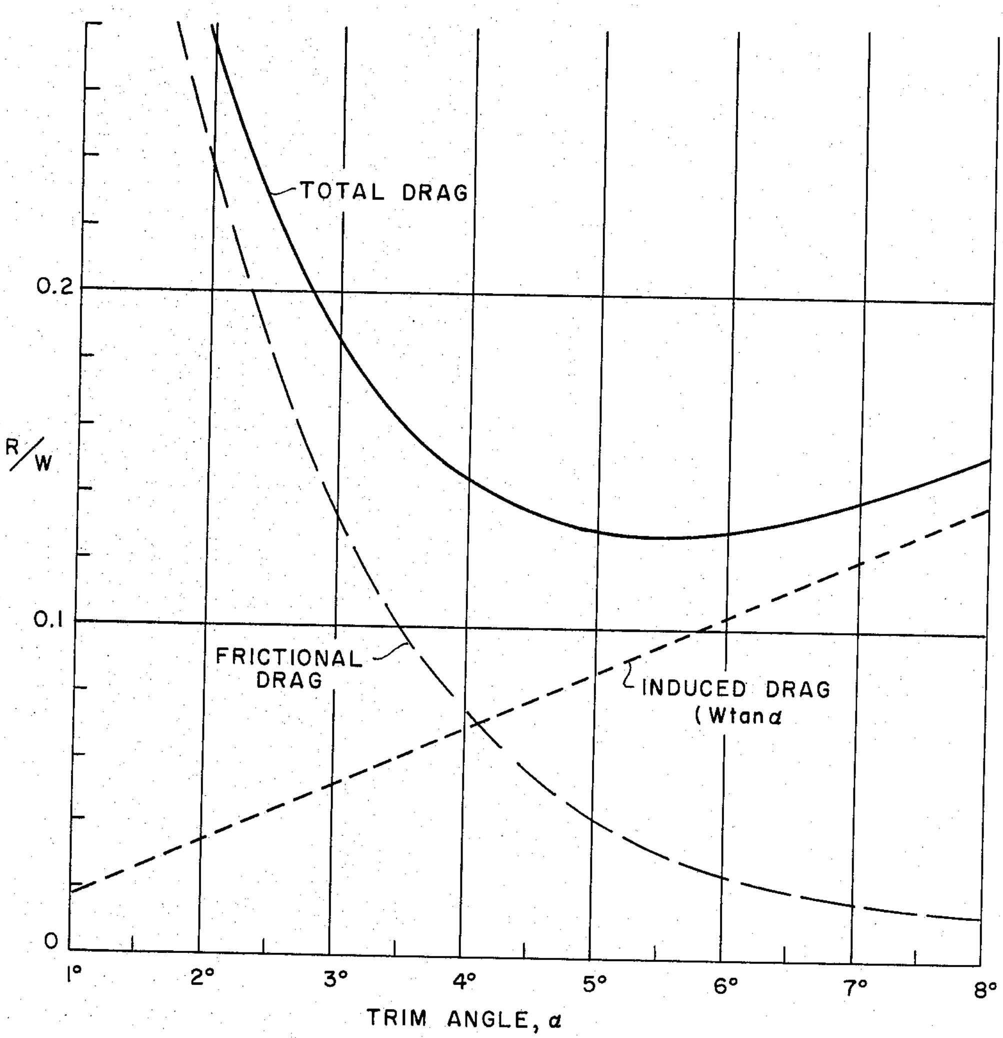

FIG. 1.

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July 12, 1966 J. PLUM 3,260,229

