United States Patent [19]

Miller

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[54] **FIN-KEEL CATAMARAN**

[76] Inventor: **Reginald T. Miller,** 700 Delaware St., Berkeley, Calif. 94710

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[21] Appl. No.: **177,930**

[52] **U.S. Cl.** **114/39,** 114/61

[51] **Int. Cl.** **B63b 35/00**

[58] **Field of Search** .... 114/39, 665 R, 665 H, 114/127–140, 144, 149, 162–165, 89, 90, 104, 106, 107; 9/1 T

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Primary Examiner—Duane A. Reger
Assistant Examiner—Jesus D. Sotelo
Attorney, Agent, or Firm—Whittemore, Hulbert & Belknap

[57] **ABSTRACT**

A catamaran type yacht is disclosed which is of very narrow overall beam, having an elongated fin-type keel adjustably mounted on the fore-to-aft center line between its dual hull sections; and this fin-keel is operated adjustably under the control of a simple manual retraction mechanism. The main or wing mast of the craft has means for pivotally mounting the same at a novel stepping sub-assembly; and the mainsail boom is connected to the mast by a gooseneck loop device which allows for a tilt at an acute angle to a vertical plane including the boom axis. Provision is also made for a vertical adjusting movement of the boom in a relatively limited degree. Each hull member is equipped with a pivotally mounted kick-up rudder, the rudders being coupled for conjoint tiller operation. A solid section forestay or job spar is employed in a novel procedure of facilitating raising of the main mast above its stepping unit; and a pop-top type cabin cover is provided for installation in small yachts, with a flexible tent auxiliary shelter operatively connected to the pop-top when the latter is erected.

25 Claims, 27 Drawing Figures

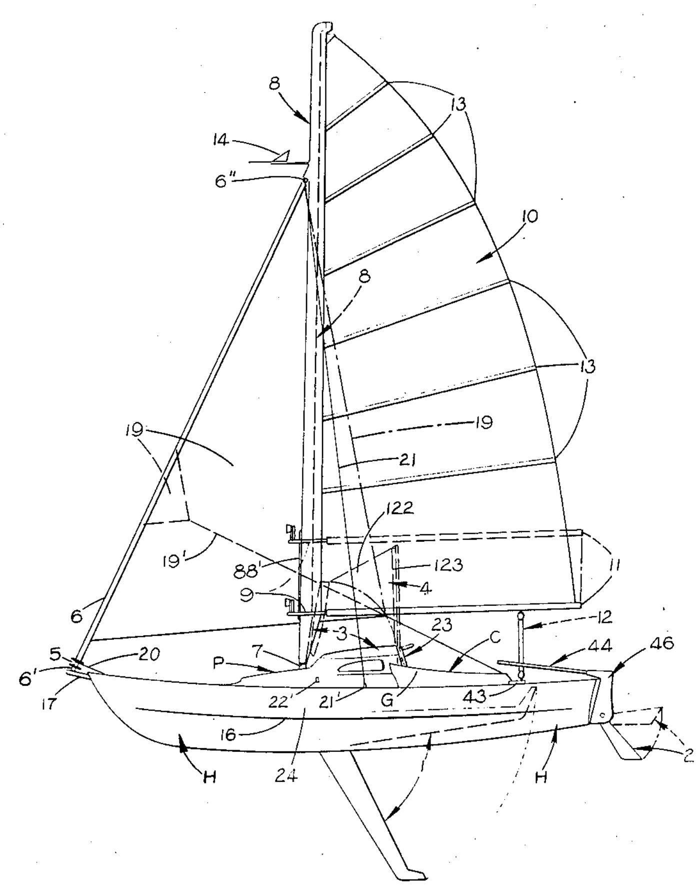
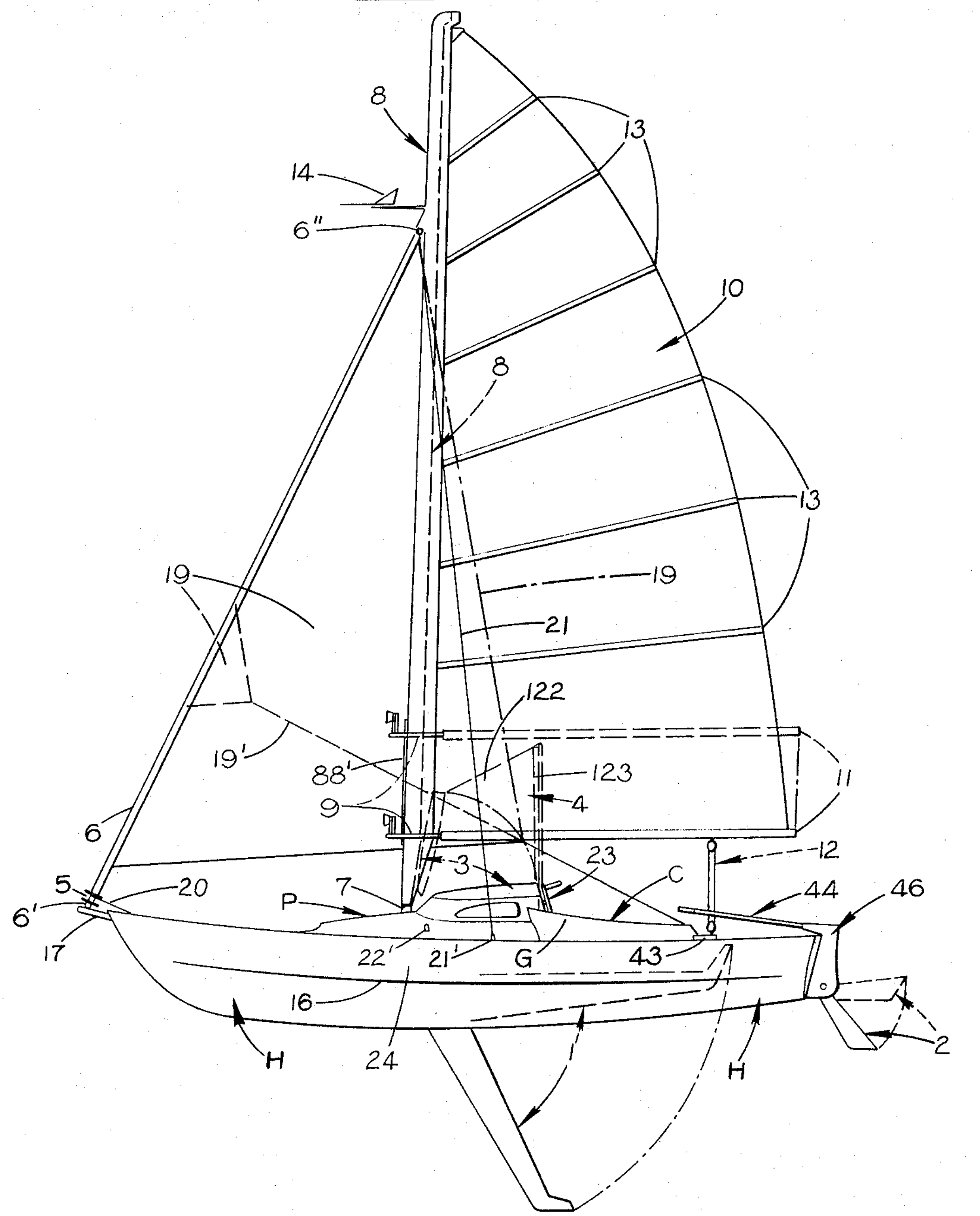


