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March 1976

Yacht Research, Design, Science & Technology
Materials and Amateur Boatbuilding
Practical Cruising, Single-Handing, Self-steering
Sail Rigs, Spars & Rigging
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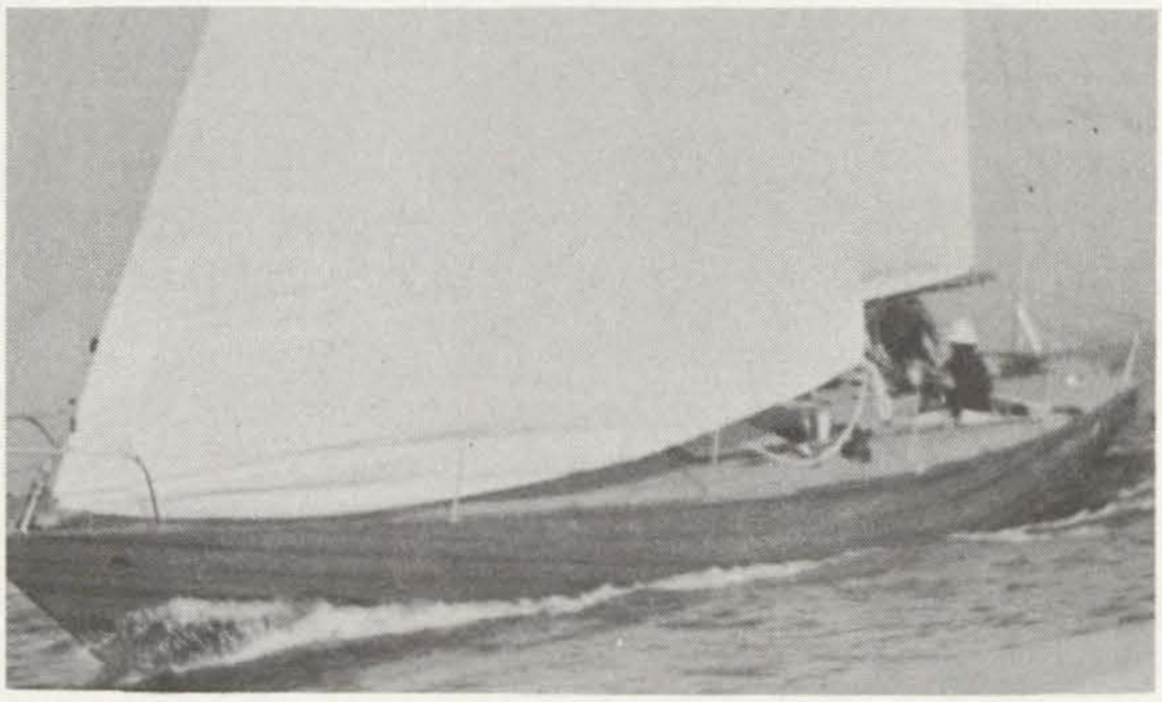
Yacht Designs: New and Old Concepts
AYRS - Florida-Caribbean Contact Group



GOLDEN DAZY
See Page 22

VAL
See Page 40

THE AMATEUR YACHT RESEARCH SOCIETY

(Founded, June, 1955 to encourage Amateur and Individual Yacht Research)

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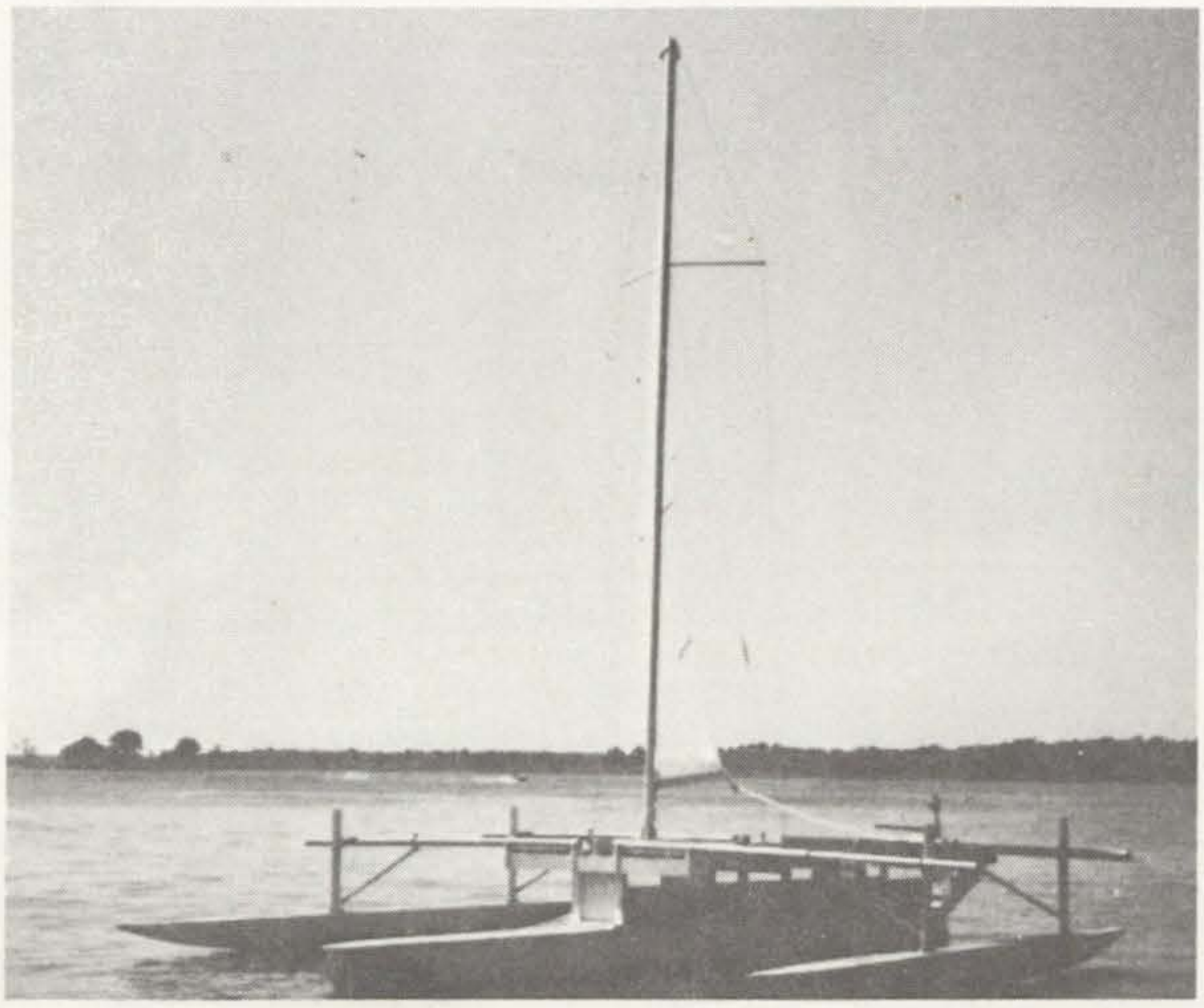

AMATEUR YACHT RESEARCH SOCIETY

The AYRS is an international, non-profit society for the amateur yachtsman, boatbuilder, yacht researcher, inventor, designer, sailor and experimentor. For an annual fee of $15.00, Members in North and South America receive six issues per year of our bi-monthly journal plus one book each year edited at AYRS Headquarters in England. The book this year is AYRS 81: SAILS 1976. The only requirement for joining is an interest in yachts and their behavior and the hope that Members will share their problems and ideas with others in the form of articles, letters, sketches, drawings and photographs.

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Editor: John W. Shortall III, 10822 92nd Avenue North, Seminole, Florida 33542.
Publisher: Richard Kelting, 607 North Cottonwood, Richardson, Texas 75080.

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Editor's Note: My thanks to Meade Gougeon for dictating the article on the building of GOLDEN DAZY and the WEST System and patiently responding to my follow-up questions. Also featured in this issue is Dick Newick's very fast and beautiful creation: VAL which he kindly wrote about and enclosed some of the first pictures. Florida and Caribbean Members note that Prof. Sciadini is collecting names of those wishing group transportation at reduced fares to the World Multihull Symposium, June 14-17, 1976 in Toronto, as sponsored by MULTIHULLS MAGAZINE with the cooperation of Canadian Multihull Services. This is an excellent opportunity for those choosing a design to buy or build to meet the designers and ask their questions in person. Cost of attending the symposium is just a small fraction of the cost of a large multihull and probably is a good investment for those in this category. Write MULTIHULLS at: 91 Newbury Ave.; No. Quincy, MA 02171.

AYRS 82 - DESIGN FOR FAST SAILING, is selling well, and we are running low on paperback copies which are for sale to AYRS Members only at $6.50 - a very good bargain. Retail price of the hard cover book is $22.00. See the review in AYRS 83A.

It has been suggested that the AYRS sponsor a design contest of some kind. A very successful AYRS design contest was held in England some years ago. Models were built and sailed from the designs and judged therefrom. I had thought that a more usual design contest might also be welcomed, perhaps divided into several categories distinguishing day-sailers from the larger boats, and multihulls from single hulls. Please let me have your ideas on this.

In the May issue, AYRS 84A, we will have an article by John Morwood on: "Yacht of the Year 2000." Other contributions on this theme are invited from Members. Surely by that time, power boats will be out of it, unless they burn our only renewable natural resource: wood. With no petroleum, we will no longer have plastic boats. What kind of pleasure yacht will the man with $10,000 (£5,000) to $100,000 (£ 50,000) be able to purchase off the floor in the year 2000?

In AYRS 84A, we continue Harry Morss' drag angle story and Joe Norwood's hydrofoil series. Joe has a second article in this issue to clarify a point in AYRS 82. Ed Mahinske has prepared an article on the solid, free-standing mast, and Prof. Venable has written on multihull cross beams. We have an extensive article from Harry Stover on the prismatic coefficient and speed in design.

Prof. Venable has written to propose that the AYRS establish a working committee on yacht strength, "initially to be charged with a study of multihull cross beams." Such a committee should include engineers and designers who would obtain basic data from sailors and builders particularly on failures. Any who are interested in taking part in such are encouraged to write me.

Renewals are overdue for AYRS Membership for the 1975 to 1976 year which began last October. The fee is now $15, and we ask for an additional $2 from those interested in our Florida-Caribbean Contact Group.

With each issue of this journal, we include a membership sheet. <u>We need new Members</u>, and I ask each of you to try to get that sheet into the hands of someone who appears interested in yacht research, amateur boatbuilding, or who is just curious about yachts and their behavior. Posting on bulletin boards at business firms, yacht clubs and libraries is one way to attract more Members. I am always happy to send more information and a free copy of our journal to any who seem interested and welcome the names and addresses of any prospects.

My thanks to the following for enclosing our membership solicitation in their mailings or for their initiative in securing publicity for the AYRS: Jim Brown, Charles Chiodi of MULTIHULLS, Meade Gougeon of Gougeon Bros., Tim Koverman, Denis Blaise of Long Island Multihull Assn., Gene Manghi, New England Multihull Assn., Dick Newick, Harold Stilson of Harstil Industries, Harry Stover, and Rod Wright of the Viking Multihull Club.

SELECTION AND EVALUATION OF YACHTS ON PERFORMANCE. In our previous AYRS-FCCG Newsletter, we published information on the Displacement-Length Ratio: DLR and Bruce Number: Br, and we use them extensively in the AYRS Journals to compare and evaluate yachts. The relationships should be understood by all who are to buy or build a boat and those interested in yacht performance under sail.

The DLR is defined as: DLR $=\Delta / (.01L)^3$ where Δ is the displacement or weight in tons of 2240 lbs each, and L is the waterline length in feet. For a fixed amount of power - whether sail area or engine - the lighter the boat the faster. As long ago as 1936, experiments in Sweden showed that the resistance of round-hulled displacement hulls was approximately proportional to the DLR. This has been confirmed by more recent tests.

We use the Bruce Number: Br, instead of the more common expressions for sail area to displacement ratio because it appears directly in Edmond Bruce's Most Important Formula for Sailing: MIFS (See AYRS 82, 55) and because it is easy to remember that the dividing line between a fast and a slow sailer is about 1.0. Br is defined as the square root of the sail area in square feet divided by the cube root of the displacement or weight with all crew and equipment in pounds:

$$Br = A_s^{1/2} \;/\; W^{1/3}.$$

It has been shown, analytically, that the ratio of boat speed to apparent wind speed is directly proportional to Br, and this has been proven experimentally in a number of cases.

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YACHT RESEARCH, DESIGN, SCIENCE AND TECHNOLOGY

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THE APPLICATION OF HYDROFOILS TO SAILING CRAFT - Part II. By Joseph Norwood, Jr.; 1021 Valencia Avenue; Coral Gables, Florida 33134.

In the preceding article of this series, we saw that hydrofoils can be used to oppose the heeling torque on a sailing boat up to the point that the hull lifts out of the water. Thus, the largest perturbation of the dynamic equilibrium of a sailing craft can be suppressed to any desired degree or eliminated altogether. The maximum righting moment of the craft is not augmented, however.

In the following discussion, we shall be concerned with the stability of this equilibrium. We define stability as the property of an equibrium state that allows it to return to equilibrium in an oscillatory manner following a displacement. Figure 1 shows what we mean. (See Figure 1 at top of page 5.)

In this figure we show two balls at rest, one at A balanced on a hilltop and one at B on the floor of the valley. If the ball at A is displaced even ever so slightly, it will roll down the hill and never return to A. We say that such an equilibrium is unstable. On the other hand, the ball at B will oscillate about its equilibrium point and eventually return to B as its energy is dissipated. This is a stable equilibrium. Let us see what this means in terms of Bruce foils. We saw that a windward Bruce foil exerts a downward force to oppose the heeling force. If the foil should chance to pop

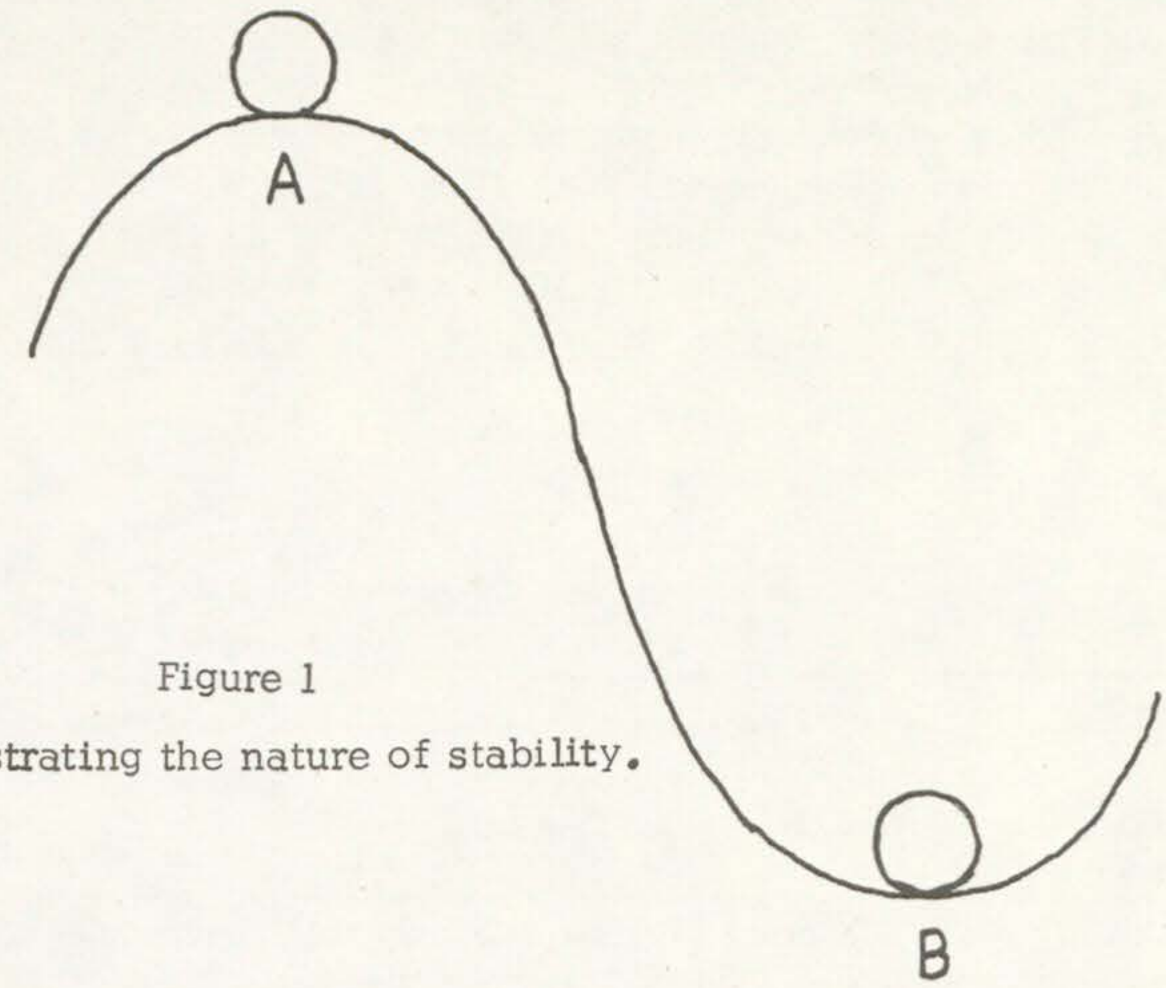


Figure 1
Illustrating the nature of stability.

out of the water owing to wave action, then the heeling torque will try to capsize the boat to leeward rather than restore the equilibrium. Windward Bruce foils are unstable to rolling perturbations. On the other hand, if a leeward Bruce foil pops out, the resulting torque is such as to rapidly restore the equilibrium. Leeward Bruce foils are stable up to the point of hull liftoff.