AUTOMATIC STABILIZER FOR WATERCRAFT

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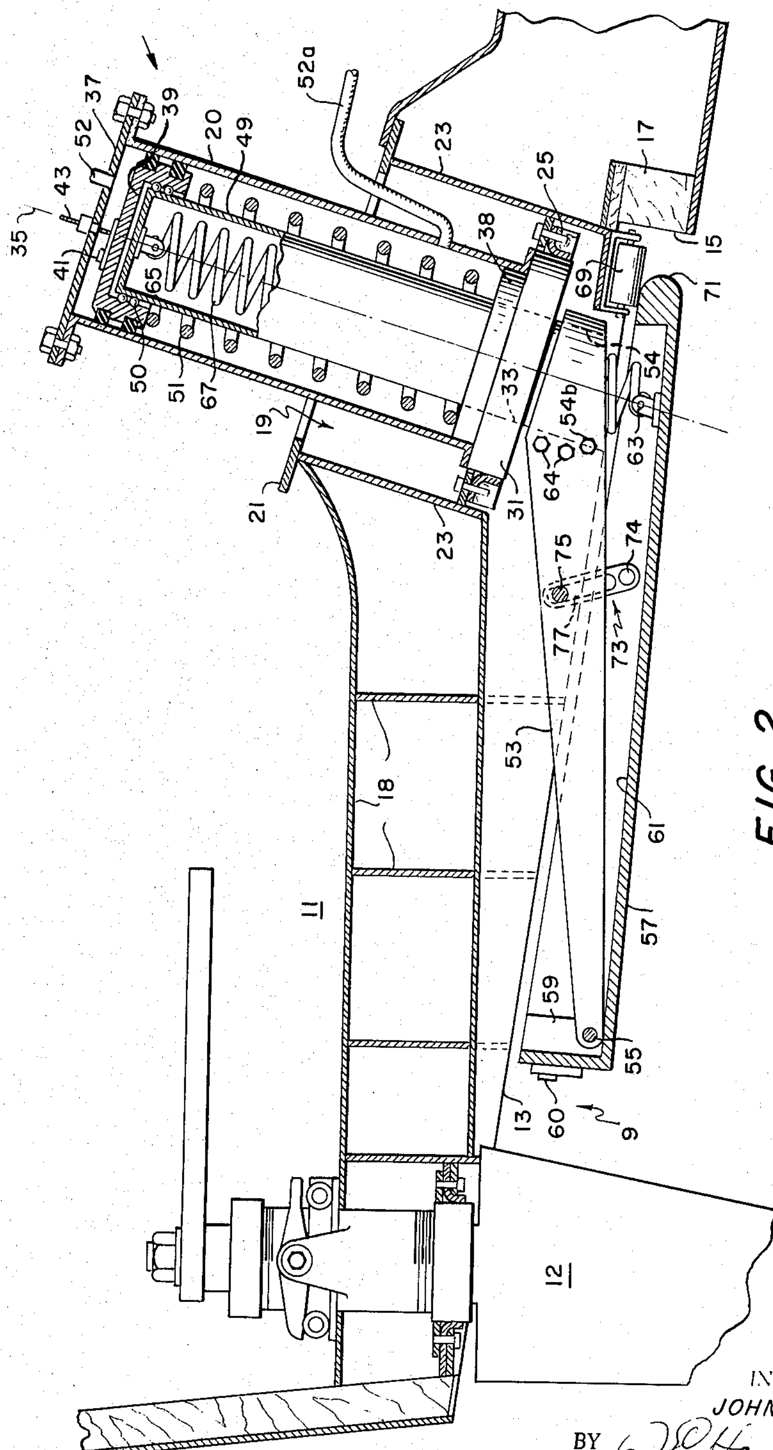

FIG. 2.

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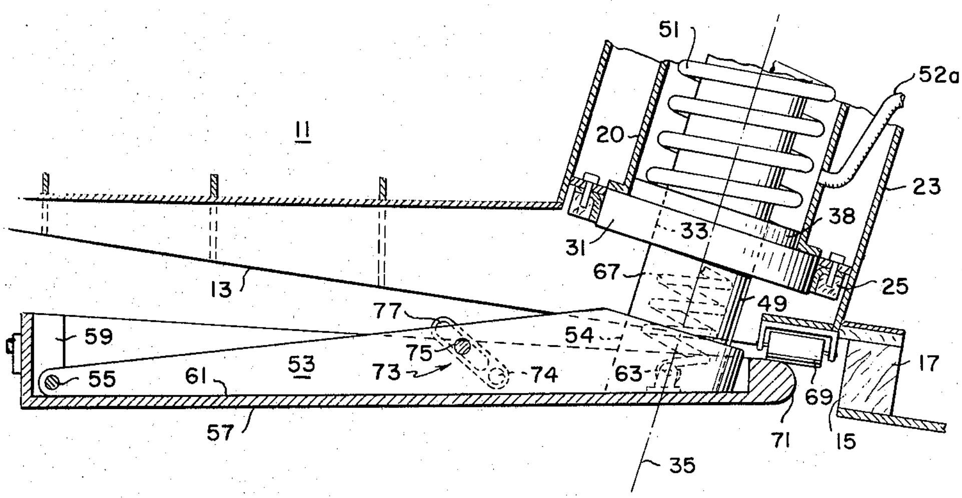

FIG. 3.

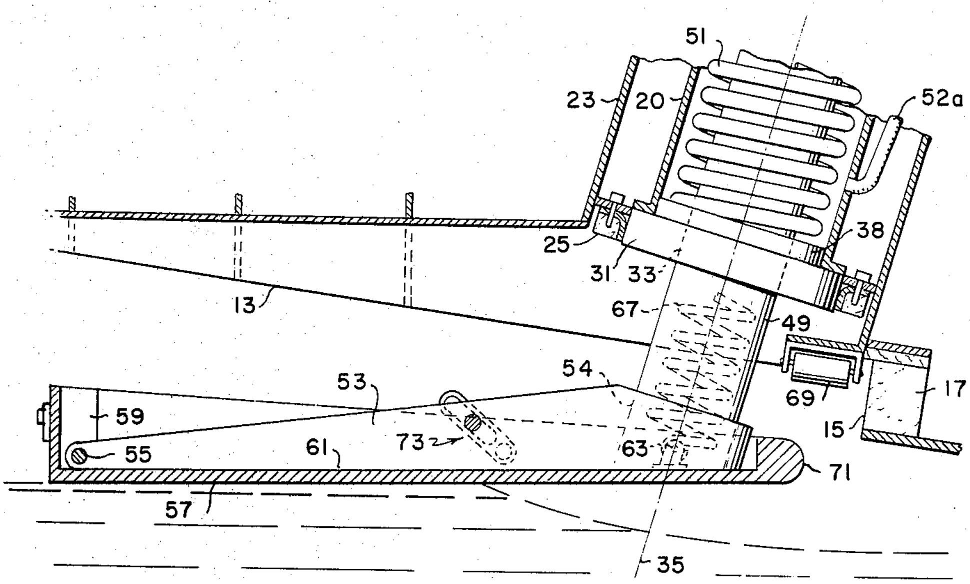

FIG. 4.