FIG 1



INVENTOR.
REGINALD T MILLER
BY
Whittemore, Hulbert & Belknap

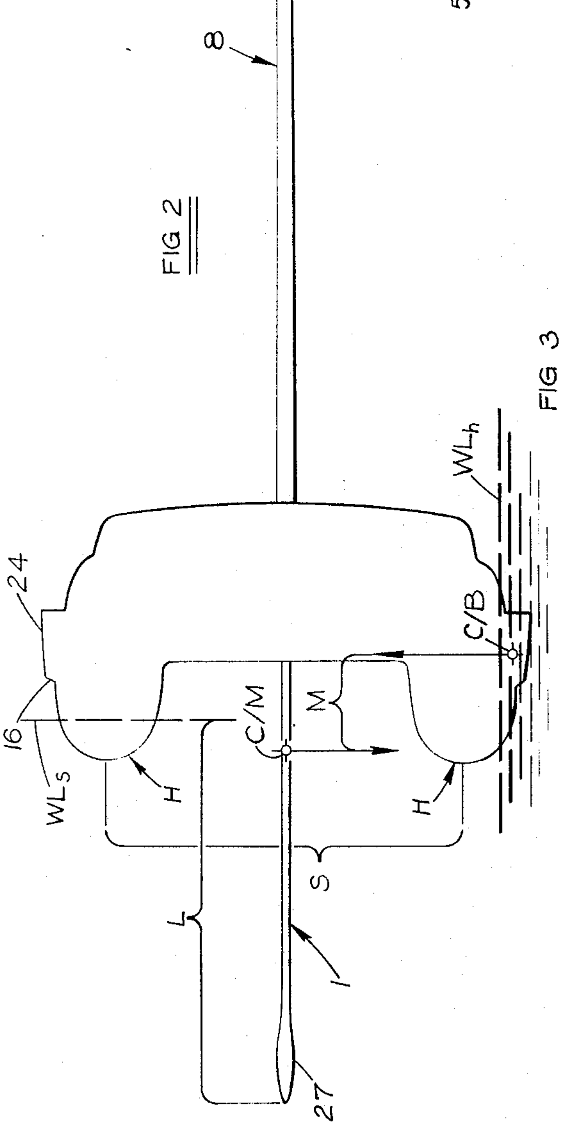


FIG 2

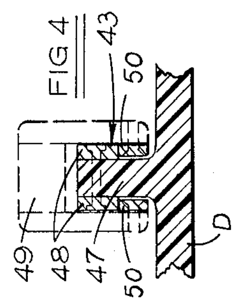


FIG 4

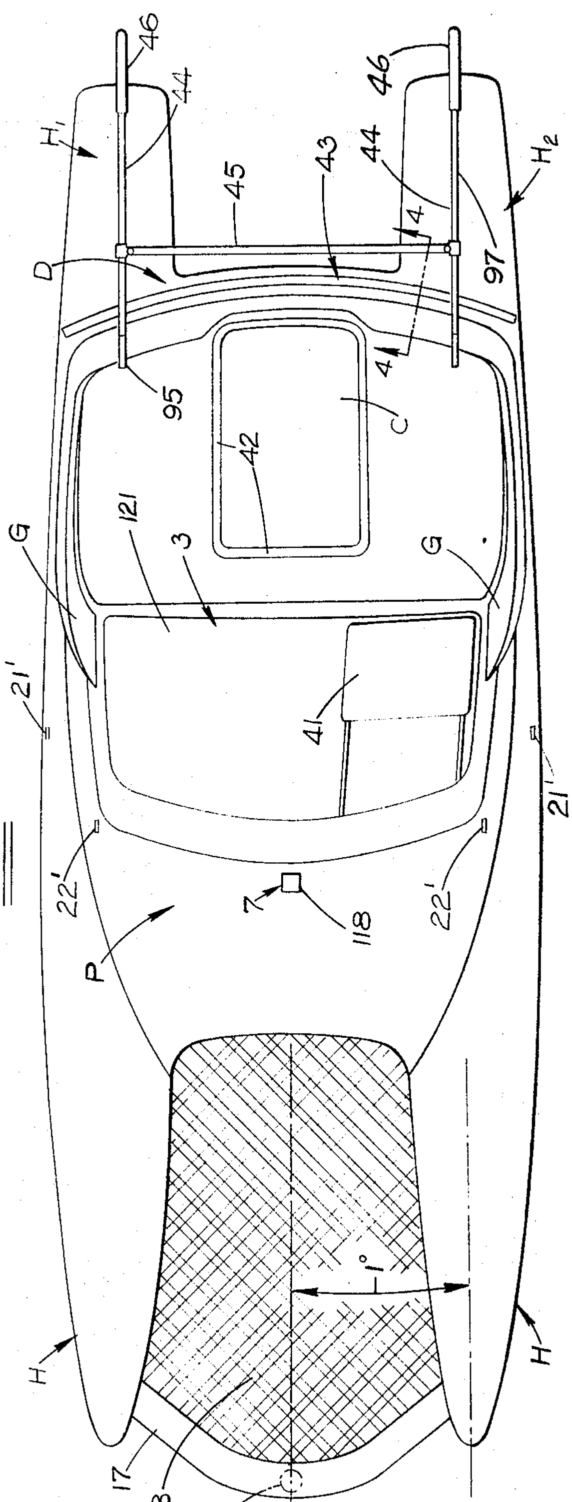


FIG 3

INVENTOR.
REGINALD T MILLER
BY
Whittemore, Hulbert & Belknap

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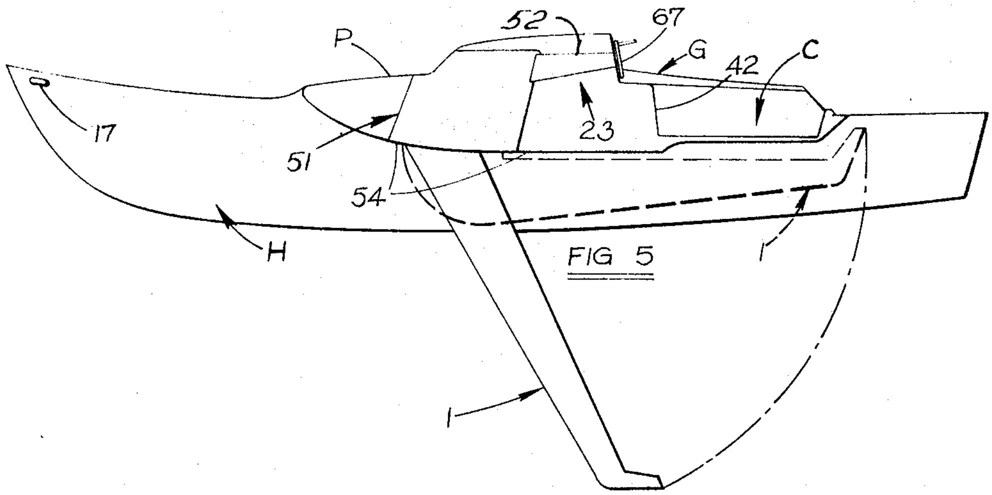

FIG 5

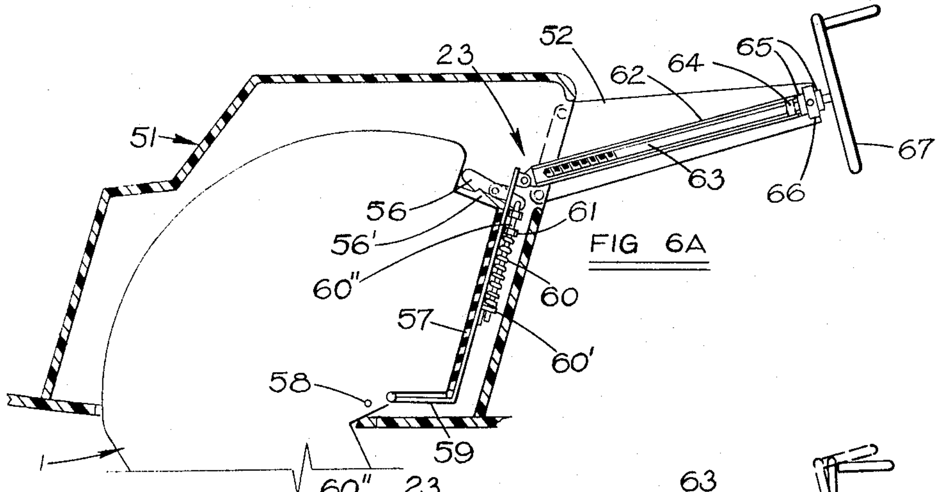

FIG 6A

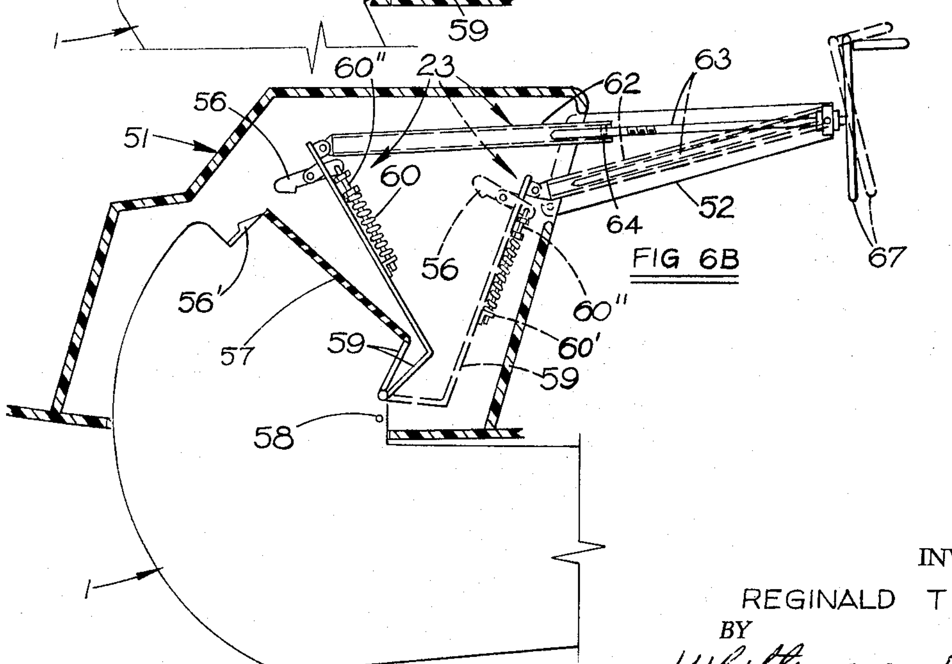

FIG 6B

INVENTOR.
REGINALD T MILLER
BY
Whittemore, Hulbert & Belknap

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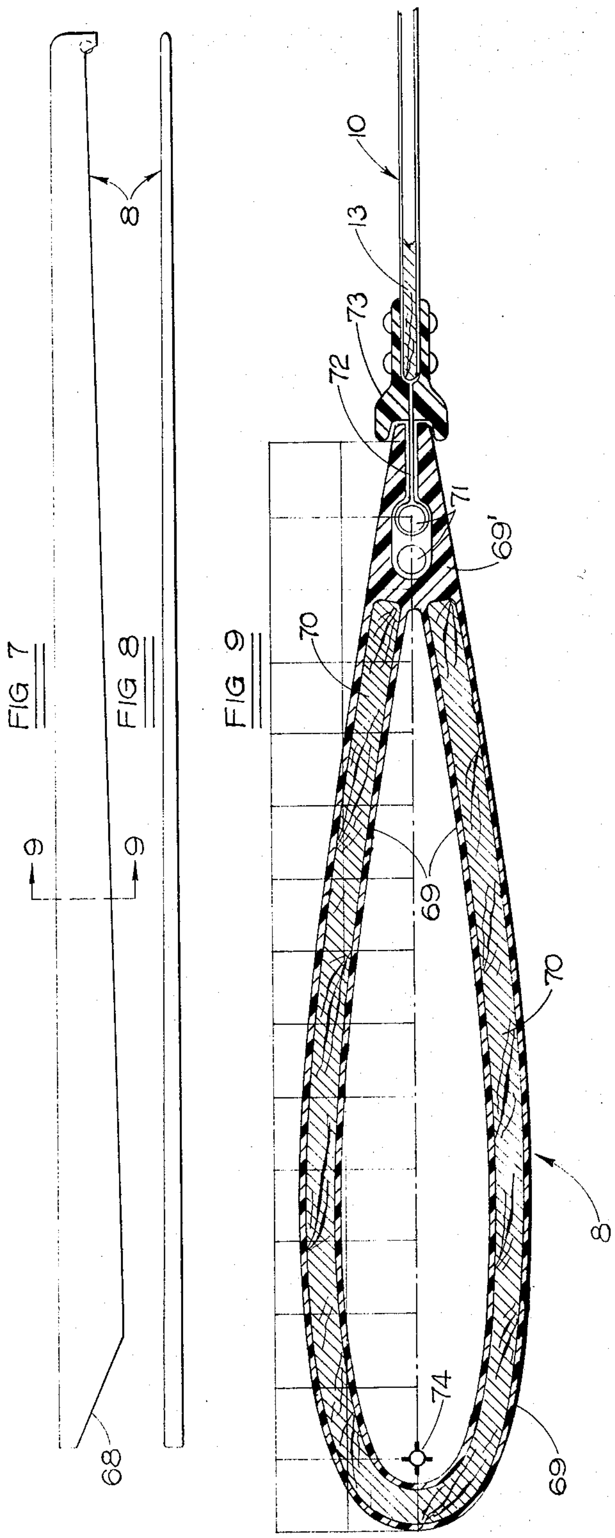