Let us see what type of foils are applicable to use on sailing craft. Hydrofoils can be lumped into two classes: those whose blades are wholly immersed and those whose blades pierce the surface. In order for the boat to enjoy vertical stability, the hydrofoils must "see" the water-air interface and thus be able to respond to a vertical displacement perturbation in such a way as to rapidly restore the original flight attitude. Fully immersed foils can only do this by operating very near the surface where lift is a sensitive function of depth or by having a surface sensor that transmits orders to the hydrofoil for required changes in angle of attack. The first method, extensively employed by the Russians in their large powered river craft, is useless in any sort of sea. The second method has been explored by Hook and others. In this writer's opinion, the control of altitude by mechanical feedback from a surface sensor involves complications undesirable in a sailing craft.

Let us therefore examine the properties of surface-piercing hydrofoils. To a reasonable degree of approximation the lift exerted by a hydrofoil at a given speed varies linearly with its depth of immersion and with the angle of attack of the water flow onto the foil, α, as shown in Fig. 2(a). If a downward perturbation occurs, the hydrofoil sees this as an addition to an increase in angle of attack (Fig. 2(b)). Thus the

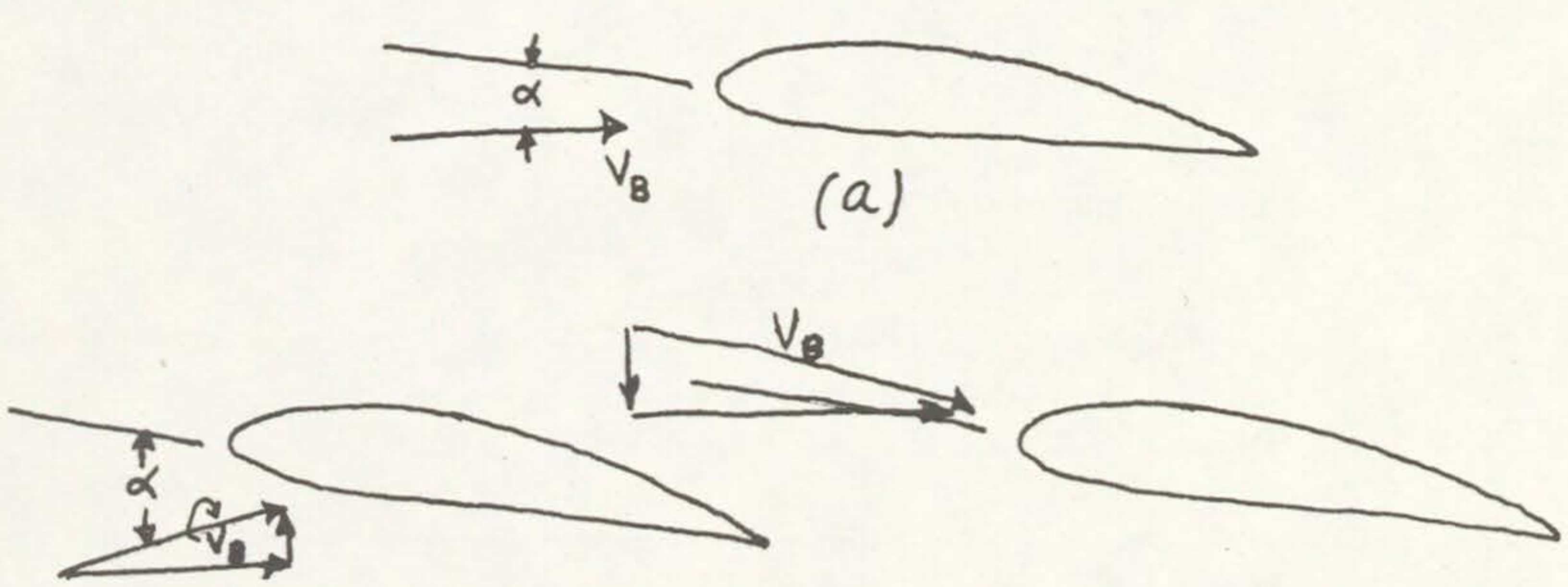
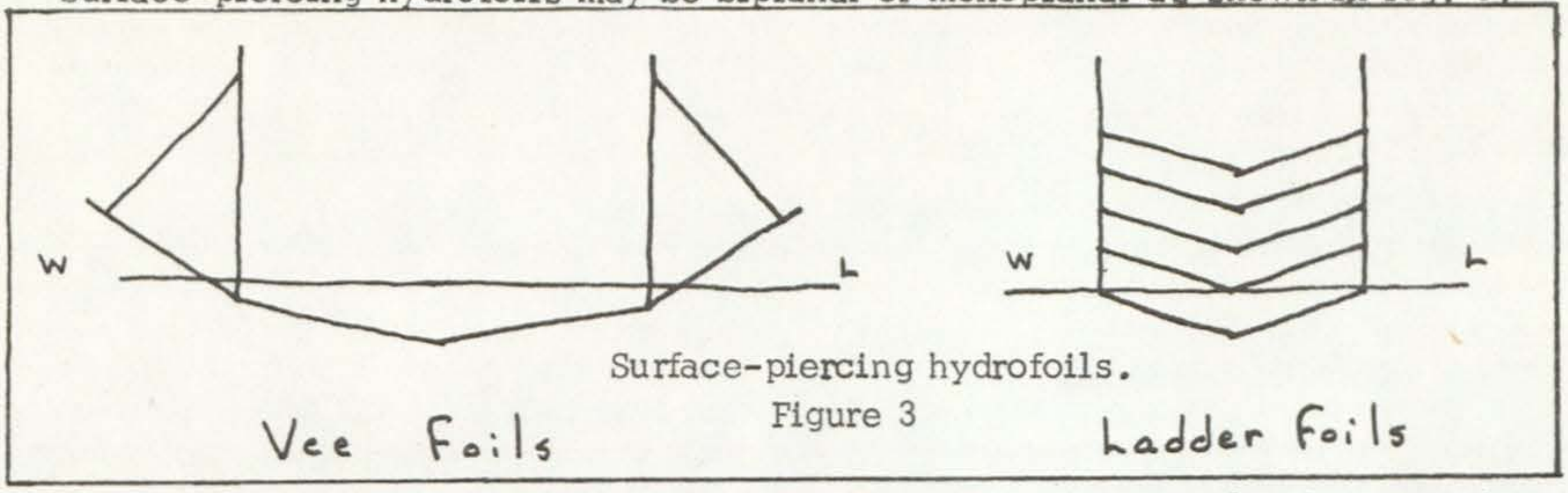


Figure 2

lift is augmented in opposition to the perturbation. Likewise, for an upward perturbation, the effect is a reduced angle of attack and the foil stalls, losing lift in opposition to the perturbation (Fig. 2(c)).

Thus, the foil resists vertical displacements with a force proportional to the displacement and another force proportional to the rate of displacement; this amounts to a damped oscillator. It is the problem of the designer to match the stiffness and damping characteristics of the system so as to obtain seakindliness.

Surface-piercing hydrofoils may be biplanar or monoplanar as shown in Fig. 3.



Surface-piercing hydrofoils.
Figure 3

For the purpose of high-speed ocean sailing, how do they operate? There are three important properties to look for: a high lift/drag ratio (L/D), a high lift/hydrofoil weight ratio, and good response to the perturbations encountered in offshore sailing. The foil rungs in a ladder arrangement have a higher aspect ratio (span/chord) than would be possible in a single-bladed foil. This is perhaps offset by a more complex strut system. Thus, in L/D there is not much to choose between the two. The ladder configuration is a much more efficient lift producer for its weight due to the stiffness of the biplanar structure. The big argument in favor of the ladder foil lies in the presence of a large reserve of non-immersed foil blades that can become immediately effective as the foil enters a wave. The Vee-foil is generally used in powered vessels where the foil-borne speed range is not very large. In sailing, the power source and consequent sailing speed varies over a wide range. In a multi-bladed ladder, the foil section can be varied from a high lift but low L/D section near the top, to a section more appropriate to high speeds near the bottom.

The principle perturbation of interest is wave action. Let us see what effect wave action can have on hydrofoils. In Fig. 4 we show that the motion of an individual particle in the water as a wave passes from left to right is an orbit that is circular with a diameter equal to the wave height at the surface and tends to a shuffling back and forth at greater depth. Consider a hydrofoil-borne craft operating into a head sea, that is, moving against the wave motion. Since the water on the front of the wave is rising, the foil sees this as an increase in angle of attack and lift is increased.

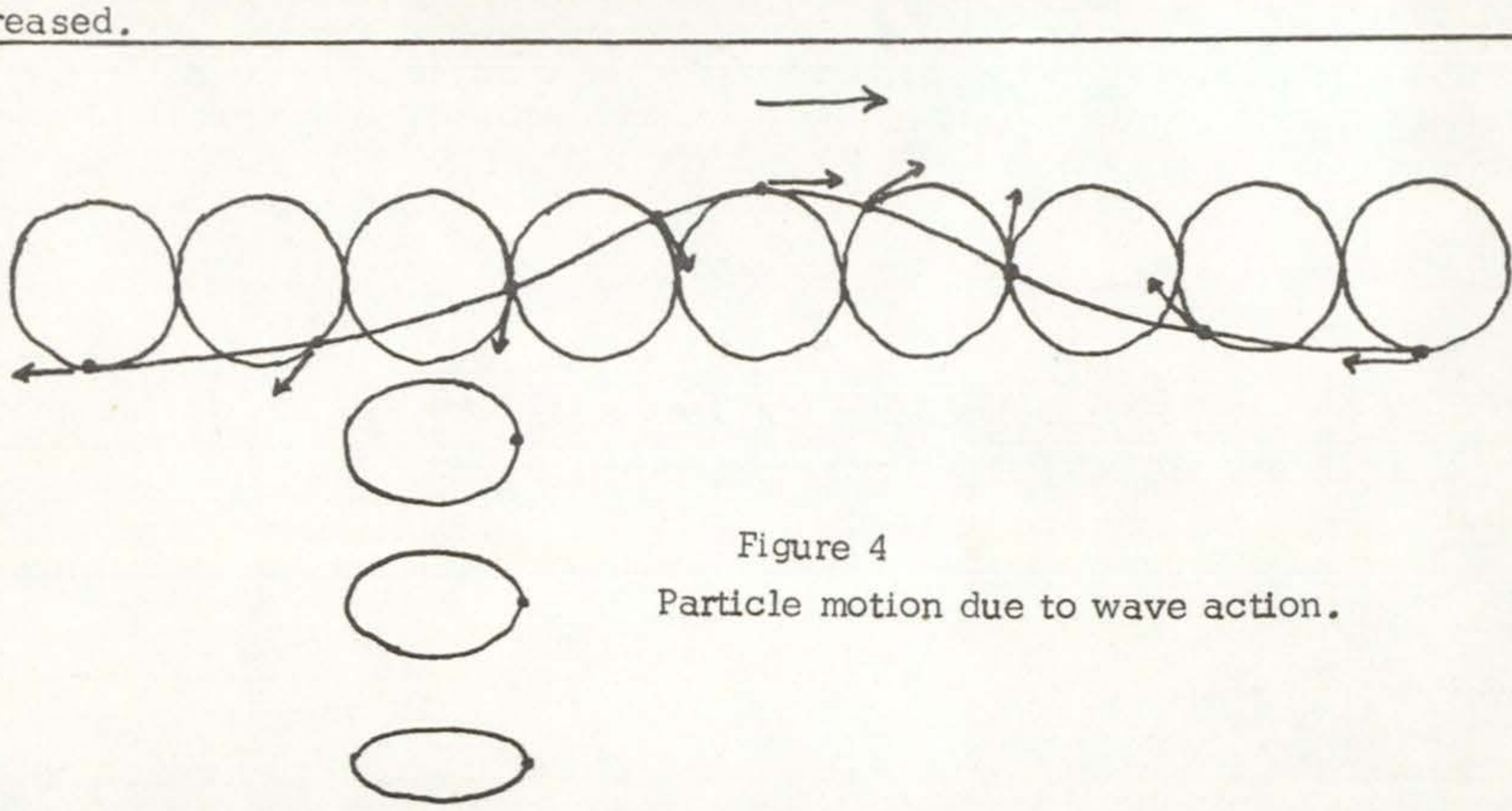


Figure 4
Particle motion due to wave action.

The hydrofoil thus tends to climb the wave rather than keep a constant altitude. On the backside of the wave the water is falling. This is seen as a decrease in angle of attack, lift decreases, and the craft tends to contour the back side of the wave as well. In a following sea, the situation is more serious. The foil-borne craft, if moving fast enough to overtake the waves, will first encounter the back side of the wave and tend to plow in. If it manages to smash through the wave, it will see rising water on the front side and the foils may acquire too much lift and jump out of the water. The sudden loss of bow lift in such a case would very likely lead to an event known in hydrofoil sailing circles as the dreaded crash-dive, wherein the bow foil suddenly loses lift and the hull re-enters the water at a great rate of speed in a decidedly nose-down attitude. Clearly, a many-bladed ladder arrangement with increased lift in the upper foil rungs offers greater accomodation to the effects of wave action than a single surface-piercing foil.

Due to the nature of hydrofoils, the pressure on the more highly-curved side is lower than that on the flat side. In surface-piercing operation, a portion of the upper side of the hydrofoil near the surface may fall below atmospheric pressure. This leads to the formation of a cavity and the entry of air from the surface, resulting in a loss of lift. This phenomenon is known as ventilation. It is controlled by the use of fences as shown in Fig. 5 and by the selection of a foil section having a fairly even distribution of lift over the upper surface.

