

When lift elements are arranged in two transverse planes as stated, the lift forces in each plane compose into a resultant force (R_f and R_a, in the fore and aft planes respectively) and no yawing couple. As long as the craft stands upright, R_f and R_a act vertically, providing the total dynamic lift. If, in consequence of the craft's deformation, the lift elements are to tilted i.e. banked that R_f and R_a, though inclined, remain parallel, these forces compose into a resultant force L, and no couple. On the other hand, should the craft's deformations cause the forces R_f and R_a to tilt by unequal angles α and β, the composition of forces would produce a couple, in addition to L. The greater $|\alpha-\beta|$, the greater the couple. These statements are based on well-known principles pertaining to composition of forces. The couple in question is a yawing couple.

The invention turns to account the above laws of mechanics, to meet the specific needs of any particular design. The intent is to combine and assemble the lift elements in such a manner as to correlate in sign and magnitude the yawing moment arising in the turn to the peculiar characteristics of the craft. The following rule is set forth and observed. If the directional stability is best satisfied by a deflection of the lift elements such as not to produce per se a yawing couple, these elements are so interconnected that on deflection, the forces R_f and R_a tilt by equal angles. R_f and R_a compose then always into a single force L, and no couple. (The contingency that the force L may pass outside the craft's center of gravity is thereby not precluded. Hence, a yawing moment, though generally small, can still appear.) All things considered, maintaining R_f and R_a always parallel, satisfies the commonest case with acceptable approximation, provided that the tilting does not cause a redistribution of the dynamic support forces between the port and starboard support elements. The presence of a vertical tail fin will insure the necessary coordination between the bending of the path and the craft's rotation about its yaw axis. How-

ever, in those instances where the safety of the turn can be improved by, or requires, the production by R_f and R_a of a certain yawing couple, the invention employs such kinematic connections between the lift elements which create, concomitant with deformation, an appropriate directional divergence between the fore and aft resultants R_f and R_a (i.e., these forces become skewed).

In watercraft of the invention which are so arranged that the lift elements contributing to the production of R_f deflect synchronously by a common angle, R_f deflects by the same angle. Likewise, when the support elements producing R_a tilt by equal angles, R_a tilts by the same angle. In other craft of the invention, the deflection of the lift elements associated in the production either of R_f or R_a may not be equal. In such cases the deflections of the associated elements can be averaged out, as it were, into a "mean deflection," and the tilt angles of R_f and R_a are the same as the mean deflections (or tilts) of the respective fore and aft lift elements. Thus, the rule set forth above can be re-stated to say that, according to the invention, the kinematic connections are such as to produce the desired divergencies between the mean tilts of the fore and aft lift elements. This statement covers the case of zero divergence.

In summary, the invention realizes dynamically supported watercraft which are steered by controlled variation of their geometry, are laterally stabilized by port and starboard hydroplaning elements, and are configured to be substantially inherently directionally stable in banked turns and in straight-aways. The dynamic lift elements of the invention are connected by controllable kinematic means which produce their coordinated deflections. The term "coordinated" expresses here and in the claims the fact that the angles by which the individual lift elements are made to deflect, are correlated as stated above, to produce the desired divergence between the mean tilts (i.e. banks) of the fore and aft lift elements.

The invention thus resolves the difficulties associated with variable geometry. Other advantages of the invention will become apparent from the consideration of the figures and the discussion of their operation.

In the drawings:

FIG. 1 is a side view of an embodiment of the invention, as applied to a watercraft supported in motion by the hydrodynamic forces acting upon the step of the hull and the bottoms of two pontoons, the latter providing lateral stabilization as well as sharing in the lift. Together with the step, they also insure longitudinal stability.

FIG. 2 is a rear view of the embodiment of FIG. 1.

FIG. 3 is a view similar to FIG. 2, but showing the watercraft in banked condition.

FIG. 4 is an enlarged portion showing the area A of FIG. 2.

FIG. 5 is a cross-sectional view taken along the line 5—5 of FIG. 3.

FIG. 6 is a side elevation of another form of the invention.