INVENTOR.
REGINALD T. MILLER

BY
Whittemore, Hulbert
& Belknap

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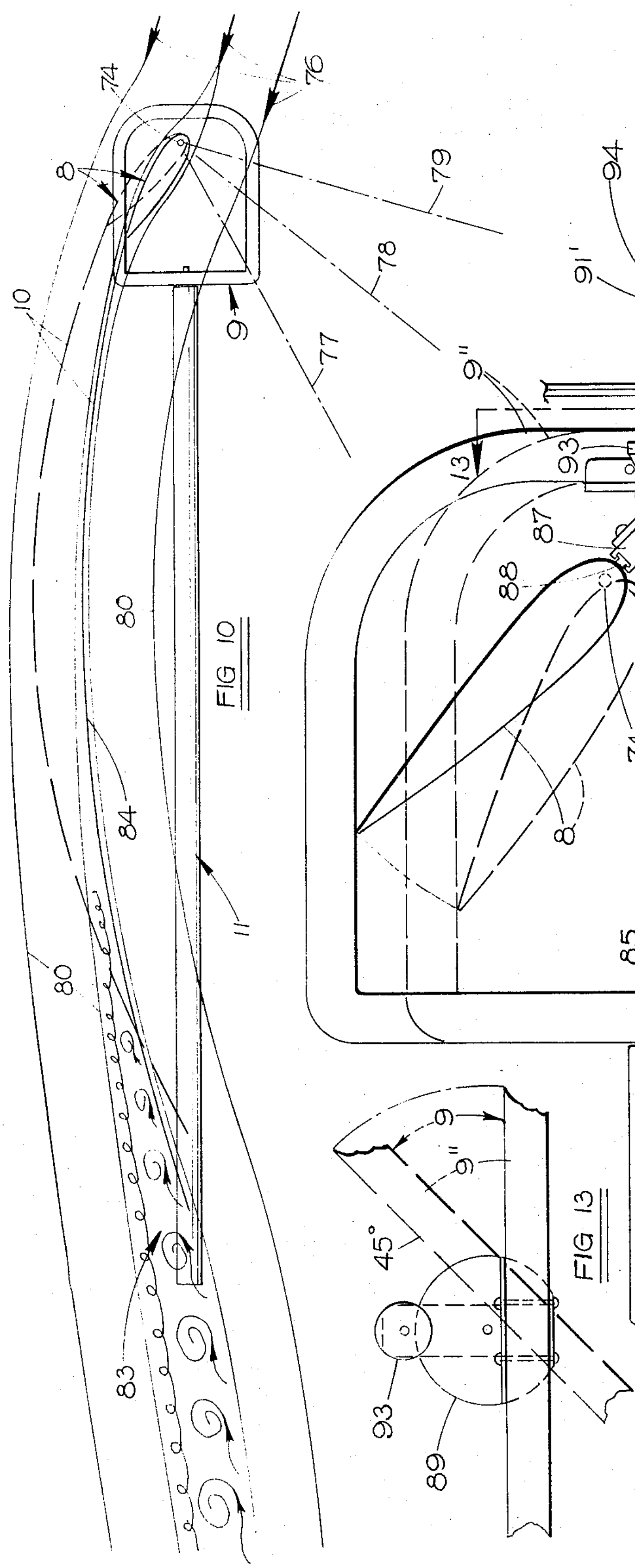

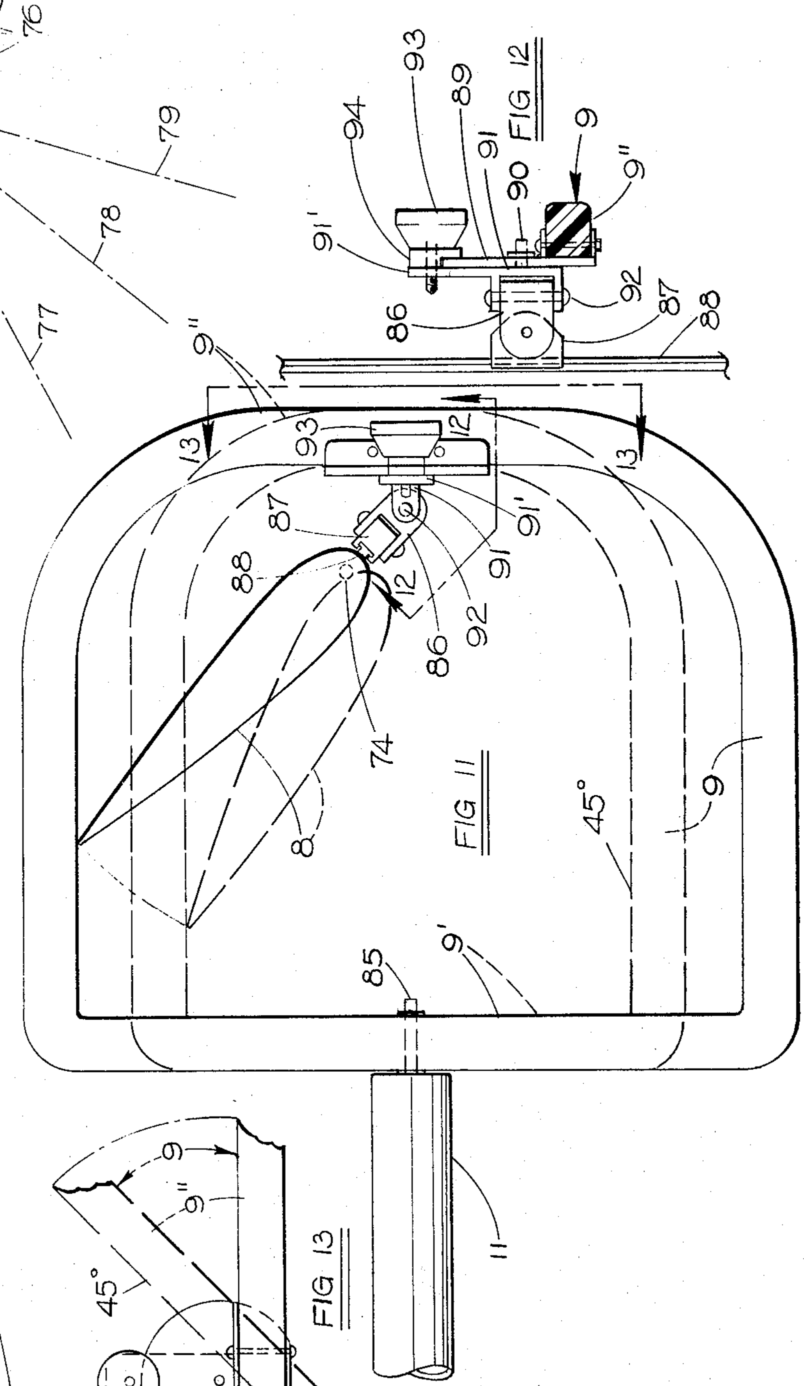

INVENTOR.