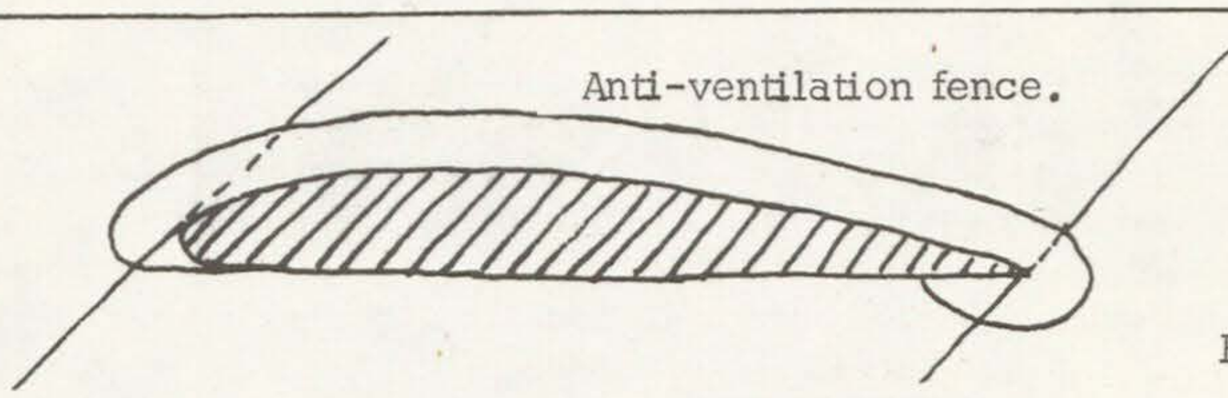


Figure 5

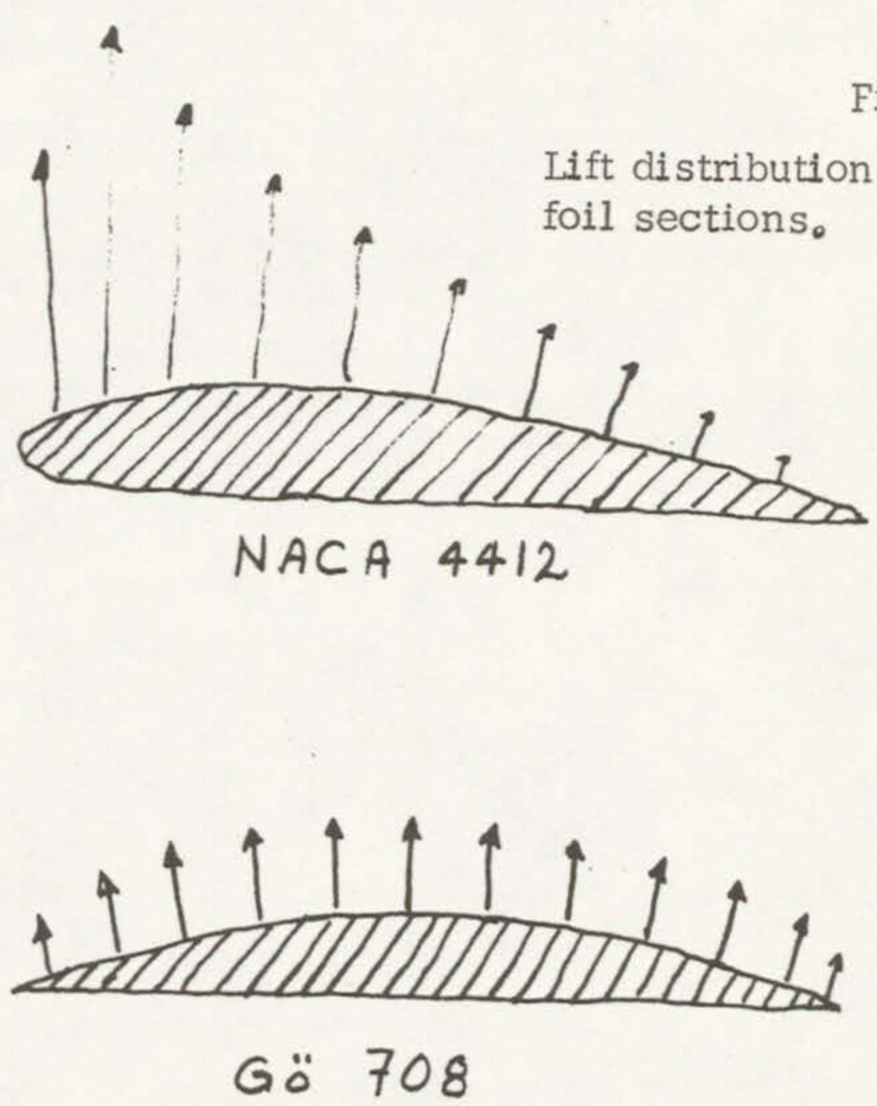
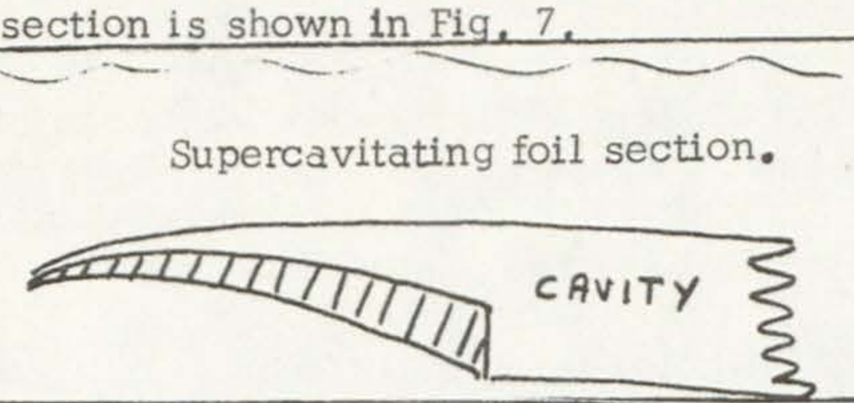


Figure 6

Lift distribution for two different foil sections.

Assuming the problem of ventilation can be managed as seems likely, the ultimate barrier is cavitation. This occurs when the surface pressure of some point on the hydrofoil surface falls below the vapor pressure of the water. Bubbles form as local boiling commences. The bubbles move aft along the foil surface and as the pressure rises, the bubbles collapse. The instantaneous pressures on the foil surface as these cavitation bubbles collapse are many thousand pounds per square inch and pitting of the foil surface results. The speed at which cavitation begins lies in the 40 knot plus range and so does not really concern us as far as sailing speeds are concerned. An ultimate contender for the world sailing speed record, however, might well be equipped with a ladder foil arrangement having a supercavitating foil on the bottom rung. Such a section is shown in Fig. 7.

Supercavitating foil section.



In the third article of this series we shall discuss the configurations into which hydrofoils have been arranged and see how they compare, using the requirements of sailing offshore as our yardstick.

Editor's Note: AYRS 83A contained references which constitute a bibliography for the serious student of hydrofoils as applied to sailing craft. Of particular note are:

1. SAILING HYDROFOILS - AYRS 74 - 285 pp. - Paperback (AYRS Members only) - $ 4.50; Bound hardcover - $ 8.50.
2. DESIGN FOR FAST SAILING - Research Afloat and Ashore: by Edmond Bruce and Harry Morss; 1976; 318 pp.; AYRS 82. Paper (AYRS Members) - $ 6.50. Bound Hard Cover (AYRS Members) - $ 11.00. ($22.00 to Non-Members.)

In the above Part II article, Dr. Norwood differs with the implication in AYRS 82 that if the beam is critical, e.g. if D=H for 45 degrees dihedral, then one can carry any amount of sail. In the letter to Dr. Feldman on p. 235, limits are placed on F_s (max) for both leeward and windward foil positions. AYRS 84A will have an article on this which is an extension of the cases considered and treated in AYRS 82.

In the next issue, Joe will continue with his Part III article which will concern: a comparison of hydrofoil configurations: aeroplane, canard, catamaran, asymmetric.

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DRAG ANGLES - MEASUREMENT - Part II. By Henry A. Morss, Jr.; 6 Ballast Lane, Marblehead, MASS 01945.

The first in this series: "Drag Angles," printed in AYRS 83A, reviewed the definition of drag angle, its applications in sailing, and the importance of drag angles in understanding sailing performance. In this paper, we are concerned with methods of measuring drag angles. An outline of relatively simple testing methods provides a fuller insight into the nature of drag angles as well as indicating how actual numerical values may be obtained.

HULL DRAG ANGLES - δ_H. In his 1967 article (Ref 1), John Morwood sketched a method for measuring the hull drag angle as shown in Fig. 1. In a current of moving water, a hull is held by two parallel bars of equal length (or even two pieces of line) at a value of leeway angle λ determined by the position of the fixed bar on shore to which the two are attached. The bars are pivoted at both ends and thus hold the hull at a fixed angle to the current while permitting it to move freely in the up-stream, downstream direction. Under these constraints, the hull will come to rest at the point where the angle between the bars and the perpendicular to the current is the hull drag angle - δ_H. (Figure 1 appears on page 9.)

This can be a very convenient method of determining the hull drag angle at any desired leeway angle when a suitable current close to shore is available.

Aside from the fact that preferred current strengths may be difficult to find, the principal drawback to the method is that a knowledge of hull drag angle vs leeway angle does not necessarily say what the drag angle may be in a given sailing situation, because the leeway angle may not be known. The relationship is very sensitive. A change of a fraction of a degree in leeway angle may produce a substantial alteration in the drag angle.