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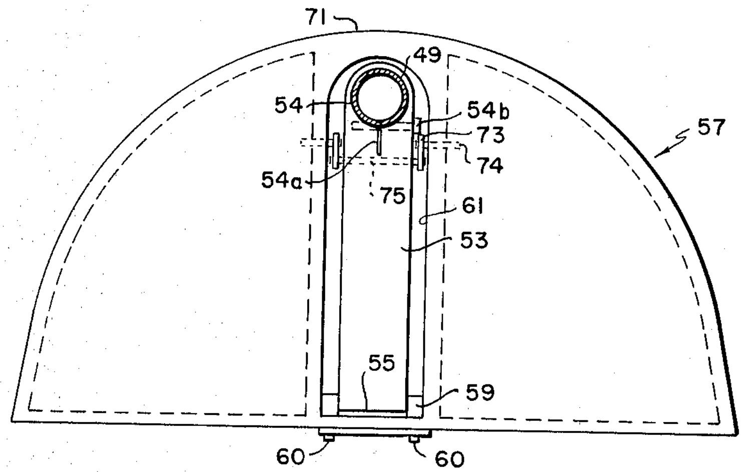

FIG. 5.

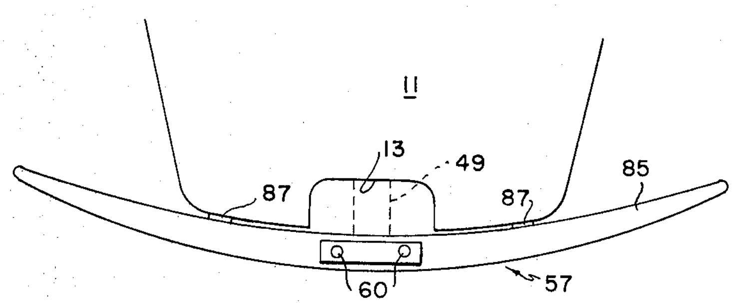

FIG. 6.

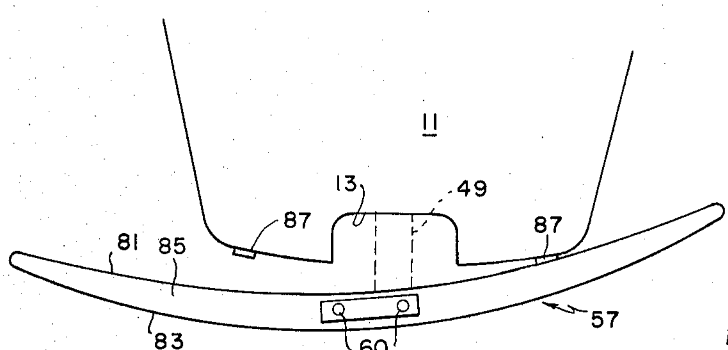

FIG. 7.

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AUTOMATIC STABILIZER FOR WATERCRAFT

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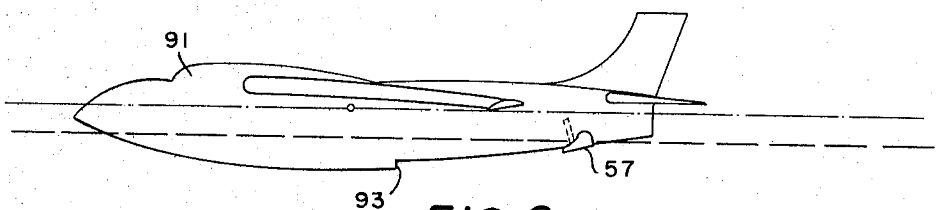

FIG. 8.

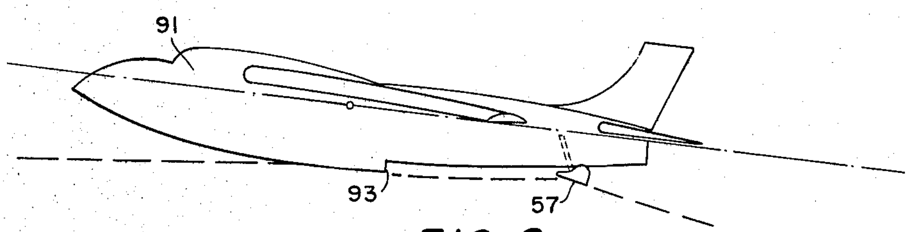

FIG. 9.

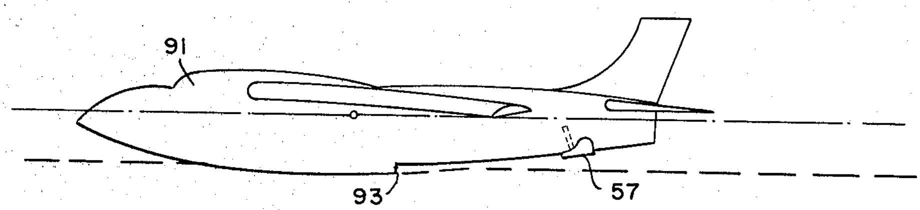

FIG. 10.