REGINALD T. MILLER

BY Whittemore Hulbert & Belknap

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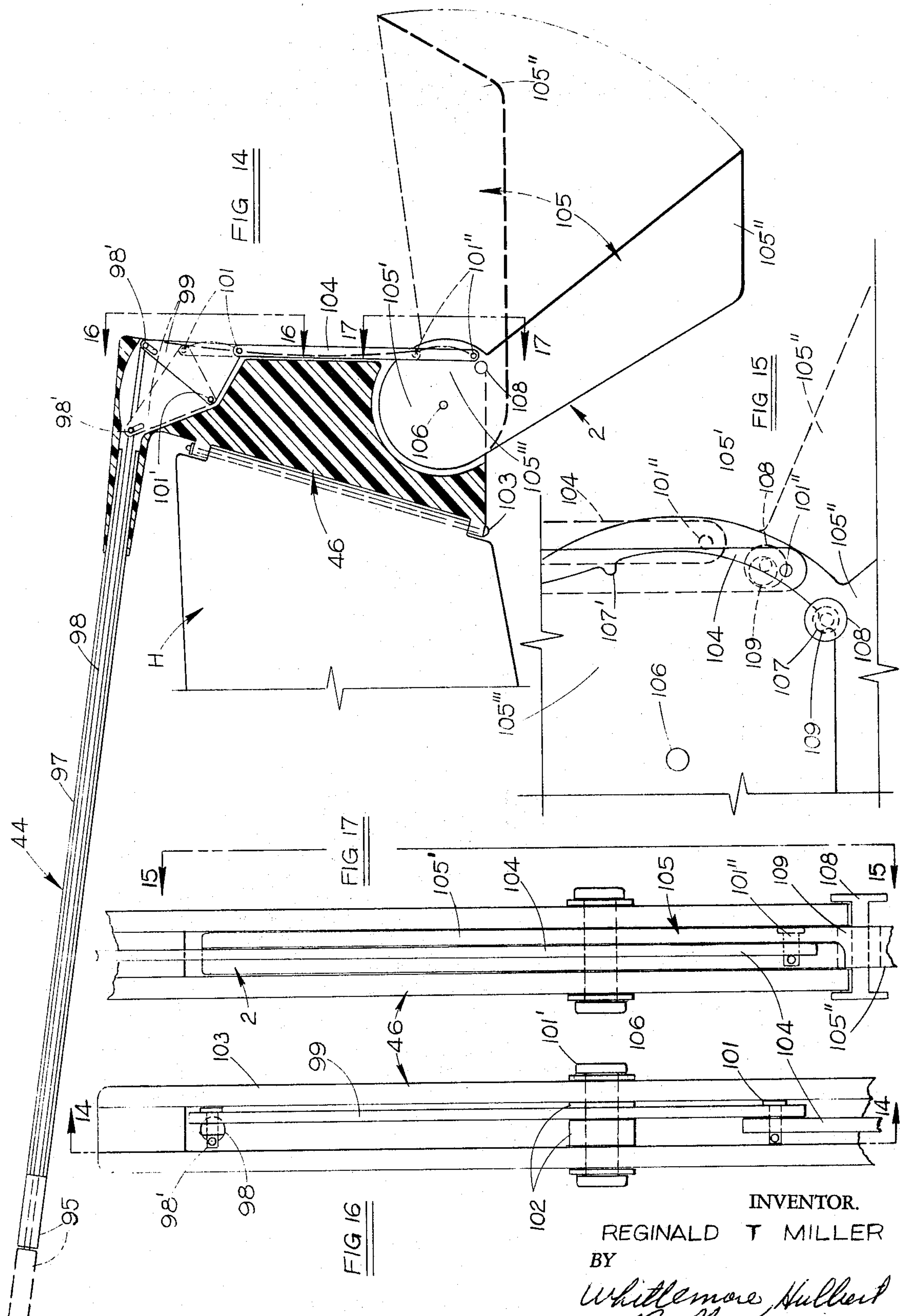
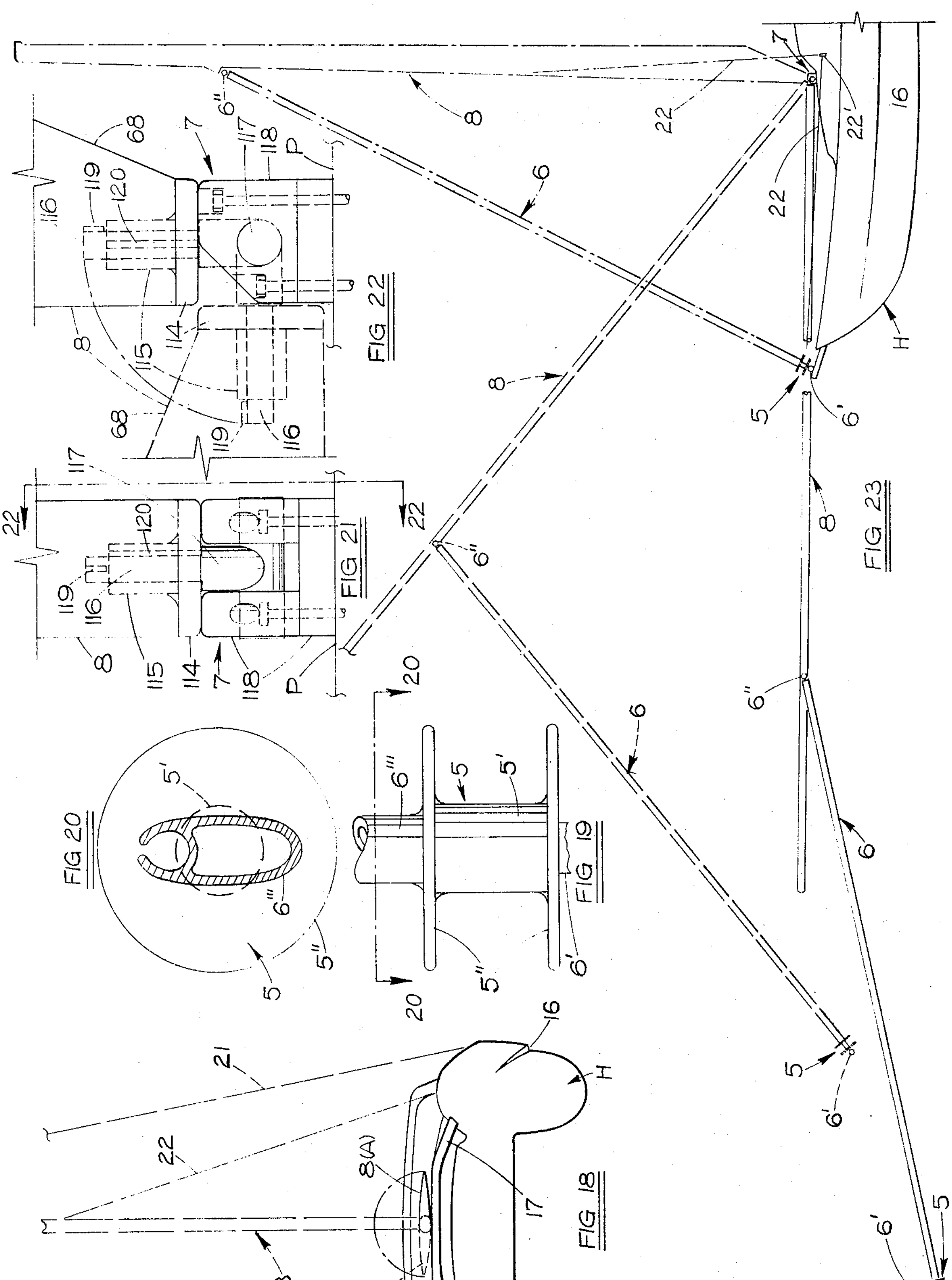


INVENTOR.

REGINALD T MILLER

BY

Whittemore, Hulbert & Belknap



INVENTOR.
REGINALD T MILLER
BY
Whittemore, Hulbert & Belknap

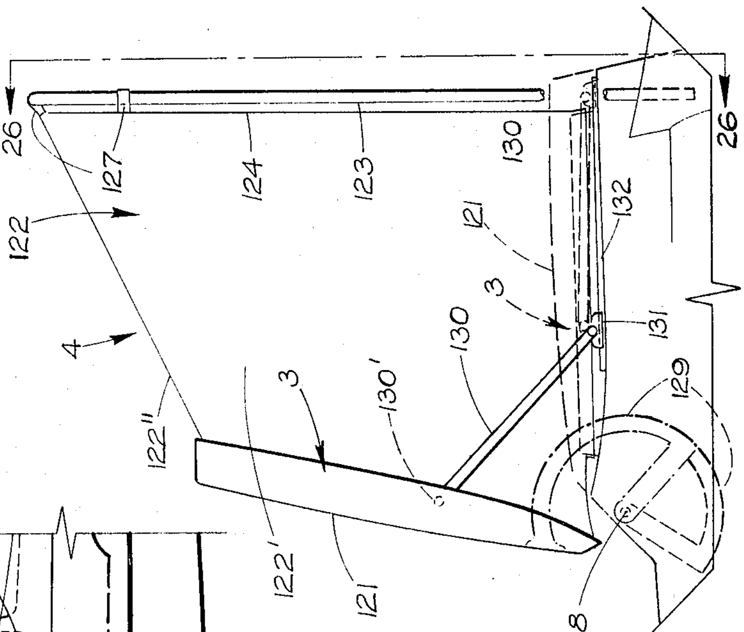


FIG 25

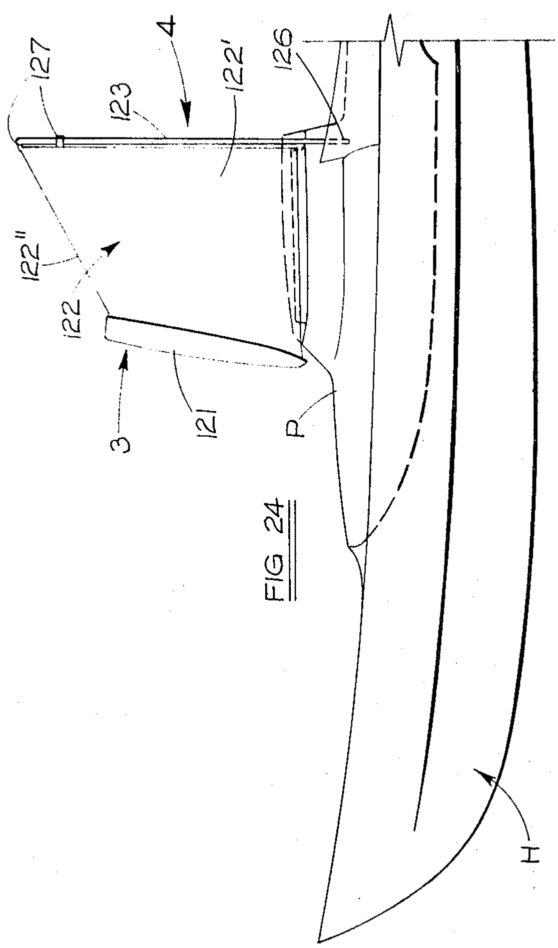


FIG 24

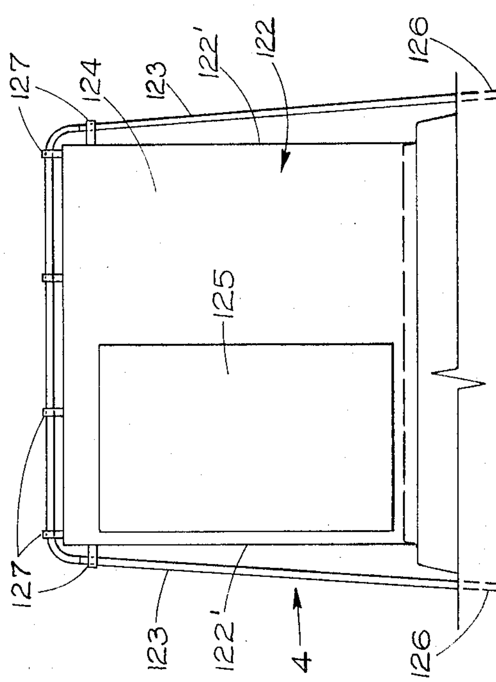


FIG 26

INVENTOR.
REGINALD T. MILLER
BY
Whittemore, Hulbert & Belknap

FIN-KEEL CATAMARAN

BACKGROUND OF THE INVENTION

1. Field of the Invention

The refined design criteria for catamaran sail boats as outlined in the Summary of the Invention to follow, are applicable to yachts of not only cruising size, e.g., 30–70 foot length, but also to small midget ocean racing class and lake sailors, since the engineering of such improvements for a midget ocean racing yacht is more difficult than for larger yachts; the design of a small 21 foot M.O.R.C. is depicted herein in the expectation that it is the most instructive.

2. Description of the Prior Art

A search reveals patents to Patterson, U.S. Pat. No. 2,991,794 of July 11, 1961, relating to a pivotally mounted hydrofoil or keel structure, as mounted amidships of a single keel craft; and patents such as Dutcher, U.S. Pat. No. 1,408,868 of March 7, 1922, showing mast and boom arrangements of a sort only most generally similar to the present improved gooseneck mast and boom coupling structure. However, none of the pertinent prior art of which I am aware reasonably shows or suggests the structural arrangements and attendent advantages described in the Summary, Specification and Discussion to follow.