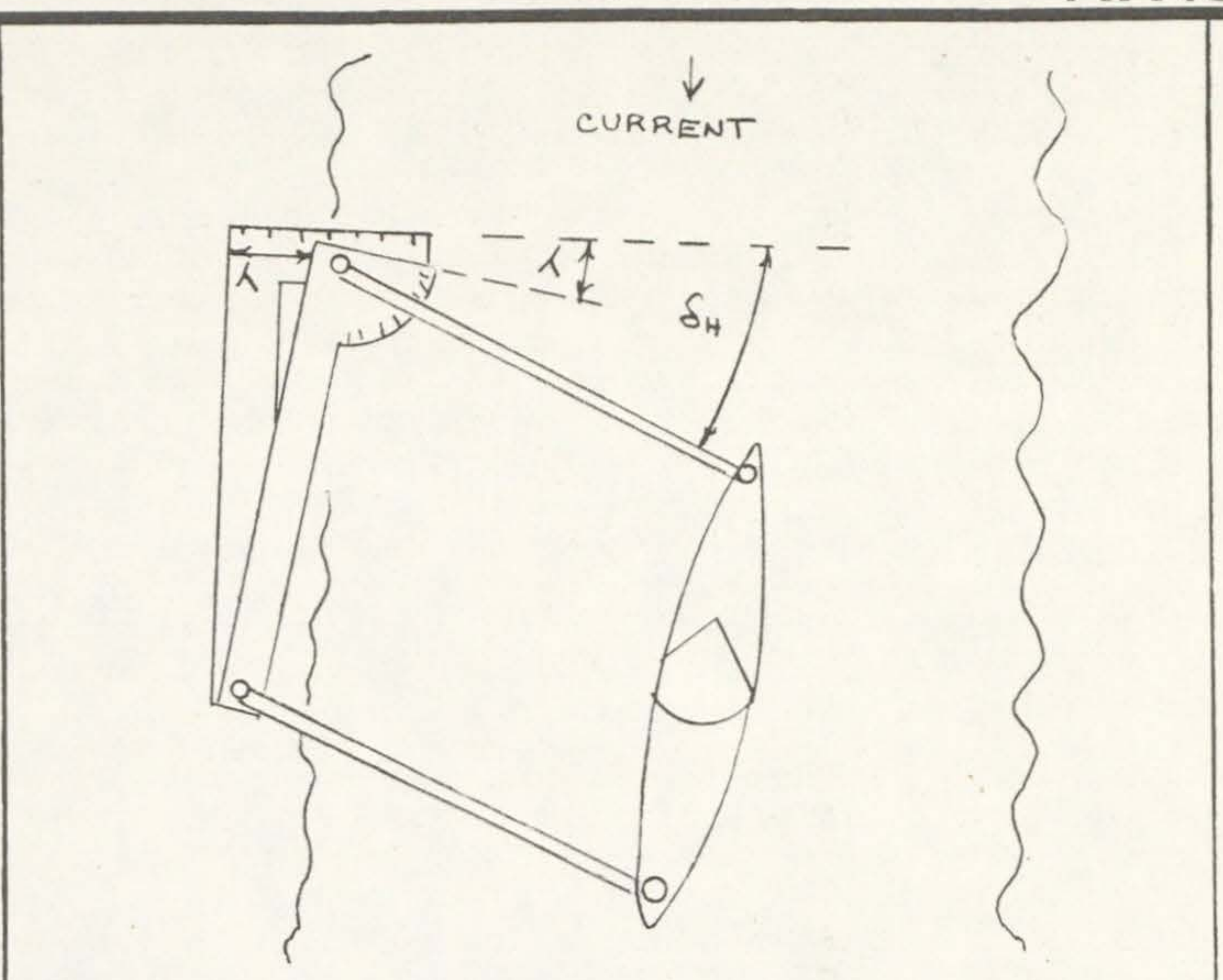

Figure 1

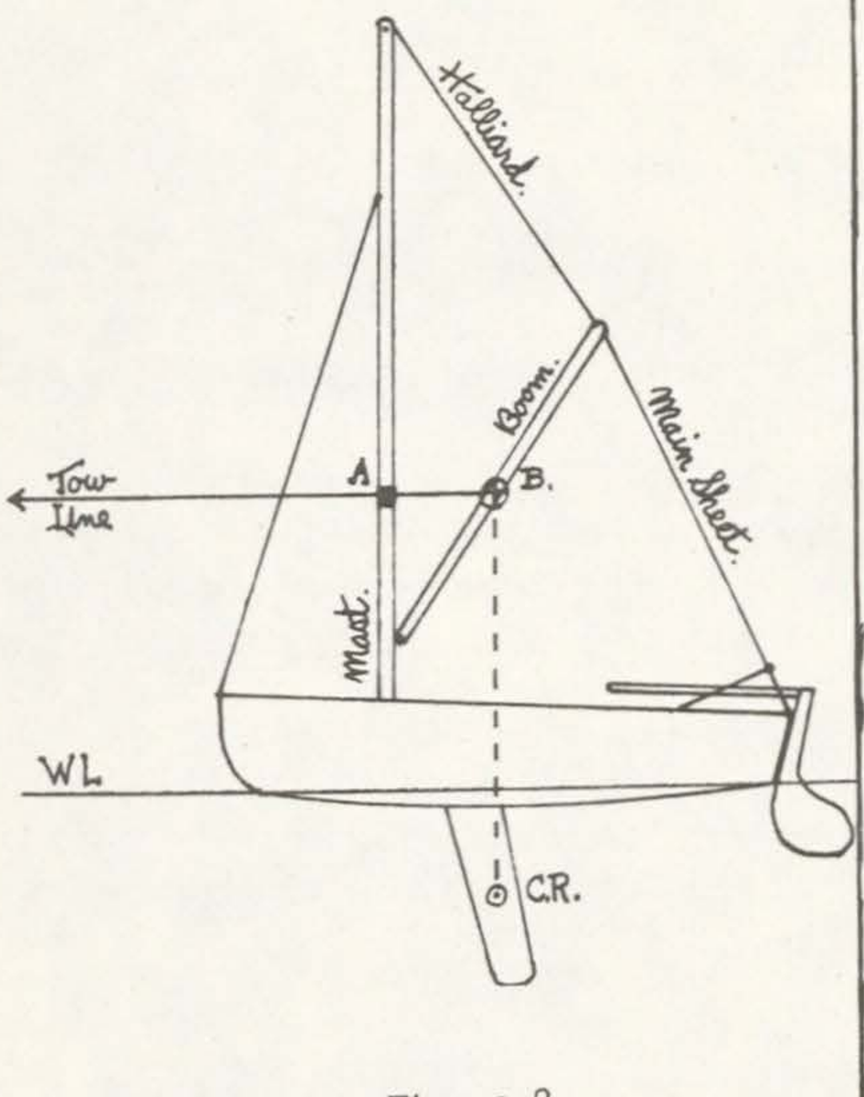

Figure 2

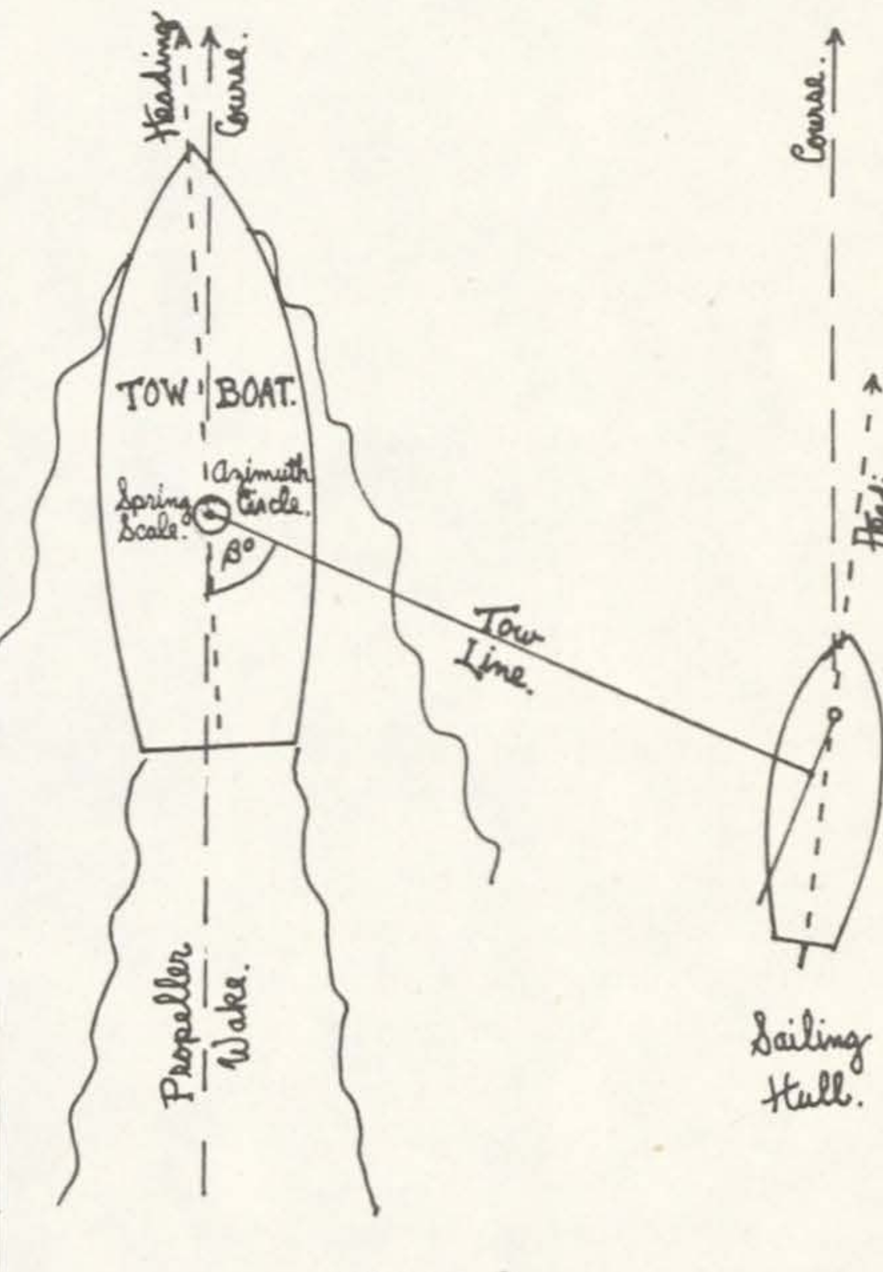

Figure 3

Another method of direct measurement of hull drag angle which is practical for small (full-sized) boats but may be rather difficult or even dangerous for large craft was suggested by Edmond Bruce in references (2) and (3). The hull is towed by a single horizontal line connected to the point of the center of effort of the sail plan. This is illustrated in Figs. 2 and 3 (See page 9) taken from references (2) and (3).

If the towing force, largely to the side of the tow boat, causes the towing craft to proceed slightly sidewise, the latter's leeway angle must also be measured along with the angle of the tow line to determine the hull drag angle.

In this method, the leeway angle of the boat being tested will adjust itself to its proper value for the prevailing "sail force" and "sailing angle." Its value is not needed if the objective is only to find the hull drag angle, but it is of interest in its own right and should be measured and recorded.

SAIL DRAG ANGLE - δ_S. Possibly the most convenient means for the direct measurement of the sail drag angle δ_S, is the "tethered boat test," described in references (2) and (3). It is illustrated in Figs. 4 and 5 taken from those articles. This test is easier for the ordinary sailor to undertake than those for measurement of hull drag angle outlined above. Both require precise measurement of angles. This test can often be conducted by the skipper single-handed. It is rather fun to do.

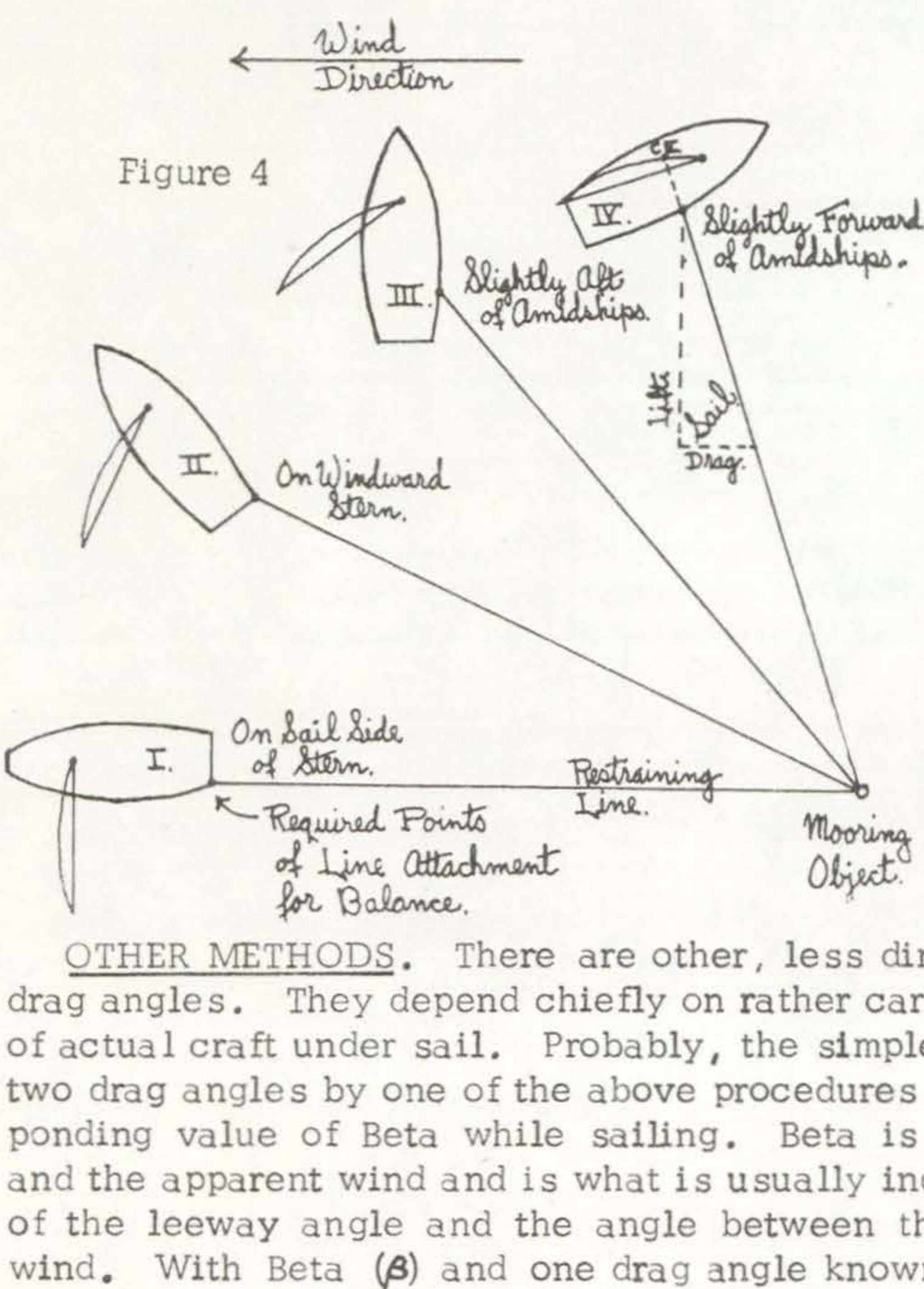

Figure 4

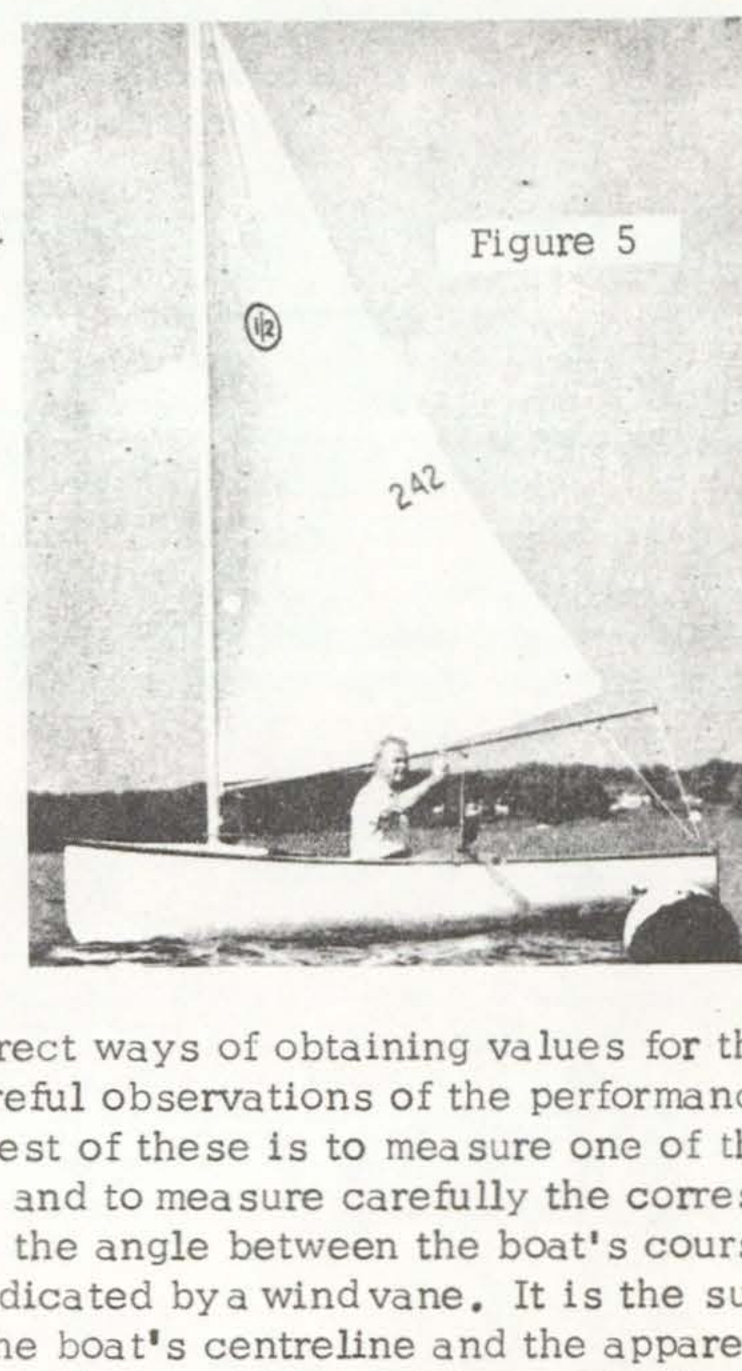

Figure 5

OTHER METHODS. There are other, less direct ways of obtaining values for the drag angles. They depend chiefly on rather careful observations of the performance of actual craft under sail. Probably, the simplest of these is to measure one of the two drag angles by one of the above procedures and to measure carefully the corresponding value of Beta while sailing. Beta is the angle between the boat's course and the apparent wind and is what is usually indicated by a wind vane. It is the sum of the leeway angle and the angle between the boat's centreline and the apparent wind. With Beta (β) and one drag angle known, the other drag angle may be found by the Course Theorem which states that Beta is the sum of the two drag angles:

References:

(1) AYRS 62; July, 1967: "The Urgent Yacht Research - Hull and Sail Drag Angles." by John Morwood.
(2) AYRS 40; July, 1962: "The Physics of Sailing Craft as Revealed by Measurements at Full Size," by Edmond Bruce.
(3) AYRS 82; 1976: References (1) and (2) articles are reproduced herein.

Editor's Note: In our next issue, the drag angle story will continue with a further paper: DRAG ANGLES (Part III) - A PRACTICAL PROGRAM FOR THE SKIPPER. The significance and utility of drag angles and their relation to sailboat performance are spelled out to some extent in AYRS 82 and in more detail in the paper just given by

Henry Morss: "Forces and Angles in Sailboat Performance;" Society of Naval Architects and Marine Engineers, January, 1976.

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HOLLOW VS. SOLID FREE-STANDING MASTS - WOOD VS. ALUMINUM FOR SPARS.

By Capt. Edmund B. Mahinske USN; 5515 Ivor St.; Springfield, Virginia 22151. USA.

It is important to note that I will be addressing the free-standing mast problem only without shrouds or stays. I accept that there are situations where one would want, or is constrained, to employ a free-standing mast. I am attempting in this article to develop some insights into the trade-offs involved when comparing hollow and solid masts.

A free-standing mast is comparatively easy to analyze, especially if we ignore the moment and shear stresses at the base. The only stresses left on the mast are those generated due to the bending moment - i.e. the wind on the sails produces a bending moment on the mast, and the latter must generate, internally, an equal and opposite restoring moment if it is to remain standing. The fibers of the mast go into stress due to the bending action. The shear forces up and down the mast can be ignored as they are small compared to the tension and compressive forces.

A further simplification is to limit our discussion to a square mast cross-section of uniform cross-section throughout its length. See Figure 1, below. For ease of mathematics, b_1, the length outside of one side, will be taken as one inch, (25 mm). The external bending moments are arbitrarily taken as applied normal to one of the mast faces.

At any selected point on the mast, we find that the applied loading has caused a stress S in pounds per square inch, in the fibers on one face and a -S in the outermost fibers in the opposite face. One face is in tension and the other in compression. By calculus, the internally-generated moment M_h for a hollow mast at the selected position is:

$$M_h = \frac{S}{6}\left[\frac{b_1^4 - b_2^4}{b_1}\right]$$ (Bending moment for hollow mast in foot-pounds)

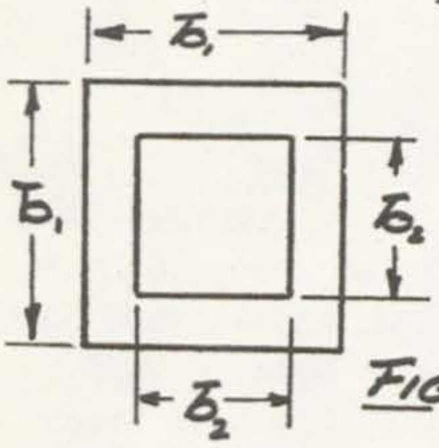

FIG. 1.

For a solid mast, b_2 would be zero, and the expression reduces to:

$$M_s = \frac{S}{6} b_1^3$$ (bending moment for solid mast in foot pounds)

Now, let's view S as the maximum allowed stress at the selected position. This might not be yield stress, but it is the maximum allowed stress to prevent yield stress from being attained further down the mast. Moments and stresses increase toward the base. If S is the maximum stress, the M_h and M_s are the maximum allowable restoring moments at the selected position for hollow and solid masts respectively. M_s is always greater than M_h.

To obtain some insight into these relationships and make comparisons, we solve for the ratio of M_h to M_s and plot this as a function of b_2/b_1 in Figure 2, page 12:

$$M_h/M_s = 1 - (b_2 / b_1)^4$$

The dashed curve is a plot of the ratio of the weight of the hollow mast - W_h to the weight of the solid mast - W_s as a function of the ratio b_2/b_1.

We see immediately from Fig. 2 that as we start to hollow out the mast, i.e. b_2 starts increasing, the maximum moment that can be generated by the mast at the selected position decreases. Qualitatively, we say that the mast becomes weaker. When b_2 is zero, we reach the solid mast condition.

It is important to note from Fig. 2 that the curve of M_h/M_s "hangs in there" for a while for low values of b_2/b_1. In our one inch (25 mm) mast, a value of 0.4" (10 mm) for b_2 would result in a reduction of 2.56% in maximum restoring moment, but significantly there would be a 16% reduction in weight. From the curves, we can determine that a hollow mast having half the weight of a solid mast would equate to a b_2/b_1 ratio of 0.707 - running this abscissa to the solid curve horizontally, we gain the information that the restoring moment ratio has decreased to 0.75, a reduction of 25%. It becomes a losing game with further increases in the ratio b_2/b_1. The mast becomes weaker at a more rapid rate.