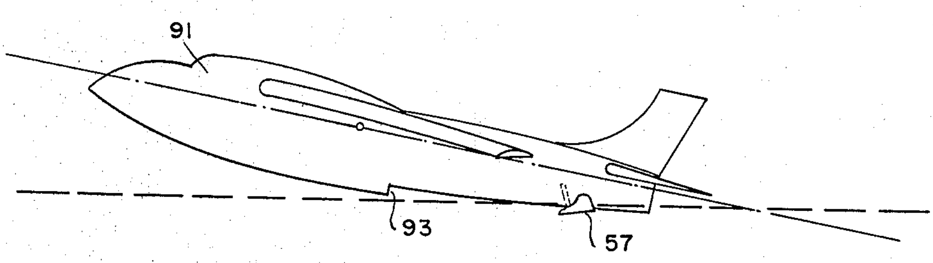

FIG. 11.

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United States Patent Office

3,260,229

Patented July 12, 1966

3,260,229

AUTOMATIC STABILIZER FOR WATERCRAFT

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Filed Feb. 25, 1965, Ser. No. 435,383
15 Claims. (Cl. 114—66.5)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to a stabilizing arrangement for stepped planing hulls and more particularly to a stabilizing arrangement which is an improvement on the device shown, described, and claimed in U.S. Patent No. 1,618,995; U.S. Patent No. 1,779,095; and U.S. Patent No. 1,875,135.

It is known to workers in this art that the stepped planing hull has great potential value if a practical solution can be found to eliminate some of its faults. Principal among these faults is the fact that the trim angle of the boat is affected much more by the magnitude and location of an added load than in the case of the stepless hull.

These problems will be readily understood when it is realized that the conventional stepped hull is supported by two planing surfaces traveling in tandem so that the afterbody is supported by water which has already been deflected by the forward planing surface.

If the forward planing surface is carrying a load, it will carve a groove in the water into which the afterbody will settle, thereby increasing the trim angle of the forebody. This increase will, in turn, increase the depth of the groove into which the afterbody will further settle. It is a vicious circle or chain reaction which greatly affects not only the trim angle of the stepped hull but also its pitching motions, which may be amplified into violent porpoising at high speed.

The amplifying effect of the downwash from the forward area can be curtailed by reducing the load on the forward planing surface to a minimum because, with a negligible load forward, there will be a negligible deflection of the water and, therefore, no amplifying effect. But without a forward load (i.e., a mass on the wave impact area), the pitching motions of the bow will be excessive and, if the waves are permitted to pass the forebody without being dispersed, the acceleration or pounding of the hull's afterbody will be violent and the bow portion of the hull will drop faster than a freely falling body. This phenomenon was clearly demonstrated during the last war when crew members in the forward sections of P.T. boats were seen "standing" in midair. This is explained by the fact that an upward acceleration of the stern will make the hull pivot about its center of gravity a moment after it has pivoted about its transom. This will accelerate the downward motion of the bow, and when the downward velocity is arrested by an oncoming wave, the maximum hull acceleration, i.e., "pounding," is produced.

Before proceeding further, it is to be understood that the statements made herein apply not only to vessels or boats having stepped planing hulls but also equally as well to stepped flying boat hulls.

In the case of the flying boat such extreme accelerations are eliminated, and control of trim is obtained by lifting the afterbody clear of the water by the airfoil stabilizers and elevators when sufficient air speed is attained. In fact, the functioning of the flying boat demonstrates adequately the advantages that can be obtained by the stepped hull if its afterbody can be lifted clear of the water and stabilized by a surfboard at the stern. It should be real-

ized that when the afterbody of the stepped hull is lifted clear of the water in this manner, the forward step is, in effect, the transom of the hull proper, and the afterbody becomes a "stern extension" by which the surfboard is towed.

In contrast to the towline by which a surfboard is usually towed without drag on the wave (or upwash) that follows a speed boat, the "stern extension" is a rigid part of the hull. To eliminate the maximum pounding and/or the "amplifying effect of the downwash," the surfboard (or the stabilizer) must, therefore, be free to follow the irregularities in the water surface on which it is riding without enforcing these on the rigid "stern extension." According to the present invention, the stabilizer supports the "stern extension" through a cushion of compressed air, the pressure of which (controlled by the pilot) decides the height at which the afterbody is lifted above the water surface. This in turn decides the magnitude of the hull's trim angle.

The magnitude of the trim angle is an important factor involved in the wavemaking resistance (called the "induced drag") of planing hulls. In FIG. 1 is shown a typical empirical resistance curve for a planing hull at the representative speed of 50 knots.

It is seen that the optimum trim angle producing the smallest drag is 5½ degrees even though the "induced drag" is enormously high. The induced drag is found by multiplying the weight of the hull by the tangent of the trim angle so that in the case of a 50 ton hull some 10,000 pounds of propeller thrust are required to overcome the "induced drag." Nevertheless, a large trim angle, which reduces the wetted area of the hull (i.e., of the forebody), gives the maximum speed of the conventional stepless hull in smooth water. This proves that the frictional resistance is a drag-producing factor out of all proportion to the other factors, including the induced drag.

Accordingly, the wetted area of the hull bottom should be reduced to the smallest possible value. But the method (conceived 50 years ago) of reducing the wetted area of the forebody by increasing the trim angle is obsolete compared with the method of eliminating all of the wetted area of the afterbody by reducing the trim angle. For instance, by reducing the latter from 6 degrees to 2 degrees at a speed of 50 knots, the 10,000 pounds of induced drag of 50 ton hull is reduced 68 percent.