FIG. 7 is a front view of the craft shown on FIG. 6.

FIG. 8 is a side view of another embodiment of the invention, similar in principle to the craft shown in the preceding figures, but utilizing different mechanical arrangements in the connection between the lift elements.

FIG. 9 is a plan view of the craft shown in FIG. 8. The mechanical connections between the lift elements are exposed by removal of the obstructing details.

FIG. 10 represents a variation of the mechanical connections shown in area D of FIG. 9.

FIG. 11 shows a substitute for the articulated parallelogram mounting of the floats represented in FIG. 8.

Important as they may otherwise be, the items which do not contribute to the understanding of the invention and are not active parts of the latter, are not necessarily shown on the figures. Thus, the figures do not consider the propulsion means, since the invention is not restricted to any particular type of propulsion. Also, structural details, which could obstruct the clarity of the drawings, are omitted.

The craft of the FIGURES 1 to 3 inclusive, is supported at rest and low speed by the buoyancy of the hull 1 and of two floats 2 and 3. At it picks up speed, hydrodynamic forces acting against the bottoms of hull and floats, lift the craft to the water surface. At sufficient speed, it is carried by three hydroplaning elements: the step B of the hull, and aft of it, the rear edges of the symmetrically arranged, outboard floats 2 and 3. Thus, the lifting elements form an isosceles triangle, the step B at the apex. This disposition could be reversed, the step B following, rather than leading, the two other supports. This "three point suspension" insures longitudinal as well as lateral stability. The three point suspension can be replaced by a four point suspension, like that of a four-wheeled vehicle. The fore and aft lift element assemblies would each constitute an entity arranged substantially in the manner of the pontoons 2 and 3 shown on the figures. The four supports would keep the hull, or any substitute thereof, above water. The hull could also remain in contact with the water and provide a fifth point of support. The support provided by aerodynamic forces acting against the hull and other components of the craft is held to be negligible in the examples shown in the figures. In watercraft where these forces contribute substantially to the lift, the pertinent components constitute additional support elements.

Directional stability is insured by the vertical tail fins C. The three lift elements of FIGURES 1, 2 and 3, i.e., hull or body 1 and floats 2 and 3, are deformably interconnected, the operator being in control of the geometry of the craft. The kinematic linkages are as follows. The floats 2 and 3 are each attached to a strut, 68 and 70 respectively. The latter are hinged to two transverse beams 72 and 74, the hinges being shown in 76, 78, 80 and 82. The beams are articulated at their mid-points 84 and 86 by hinges 88 and 90 to the hull 1. All the hinges are parallel to the longitudinal plane of the hull, the hinges 88 and 90 being in its median plane. The attachment of the float to its strut can be rigid, or it may incorporate a shock absorbing device.

Thus, each float is connected to the hull, i.e., to the third lift element B, by what is known as a kinematic chain. The invention does not limit the number of links constituting the chain. The simplest—"a four-link chain" (also known as "articulated quadrilateral") is shown on the figures. The links pertaining to the float 2 are: the strut 68, or more specifically, its portion contained between the hinges 78 and 76; the left hand branches of the beams 72 and 74; and that portion of the hull 1 which is contained between the hinges 88 and 90. Correspondingly, the links pertaining to float 3 are: the strut 70, the right hand branches of the beams 72 and 74, and the hull. Two of the links of one chain being integral with two links of the other, the chains are synchronized in their deflections. However, this is just one of many possible means of interconnecting the chains. They need not necessarily be linked in this particular manner.

The two chains can be deflected into, and held in, the desired configuration by an appropriate control system. One such system is shown in FIGURES 4 and 5. The beam 74 and the spindle 92 are held together by means of a key 94. Another key 98 retains a horn 96 on the spindle 92. The latter is mounted in a bearing 100 in the stern-post of hull 1. Cables 102 and 104 pass over pulleys 106 and 108, and connect the horn with the control wheel (not shown). By means of the cables 102 and 104, the operator can exercise a lateral force on horn 96, as desired. This will result in impressing a torque on beam 74 and cause thereby the quadrilaterals to deflect.