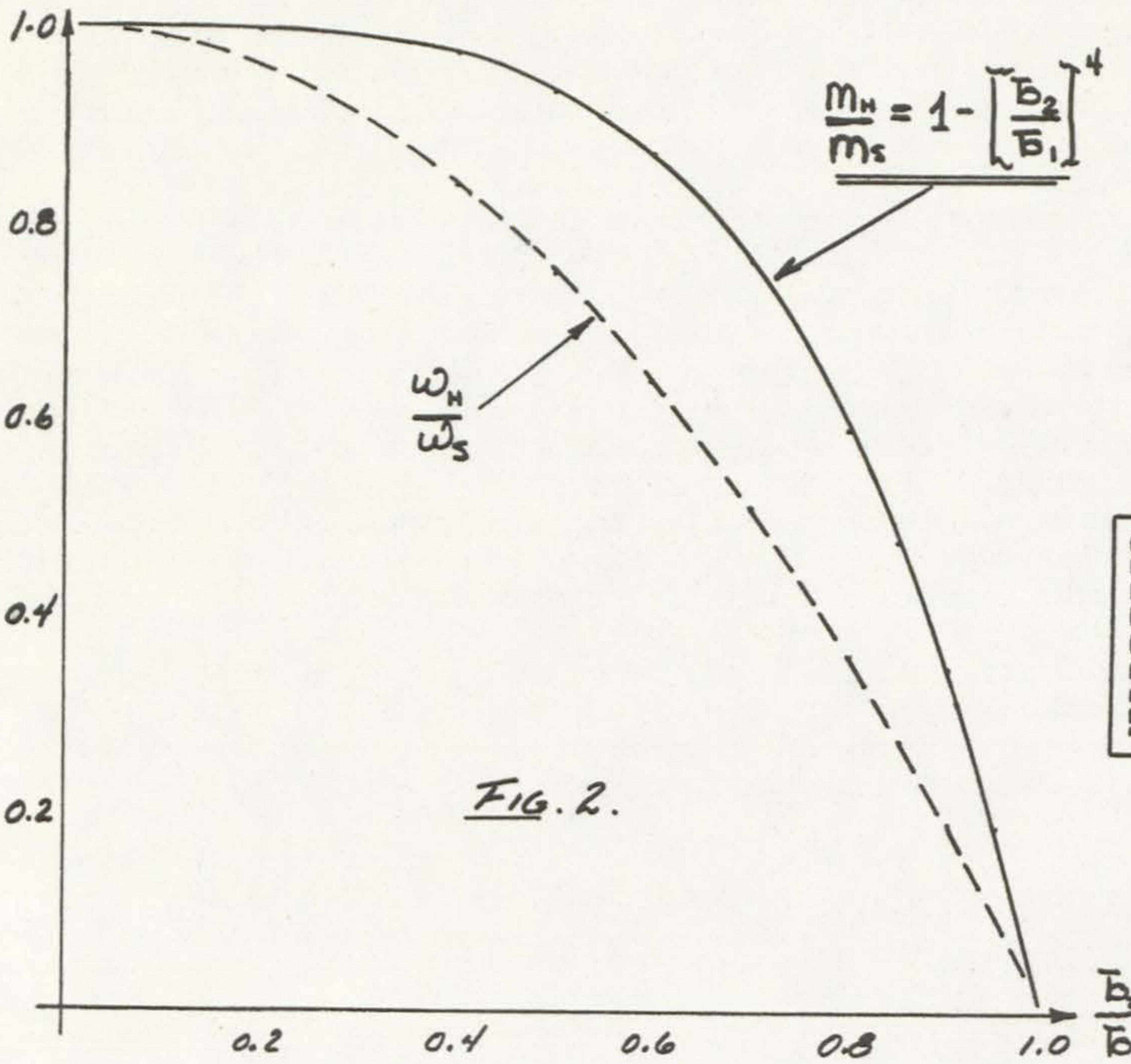

FIG. 2.

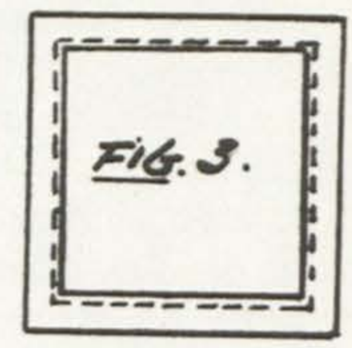

FIG. 3.

What is killing us in this analysis is that we are constrained by our original rule to working within the one inch square. b_1 was always to have the value of one inch. In fact, however, the mast would accomplish more if b_1 were allowed to exceed one inch. For example, we can pose the following problem: If we allow both b_1 and b_2 to vary, what are their values for a hollow mast as strong as the solid one inch mast? ($M_h = M_s$). Working this out, we find: $b_1 = 1.207"$ (31 mm); $b_2 = 0.975"$ (25 mm). Figure 3 shows the result. The dotted line represents the one inch square. I leave it to the reader as to whether he would accept the increase in size indicated in exchange for a weight reduction of 50%.

Wood is the most wonderful material with which to work. Like Ephraim C. S. Clark the Lord Himself loved wood. Why else would He have made trees of it? But, wood works better for trees than for masts, especially hollow masts. Remember that such must have preservation, inside as well as out, and drain holes at the base. What happens if we replace our one inch solid wooden mast with one of one inch solid aluminum? The compressive and tensile strengths of aluminum are about five times that of spruce. Going through the formulas, I find that the hollow aluminum mast equivalent would have the following dimensions: $b_1 = 1.0"$ (25 mm) $b_2 = 0.9457"$ (24 mm). The startling result is the weight reduction. Based on a density for spruce of 27 lbs. per cu. ft. (0.43 gm/cc) and aluminum of 165 lbs. per cu. ft. (2.64 gm/cc), the weight reduction turns out to be 35.4%. Taking into account other advantages that accrue by using aluminum, I think one would be best advised to think twice before going the wooden mast route.

Editor's Note: Ed is commenting on two letters written by Ephraim C.S. Clark on his solid wishbone mast of wood and published in FCCG No. 3, the November, 1975 issue of our AYRS-FCCG Newsletter. I have another article from Ed here: "The Solid Free-Standing Mast." which we will publish in the next issue, and I am trying to encourage him to suggest some designs for the stayless mast as applied to modern sailing craft - surely the next new, radical development to come along. Ed's comment on wood being wonderful but ... reminds me of the jibe about plastic boats: "If God had intended man to build boats of fibreglass, he would have planted fibreglass trees." Then there is the polyestermite ...

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APPLICATIONS OF WAVE DRAG THEORY TO SAILING YACHT DESIGN. Letters from: Prof. Walter Castles Jr.; Box 370; Big Pine Key, Florida 33043. USA.

Dear Jack,

The basic reference for the derivations of the general wave drag theory equation is: "Proceedings of the Royal Society," A; Vol. 138; p. 342; 1932, and full credit should go to the author: T. H. Havelock. The applications and programs worked out are as follows and are available from the Hewlett Packard HP-65 Users Library:

Prog. No. 02860 A: "Wave Resistance of Catamarans and Slim, Shoal Draft, Monohulls." - 2 chips. This is a four singularity approximation to the exact wave drag equations which I could never use before the HP 65 came along, since it would have taken weeks to compute a value on a desk calculator, while the HP 65 does this in about 10 minutes.

Prog. No. 03045 A: "Induced Resistance of Catamarans and Monohulls." - 2 chips. First order airplane wing theory, which the boat people have been trying to use, becomes increasingly inaccurate as the aspect ratio of the lifting surfaces (i.e. sail, centerboard, keel etc.) drops below 4. This program is a quite accurate approximation of second order theory and is good for any aspect ratio from zero to infinity. For example, my cat hulls have neither keels nor centerboards and a geometric aspect ratio of 0.06, including the 1 1/2 inch vortex generators on the bottoms. This is effectively doubled by the air-water interface but even so, the first order theory would indicate that the boats could barely get to windward - whereas they will split 90 degree tacks, as indicated by this program.

Prog. No. 03194 A: "The Skin Friction Resistance of Catamarans and Monohulls." - 1 chip.

I also have developed a program for the net lateral and forward forces of a sloop rig - 2 chips - which I hope to get around to sending in one of these days plus the final program to put the four programs together and iterate a performance solution.

Sincerely, Walter Castles

Letter from: Jack Shortall

Dear Walter,

Thank you for your subscriptions to the AYRS and AYRS-FCCG as well as the descriptions of your catamaran and your derivations. Can you send me the basic equations? I cannot afford an HP 65 at $795 so will have to hope the price comes down, way down. You chose a catamaran as a high speed vehicle, Joe Norwood believes the proa to be the answer, and Harry Morss is launching his Newick high speed trimaran with hydrofoils of his own design. I would guess that the yacht of the future is a single hull sailboat with hydrofoil stabilizers for no heel and maximum sail drive. Harry Stover would plump for one kite sail connected to one hydrofoil with a man somewhere in between.

Sincerely, Jack Shortall

Dear Jack,

For your purposes, perhaps the new HP 25 programmable (40 keystroke program memory) computer at $195 might be suitable. It is very easy to program and has a surprising computational capacity since all commands are merged, and each stored command is addressed. I am in the dark as to whether you want the derivations or just the equations, so will send just the latter for the moment:

A. Wave Resistance - 4 Singularity Approximation:

Let $R = 1/2\rho(A/L)^2V^2C_w$ where: R = wave resistance in pounds for one hull; ρ = mass density in slugs/ft^3 (= 2 for sea water); A = maximum underwater cross-sectional area of one hull in ft.^{2}; L = waterline length in feet; V = velocity in feet/

sec.; C_W = wave drag coefficient.

Then for a catamaran - both hulls:

$$C_W = \frac{2}{\pi F^4}\int_0^{\pi/2}\left[1-\cos\left(p/F^2 \sec\theta\right)\right]\left[1+\cos\left(bp/F^2 \sec\theta \tan\theta\right)\right] e^{-\frac{2Z}{F^2}\sec^2\theta} \sec^3\theta \, d\theta$$

where: F = Froude Number = $V/\sqrt{gL}$; p = prismatic coefficient = displacement/AL; b = hull spacing/pL (hull spacing between centerlines); Z = (depth of centroid of A)/L; θ = parameter. Equation (1) is the devil to numerically integrate with any accuracy on account of the variable period of the integrand. I found the following transformations which makes the period uniform and Simpson's Rule can be used to integrate the expression:

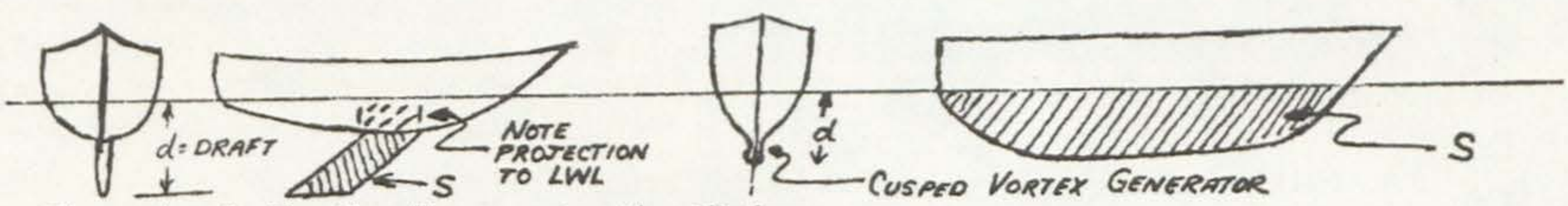
Let $B = p/F^2 \sec\theta$, then:

$$\pi p^2 C_W/2 = \int_{\beta_0}^{\infty}(1-\cos\beta)\left[1+\cos\left(b'\beta\sqrt{\beta^2-c}\right)\right]\frac{\beta^2 e^{-a\beta^2}}{(\beta^2-c)^{1/2}}\,d\beta$$

where: $\beta_0 = p/F^2$; $a = 2Z/p\beta_0$; b' = hull spacing/β_0 Lp; $c = \beta_0 2$. From Equation (1), the value of the integrand, I, at the lower limit is: $I = 2\beta_0{}^2(1-\cos\beta_0)\, e^{-a\beta_0^2}$. For a slim, shoal-draft monohull, Equation (2) gives the correct answer using b' = 0.

B. Induced Resistance Arising from Sail Lateral Force (Lift):

Let "S" be the "effective" lateral area as shown below:



Then the "effective" aspect ratio AR is:

$AR = \frac{2d^2\cos^2\delta}{S}$ where: d = draft (no heel); δ = heel angle; S = effective lateral

lateral area.

Then for AR cos$\Lambda \geq 2$, where Λ = sweep angle (from the vertical):

$$C_L = \left(\frac{2\pi AR\cos\Lambda}{AR\cos\Lambda+2}\right)\alpha+\alpha^2 = \left(\frac{2\pi A}{A+2}+\alpha\right)\alpha \quad \text{WHERE } A = AR\cos\Lambda$$

$$\alpha = -\left(\frac{\pi AR\cos\Lambda}{AR\cos A+2}\right)+\left[\left(\frac{\pi AR\cos\Lambda}{AR\cos\Lambda+2}\right)^2+C_L\right]^{1/2} = \frac{-\pi A}{A+2}+\left[\left(\frac{\pi A}{A+2}\right)^2+C_L\right]^{1/2}$$

$$C_{Di} = \left[\frac{4\pi A}{(A+2)^2}+\alpha\left(1-\frac{\alpha}{2\pi}\right)\right]\alpha^2 \quad \text{FOR ALPHA IN RADIANS}$$

WHERE: HULL LATERAL FORCE = $\frac{1}{2}\rho S V^2 C_L$; HULL INDUCED RESISTANCE = $\frac{1}{2}\rho S V^2 C_{Di}$;

HULL LEE ANGLE = α (ANGLE OF ATTACK)

FOR $AR\cos\Lambda \leq 2$: $C_L = \left(\frac{1}{2}\pi A+\alpha\right)\alpha$; $\alpha = -\frac{1}{4}\pi A+\left[\left(\frac{1}{4}\pi A\right)^2+C_L\right]^{1/2}$

$$C_{Di} = \left[\frac{1}{4}\pi A+\alpha\left(1-\frac{\alpha}{2\pi}\right)\right]\alpha^2$$

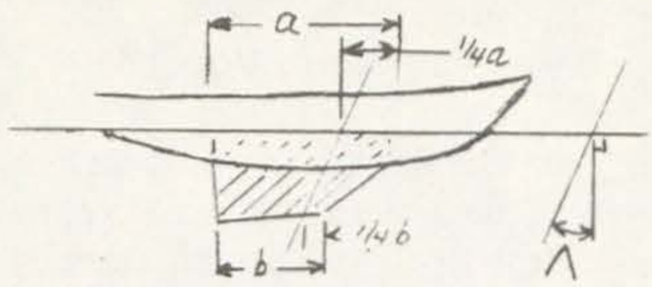
Comparison of the above equations with experimental data from the book Hydrodynamic Drag by Hoerner shows good agreement between experimental and calculated values of C_{Di} for zero sweep angle.

The above equations take into account the vortex sheet shed from the "wing tip," i.e. the bottom of the keel, as well as that from the "trailing edge," i.e. the back of the keel, which is all that is taken into account by "lifting line," airplane wing theory.

For sails, AR = Luff^2/Area where the area is that of the non-overlapping portion. Depending on the sails, the maximum lift coefficient would probably be in the range: $0.6 < C_L < 1.2$, where the lower limit would be for average mainsails alone, and the upper would be for the best sloop rig with everything just right - sheeting, overlap, luff tension, etc.

The two sets of equations give the same values at AR = 2. Then in the approximate value for the AR at which the downwash angle at the trailing edge, as computed by the lifting line theory, would be tangent to the surface, if one existed in the lifting line theory. At any lower AR the flow would have to be through the surface of the back part for the usual theory to give a result.

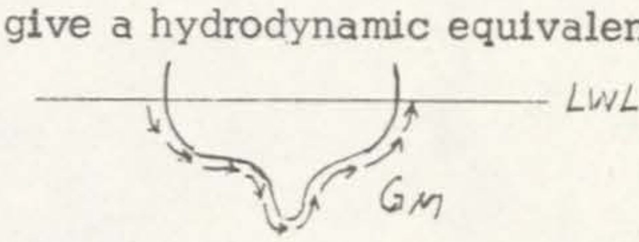
The sweep angle Λ should be measured to the "center of gravity" of the bound vortex system. For high AR, symmetrical airfoil wing thickness (?) would be one-quarter of the way back. Camber moves the vortex CG further back. For the lower AR's, where the lift from that part of the bound vortex system which is shed at the wing tip is large, the CG of the bound Vortex system will be somewhat further back. I suggest measuring the sweep angle, Λ, as sketched below:



I am confident that these equations will give an accurate value for the ratio of the "induced drag" to the "lift". However, the calculated values of the "angle of attack": α, are not to be taken too literally, since the slope of the lift curve for a hull-keel combination is greatly dependent on local flow separation, surface roughness and other variables. Actually, the α values are just parameters and it is only the ratio of C_{Di} to C_L that has any effect on the boat's performance, and the leeway angle at which this occurs is immaterial - except insofar as it might have an effect on the trimming of the sails. The above statement assumes sufficient lateral area so no large flow separation occurs - i.e. enough "S" so $C_L = 0.6$ or so for slab-sided surfaces.