Since the induced drag is a function of the hull weight and the trim angle, it becomes increasingly clear that the optimum trim angle of the planing surface should have the smallest possible value. This is especially important in the case of a craft designed for carrying heavy loads at high speeds. Such a quality has been found in the cambered planing surface which is described and claimed by me in U.S. Patent No. 1,618,995 issued March 1, 1927.

If the camber of a longitudinally concave planing surface starts with an angle of attack of zero degree, the downward acceleration of the water particles along the camber will be gentle and uniform, which in turn will produce a reaction (or lift) of surprisingly high efficiency. In fact, papers by Wagner (1932 and 1933); Tulin (1957); advocate the use of the cambered planing surface for reducing the drag, especially the wavemaking drag.

The frictional resistance of the cambered planing surface cannot be ignored. But if the area (or beam) of the latter is excessive for the load carried at the boat's maximum speed, the angle of attack of the camber can, of course, be reduced to zero. In other words, if a trim controlled stepped hull with a cambered planing surface already gets into planing condition at 30 m.p.h.; with zero angle at attack its beam and wetted area will be far too large at 60 m.p.h. Therefore, an additional load on such a hull will neither require an increase of trim angle nor a larger planing area. Hence, neither the induced drag nor the frictional resistance will be increased by an additional load at 60 m.p.h.

It is obvious that cambered bottom lines cannot be used in stepless planing hulls without causing a nose-down attitude which will increase the wetted area of the forebody and the tendency to broach in following seas. However, the efficiency of the camber when combined with control of trim has been confirmed in actual service by the stepped hulls of flying boats, such camber having been previously incorporated into the stepped hulls of flying boats by the U.S. Navy (1927). Further confirmation was provided by F. W. Horenburger, surveyor of the American Power Boat Association, who timed a 500-h.p., 40-ft. stabilized stepped hull with a cambered planing surface at 62.5 m.p.h. Its maximum speed was attained with a ballast of 4000 pounds or a 33 percent increase of the hull weight. In this case the stabilizer carried about 15 percent of the load or some 2000 pounds while 14,000 pounds was carried by the forward planing surface.

Since hull accelerations (pounding) are inversely proportional to the mass at the wave impact area and directly proportional to the magnitude of the trim angle, the present invention improves the speed and comfort of small craft. And since the present invention permits the pilot to reduce the trim in head seas and increase it in following seas, the invention is also an improvement in the safety of the small craft.

It is, therefore, an object to the present invention to provide a stabilizer for a stepped planing hull which may be controlled to have negative and positive trim angles and further to have hydrodynamic surfaces which are simple to manufacture and which are capable of providing lift action without causing directional forces.

The present invention when applied to flying boat stepped hull configurations enhances not only the takeoff mode of the aircraft but also enhances its landing mode. For example, during the takeoff mode, the increasing trim angle of the hull during acceleration is also enforced on the stabilizer which will travel submerged until its trim angle has become sufficiently lift producing to enable it to break through the water surface and become a surf riding aquaplane. Once the stabilizer acts as an aquaplane, the drag induced on the afterbody of the aircraft is so greatly reduced that the airplane may easily take off with loads substantially greater than would be otherwise possible without the stabilizer. The further advantage accruing to the present invention is the fact that when the flying boat is initially moved in its takeoff mode, the stabilizer is at a negative trim angle. Therefore, upon movement of the aircraft, the stabilizer tends to pull down on the stern portion of the aircraft thereby forcing the aircraft into an initially positive trim angle and further counteracting the moments of the thrust of the propellers which would tend to cause the airplane to nose down.

During the landing mode of the flying boat, as the aircraft approaches and makes contact in its stern portion with the water, the stabilizer has a negative trim angle tending to pull down the stern, slowing down the aircraft and preventing the aircraft from nosediving.

A principal object of the present invention is to provide a stabilizing arrangement enabling heavily loaded stepped flying boat hulls to acquire the optimum trim angle or lift-drag ratio during the time the flying boat is accelerated to higher speeds.

The foregoing objects and advantages of the invention as other features of the invention will be better understood by reference to the following detailed description and accompanying drawings in which:

FIG. 1 (previously referred to) is a graph depicting drag characteristics of planing craft;

FIG. 2 is a view in modified longitudinal cross-section of the stern portion of a stepped planing hull provided with a stabilizer shown in its retracted position and control means therefor in accordance with the invention;

FIGS. 3 and 4 are views in modified longitudinal cross-section of the stabilizer of FIG. 2 in its partially extended and fully extended positions respectively;

FIGS. 5, 6 and 7 are views of the stabilizer in various positions during its operation according to the invention;

FIGS. 8, 9, 10 and 11 are side views of a flying boat incorporating the stabilizer according to the present invention and showing the flying boat in relative positions with respect to the water during landing or takeoff.

The stabilizer according to the present invention is shown in FIG. 2 arranged in a recessed portion **9** below the stern portion of a boat hull **11** having a rudder **12**. The recessed portion **9** has a longitudinal central recess **13**, best seen in FIGS. 6 and 7, extending to the transom. The forward end of the recessed portion **9** terminates in a shallow step **15** defined by a thwartships blocks **17**. As an non-limiting example, the depth of the step **15** may be about 2 inches in a boat approximately 30 feet long.