The FIGURES 1, 2 and 3 illustrate the representative case of the craft having its fore and aft lift elements coordinated for equal tilts. The quadrilaterals 76–88–90–78 and 80–88–90–82 are given the configuration of articulated

parallelograms, the opposite sides in each quadrilateral being made equal. This geometry causes all three lift elements—the hull and both floats—to tilt in unison by equal angles. FIGURE 3 shows the shape assumed by the quadrilaterals on deflection to an arbitrarily chosen angle of tilt. The opposite sides of the quadrilaterals have remained parallel. Since the floats 2 and 3 are kept by gravity in hydroplaning contact with the water, the beams 72 and 74 remain horizontal (the oscillations caused by the waves can be neglected for the purposes of discussion). It is the struts 68 and 70, together with their floats, and the hull 1, that have tilted—all by the same angle. Thus, the parallelogram configuration of the quadrilaterals satisfies the conditions of coordination, as chosen for this example. However, the kinematic connections of the invention are not limited to the articulated parallelogram. The designer is free to dimension the links of the kinematic chains as best suits his particular craft. For example, a four-link kinematic chain can have its opposite sides unequal, or have only two sides equal. Depending on the relative lengths of the sides, and in general on the geometric parameters of the chains, their deformations from the neutral configuration, will produce coordinated uneven mean tilts of the fore and aft lift elements.

The control torque impressed on the horn 96 cannot move the beam 74 away from its substantially horizontal position. Instead, the forces which tend to move the horn and the beam, react on hull 1 and, as has been seen, tilt the latter and the floats 2 and 3. Since this is achieved by physical effort, the requirement may arise for irreversible controls, servo-controls, or boost mechanisms. These are of standard use in control procedures, it is therefore not necessary to describe any particular form.

The watercraft shown in FIGURES 6 and 7 has much in common with that shown in FIGURES 1, 2 and 3. However, the hydroplaning elements providing lateral stability are hydroskis, in place of the floats of FIGURE 1 (at rest, adequate buoyancy is provided by the hull alone). The lateral lift elements 2 and 3 are in front of the craft, the step B of the hull is behind them, which reverses the previously shown disposition. Finally, the kinematic connections between the deflectable components of the craft, though still being performed by four-link kinematic chains, have abandoned the "articulated parallelogram" configuration in favor of one which having uneven opposite sides, produces yawing couples on deflection. It is accepted here that, considering all the forces which act on the craft (including aerodynamic forces and those of propulsion), production of these couples is beneficial in a turn, just as the opposite assumption governed the constitution of the linkage of the preceding embodiment.

Referring to FIGURES 6 and 7, the skis 2 and 3 are hinged to the hull 1 by means of two four-link kinematic chains formed by the quadrilaterals hinged respectively at: 126, 128, 130 and 132; and 134, 136, 138 and 140. The control system is represented by the cables 144 and 146, which run from the respective ski assemblies over pulleys 148 and 150 to the operator. The two kinematic chains are also linked together by means of a rod 142 hinged at both ends to the appropriate links of the chains. Among the advantages obtained from interconnecting the chains (as opposed to independently operated controls) is that of the bar 142 relieving considerably the loads which would be fed into the control system. Thanks to the bar, the controls must contain only the differential lift forces occasionally developed by the skis 2 and 3. The hull 1 is provided with vertical tail fin C, which can be of the fixed or movable type, or a combination of both, just as the tail fins C also equip floats 2 and 3 of FIGURE 2.