SUMMARY OF THE INVENTION

The herein-presented improvements in the design of cruising catamarans are varied in nature, and have materially reduced or eliminated many drawbacks of the standard beam-catamaran relying upon yacht weight and beam for stability, and it is a fact that at a 65°–75° angle of heel the beam-catamaran will capsize. This primary problem of stability has been eliminated in my improvement by its introducing a long retractable fin-keel mounted along the center line of the bridge or wing area. The length of this fin-keel is about one-third of the LWL of the craft so that the ballast required to insure high efficiency is not excessive. The long length of this fin-keel is not objectionable since it is easily retractable, on release of an associated safety mechanism, in case it should encounter a positive obstacle or strike the bottom, as in beaching. The readily adjustable nature of certain control mechanisms for the fin-keel allows for adjustment of the latter at any indicated angle so the catamaran can in effect be "tuned" for sailing efficiently without a jib sail, as under heavy wind conditions. It can also be adjusted for shallow water situations, as for a beach departure.

The presence of this long fin-keel enables the overall beam of the yacht to be reduced from a normal 40 percent to 50 percent of the hull length to a minimum allowable before wave interference between the hulls introduces excessive drag, namely 33 percent of the length of the hull members. This factor is important because it saves in overall yacht weight, since weight is a function of surface area. Reduced weight improves speed. Narrow beam also signifies an expenditure of less energy to turn the yacht, and hence tacking ability is improved.

The improved fin-keel catamaran has been designed with its twin hulls toed out one or two degrees, which has a beneficial effect when sailing to windward. With the weather hull flying, as is the normal sailing characteristic when beating to windward, the fin-keel assumes the proper angle to eliminate lateral crab angle. Thus drag due to crab angle effects is eliminated and efficiency is again improved.

A methematical analysis of the characteristics of a catamaran as keel-refined in this way shows an improved wind velocity vs. stability curve from which it can be deduced that the fin-keel catamaran can easily be sailed at 15° to 30° angles of heel, thus eliminating the drag of the weather hull and still giving rise to no fear of capsize.

To recapitulate:

1. Because of the positive restoring forces, even at large angles of heel, capsize is eliminated.

2. Windward performance is improved because (a) skin-friction drag is reduced 35 percent as the weather hull lifts (flies); (b) windage drag is reduced 10–30 percent because of a narrower hull design; (c) crab-angle drag is significantly reduced because lateral resistance is carried by the efficient fin-keel, and not by the hulls, by reason of their being toed out, and (d) the narrow hull spacing requires less energy to turn, thereby improving tacking.

3. Narrow design also facilitates docking.

4. The pivoting fin-keel can be adjusted to any angle, so that (a) precise tuning of the sails or sail (if the main is used alone or is reefed) is possible while under way; (b) the all-up keel position allows beaching; (c) when maneuvering in shallow waters the fin-keel can be adjusted to the level of the draft of the hulls, and still provide the minimum lateral resistance needed for tacking; and (d) when running down wind and requiring no lateral resistance, keel drag may be eliminated by elevating the fin-keel to its all-up position, thus reducing overall drag.

While the above discussed fin-keel and hull considerations are of major importance in a yacht according to the invention, the further mast, mast stepping, mast-boom coupling, rudder and other improvements, as shown and hereinafter described under special headings, are also considered to be of substantial novelty and merit.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a view in side or beam elevation generally illustrating the hull of the craft as equipped with various improved structural features of the invention referred to in the Abstract;

FIG. **2** is a very schematic stern elevational view of the boat outline at a 90° angle of heel to starboard;

FIG. **3** is a view in top plan of the general hull and deck layout;

FIG. **4** is a fragmentary enlarged scale view in vertical section on line **4**—**4** of FIG. **3**, illustrating a novel mainsail track feature;

FIG. **5** is a beam elevation similar to FIG. **1**, but more clearly showing the general arrangement of a fin-keel enclosure trunk and a crank-type operating device for the keel;

FIGS. **6A** and **6B** are similar fragmentary views in vertical fore-to-aft cross section mid-beam of the craft, showing details of a safety release and retrieve mechanism for the keel, FIG. **6A** representing a keel-latched condition prior to keel release and FIG. **6B** depicting, in solid and dotted line, positions of the parts after release and retrieval of the fin-keel;

FIG. 7 is a schematic side elevation in very small scale of an upwardly tapered main mast pursuant to the invention;

FIG. 8 is an end or prow elevation of the mast outline of FIG. 7;

FIG. 9 is an enlarged scale fragmentary view in section on a line corresponding to line 9—9 of FIG. 7, in which the nature of the mast construction is shown, along with associated halyard and batten features of the mainsail;

FIG. 10 is a schematic view in plan showing the nature of laminar air flow in relation to the mast and mainsail in different angularly cambered positions of the mast's sail, also indicating different angular dispositions of the yacht axis in sailing;

FIG. 11 is a plan view illustrating details of a tiltably adjustable and settable yoke or gooseneck boom-to-mast connection which is of value in tacking, optional horizontal and 45° angularly tilted settings of the gooseneck being indicated respectively in solid and dotted line in the figure;

FIGS. 12 and 13 are respectively fragmentary views in section on broken section line 12—12, and in elevation as viewed from line 13—13 of FIG. 11;

FIG. 14 is a view in side elevation as partially sectioned vertically in a generally fore-to-aft plane, i.e., on the line 14—14 of FIG. 16, through one of the hull section's rudder trunk member, the view illustrating specific rudder details in down and up positions of the rudder blade proper, as in solid and dotted line, respectively;

FIG. 15 is a fragmentary side view of a portion of the rudder and encasing rudder trunk arrangement, being viewed from the cross-beam direction of the line 15—15 of FIG. 16;

FIGS. 16 and 17 are fragmentary upper and lower stern elevational views of the said arrangement, as viewed from the respective lines 16—16 and 17—17 of FIG. 14;

FIG. 18 is a view in fore-end elevation schematically illustrating a procedure of mounting the main mast of the craft to a stepping sub-assembly or unit;

FIG. 19 is a fragmentary elevational view of a jib spar and jib reefing drum sub-assembly;

FIG. 20 is a view in horizontal section on line 20—20 of FIG. 19;

FIGS. 21 and 22 are, respectively, fragmentary views in front and side elevation of mast stepping structure details;

FIG. 23 is a schematic side view of the prow section of the craft, which supplements FIG. 18 in regard to the procedure of the raising of the mast by operations performed on the jib spar;

FIG. 24 is a fragmentary beam-elevational view schematically depicting a pop-top and tent unit as mounted to the superstructure of the boat;

FIG 25 is a fragmentary view in enlarged scale side elevation illustrating details of that unit; and

FIG. 26 is a fragmentary view in aft elevation, as from the line 26—26 of FIG. 25.

DESCRIPTION OF A PREFERRED EMBODIMENT

General Arrangements

FIGS. 1, 2 and 3 of the drawings show the dual hull craft of the invention as being provided with a pivotally mounted fin-keel, generally designated 1, mounted medially between identical molded fiberglass port and starboard hull sections H of the craft; and twin rudders 2, one on each of said sections. The latter are arranged not to toe outwardly from the fore and aft center line of the boat at a mild angle, as are the hulls, but are parallel and on the same parallel axis as the keel. FIG. 3 shows the mild angle of toe-out of the hull members H divergently in relation to the center line C/L of the craft to improve the windward sailing characteristic, as mentioned above. A hinged pop-top hatchway cover of a pop-top designated 3, is shown in FIG. 1 as being upwardly swingable through a bit less than 90° from a normal solid line cruising position thereof to the position depicted in dotted line, at which a tent 4 may be set up aft of it to shield the area behind the pop-top 3. The latter extends over somewhat more than half the starboard-to-port cabin area of the vessel.

FIG. 1 shows a roller reefing drum 5 as mounted fast at the lower end of a solid-section jib spar 6, the spar and drum having a pivotal ball and socket-type support at 6′ at the bottom thereof; and a mast step 7 is mounted fixedly atop a curved deck panel P spanning and being integrally molded with the hull members H above the wing area between the latter.

The reference numeral 8 generally designates the improved fiberglass main wing mast pursuant to the invention, on which a special gooseneck unit 9 adjustably mounts the mainsail 10 at its boom 11 to the mast. The boom is shown in solid line in FIG. 1 in the normal sailing position and in dotted line when raised for lifting of the pop-top 3 and erection of tent 4, as will be described. Full length battens 13 are applied to the main wing sail 10; and a main sheet pulley system 12, schematically shown, is conventionally employed. An apparent wind indicator 14 is fastened to the forward surface of mast 8, directly above a pivotal ball and socket-type connection to the latter of the top of jib spar 6, as at 6″. This enables the captain to ascertain immediately and at any time whether or not the mast 8 is oriented or tuned correctly to the prevailing wind condition. As indicated in FIG. 1, a lower bulge line 16, which defines the bottom of an elongated stabilizing bulge 24 on the outer side of each hull member H, is approximately mid-way between the gunwhale and keel line surfaces of said members.

The roller reefing drum 5 for jib spar 6 is rotatively mounted midway along the top of a forestay cross arm 17 spanning between the hull members H; and this arm also supports the forward margin of a Dacron strap-fabricated safety net 18 (FIG. 2). The craft's jib 19 is reefed easily toward or to the shortened position thereof, shown in dotted line in FIG. 1, by rotation of the reefing drum 5, as through tensioning of a line 20 fixed to and wound about the drum, the line extending aft to the cockpit for convenient operation. Jib 19 is unreefed toward or to the fully spread position indicated in dot-dash line in FIG. 1 by tensioning jib-setting line 19′ from the cockpit area, generally designated C.

Main mast side stays 21 normally attach downwardly to chain plates 21′ fixed on hull members H, H; but temporary mast stays 22 will be employed during stepping and raising of the mast 8 (FIGS. 18 and 23), the stays 22 being releasably snapped to another set of chain plates 22′ more closely adjacent the mast step sub-assembly or unit 7.

The reference numeral 23 appearing in FIG. 1 generally designates a crank-wheel operated device (illustrated in detail in FIGS. 6A and 6B) for elevating and lowering the fin-keel 1. FIG. 1 also shows in dotted line the beam profile of mast 8 at a full swing or 45° angle of trim contemplated by the invention, the normal straight fore-to-aft profile appearing in solid line.

As viewed in plan in FIG. 3, in addition to jib spar, hull cross-arm and mast step features referred to above in a general way, the craft affords a cabin space or hatchway just forward of the open cockpit C which space is normally covered by the pop-top 3; and the deck's above-cabin structure includes a slidable hatch 41 on the port forward side of cockpit C, the latter being defined by upright siding 42. A curved mainsail stay track 43 is fixed to an after deck D spanning and rigidly connecting (in coaction with the fore deck panel P) the hull sections H, extending across the deck aft of the cockpit; and tillers 44 coupled by a rugged cross arm 45 extend rearwardly over the respective hull members H into rudder cages or trunks 46 pivotally hung aft of those members. The nature of the tiller and rudder sub-assemblies is illustrated in FIGS. 14–17, inclusive. Splash guards G protect the cockpit's occupant.