Transverse and longitudinal structural members **18** of the craft near the step **15** are arranged to define a generally cylindrical space **19** for housing a canted cylinder **20**. The top of the space **19** is defined by a sturdy structural frame **21** rigidly attached to hull members. The sides of the space **19** are defined by members **23** secured at their tops to the hull members and member **21** and at their bottom to the hull. The members **21** and **23** provide a strong base so that a clamp (not shown) may be mounted on the member **21** to hold the cylinder **20** rigidly in place.

The bottom of the opening **19** is sealed against sea water by an annular sealing element **25** of any suitable construction. The annular member **25** also serves as a radial support for an end fitting **31** having an axial bore **33** and fluidtightly secured to the bottom of the cylinder **20**.

The axis of the canted cylinder **20** is indicated by numeral **35** and has its upper end substantially forward of its lower end. The upper end of the cylinder **20** is fluidtightly sealed by a head **37**.

Located within the cylinder at its bottom just above the end fitting **31** is annular seal and roller bearing unit **38** of any suitable construction.

A double acting piston **39** is mounted within the cylinder **20** and has on its upper surface a mounting element **41** for receiving a wire **43**. The wire **43** passes fluidtightly through the head **37** and extends to an instrument panel on the craft for indicating the exact axial position of the piston **39** in the cylinder **20**.

A hollow piston rod **49** is rotatably mounted at its upper end to the piston **39** by means of a ball bearing **50** of any suitable construction and arranged so that the rod **49** does not move axially relative to the piston **39**. The piston rod **49** therefore moves axially with piston **39** but rotates independently thereof about the canted axis **35**. The diameter of the piston rod **49** is such that the rod passes in close sliding relation with the inner race of the roller bearing in unit **38**. The cylinder **20** is thus sealed at both ends.

A compression spring **51** is located between the wall of the cylinder **20** and the piston rod **49** and has its upper end resting against the lower surface of the piston **39** and its lower end resting against the upper surface of the unit **38**. The purpose of the spring **51** is to hold the piston in place when the stabilizer and its controlling means are not in actual operational use. The spring **51** also acts as a stop to prevent excessive downward movement of the piston.

The axial position of the piston **39** is controlled by means of high pressure air coupled to the cylinder **20** via an upper conduit **52** and a lower conduit **52***a*. The high pressure air may contain a small amount of oil entrained therewith to provide a good seal between piston **39** and cylinder **20**.

Rigidly attached to the lower end of the piston rod **49** is a foot **53** made of sturdy material such as metal. As best seen in FIG. 5, the forward end of the foot has a bore **54** and a central longitudinal slot **54***a* extending a short distance aftwardly therefrom. A plurality of studs **54***b* pass transversely thru the slot **54***a*, foot **53**, the lowermost of the studs passing thru a portion of the wall of rod **49**, to securely hold the foot **53** rigid to the rod **49**. Thus the entire foot **53** moves in unison with the piston rod **49** in rotation and translation.

At the aft end of the foot **53** is a transverse hinge defined by a pin **55**. The stabilizer element **57**, is connected at its aft end to the pin **55** by means of a block **59** carrying the pin **55**. Studs **60** secure the block **59** to the stabilizer and hold the block in place. The exact shape of the surfaces of stabilizer **57** will be described in more detail in conjunction with FIGS. 5 thru 7.

The upper portion of the stabilizer **57** has a longitudinal central recess **61** into which, as shown in FIGS. 3 and 4, the foot **53** is pushed when the stabilizer **57** is lowered. Secured to the forward end of the recess **61** of the stabilizer is an eyelet **63**. The eyelet **63** is located approximately on the axis **35**. A depending eyelet **65** is attached to the upper interior end of the piston rod **49**. A tension spring **67** has its upper end connected to the eyelet **65** and its lower end connected to the eyelet **63**, so that the spring **67** tends to draw the forward end of stabilizer **57** toward the foot **53**.

Just aft of the step **15** is provided a roller element **69** having a longitudinal axis of rotation. The stabilizer **57** has a faired leading edge **71** the upper surface of which is held in intimate contact with the bottom surface of the roller **69** by the action of the tension spring **67** thereby providing a pivot for the stabilizer during the initial stages of downward motion of the stabilizer.

A limit stop **73** mounted on each side of the foot **53** is rotatably mounted on a transverse pin **74**. The pins **74** are mounted on each side of the recess **61** of the stabilizer. The foot **53** has a pin **75** extending transversely thru the foot **53**. The limit stop **73** has an elongated central slot **77** receiving the pin **75** so that the movements of the stabilizer **57** away from the foot **53** are limited.

As previously mentioned, stabilizer **57**, shown in a drawn up (retracted) position in FIG. 2 has in that position an attack angle that is negative with respect to the forebody.