The craft of FIGURES 8 and 9 includes a central body (hull) 1, which is supported by four floats (pontoons) 2, 3, 2′ and 3′. The floats provide static buoyancy at rest, and dynamic lift at operational speeds. In an alternate design, the number of floats could be reduced to three (two laterally spaced in the rear, and one astride the plane of symmetry in front, or vice versa). In still another design, the hull could be lowered to the water level, to provide buoyancy at rest. Also, the craft could be designed to float at rest on its hull 1, and run upon take-off on three, four or more hydroskis, the latter substituting in operation for the floats 2, 3, 2′ and 3′ of FIGURES 8 and 9. The invention is compatible with various other layouts, including one comprising two floats, or surface piercing hydrofoils, or skis, etc., and one fully immersed hydrofoil, the three elements being established in triangular formation. These arrangements apply also to, and have been mentioned in connection with possible mutations of FIGURE 1. In all these configurations, the lift elements mounted on the sides provide lateral stability at controllable bank angles.

Steering of the craft by banking is achieved by the method identical with that employed in the preceding figures, i.e., by differential lowering and raising of the support elements assembled on the sides, while the tail fins C contribute to its directional stabilization. It will be shown that the craft can be so constructed that the support elements will produce no yawing couples. On the other hand, an alternate construction discussed in connection with FIGURE 10, provides for the generation in the turn of yawing couples or moments of sign and magnitude tailored to the characteristics of the particular craft. In this respect, the watercraft of FIGURES 8 through 11, and its variations, are similar to those of the preceding figures. The similarity extends also to the fact that the stabilizing elements on both sides share equally in the lift of the craft, whether the latter is kept on equal keel in a straightaway or banked in a turn; though it is feasible to make them act otherwise.

The most significant distinction between the craft of FIGURES 8 and 9 and the previously discussed configurations is in the mechanism connecting the port and starboard support elements. This mechanism will be now described.

The pontoons 2 and 3 constitute the fore pair of supports, jointly generating the force R_f. The aft pair of pontoons, 2′ and 3′, produces the force R_a. In both pairs, the floats are identically interconnected, and there is symmetry in the arrangement of each of these pairs. Hence, the description will be limited to that of one of the pairs. The float 2 is surmounted by a strut 68, which is shown to be of one piece, but which could incorporate a shock absorbing device. The assembly offers other convenient locations for the shock absorber which need not be detailed here. The strut 68 is related to the body 1 by means of two parallel links 20 and 22 of equal length, extending longitudinally. These links are freely hinged in 24 and 26 respectively to the strut 68. The hinge axes are oriented substantially in the transverse direction. The rear end of one of the links—link 20 in the occurrence—is freely hinged in 28 to the body 1, or to an extension thereof. Link 22 is keyed in 30 to a shaft 32 which penetrates into the body 1, and is held in bearings diagrammatically indicated in 34 and 36. The shaft 32 and the hinges 24, 26 and 28 are parallel. Thus, the float 12 is connected to the body 1 by an articulated parallelogram 24–26–30–28. The function of this parallelogram mounting is to maintain the float 2 at substantially a constant trim angle, when due to the deflections of the parallelogram the float 2 rises or falls with respect to the body. Except for this consideration of constancy of the trim angle, there is no need for articulated-parallelogram mounting.

The FIGURE 11 shows a substiute for the parallelogram mounting of FIGURE 9, whereby a single oblique strut 68′, keyed to shaft 32 and hinged to the pontoon 2, takes place of the strut 68 and all the linkage. The pontoon is free to assume its own trim angle which is main-

tained within the proper limits by action of the hydrodynamic forces.

Returning to FIGURES 8 and 9; at its end opposite to the link, the shaft 32 carries a bevel gear 38 which meshes at a right angle with a gear 40, the latter being secured to a longitudinal shaft 44 held in bearings. The float 3 which is mounted in an identical manner, has its bevel gear 42 meshing with the same gear 40, as shown. Thus, the floats 2 and 3 are differentially interconnected; by rotating gear 40, it is feasible for the operator to lower one of the floats with reference to the body 1 and raise the other float by the same angle.