C. Skin Friction Resistance.

1. Compute average streamline length to give a hydrodynamic equivalent to waterline length: $L = S_W/G_m$,
where: S_W = wetted area;
G_m = girth/perimeter maximum section underwater.



2. Compute average Reynolds Number: $R_n = VL/\gamma$
where: V = velocity in feet/second (1.69 ft/sec = 1 knot);
γ = kinematic viscosity = 1.25×10^{-5} for sea water (57.5°F.). γ changes rather rapidly with temperature. At 86°F, it is 0.86×10^{-5}, some 31% lower.

3. Compute average turbulent skin friction drag coefficients:
$$C_f = 0.472/(\log R_n)^{2.58}$$

4. Compute the hull skin friction drag coefficient:
$$C_{fh} = (C_f + 0.0005)\left[1 + 1.5\left(\frac{d}{L}\right)^{.5} + 7\left(\frac{d}{L}\right)^{3}\right]$$

where: $d = 1/2(D + B)$; D = draft; B = maximum beam waterline.

The 0.0005 is to allow for the fact that the best boat finishes are really not as smooth as the theory would assume. The first d/L factor is an approximate correction for the over-velocity at the surface arising from the displacement. The second d/L factor makes an allowance for the inevitable flow separations near the stern. There is no allowance for wave effects which could be quite large on a shoal draft hull.

Then the skin resistance of the hull is:

$R_f = 1/2\rho S_w V^2 C_f$ where V is velocity in feet per second.

The drag of rudders, centerboards and other projections should be calculated separately and added to R_f, since the Reynold's Numbers for these surfaces are so low that their C_f's are likely to be around 3 or 4 times that for the hull.

The above equations will be somewhat conservative for a really well-designed and constructed hull shape, since they assume no laminar flow at all, and there will always be some at the forward end of the hull. Thus the equations probably allow for the effects of small waves when applied to a very good design.

If one has gaps or slots - such as between the forward end of the rudder and the aft edge of the keel - there will be a pair of standing vortices at these locations, and their drag is quite high:

Drag = 1/3 (depth) (length) (width) $(1/2\rho V^2)$ for each side which is about the value of two similar projections.

In the old days in the airplane literature, one saw many references to a drag called "form drag," referring to a drag one obtained by integrating (adding up) the pressures over the body - and one still sees this in the boat literature. This is essentially zero for good shapes with no major flow separations.

Sincerely, Walter Castles

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THE ARTICULATED, BALLASTED TRIMARAN. By Harry B. Stover, Rt. 2, Box 434A, Lancaster, Va. 22503.

Figures 1, 2, and 3 show a thirty inch breadboard model of a proposed 15'0" articulated, ballasted trimaran which I hope is a new type. The AB trimaran has some unusual features and possible advantages which might be worth investigating.

Figure 1 - Sailing Normally

Figure 2 - Windward float out of the water

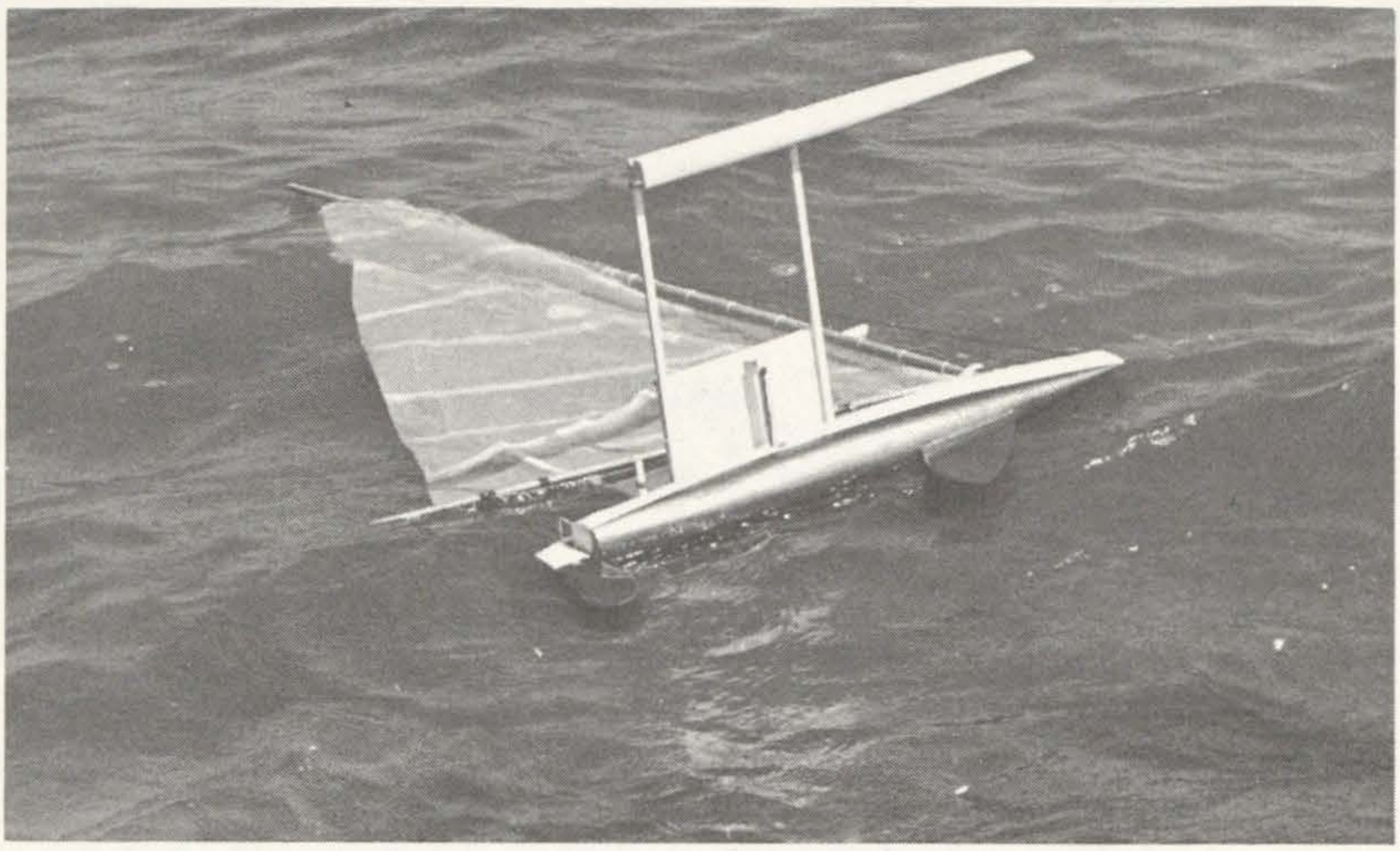

Figure 3 - Knockdown

The floats have ballast tanks above the waterline and the tank in the windward float is filled with ballast water as needed. The boat speed is sufficient to put water into the tank by dynamic head against a retractable scoop. Upon changing tacks the water is dumped from one tank and the other tank is filled. The wing structure is hinged and spring loaded in such a way that the leeward float can never be submerged even though its design displacement is only about 170 pounds for the 15'0" boat. In the event of a knockdown, the leeward float stays on the surface and the mast lies across the float. Figure 3 shows the model in the knockdown condition. The tip of the float can be seen protruding forward of the mast. This feature prevents the 180 degree capsize. As soon as the knockdown force is reduced the spring loaded feature in the wing structure causes the boat to return to the upright position.

If the boat should capsize through 180 degrees by pitchpoling, the boat can still be righted by winching down both floats. All that is required is that the shrouds attach to winches which can be cranked from underneath and also that the floats be small enough to be submerged without lifting the center hull out of water. When the floats are submerged sufficiently the craft flops from the 180 degree capsize to the 90 degree capsize position. From the 90 degree capsize position the craft, due to the spring loaded feature, comes upright as winch tension in the shrouds is relaxed.

From hydraulics, we have the expression:

$$h = \frac{V^2}{2g}$$

for h = head in feet; V = velocity in feet per second; and g = acceleration of gravity.

which tells us how high a scoop pushes water. Calculation indicates that various speeds raise water as follows:

Speed - miles per hour	4	6	8	10	12
Height raised - feet	0.5	1.2	2.1	3.3	4.8

Lead weights were used to simulate water ballast on the model but the above indicates that any speed above about 6 miles per hour can be counted on to put water in a tank above the waterline. The tension in the spring loaded hinge feature is sufficient to provide stability up to, say, 6 miles per hour, at which point the ballast water comes aboard and provides stability for additional speed.

In light winds, and at low speeds, it is not necessary to add ballast water.

The model uses rubber bands to supply the force for spring loading. The bands go from side to side underneath a crossmember and through the boat. Some indication of this can be seen in Figure 3. If I were to build the 15' boat I believe I would continue to use rubber, similar to shock cord but actually cut from inner tubes. On a larger craft I think I would use an hydraulic system with an accumulator.

There is another mode in which the AB type can be sailed which is equivalent to a flying proa.

The winches attached to the shrouds can each be fitted with a controllable ratchet and a low capacity take-up feature. For example, the take-up feature might consist of twisted rubber strands attached to the winch crank gear shaft in the same way that rubber model airplanes are set up.

In operation, the craft is allowed to heel as shown by Figure 2. The leeward winch automatically takes up the slack in the leeward shroud and the ratchet holds this slack. Ballast water is then put into the windward float tank and this lifts the leeward float out of the water. The spring loaded feature is still available to prevent capsize in case of a knockdown. If the helmsman is skillful enough he can sail the AB trimaran in this mode with floats clear of the water.

There is one final possibility related to the AB type. One of the problems connected with multihulls stems from their great beam and the cost of berthing such craft in ordinary marina slips. It is conceivable that one could have a low cost, fairly narrow, two hulled auxiliary float which would stabilize the craft when the wing structure is raised. This would permit the AB type to moor in an ordinary slip. In practice, the AB trimaran, together with its auxiliary float, would leave the slip and the auxiliary float would be anchored. The wings of the trimaran would then be lowered and the trimaran would sail away. Upon completion of the sail the process would be reversed to return the trimaran to its slip.

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PARALLELISM OF OUTRIGGER FLOATS. By Edwin Doran, Jr.; 1114 Langford, College Station, Texas 77840.

Introduction.

Modern trimarans have floats whose long axis parallels that of the main hull, whereas a decade or so ago it was considered that floats should be toed in a bit. There is evidence to indicate that a heretofore ignored possibility, toeing floats out a bit, will improve trimaran sailing performance.

Historical Development.

During the first decade of existence of the AYRS half a dozen references on this point indicated that floats should be toed in slightly in order to give a bit of lift to windward as the lee float buried deeper into the water. No written mention of the matter in the years since 1967 has come to my attention, but all trimaran plans of the last decade which I have seen show float axes parallel to the main hull axis. Presumably toe-in was found to be inefficient and simply abandoned.

Having been aware of the toe-in hypothesis for more than ten years I was much surprised during field work in 1970 to discover that all double outrigger canoes seen in the Phillippines, and especially in Sulu, have floats which are toed out. Careful measurements on four different boat types indicate toe-out of 1, 1.5, 1.5, and 3.5 degrees respectively. It began to look as though native designers and users of double outrigger canoes discovered something long ago which modern trimaran builders have missed.

For comparison a careful check was made through Haddon and Hornell's Canoes of Oceania to discover that essentially all single outrigger canoes in Polynesia, Micronesia, and Melanesia have floats parallel to the hull. The one exception is a small, paddling canoe of the Ellice Islands which has the float slightly toed in, presumably to counteract float drag and make paddling in a straight line easier. The reason for parallel floats on these canoes seems clear and will be discussed below.

The Experiment.

Although a rational explanation for toe-out of floats was hypothesized soon after noting their existence it seemed necessary as a first step in substantiation to demonstrate that toe-out was related to improved performance. For this and other reasons Moby Dick, a trimaran-cum-double outrigger canoe analogue, was designed, ultimately built, and its performance measured. In order to construct the boat as cheaply and as quickly as possible, and because no long-term use was envisioned, no effort was expended on aesthetic considerations. In short Moby is not a particularly handsome boat.

The drawing and photograph (Figs. 1 and 2) illustrate the boat's principal characteristics. In essence the main hull is an aluminum U-shape, foam-filled, 18 inches wide by 20 inches deep, with the waterline at nine inches giving a semicircular underwater shape. The length overall is 28 feet; waterline length is 27.5 feet. The bow is roughly faired for four feet, but the stern is a flat transom, inclined slightly forward. Under sail there is laminar flow around the bow knuckle, but the turbulence and drag around the after end are notably high. (See Figure 2 on Page 2.)

The floats, which extend 12 feet to each side by means of 3" x 1/4" aluminum tubes, are also of a U-shape, are 12 inches in each dimension, are 20 feet long, and are nicely faired on both ends. A T-shaped spine was constructed of quarter-inch plywood, sprayed with polyurethane foam, faired, then covered with fiberglass and polyester resin to produce floats weighting about 100 pounds each. The floats may be adjusted vertically, horizontally, and with varying angles of axis to that of the main hull.

The sail rig is that of a standard Venture 22. Actual measured areas are 120 sq. ft. for the mainsail, 84 sq. ft. for a small Genoa, and a total of 204 square feet. Total weight of boat plus crew of three is estimated rather carefully at 1800 pounds. The Bruce number, $\sqrt{SA}/\sqrt[3]{Wt}$, is thus 1.17, and the boat is appreciably underpowered and overweighted. On the day of strongest winds in which the boat has been sailed, apparent wind speeds to 27 knots when close-hauled, the lee float still lacked two or three inches of being submerged. Chain plate and outrigger beam stresses were the only factors giving concern under these conditions.

To maintain shallow-water and beaching capability the rudder is designed to kick-up. It is of fairly high aspect ratio, with 2.5 square feet submerged lateral plane. When first launched the boat made an incredible amount of leeway and would not go to windward at all. A leeboard was added, 8 square feet of submerged lateral plane, which permits windward sailing of reasonable efficiency.

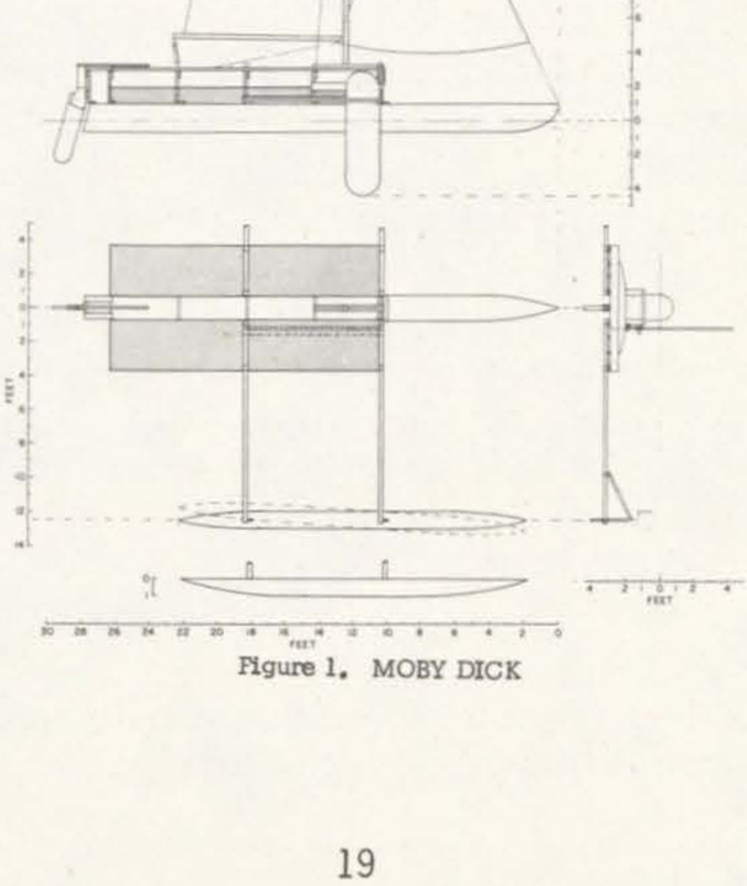


Figure 1. MOBY DICK

Measuring instruments are similar to those used by Bruce and described in these pages before. A Simerl anemometer and boat speed meter, plus a windvane read mechanically on a calibrated drum, plus an inefficient leeway measuring device were used for most measurements. A Dwyer plastic anemometer of pitot type, calibrated against an accurate Simerl anemometer, was used on one occasion when the other instrument failed. Boat speed, apparent wind speed, angle of apparent wind to heading, and leeway were measured while underway, then V_T, V_S, and γ calculated from the field data.