FIG. 4 shows structural details of the mainsail track 43 to include an upright track core formation 47 integrally molded as part of the hull deck D, projecting at 90° to the upper surface of the latter. Stainless steel straps 48 are riveted on opposite sides of the core 47, extending the entire length of track 43; and an inverted U-shaped mainsail track carriage 49 of the pulley system 12, appearing in dotted line in FIG. 4, rides the track, as guided by anti-friction rollers 50 beneath the straps 48, the rollers being pivotally mounted internally of parallel lower legs of the carriage 49.

FIN-KEEL AND HULL CONSIDERATIONS

FIG. 2 shows the catamaran hull at a 90° angle of star-board heel, indicating how the position of an external hull bulge 24 on each hull section above the line 16 affords various operational improvements in consequence of and in conjunction with the keel features. In this view, the effective overall fin-keel length L is to be considered to be one-third of the load water line length of the hull, being instanced as 7 feet; and the hull separation S between center lines of the hull members H will be considered to be the same, i.e., 7 feet for hulls 21 feet in length. Lead ballast 27 at the foot of keel 1 is minimal for needed stability due to the length of fin keel 1. The center of mass C/M of the craft, being located as designated in FIG. 2, then acts on a lever or moment arm of length M from a center of buoyancy C/B shown as being on a line normal to the keel 1 and water line WL_h when the craft is at an extreme 90° heel angle. The relationship of the load water line WL_s under a normal static condition is indicated in dotted line in FIG. 2.

Thus, it is seen that the hull bulge 24 improves the position of the center of buoyancy C/B; the restoring moment arm force couple represented by the product of mass at C/M times moment arm is maximized. Bulge 24 also obviously reduces spray into the cockpit C and imparts a beautiful line to the hull, giving the illusion of a longer one of enhanced eye appeal. Other more significant features of advantage have been enumerated in the preceding Summary.

FIN-KEEL ADJUSTMENT

FIG. 5 shows the hull structure of craft to include a fin-keel centerboard trunk 51 located mid-way between the hull members, from which trunk the keel 1 pivotally depends, and at which the keel is adjusted as to its fully extended angular position appearing in solid line or any intermediate position between that and a fully retracted position (dotted line). Parallel after-brackets 52 are rigidly attached to the walls of keel trunk 51 for a purpose to be described.

The profile line of the starboard hull H and section of the wing member appears at 54 in FIG. 5, the port section line being the same. The forestay cross arm 17 attaches rigidly between these hull members near the upper prow apex thereof, as indicated in that figure.

Reference being had to FIGS. 6A and 6B for specific details, said trunk 51 is internally recessed from its rear to house the arcuate top of keel 1; and a safety release latch arm 56 pivotally mounted between the trunk walls is releasably engageable forwardly with a latch detent formation 56′ on the keel top. Arm 56 is resiliently urged counterclockwise for this engagement by means to be described; and a rubber shock absorber pad 57 is fixedly applied to the aft upper keel portion, directly to its rear, the pad normally, in the sailing position shown in FIG. 6A, rearwardly abutting an operating part to be described. Under any significant positive aft-wise pressure on keel 1 the latch 56 will yield and lift so that the keel can swing free and avoid damage.

Keel 1 is mounted within the trunk 51 to swing pivotally about a horizontal axis at 58, just forward of a latch hinge connection represented by an angled strap member 59. This is the part normally abutted resiliently by the keel's cushion pad 57. An appropriately biased coil compression spring 60 acts against a fixed bottom stop 60′ on the rear of strap 59, and a tail portion of the pivoted latch arm 56 is connected to a rod 60″ centered in spring 60 and slidable through stop 60′; and provision is made for an adjustment of the compression of spring 60, as by a nut 61 threaded on rod 60″ and upwardly abutted by the spring 60 to urge latch 56 counterclockwise. FIG. 6A shows the keel as normally latched for cruising, and latch 56 releases to enable fin-keel 1 to swing counterclockwise freely (FIG. 6B), should the keel strike an obstacle or beach in any angular keel setting from full extension toward or to full retraction. These positions are of course taken with the keel in latch.

The operational control of the keel position, over and above the automatic safety unlatching, is regulated by the adjustment device 23. It comprises an elongated tube 62 which is pivotally connected forwardly to a bracket ear at the top of angle strap 59 and is threadedly engaged at an aft end thereof by an elongated control rod 63 coaxially movable in the tube. For the purpose the tube 62 is equipped with a nut member 64 fixed in its outer end and threadedly engaged by the rod 63. Retainer bearings 65 are welded to the rod on opposite sides of a fixed rotative rod journal bearing 66, which has a pivotal swivel mount at the rear of and between parallel after-brackets 52. The latter may be molded integral with the hull and superstructure of the craft. A hand wheel 67 is fixed on the outer end of rod 63, being rotated for controlling the positioning of fin-keel 1 throughout the range of adjustments indicated in FIGS. 6A and 6B, in the latter of which the safety release action is shown in solid and dotted line.

MAST CONSTRUCTION

As generally shown in FIGS. 7 and 8, the elongated length of the mast 8, as molded of fiberglass in a hollow horizontal cross section (FIG. 9), tapers uniformly from a stepping base (FIG. 7), which is shaped to have a forward to aft upward bevel 68, to its mainstayed top. Its width also tapers very mildly from bottom to top, as appears in FIG. 8, and the compounded tapering lowers the center of mast mass to further improve the efficiency of the yacht in point of weight distribution.

Referring to FIG. 9, the mast 8 is of hollow cross-section in a mildly arced tear-drop outline enclosing a vertically cored space which will of course naturally diminish in area from bottom to top over its extended length. Parallel arcuate fiberglass walls 69 of the mast are filled by a balsa core 70, said walls merging aft-wise into a thickened mast body portion 69′, which is vertically contoured in molding to provide a rearwardly slotted space receiving the usual halyard tackle 71. The leading edge portion 72 of the schematically depicted dacron mainsail 10 is appropriately connected through the mast's slot to said tackle; and FIG. 9 also shows the oak battens 13 as rivet-secured in a molded fiberglass batten track member 73 of the sail. The reference numeral 74 designates the axis of the wing mast pivot action, now to be described, as about an upright pivot stem which appears in FIGS. 21 and 22.

AERODYNAMIC EFFECTS

FIG. 10 is laid out in top plan to schematically show the mast 8 and sail 10 as they affect the laminar air flow on the lee side thereof in a degree to increase the sail drive up to the extent of 20 percent. It also depicts how sail camber may be adjusted for different wind velocities.

Thus, if an apparent wind direction is as indicated by directional arrows 76 in FIG. 10, and the numerals 77, 78 and 79 are respectively considered as representing directional orientations of the yacht axis at close haul, close reach and reach, the numerals 80 represent air flow lines on weather and lee sides of the sail 10 with the mast 8 positioned as indicated in solid line in FIG. 10. The mast set as appears in dotted line in FIG. 10, indicates a camber adjustment (by means shown in FIGS. 11–13) for very slow winds. In each case the laminar flow exhibits no turbulence or eddies along the attack zone of the sail, thus affording the substantially increased percent sail drive. Such turbulent flow, as indicated at 83, is delayed until the rear marginal portion of sail 10 is reached. As depicted in solid line in FIG. 10, the mast'sail's zero angle camber adjustment, as at 84, is for normal moderate winds.

Details of the boom's yoke gooseneck connection 9 are shown in solid line in FIGS. 11, 12 and 13 in a setting enabling wing mast 8 to pivot on the axis 74 (FIG. 10). A 45° cambered setting of the gooseneck appears in dotted line in FIGS. 11 and 13; and the arrangement to these ends is one having very few parts allowing the wing mast to swing automatically during a tack from a normal sailing setting into a predetermined angle of attack, in either of which positions the mast orientation may be manually set and held, as appears in solid and dotted lines in FIG. 11.

Thus, the forward end of boom 11 has a pivotal mount, on the axis of a pin 85 fixed on that end, to an aft cross piece 9′ of the generally rectangular gooseneck yoke 9; and a forward crossbar 9″ of the gooseneck carries certain camber-adjustment details of the improvement.

These include a U-shaped universal pivot strap 86 between the legs of which a slide block 87 is pin-connected to allow gooseneck assembly 9 to swing up and down with the boom. Such motions are typical during sailing maneuvers. Block 87 has a groove and tongue-type slidable engagement along an elongated vertical guide strap 88 attached to the forward edge of mast 8, adjacent the bottom of the latter; and this enables a limited elevation of boom 11, from a normal sailing position, shown in solid line in FIG. 1, to a raised dotted line position to accommodate the pop-top 3 when the latter is swung upwardly to its dotted line position and held therein by means to be described.

Again referring to FIGS. 11–13, and in particular FIG. 12, a quasi-circular brake plate 89 is pivotally mounted on a pin axis at 90 to a bracket 91, which is specially formed to provide a pair of legs between which the bight of the U-shaped pivotal member 86 is received, the bight passing about a rivet or stud 92. An integral upper extension 91′ of special bracket 91 threadedly receives a stem of a friction stop hand knob 93, which stem extends through a brake shoe 94. A part of that shoe radially overhangs the arcuate upper edge brake plate 89, as appears in FIGS. 12 and 13. Adjacent its lower straight sectored edge the brake plate 89 is equipped with a channel formation within which the forward cross-piece 9″ of gooseneck 11 is rivet-secured.

Thus, when the hand knob 93 and brake shoe 94 are loosened the plate and the gooseneck yoke may be swung about the former's pivot at 90 and then re-clamped by threadedly taking up brake shoe 94; and FIGS. 11 and 13 show such a camber adjustment, to the extent of 45°, of swing of the gooseneck 9 from the normal solid line position to the dotted line camber position. The mast 8 needs swing only 30°, as universally coupled to the gooseneck 9 at the slide block 87, strap 86 and stud 92, and as automatically rotated through the agency of that linkage, when the gooseneck is tilted to the mentioned degree, about the vertical axis of the mast stepping means (to be described).