The hydrodynamic forces developed by the floats 2 and 3 produce torques in the shaft 32 and its counterpart 33. When the hydrodynamic forces of floats 2 and 3 are equal (as normally they will be), the two torques balance out and are not transmitted through the shaft 44 to the controls. However, the operation of the gear 40 disturbs the balance. A torque appears in the shaft 44, and must be overcome. To reduce the manual effort, the control system may be provided with a boost mechanism using external power. FIGURE 9 shows diagrammatically a boost mechanism in 46, which will not be described, since power boost mechanisms are well known in the art. One boost mechanism, fully applicable to this case, is described in my co-pending application Serial No. 801,793, now Patent No. 3,124,096, of which the present application is a continuation-in-part. Another, and related, method for relieving the control effort, consists in applying to the hull 1 by some outside means, a rolling moment which helps to tilt the hull and operate thereby the floats in the desired direction. For example, such relief could be provided by the controllable aerodynamic surfaces producing rolling moments which are described in my co-pending appliaction for Surface Watercraft, Serial No. 344,977, filed on February 14, 1964. If the assistance thus given is only a partial one, it is necessary to couple the operation of gear 40 with the control of the aerodynamic surface. But it is entirely feasible to derive the whole banking and stabilizing effect from the outside source alone, be it the above mentioned aerodynamic surface or any other appropriate device. In that case, control of the gear 40 would become redundant. Instead of being connected to the controls—directly, or by medium of a boost mechanism—the gear 40 can be allowed to rotate idly. The whole operation is discussed in the last mentioned co-pending application. The foregoing remarks apply to all the embodiments of the invention shown in this specification.

The floats 2' and 3' of the rear pair are assembled similarly to the floats 2 and 3, and are interconnected by a gear 48. It is optional to connect, or not to connect, this assembly to the controls. It is obvious that if one pair of floats is differentially deflected, the other pair is compelled to follow, since all four floats seek to retain contact with the water. In fact, if the hull is banked for any reason at all, all the floats deflect and bank. Thus, the gear can be mounted idly, or it may be driven together with gear 40. This option is symbolized in FIGURE 9, by showing in dashed lines a shaft 50 relating gear 48 to the control system. Which of the two pair of floats, the fore or the aft, is to be controlled, is naturally a matter of option.

In the arrangement of FIGURES 9 and 11, the hydroplaning surfaces of floats 2, 3, 2' and 3' retain a constant angle with the plane of symmetry of the craft, regardless of the relative positions of the floats. Consequently, the forces R_f and R_a are always co-planar, and produce no yawing couple. By contrast, the FIGURE 10 shows a modified arrangement, whereby the operation of the floats produces a yawing couple. This figure represents the area which corresponds to area D in FIGURE 9. For ease of comparison, the corresponding components retain the same numeration. The modification consists in that the shafts 32 and 33 are established symmetrically at an angle to the transverse direction, whereas in FIGURE 9, they are shown to lay in the transverse plane itself. All hinges of the articulated parallelograms (not shown) entering in the assemblies of the floats 2 and 3, are parallel to the respective shafts 32 and 33. Due to the obliqueness of the shaft and hinges, the deflection of the parallelograms produces not a pure up and down movement of floats 2 and 3, but it associated also with a rotation of the floats about longitudinal axes. Indeed, the deflection of the float can be resolved into two rotations, one about a longitudinal, the other about a transverse axis. The transverse rotations duplicate the movements achieved in FIGURE 9. The longitudinal rotations produce a lateral tilt of the floats. Consequently, the angle between the plane of geometry of hull 1 and the hydroplaning surfaces of floats 2 and 3 changes as the parallelograms deflect. By comparison with FIGURE 9, this creates in the turn for the floats 2 and 3 an incremental bank angle, positive, or negative depending on whether the angle γ has been increased or decreased from its 180° value. In summary, the bank angle of the support elements 2 and 3 is increased or decreased, as the case may be, and the force R_f is moved out of the plane of symmetry. The force R_a can likewise be moved in the same manner. To what extent the forces R_f and R_a are skewed, depends solely on the relative values assigned to the respective angles γ. Thus, by design layout, a yawing couple can be created, whenever the floats are differentially deflected from their neutral positions. The magnitude and sign of the yawing couple is a built-in feature of the design.

Although the invention has been described and illustrated with particular reference being made to the embodiments shown in the drawings, it will be readily understood that many modifications and rearrangements of parts can be made without departing from the spirit and scope of the invention.