Over a period of more than a year, utilizing a variety of pick-up crews of greater or less skill, a series of measurements were taken. Crew weight was maintained at about 500 pounds in each test, and all other variables held as constant as possible. The three categories of tests were with float parallel to the main hull and with the toed-in, then toed out, at angles of four degrees to the main hull.

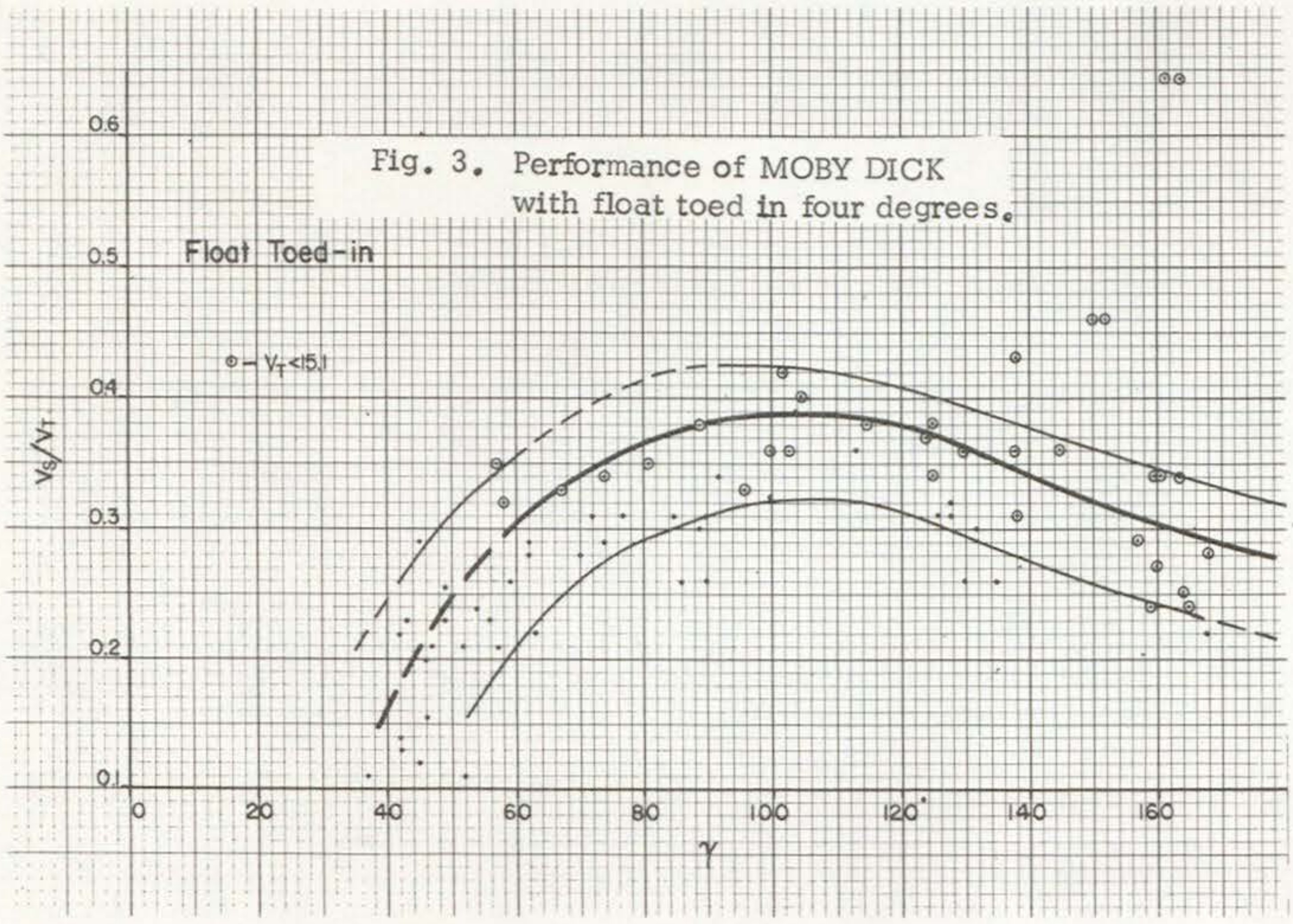


Fig. 3. Performance of MOBY DICK with float toed in four degrees.

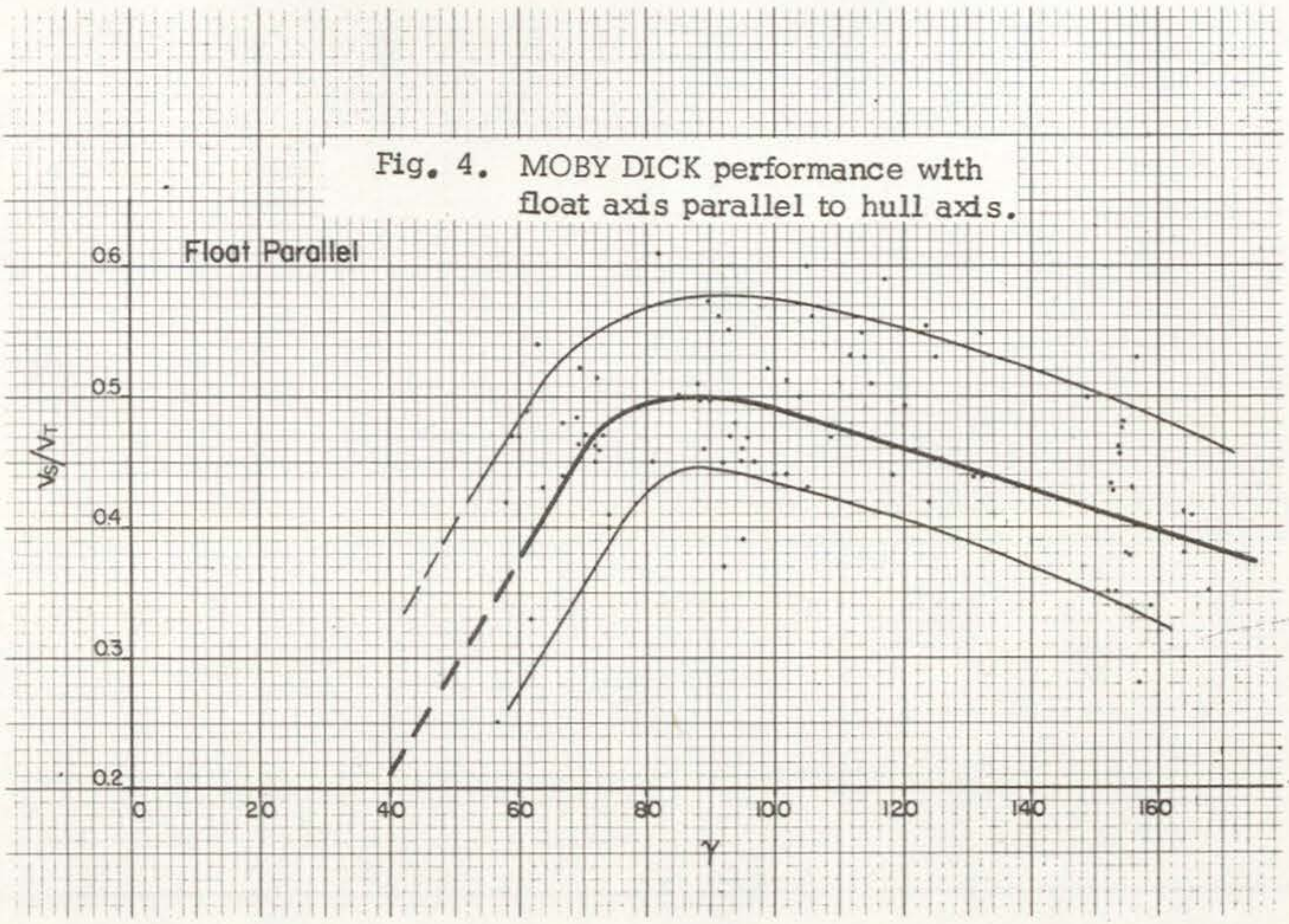


Fig. 4. MOBY DICK performance with float axis parallel to hull axis.

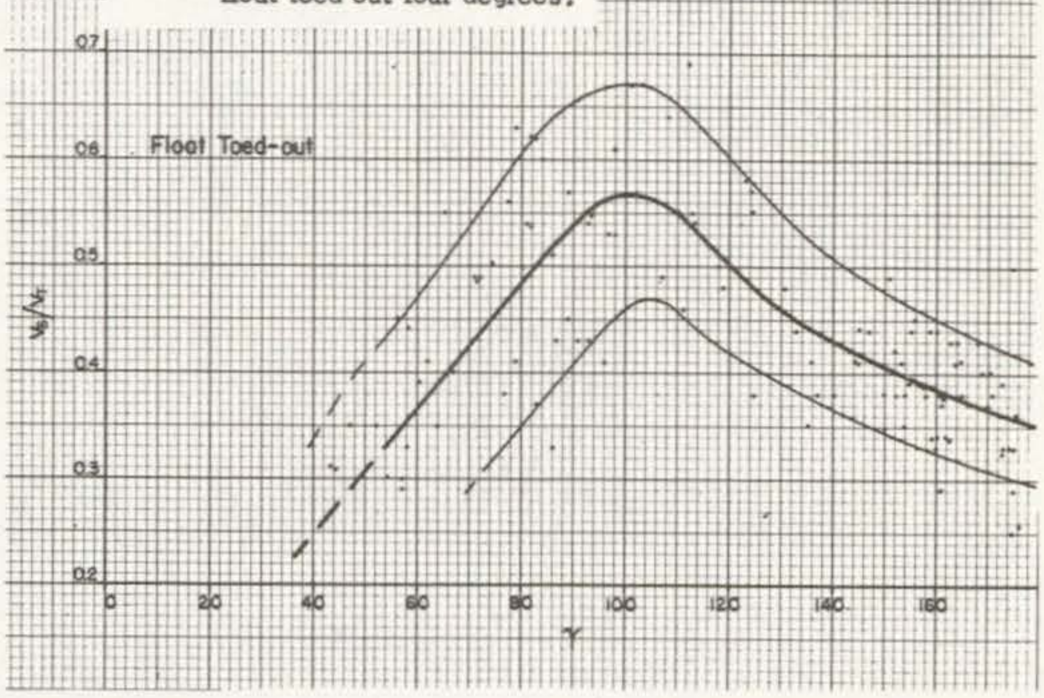
The Results.

Figures 3, 4, and 5 indicate the results (on rectangular graph paper, V_S/V_T plotted against gamma) for the three positions. These three graphs are purposely included here to allow readers to make their own judgments as to the reasonableness of the deductions. The distressing scatter of points arises from several factors: rather poor instrumentation, lack of skill in untrained observers who were inaccurate in mentally averaging quickly swinging needles on dials, a series of trials extending over a full year, and an inland lake site in which wind direction and speed change rapidly. The data of Figure 3, in particular, were taken on a day in which wind speeds (V_T) varied between 7 and 24 knots, much of the time in the higher ranges. For this reason, and because it is well known that V_S/V_T is no longer a straight-line relationship above about fifteen knots of wind speed, the lower wind speeds were emphasized in drawing the performance curve.

On each figure a curve which approximates one standard deviation is drawn above and below the performance curve. Because the performance curves vary in position, in the critical area around gamma 90-110, by at least one standard deviation it is felt that these curves, despite the obvious inaccuracies of the experiment do indeed represent a real difference in boat performance with the several float configurations. Hopefully others will test similar configurations and either confirm or dispute my interpretations.

Finally, Figure 6 is a polar graph of the three performance curves which illustrates the notable increase in performance of the toed-out configuration on a broad reach and the much better performance of both toed-out and parallel configurations over the one which is toed in.

Fig. 5. MOBY DICK performance with float toed out four degrees.



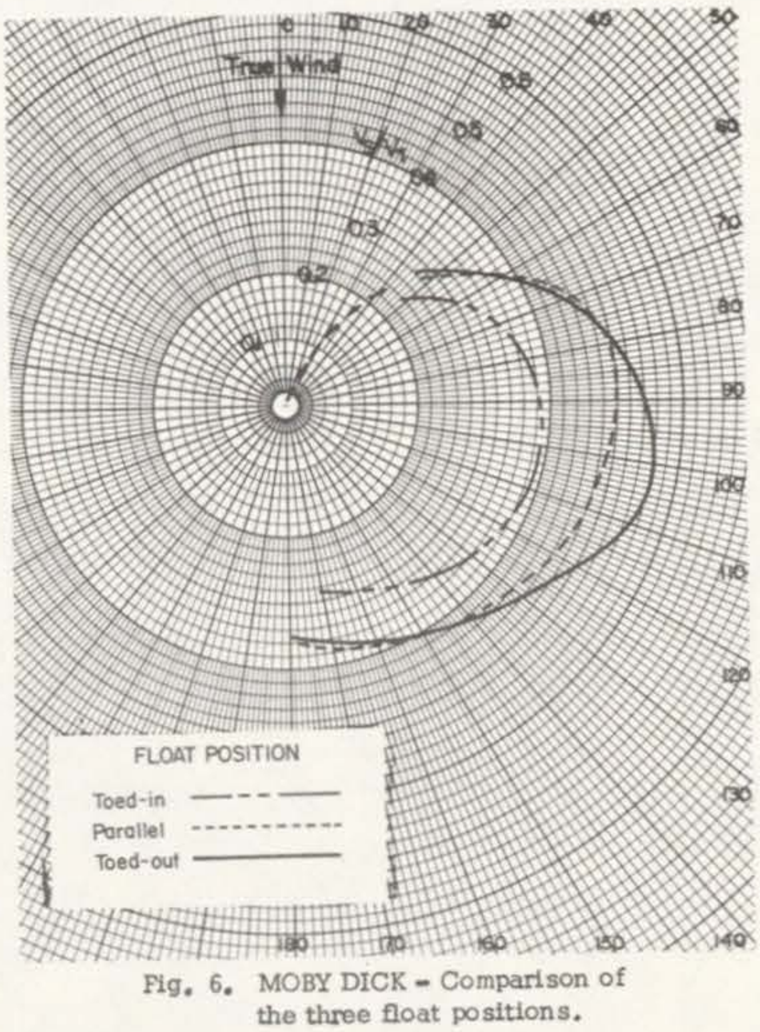


Fig. 6. MOBY DICK - Comparison of the three float positions.

An Explanation.

It was apparent in making sailing measurements on double outrigger canoes in the Philippines that they made distressing amounts of leeway, up to 10 or 12 degrees when close-hauled. It soon occurred to me that toe-out of floats was an empirical recognition of the excess drag caused by both the main hull and leeward float making sizable leeway. With the float toed out the water flow came much closer to paralleling the float, hence should cause lowered drag.

In the case of Moby Dick the leeway at gammas of 90 to 110 is on the order of five degrees. This being the case the float should make good a course only about a degree off its longitudinal axis when toed out at 4 degrees. Such a course should reduce the drag by an appreciable amount, and observation while sailing bears this out. The float slides through the water with almost no wave-making and with a hardly perceptible wake.

When close-hauled Moby makes 6-8 degrees of leeway and the toe-out effect, although probably advantageous, is masked by the excessive leeway. The advantage of toe-out is lost when running and some slight decrease in performance seems to occur here, but it lies well within probable errors of measurement.

Parallel floats on all single outrigger canoes of Polynesia, Micronesia, and Melanesia are rational in view of the sailing techniques used. Polynesian canoes are tacked head to wind and an advantage on one tack would become a disadvantage on the other. Micronesian and Melanesian single outriggers are shunted to maintain the float always to windward. Again, as bow and stern alternate and the boat goes in opposite directions any toe-out in one direction would become toe-in, hence inefficient, in the other direction.

In sum, toe-out of floats on Indonesian double-outriggers seems to be based on empirical recognition of greater efficiency. It appears that modern trimarans also would benefit from toeing out their floats at an angle which approximates the leeway angle on a beam reach.