RUDDER OPERATION

Structural details of the arrangement for operating the rudder assembly 2, as mounted along with its operating control linkage (to be described), from the operative, solid line position of FIG. 1 to the retracted dotted line position of FIG. 1, are illustrated in FIGS. 14–17. A tiller hand grip 95 coaxial with and on the end of an elongated tiller tube 97 is affixed to a still longer adjusting rod 98 coaxially disposed in the tube; and the rod is pin-and-slot connected at 98′ to an upper apex portion of a triangular control plate 99. Plate 99 is received in an upper aft recess in a molded fiberglass rudder trunk 46; and as appears best in FIGS. 14 and 16, an aft lower apex portion of plate 99 carries a pin 101 through which an articulation to rudder structure 2 is in part completed (as will be described); while the forward lower apex portion of plate 99 carries another pin 101′, by which the plate is pivotally mounted to the remainder of the swinging rudder sub-assembly 2. Spacers 102 are interposed between plate 99 and adjacent wall portions of the rudder trunk recess which houses the plate. The trunk swings for steering about the axis of an upwardly and rearwardly inclined pivot pin **103** at the tail of the hull member H.

As thus pivotally mounted in an upper recess of trunk **46**, the plate **99** has a flat operating rod or link **104** pivoted thereto at its lower apex pin **101**, the link **104** extending downward to a point adjacent the bottom aft corner of rudder trunk **46**, where it is pivotally connected by a third pin **101''** to a vertically adjustable rudder blade proper **105**. Trunk **46** is recessed at its rear to accommodate a limit vertical position of link **104** appearing in FIG. **14**; and the link's rudder connection pin **101''** is located adjacent the junction of a quasi-circular upper body portion **105'** of rudder blade **105** and aft blade tail portion **105''**. The portion **105'** is centrally pivoted by a pin **106** in a lower aft recess between the upright walls of trunk **46** and is, like plate **99** and link **104**, partially housed within the molded trunk body, the portion **105'** projecting only slightly from the trunk's lower rear corner.

Thus, a pull on the tiller hand grip **95** to rock the triangular line of force-directing plate **99** counterclockwise (as viewed in FIG. **14**) will swing rudder blade part **105''** upwardly from its extreme extended down position shown in solid line in FIG. **14**, or an intermediately extended position, to the fully retracted, dotted line position of FIG. **14**. This controlled operation is of value in enabling rudder unit **2** to be cleaned of weeds, or to prevent damage thereto while beaching.

FIG. **15** shows the rudder blade-receiving recess as having a plate member **105'''** fixed to a wall thereof, the member presenting a convexly arcuate aft edge. This edge is provided with a pair of arcuately spaced stop notches or recesses **107, 107'** to assist in holding rudder **2** in either of the extreme down and up positions depicted in FIG. **14**. For this purpose, the rudder is equipped, directly adjacent its link pivot pin **101''**, whith a double headed stop pin **108**, the heads of which ride the outer sides of the rudder trunk walls adjacent the bottom of the latter. Pin **108** is medially encircled by a cylindrical rubber spacer **109** extending between the trunk walls; and as the link **104** elevates from the solid line position of FIG. **15** to the dotted line position of that figure, the pin **108** travels the arcuate contour of plate **105'''**, departing from a seat in the lower stop notch **107** to a seat in the upper notch **107'**, and thereby enabling the tiller operator to sense the arrival of the rudder at either of the positions shown in FIG. **14**. Each rudder trunk **46** swings bodily with its blade **105** about the acutely and upwardly aft-inclined axis of its pivot pin connection **103** to the hull member H, with the rudder tillers **44** ganged for simultaneous action by crossbar **45** (FIG. **3**).

MAST STEPPING AND STAYING

The schematic view of FIG. **18**, from the prow direction of the craft, shows the mast **8** in dot-dash in its normal operative position, in solid line in an initial horizontal position A for assembly, and in dotted line in a subsequent assembly position B. In both of these preliminary assembly positions, the mast **8** extends forward on the axis of the craft and over its prow from the deck-mounted stepping unit **7**. See also FIG. **23**. At this time the temporary side stays **22** are clipped at their bottoms to the chain plates **22'**.

Now referring to FIGS. **21** and **22**, for coaction with the step unit or sub-assembly **7** the mast **8** is equipped at its foot with a fixed metal socket pad **114** having a tubular socket portion **115** recessed into the mast; which socket part is removably telescoped on a reduced sized stem portion **116** of a swivel or trunnion member **117** of unit **7** which is of inverted T-shape. Oppositely extending arms of member **117** are journalled in spaced upright furcations of a forked stepping block **118** bolted or otherwise rigidly secured atop the deck panel P, and the furcations are forwardly beveled (FIG. **22**) for clearance accommodating the mast's swing in being stepped and unstepped.

Trunnion stem **116** has a short key formation **119** at its top which is slidably receivable in a keyway slot formation **120** when oriented cross beam-wise with the latter; and with the mast oriented in preliminary stepping position A (FIG. **18**) the socket **120** and trunnion stem have their keyway and key thus oriented for initial telescoped horizontal interfit when stepping commences. From this position the mast is flipped 180° counterclockwise on its axis (FIG. **18**) to the "B" position, in which stem key **119** laps the end of socket **115**, thus insuring that the mast will not slip off the stepping base or block **118** during raising, and also stabilizing mast **8** in that movement.

Referring to FIG. **23** in conjunction with FIG. **18**, with the temporary lower side stays **22** attached between the chain plates **22'** and with jib spar **6** extended from its operative, main mast-coupled connection at **6''** to a point well forward of the end of mast **8**, the spar is employed as an implement to exert an upward push on the mast, thereby swinging the latter in a vertical plane through dotted line positions, per FIG. **23**, to its fully erected dot-dash line position, whereupon the mainstays **21** are applied and the temporary stays **22** are dismantled, the mast having of course re-rotated 90° to its normal fore-aft orientation. Stepping block stem **116** and mast socket **115** physically represent the axis **74** of pivotal mast action mentioned at the end of the mast construction description.

JIB SPAR REEFING DRUM

FIGS. **19** and **20** show the jib reefing drum **5**, as appropriately pivoted or rotatably mounted at spar pivot **6'** on the mid-point of the forestay cross arm **17**, to comprise a reel-like body **5'** having parallel circular line-confining flanges **5''**, to the uppermost of which a jib spar receiving end **6'''** is welded. The latter has a hollow outline in a special elongated elliptical cross section affording a circular socket, as depicted in FIG. **20**.

POP-TOP AND TENT

Referring to FIGS. **24, 25** and **26**, the pop-top and tent unit, as generally designated **3**, comprises a generally rectangular hatchway cover **121** pivoted adjacent its forward margin (by means to be described) to the hull deck panel P; and the pre-sewed canvas tent structure **4** is sustained at its rear when erected by an inverted U-shaped frame **123** of a rod-like nature. Structure **4** includes a box-section tent **122** having side panels **122'** joined by a top panel **122''**, and by preference, an aft fabric panel **124** is equipped with a swingable door sub-panel **125**. Frame **123** is suitably mounted removably to the craft's cabin or hatchway superstructure by inserting its lower leg portions **126** in appropriate sockets of the said structure; and snap fastened loops **127** marginally connect the tent's side top and aft panels to the frame rod structure **123**.

As shown in FIG. **25**, the cover **121** of pop-top unit **3** has a pivotal horizontal mount at **128** to the forward zone of said superstructure through the agency of a quadrant-shaped arm **129** welded or otherwise affixed at its free end to the inner forward portion of cover **121.** Somewhat to the rear of this connection, a pair of supporting and stabilizing links **130** are pivotally connected at **130'** to the interior of cover **121**; and the opposite ends of these links each have a pivotal and slidably guided connection, as by means of a shoe **131,** to an elongated fore-to-aft guide rail **132,** along which rails the links slide as cover panel **121** is swung between the solid and dot-dash line positions of FIG. **25.** Appropriate provisions may be made to releasably latch pop-top cover **121,** in either of the positions appearing in that view, the tent having been stowed beneath the cover.

DISCUSSION

A catamaran that relies on beam for stability (beam-catamaran) reaches maximum stability at a small angle of heel, 7° being typical, and thereafter stability decreases rapidly. At 70° there is no stability and the catamaran will capsize. Hence, designers must use a wide beam to insure that the catamaran never heels beyond the critical 7° angle. On the other hand, the wide beam causes deteriorating performance to windward because of the extra windage, turning ability also deteriorates with increased beam, and special docking facilities are required for beamy yachts.

Many drawbacks inherent in the beam-catamaran design can be reduced or eliminated, and the advantages mentioned in the Summary attained, by the innovation of reducing the beam, eliminating the usual centerboards in each hull, and adding what is in effect a long ballast-tipped centerboard between the hulls, which centerboard pivots and has therefore been referred to as a pivoting fin-keel.

Consider two cruising catamarans 30 feet long, one a beam type and the other a fin-keel type. The fin-keel catamaran is narrow with an overall beam of 10 feet (1/3 × length) and the beam-catamaran has an overall beam of 15 feet (1/2 × length). The weight of each yacht is proportional to the surface area, so the beam-catamaran is heavier because its spanning deck and bridge area is larger. The extra weight inherent in the beam-catamaran thus becomes an important factor when comparing the two.

If it be assumed for simplicity that the weight of each yacht is one pound per square foot of surface area, the bridge area of the fin-keel catamaran is then 170 ft^2 and thus it weighs 170 lbs. The bridge area of the beam-catamaran is more than twice this area, being 380 square feet, but, because of the nature of its structural design, the weight per square foot would increase substantially under a realistic criterion, to achieve equivalent structural integrity. Hence, a conservative weight/ft. estimate would be 2 lbs., and the bridge for the beam-catamaran would thus weigh 760 lbs.

Each hull would have an area of approximately 330 ft^2, and at 1 lb. per sq. ft. would weigh 330 lbs. The rigging of each catamaran may be estimated at 100 lbs., and the center of mass at 20 feet above the LWL.

My pivoting fin-keel yacht is designed with a ballast of 1/4 to 1/3 the hull weight. For contrast 300 lbs. and 600 lbs. will be chosen for examples. The distance of the center of mass of the fin keel below the LWL is designed at 1/5 to 1/3 the length, and for the present purpose 10 feet is arbitrarily chosen.

Using these figures the center of mass of each yacht is calculated using moments; it can be arrived at that the center of mass for the beam-catamaran is located at 3.25 feet above the LWL, 0.14 feet thereabove for the 300 lb. fin-keel catamaran, and 2.3 feet below the LWL for the 600 lb. fin-keel catamaran.