The magnitude of the trim angle or positive attack angle of the stabilizer is dependent upon the attack angle of the bottom surface of the foot **53** as installed. Any suitable means may be employed for adjusting the attack angle of the foot during or after the original installation of the equipment. When, as shown in FIG. 3, the foot is initially lowered by applying air to the cylinder via conduit **52**, the stabilizer **57** rotates about the pin **55** and pivots with some aftward sliding motion at its leading edge **71** so that the entire bottom surface of the foot **53** is in intimate contact with the floor of the recess **61**. Consequently the stabilizer is advantageously supported along nearly its entire length by the foot **53** when the foot is lowered to and below its position shown in FIG. 3. The stabilizer may be lowered to any position until the piston is stopped by spring **51**.

When the foot **53** is lowered still further, it loses contact at its leading edge with the roller **69**. The stabilizer has a positive trim angle and is completely free to move in modes following local water disturbances. The FIG. 4 position of the stabilizer is the desired position for use in the planing mode of the craft. The movement of water in relation to the stabilizer **57** is exemplarily indicated in FIG. 4. The motion of the stabilizer in its "free" position (FIG. 4) can be understood by realizing that the stabilizer when planing always tends to remain oriented in a horizontal plane, even when the craft is heeling. Recall that the piston rod **49** may rotate about forwardly canted axis **35**. With such a canted axis, when the stabilizer **57** has positive trim angles, rotation of the stabilizer about the canted axis **35** causes one aft corner of the stabilizer to be elevated while the other aft corner is lowered. When the craft heels, the axis **35** of course, moves with the craft and the stabilizer initially heels with the craft. Subsequently, the stabilizer rotates about axis **35**. The rotation of the stabilizer is caused by greater drag acting on the low side of the stabilizer. This rotation of the stabilizer about the canted axis **35** causes the initially low side of the stabilizer to return to same, or another horizontal plane with its longitudinal axis different from that of the heeled craft. Thus the stabilizer remains essentially horizontal when the craft is heeled.

As seen in FIGS. 5, 6 and 7, the stabilizer **57** is formed of two continuously curved surfaces symmetrical about the longitudinal axis of the stabilizer and meeting each other at the leading edge and sides. The curved surfaces may be portions of right circular cylinders, or any other cylindrical or continuously curved shape. As an example, but not a limitation, the stabilizer as shown has upper and lower curved surfaces **81** and **83**, the curvature of the lower surface being greater than that of the upper. The lower surface is transversely convex with respect to the water, and in all its transverse cross sections the stabilizer has essentially a crescent shape. In longitudinal cross section, the stabilizer has a wedge shape with a faired leading edge (FIGS. 2 thru 4), and in plan view (FIG. 5) the stabilizer has a generally semi-circular shape. A sturdy crescent-shaped strength member **85** supports the aft ends of the surfaces **81** and **83**. The surfaces may be made of any suitable material, e.g. metal or Fiberglas, or the like, and may be joined at their edges and at strength member **85** in any suitable manner, as by welding, bonding, etc. Preferably the stabilizer may be formed to have a unitary integral structure by any suitable method, such as by injection molding, lay-up, casting, etc.

Near the outer edge of the deadrise beneath each side of the stern is located a block **87** made of any suitable slippery material such as nylon, Teflon, Kel–F or the like. When the stabilizer **57** is to be drawn up (retracted) from its positions shown in FIG. 4 and FIG. 3 to that shown in FIG. 2 (and FIG. 6), the blocks **85** serve to center the stabilizer. This action is shown in FIG. 7. The upper surface **81** may have one side in a higher position than the other relative to craft **11** due to local water conditions, or due to heeling. As exemplarily shown in FIG. 7 the right hand side of the stabilizer is higher. As the stabilizer is drawn up (by injecting high pressure air into the cylinder via lower conduit **52***a*), the higher right hand side eventually comes into intimate contact with a block **85**. As the stabilizer moves upward the surface **81** slides essentially laterally along past the block **87**, the block **87** having a camming action. When the stabilizer is fully retracted (FIG. 6), the longitudinal axis of the stabilizer parallels that of the craft **11**.

In FIGS. 8–11, the invention is shown applied to a flying boat **91** having a midships step **93** in the hull. The stabilizer **57** is shown mounted on the afterbody near the tail end of the hull and is depicted in exaggerated positions for purposes of descriptive clarity.

During takeoff, power is applied to the flying boat which is at rest as shown in FIG. 8. Ordinarily a sudden increase in power would tend to cause the flying boat to nose dive. However, according to the invention, the stabilizer is given a suitable negative trim angle so that when power is initially applied, and the flying boat begins to move, the stabilizer tends to pull the afterbody down. The lowering of the afterbody immediately establishes a positive trim angle for the flying boat, reducing total drag. As the flying boat speed is increased, say to about 10 kts., as shown in FIG. 9, the stabilizer **57** is given a suitable positive trim angle, resulting in lifting the afterbody to prevent excessive hull trim angle. Minimizing the trim angle of the hull reduces induced drag and enables greater take off loads and shorter take off runs than would be possible with large hull trim angles during take off. As can be seen in FIG. 9, the hull planes on the step **93** and the stabilizer **57** in tandem therewith. The advantageous use of the stabilizer thus results in a minimum of wetted area and a minimum trim angle, thus reducing total drag.

As the flying boat speed is further increased, the airfoils in the tail eventually lift the afterbody from the water, as shown in FIG. 10. The stabilizer may then be retracted as shown. The amount of lift necessary to pull the afterbody from the water is reduced according to the invention because of less wetted area in the afterbody and because of the aiding stern-lifting action of the stabilizer. The flying boat is then planing at high speed on its forebody and is ready for lift off.