The newly introduced FIGURES 8 through 11 combine the features of the previously disclosed embodiment of the invention.

What I claim is:

1. A surface watercraft including a body, a plurality of at least three support elements generating dynamic lift forces during run to support said body, at least two of the support elements being hydroplaning elements laterally disposed on opposite sides of the body, said plurality of support elements including fore and aft support elements, operable kinematic means interconnecting at least two of said support elements and said body, steering means to operate said kinematic means and to tilt said support elements and said body relative to the water surface, said kinematic means including means to correlate the tilt angles of said fore and aft support elements into coordinated mean tilts whereby the resultants of the dynamic lift forces associated with said fore and aft support elements are tilted relative to each other by an angle of such sign and magnitude as to produce a yawing couple substantially neutralizing such other yawing couples and moments which oppose alignment of said watercraft with the tangent to its trajectory, and means for substantial inherent directional stabilization of said watercraft.

2. The watercraft of claim 1 wherein said kinematic means are arranged to produce equal mean tilts of said fore and aft support elements.

3. The watercraft of claim 1 wherein said kinematic means are arranged to produce programmed divergencies between the mean tilts of said fore and aft support elements.

4. The watercraft of claim 1 wherein said means for inherent directional stabilization is at least one fixed vertical tail fin.

5. The watercraft of claim 1 wherein said kinematic means are kinematic chains connecting each of said support elements to another of said support elements.

6. The watercraft of claim 5 wherein said kinematic chains are articulated quadrilaterals.

7. The watercraft of claim 6 wherein said articulated quadrilaterals are articulated parallelograms.

8. The watercraft of claim 6 wherein said articulated quadrilaterals are constituted by four links with at least two of the opposite links of said quadrilateral having different lengths.

9. The watercraft of claim 1 wherein said plurality of support elements include one element attached to said body and two laterally disposed hydroplaning elements, said operable kinematic means including a strut secured to each of said pair of lateral support elements, two beams interconnecting said pair of lateral support elements, hinges connecting each of said beams at its mid-span to said body, hinges connecting the ends of each of said beams to each of said struts, the axes of said hinges being parallel to the longitudinal axis of said body of said watercraft, one of said beams being controllable in its rotation about said mid-span hinge connected to said one beam whereby the rotation of said one beam produces differential lowering and raising of said lateral support elements to tilt them and the body of the watercraft with reference to the water surface.

10. The watercraft of claim 1 wherein said support elements include at least one pair of elements positioned on opposite sides of said body and said kinematic means includes a shaft connected to one of said pair of support elements on one side of said watercraft and a shaft connected to the other of said pair of support elements on the other side of said watercraft, said shafts being rotatively mounted in bearings supported by said body of said watercraft, and means differentially interconnecting said shafts to cause said shafts to rotate differentially when activated whereby one of said pair of support elements rises and the other of said pair of support elements falls relative to each other to tilt said support elements and said body with respect to the water surface.

11. The water craft of claim 10 wherein said two interconnected shafts are located in a transverse plane whereby the rotation of said shafts causes said body of said watercraft and said support elements connected by said shafts to tilt by the same angle.

12. The watercraft of claim 10 wherein said two interconnected shafts are disposed at an angle to each other and to the transverse plane of said body of said watercraft whereby the rotation of said shafts causes said support elements connected by said shafts to tilt by an angle unequal to the tilt of said body of said watercraft.

13. The surface watercraft of claim 1 wherein said support elements are four hydroplaning surfaces, two of said hydroplaning surfaces being laterally disposed on opposite sides of said body to form a first pair of support elements, the other two of said hydroplaning surfaces being laterally disposed on opposite sides of said body to form a second pair of support elements, said two pairs being longitudinally spaced relative to each other, means differentially interconnecting said first pair of support elements to each other to produce differential movement of said first pair with respect to each other, means differentially interconnecting said second pair of said support elements to each other to produce differential movement of said second pair with respect to each other, and means to actuate at least one of said differentially interconnecting means.

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