As each catamaran heels at various angles the width of tha beam and the location of the center of mass produce restoring forces; and as mentioned above, the restoring moment for the conventional beam-catamaran reaches its maximum value at 7°. It falls off more quickly than any other yacht, and below zero at 70°, beyond which value the craft will capsize. Therefore, the beam-catamaran must be handled with extreme caution in heavy winds; and when the weather hull lifts the crew must quickly release the sheets to prevent capsize. Hence a beam-catamaran necessarily sails, under prudent handling, with both hulls in the water.

By comparison, a plotting of moment values results in a gently rising curve for the 300 lb. fin-keel catamaran, maximum restoring moment being at 13° heel, followed by a gentle tapering off. At 100° angle of heel there is still 40 percent restoring moment left. More dramatic is the curve for the 600 lb. fin-keel catamaran, which rises quickly; at 100° heel angle, 75 percent restoring moment remains. There is no critical wind velocity, barring of course foolish handling in gale force winds which could tumble not only a catamaran but a ballasted monohull. These "gentle" curves allow the crew adequate time to adjust the sheets so that the angle of heel can be chosen.

Therefore, conceivably with wind velocities of 12–20 mph the crew of the 300 lb. fin-keel catamaran could easily sail on one hull. A similar condition exists for the crew of the 600 lb. fin-keel catamaran with wind velocities of 15–25 mph. By adjusting the sheets a heeling angle of 15°–25° could easily be maintained.

Most of the drag at low speeds is due to skin friction. At medium and high speeds skin friction accounts for half of the total drag. Consequently the design trend has been to semicircular hull sections which give the least surface area per unit buoyancy.

Since the beam catamaran necessarily sails with both hulls in the water, the designer assumes the weight is distributed equally between the two hulls when designing for minimum wetted area. A simple analysis can be made by considering a midsection designed with semicircular hulls, involving considerations such as the buoyancy or volume displaced by the hulls being proportional to the area of the semicircle:

$$1/2\ \pi R^2$$

or for both hulls:

$$\pi R^2$$

The wetted surface is proportional to the circumference of the semicircle:

$$1/2\ 2\pi R$$

or for both hulls:

$$2\pi R$$

Assume the value R = 1 for convenience, then

Displacement = π

Wetted Area = 2π

If we now consider one hull as displacing the total weight, the displacement of this new hull must be π, and to find its radius we equate to the area equation of a semi-circle:

$$\pi = 1/2\, R^2\pi;\; R = \sqrt{2} = 1.414$$

The wetted area of this single hull is:

$$2R\pi/2 = \pi\sqrt{2}$$

Comparing the wetted areas:

$$2\pi/\sqrt{2}\pi = 1.414$$

Hence it is concluded that the beam-catamaran has 41 percent plus more wetted surface. Actually, because of the spindle shape of entry and exit the value is more precisely 35 percent.

Some mention of beam-catamaran centerboard area must be made to make complete the comparison of that catamaran and my fin-keel catamaran. The beam-catamaran usually has one board in each hull; and the total centerboard area for semicircular section hulls is usually 2 percent of the sail area. A 10 square feed centerboard area for a 500 ft^2 sail plan is typical.

A comparable fin-keel catamaran may have 50 percent more area (3 percent of the sail area plan), because an exceptionally long centerboard is desirable. Also the fin-keel will be thicker to have the necessary strength. While the extra surface area and thicker section may increase skin friction and wave drag, nevertheless offsetting these disadvantages are two positive effects: (a) The aspect ratio of the fin-keel will be about twice that of the centerboards, and thus will develop more than twice as much lift for the same amount of drag; and (b) since the fin-keel is positioned in the middle of the bridge superstructure the hulls can be toed out several degrees, thus reducing crab angle drag when beating to windward.

In as much as wave interference causes considerable drag when the hulls are spaced too closely, the hull spacing for the fin-keel catamaran should be the minimum acceptable without introducing excessive drag, in which case this effect thus need not be considered as a dynamic factor affecting cruising.

What is claimed is:

1. A catamaran sailing craft having a fin-keel pivotally mounted on a horizontal axis adjacent an upper portion thereof to depend between and well below elongated twin hull members of the craft in a fully downwardly extended cruising setting of the keel, said hull members being on centers spaced from one another a distance approximating one-third of the load water line hull length, the hull members having a mildly angled, forwardly divergent toe-out in relation to the centerline of the craft and being rigidly and permanently inter-connected in laterally spaced relation to one another by a spanning deck structure, said structure including an upright centerboard trunk mid-way between the hull members in which a pivoted end of said fin-keel is disposed, said keel being elongated in length, in relation to the length and lateral spacing of the hull members, to an extent also approximating one-third of the load water line hull length and being weighted adjacent the keel end, and means for adjustably positioning and maintaining the keel in selective settings between said fully extended one and a fully retracted setting in which the keel is housed and directed well aft-wise of the hull length.

2. The craft of claim **1**, in which said positioning and maintaining means includes a connection within said trunk to said upper keel portion, and manually controlled means disposed external of the trunk for operating said connection in adjusting the keel setting.

3. The craft of claim **2**, in which said connection comprises an elongated threaded rod and nut linkage connected at opposite ends thereof to said keel portion and said manually controlled means.

4. The craft of claim **1**, and further comprising a releasable latch device resiliently holding said keel in any setting thereof, said device being yieldable upon the keel's encountering a substantial obstacle to enable the keel to swing aft-ward, independently of said positioning and maintaining means, about the pivotal keel-mounting axis.

5. The craft of claim **2**, and further comprising a releasable latch device resiliently holding said keel in any setting thereof, said device being yieldable upon the keel's encountering a substantial obstacle to enable the keel to swing aft-ward, independently of said positioning and maintaining means, about the pivotal keel-mounting axis.

6. The craft of claim **3**, and further comprising a releasable latch device resiliently holding said keel in any setting thereof, said device being yieldable upon the keel's encountering a substantial obstacle to enable the keel to swing aft-ward independently of said positioning and maintaining means about the pivotal keel-mounting axis.

7. A sailing craft having a mast mounted to swing about the axis of an upright step connection to the hull structure of the craft, a sail boom, and a yoke unit articulating the boom to the mast, said unit including a gooseneck member mounting said boom and tiltable about a substantially horizontal axis, and a linkage operatively connected between the mast and gooseneck to cause a swing of the former about its said step connection axis in response to a tilt of the latter about its said horizontal axis.

8. The craft of claim **7**, in which said articulating linkage is a universal type one translating the horizontal axis gooseneck tilt to the upright axis mast swing.

9. The craft of claim **7**, in which said step connection includes a swivel device enabling the mast to be pivotally lowered and raised in the order of 180° in an operation of stepping the mast.

10. The craft of claim **7** in the form of a catamaran, in which said step connection is located between the craft's twin hulls and includes a swivel device enabling the mast to be pivotally lowered and raised in the order of 180° in an operation of stepping the mast.

11. The craft of claim **9**, in which said swivel device also provides a part at which said mast has its said axis of swing in response to the tilt of the gooseneck.

12. The craft of claim **10**, in which said swivel device also provides a part at which said mast has its said axis of swing in response to the tilt of the gooseneck.

13. The craft of claim **7**, and further comprising means to secure said gooseneck in selectively tilted positions.

14. The craft of claim **1**, and further comprising a jib mounting spar extending between an elevated point above the craft and a cross-member spanning the space between the hull members, and a jib reel drum rotatably supporting the lower end of said spar on said cross-member midway of the length of the latter.

15. A catamaran sailing craft having a fin-keel pivotally mounted on a horizontal axis adjacent an upper portion thereof to depend between and well below the twin hull members of the craft in a fully extended cruising setting of the keel, said keel being elongated in length to the extent of substantial fraction of the hull length and being weighted adjacent the keel end, means for adjustably positioning and maintaining the keel in selective settings between said fully extended one and a fully retracted setting in which the keel is directed well aft-wise of the hull length, and a rudder unit including a rudder trunk pivotally mounted on the aft end of each of said hull members, a rudder blade pivotally mounted to adjust about a horizontal axis and at least partially housed in said trunk, a tiller extending into said trunk, and a linkage also at least partially housed in said trunk and providing a direction-changing adjustment connection between said tiller and said blade.

16. The craft of claim **15,** in which said rudder trunk has internal means to releasably hold the rudder blade in a vertically adjusted position thereof.

17. The craft of claim **1,** and further comprising a pop-top and tent unit mounted to swing on a horizontal axis abeam of said hull members, said unit including a cover member pivotal about said axis and overlaying a hatchway or cabin space of the craft between said hull members when the cover member is in a lowered condition, and a tent attached to said cover member and shielding said space when the cover member is in a raised position.

18. The craft of claim **1,** in which said hulls each present an outer fore-to-aft elongated side bulge adjacent and beneath said deck structure, said bulges extending a substantial portion of the length of the hull members and improving the position of the center of buoyancy of the craft.

19. A catamaran-type craft having an elongated fin-keel mounted to depend centrally between fixedly and permanently connected, laterally spaced twin hulls of the craft in a relationship to the normal load water line length of said craft and to the lateral spacing of said hulls such that the effective length of said keel beneath the craft's normal load water level in a fully extended downward position of the keel approximates one-third of said water line length, and that the longitudinal centerline of said hulls are transversely spaced from one a distance also approximating one-third of said water line length.

20. The craft of claim **19,** in which said hull centerlines diverge forwardly at a mild angle relative to the longitudinal centerline of the craft as a whole.

21. The craft of claim **19,** in which said fin keel is pivotally mounted on a horizontal axis for upward adjustment from said fully extended position toward a more horizontal, retracted position, and vice versa.

22. The craft of claim **20,** in which said fin keel is pivotally mounted on a horizontal axis for upward adjustment from said fully extended position toward a more horizontal, retracted position, and vice versa.

23. The craft of claim **19,** and further comprising a deck structure by which said hulls are rigidly and permanently inter-connected in laterally spaced relation to one another, said hulls each presenting an outer fore-to-aft elongated side bulge adjacent and beneath said deck structure, said bulges extending a substantial portion of the length of the hull members and improving the position of the center of buoyancy of the craft.

24. The craft of claim **23,** in which said hull centerlines diverge forwardly at a mild angle relative to the longitudinal centerline of the craft as a whole.

25. The craft of claim **23,** in which said fin keel is pivotally mounted on a horizontal axis for upward adjustment from said fully extended position toward a more horizontal, retracted position, and vice versa.

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