During landing the stabilizer **57** is maintained in its retracted, negative trim angle position so that, as shown in FIG. 11, as the flying boat touches down, a moment before the forebody touches the water surface, the stabilizer will become submerged at a negative trim angle (shown somewhat exaggerated in FIG. 11). The effect of the action of the stabilizer is to "anchor" the afterbody to the water surface while decelerating the hull with its drag.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. Stabilizing apparatus for a planing craft of the type having a stepped hull comprising:

a stabilizing element positioned on the afterbody;

said stabilizing element having on its underside a planing surface;

movable body means located in the craft above the location of the stabilizing element;

said movable body means being arranged for movement along, and rotation about, an axis in the longitudinal plane of the craft extending thru a forward portion of said stabilizing element;

said axis being canted whereby the upper end of said axis is forward of the lower end thereof;

a longitudinally disposed elongated body member rigidly connected at its forward end to said movable body means and rotatably connected at its aft end on a transverse axis to the aft end of said stabilizing element;

whereby upon movement of said movable body means the afterbody of said stabilizing element pivots about a transverse axis located approximately at the leading edge portion of the stabilizing element;

said stabilizing element thereby being retractable to negative trim angles and extendable to positive trim angles responsive to movement of said movable body means.

2. Apparatus according to claim **1** including elastic means connecting the forebody portion of said stabilizing element to said movable body means whereby the leading edge portion thereof is further held in place.

3. Apparatus according to claim **1** wherein said stabilizing element is comprised of an upper curved surface and a lower curved surface of greater curvature than the upper surface and coextensive therewith, said surfaces being joined at their edges, to define in plan view semicircular shape, said stabilizing element having elongated essentially wedge-shaped longitudinal cross sections.

4. Apparatus according to claim **3** wherein said upper curved surface has a longitudinal recess therein for receiving said elongated body member.

5. Apparatus according to claim **3** wherein each of said curved surfaces is cylindrical about a longitudinal axis of the stabilizing element.

6. Apparatus according to claim **3** including a body of relatively slippery material mounted on the bottom of the after body on each side of the centerline for intimate sliding contact with the after portions of the upper surface of said stabilizing element whereby said bodies provide camming means for enhancing centering of the stabilizing element when drawn up.

7. Apparatus according to claim **3** including a rotatable element mounted for rotation about a longitudinal axis of the craft, said rotatable element bearing against the upper portion of the leading edge of said stabilizing element.

8. Apparatus according to claim **1** wherein said movable means comprises a piston mounted within a closed cylinder coaxial with said axis, said piston having a depending tube rigidly attached thereto.

9. Apparatus according to claim **8** wherein said movable means further comprises a spring positioned within said tube and connecting said piston to said stabilizing element along said axis.

10. Apparatus according to claim **9** wherein said movable means further comprises controllable means for providing fluid under pressure for acting on said piston to move it upwardly and downwardly along said axis, and a further spring arrangeed within said cylinder to urge an upward force against said piston.

11. Apparatus according to claim **10** but further comprising means attached to said piston for indicating the axial position of said piston in the cylinder, whereby the position of said stabilizing element is accurately determined.

12. Stabilizing apparatus for a planing craft of the type having a stepped hull, said hull being provided in its afterbody with a shallow recessed portion, said apparatus comprising:

a stabilizing element positioned in the recessed portion of the afterbody;

said stabilizing element having gently curved closely overlying upper and lower surfaces at least approximately circular in transverse cross section;

said stabilizing element in plan view being generally delta shaped with a curved leading edge;

a reciprocating piston located in the craft above the stabilizing element;

said reciprocating piston being arranged within a closed cylinder for sealed sliding movement therein both axially and rotationally about the axis of the cylinder;

said reciprocating piston having rigidly attached thereto a depending element protruding into said recessed portion;

the axis of said cylinder being in the longitudinal plane of the craft and canted whereby the upper end of the axis is forward of the lower end thereof, the lower end of the axis extending thru the stabilizing element at a point thereon near the leading edge, the aftward-facing angle at which the axis meets the longitudinal section of the stabilizing element being at least obtuse;

a longitudinally disposed elongated body member having a given attack angle rigidly connected at its forward end to the protruding portion of said reciprocating element and rotatably connected at its aft end on a transverse axis to the aft end of said stabilizing element;

whereby upon movement of said movable body means the afterbody of said stabilizing element is rotatable about a transverse axis located approximately at the leading edge portion of the stabilizing element, said leading edge portion capable of being held in place in the recessed portion of the craft by the planing action of the stabilizing element;

said stabilizing element thereby being retractable to negative trim angles and extendable to positive trim angles responsive to movement of said movable body means and further being rotatable about said axis.

13. Apparatus according to claim 12 wherein said depending element comprises a tube;

and a tension spring disposed within said tube connected at its upper end to said piston and at its lower end to said stabilizing element.

14. Apparatus according to claim 12 wherein said stabilizing element has a longitudinally disposed recess in its upper surface for receiving said elongated body member when said piston is moved downwardly, said elongated body providing support for the stabilizing element along a substantial longitudinal length of the stabilizing element.

15. Apparatus according to claim 14 including retaining means connecting said stabilizing element and said elongated member to prevent excessive relative movement therebetween.

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