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MATERIALS AND BOATBUILDING

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The WEST System - Building GOLDEN DAZY. By Meade Gougeon, Gougeon Brothers, 706 Martin Street, Bay City, Michigan 48706. USA.

For this article, I thought it might be interesting to follow the construction of an actual yacht hull where the WEST system was used. GOLDEN DAZY is a keel yacht designed to compete in the two ton racing class. She was the winner of the Canada's Cup Races in late 1975. I know that many of the people in AYRS are multihull devotees, but in fact we have a lot of keel boat people too. I think the multi-sailors can learn from keel boat construction. The techniques are unique being a combination of strip planking and cold-moulded/multiple diagonal wood and using the Wood Epoxy Saturation Technique (WEST), developed by our firm.

GOLDEN DAZY - Particulars:

Designer: Ron Holland, Ireland. Sail Maker: North Sails Midwest. Rigging: Bergstrom & Ridder, Sweden. Builder: Gougeon Brothers. Loa: 41'6" (12.6 m). LWL: 34' (10.4 m). Beam: 12'4" (3.8 m). Draft: 7' (2.1 m). Sail Area (A_s): 1050 sq. ft. (97.5 sq. m) for 100% fore-triangle. Displacement: W = 17,800 lbs (8 tons/8074 kg). Ballast: 9400 lbs (53%) (4264 kg). Prismatic Coefficient: $C_p = 0.64$. Engine: Volvo MD-21A - 61 hp max. Bruce No.: Br = 1.24 (min.) ($Br = A_s^{1/2} / W^{1/3}$) ($Ft/lbs^{1/3}$) Displacement-Length Ratio: DLR = 202. ($\Delta/(.01LWL)^3$ (tons/ft^3).

GOLDEN DAZY had the stiffest, strongest hull of any of the Canada's Cup contenders. Two of the boats in this series were built by Hook out of Marblehead, and in these hulls they used some of the most sophisticated modern materials available. This included total Airex (r) coring, and one hull used \$20,000 (£ 10,000) of Kevlar as a covering material - both uni-directional and cloth. This hull was rumored to have cost well over \$100,000 (£ 50,000) - very expensive construction: LEADING EDGE owned by Eugene Mandry. Another yacht built in the same manner was NIKE owned by Mr. Timken. While these boats were stiff and rigid and did well, they were certainly not as rigid as the wooden boat was.

Two other boats that were almost as successful as GOLDEN DAZY and which gave her tough competition had aluminum hulls. Other than wood, aluminum is probably my favorite engineering material. Both of these boats were built by top-notch firms: RICOCHET by Palmer Johnson, and AGGRESSIVE by Spar Craft of Costa Mesa, California. They did beautiful work in putting together extremely light hulls.

Thus, the Canada's Cup Races provided an opportunity to compare several boatbuilding materials and methods: wood/epoxy, Airex/Fiberglass, Airex/Kevlar and aluminum. The biggest race-winning factor is headstay tension, so what we were concerned with was building GOLDEN DAZY to have a very high stiffness to weight ratio. It may surprise some to see wood come out so well in comparison. All of the boats were built to be strong enough - what we were really trying to do was to maintain dimensional stability. GOLDEN DAZY was able to pull 9,000 lbs (4082 kg) on backstay to keep the forestay extremely rigid. In the heavier winds, forestay sag is a real problem in maintaining draft control. In the very powerful, modern IOR racers with tall rigs and heavy, deep keels, the loads are so immense that physical deformation of the hull is extremely critical. Any deformation at all makes the rigging distort, and the boat suffers in the speed department - not a great deal, but five or ten percent, which is a good distance in a sailboat race. GOLDEN DAZY carried her sail rig on a 58 ft. (17.7 m) mast with over 4 long tons (4264 kg) of ballast down to a draft of 7 feet (2.1 m).

CONSTRUCTION TECHNIQUE.

The first picture, Fig. 1 (below), shows the basic hull of GOLDEN DAZY with 1 1/4" (32 mm) wide by 5/8" (16 mm) thick Western Red Cedar strip planks as the first layer.

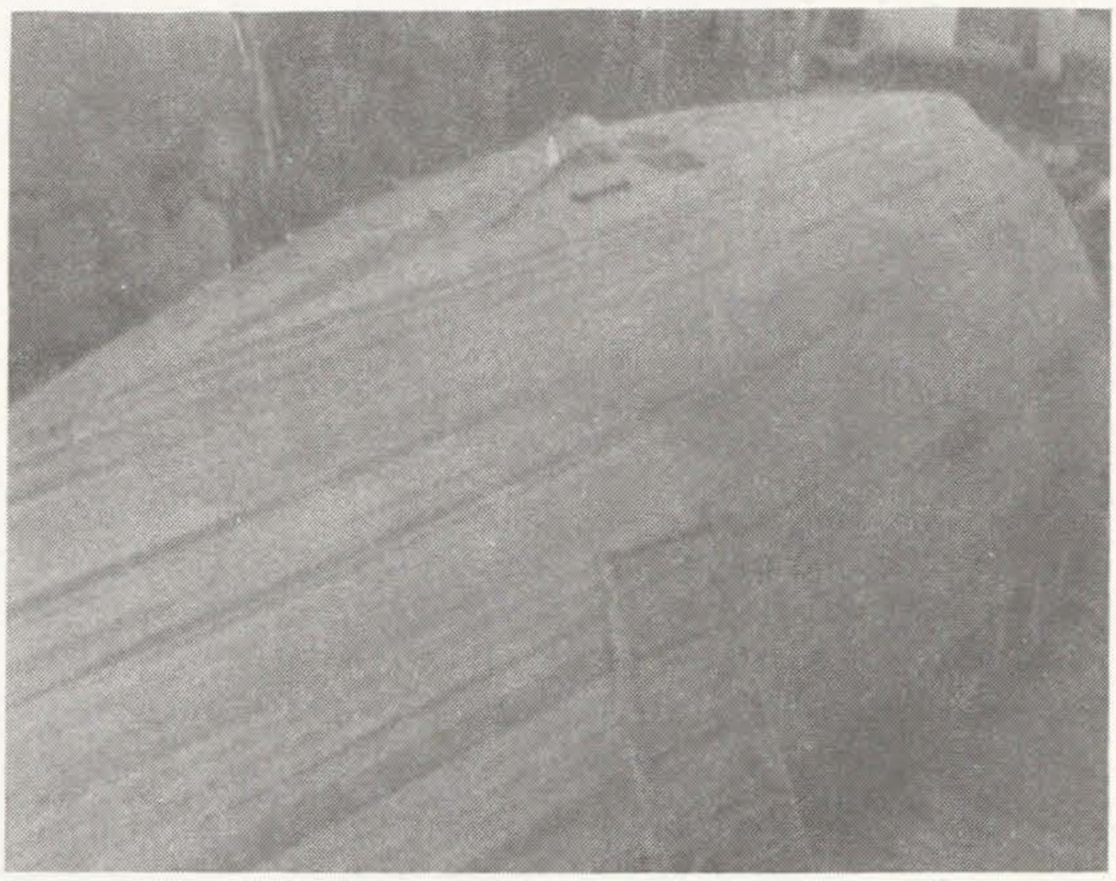
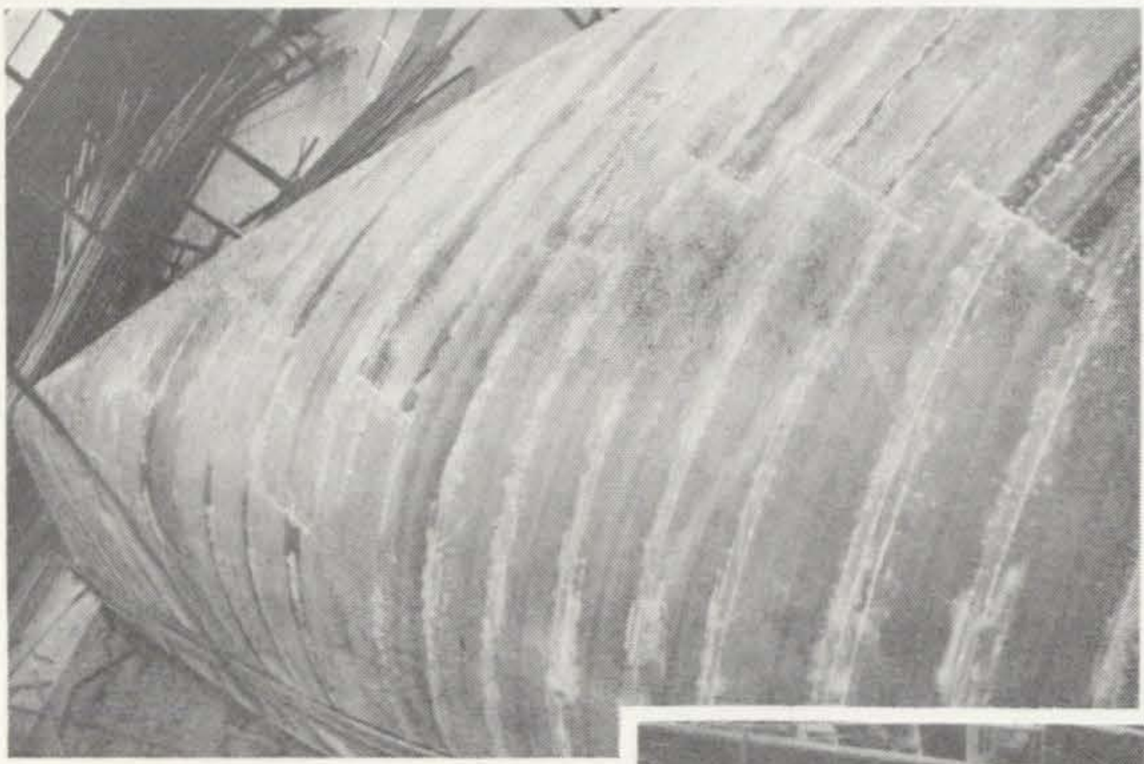


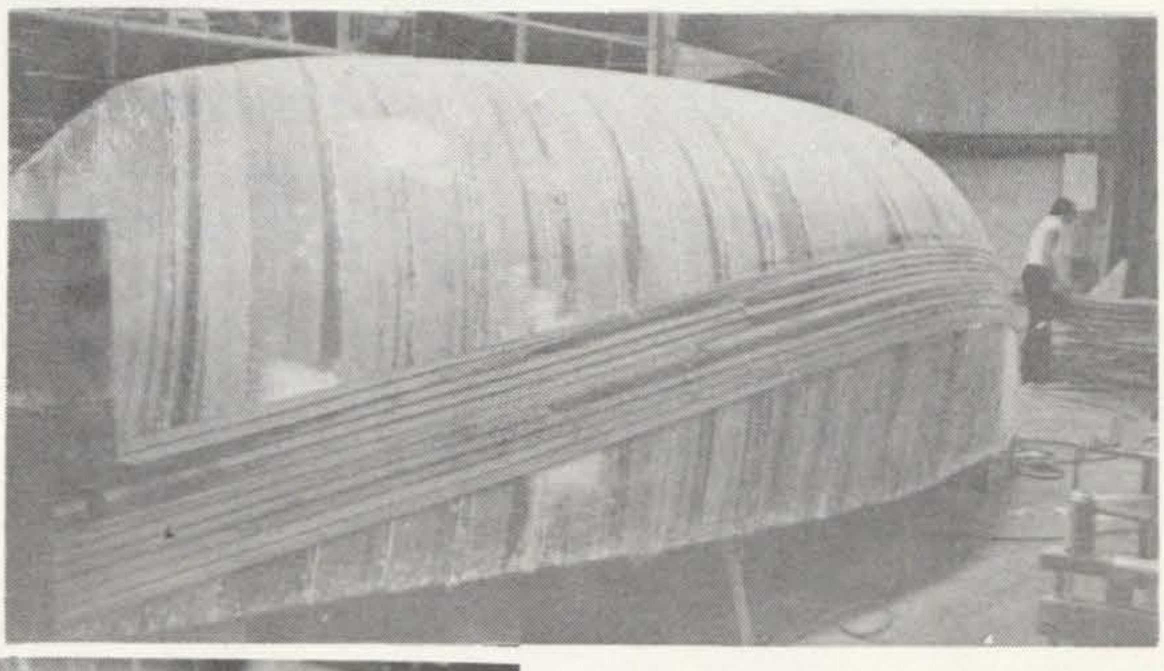
Fig. 1

Fabricated in advance were the main bulkheads, frames laminated from 1/4" (6 mm) Honduras mahogany strips, and temporary, dummy frames or bulkheads of chip board. The strip planking was held to the latter by temporarily screwing each strip to the dummy bulkhead to hold it in place until the glue between the planks dried. This hull was planked up very fast at about 30 to 35 planks per day. It is important to emphasize that the builder start at one point with each plank and work both ways to avoid tapering. This reduces the time required by one-third or so. The glue used for the strips was a combination of epoxy resin and microballoons equal to the grain strength of the cedar. The planks are permanently screwed to the main bulkheads - one of the few places where conventional fasteners were used. None of the planks need to be beveled - the gap filling epoxy mixture takes up the difference in bevels. A crew of four men planked this boat up in about eight days, and this could probably now be improved since we've had experience. To hold the strip planks between frames and main and dummy bulkheads, we drilled 1/8" (3 mm) holes down through the adjacent plank and inserted glued dowels. Fig. 1 shows the hull all glued up, and we're starting to fair and smooth it with planes in preparation for veneering which does not take long.

The veneering is really the easy part, because after coating with epoxy, we can staple each layer of 1/8" (3 mm) veneer right on to the 5/8" (16 mm) strip planking which acts as our mould in double-diagonal fashion - about 40-45 degrees from the perpendicular. We use four Duofast staplers in our shop. The basic machine is one which will drive broadback staples from 1/4" (6 mm) to 9/16" (14 mm) long. We have two thin wire staplers which when used for interior joinery assembly are hardly visible. We also use a large nailer which drives up to 2 1/2" (64 mm) nails for jigs etc. and some hand staple guns for pattern and fixture assemblies. Staples add a good bit of strength to the boat and have about the same holding power as nails but are finer and do not split or deform the wood. We use steel staples for the internal layers. When sealed in epoxy, there is no rust problem. On the outside layer, aluminum staples are fastened as they can be filed and sanded down if necessary when finishing the hull for epoxy coating.

Figs. 2, 3 and 4 (Below) show the veneering process. Per Fig. 2, wherever possible, we carry the veneer plank past the bottom centerline so there is not a single line going down the middle of the boat that could be a potential break point or fracture joint. The hull becomes a true monocoque as there is no single point of maximum stress. The second layer goes on in much the same way and butts on to planks from the other side in a jagged pattern. Filling compound is visible where there were depressions and defects, so that a thin glue line may be maintained between layers.





Lamination is a simple but important job, and it can be done quite fast. If you look closely at Fig. 2, you will see some two inch (5.1 cm) wide veneers between each plank as filler strips. The hull planks are stapled and glued fairly close to each other and then a two inch swath is cut from a plank already in place on the hull. To avoid scribing the veneers and beveling by hand, a special tool was developed. This is an electric-motor-driven 1 1/2" (38 mm) circular saw with a bent, springy guide to adjust to hull contour. The guide bears against the adjacent plank. A router with guide bushings could be used as well. This is a very fast technique. We simply pre-cut two inch veneers which fit the space and which are glued and stapled down. Instead of having to fit each veneer to the next by tedious and laborious conventional methods, we use this tool that does it in a matter of seconds. Veneering up a hull is a pretty fast task for us. When I talk to some people, they think it is very time-consuming, and maybe it is when you first set out to do this. Our experience is that four people can put on one layer per day on this 41' 6" (12.6 m) hull, so that means with four layers we have 16 man-days tied up.

The last layer on this hull was done longitudinally as shown in Fig. 5 (below) for reasons of beauty as well as to allow the longitudinal wood grain to help the deck take compression loads. The bottom part of the boat is chiefly a tension member because of the keel. Epoxy saturation - three coats of epoxy resin - has been completed in Fig. 5. As the hull was turned upright, it was completely wet-sanded and then block-sanded down to 300 grit. It was then finished with a really excellent varnish with ultra-violet filter. GOLDEN DAZY has the outstanding appearance of a varnished wooden hull without the maintenance usually necessary. She should receive one coat of varnish each year, and it will not be necessary to wood her down for six years. We use 10-15 Captain's Varnish as manufactured by the Z-Spar people - Andrew Brown Company.

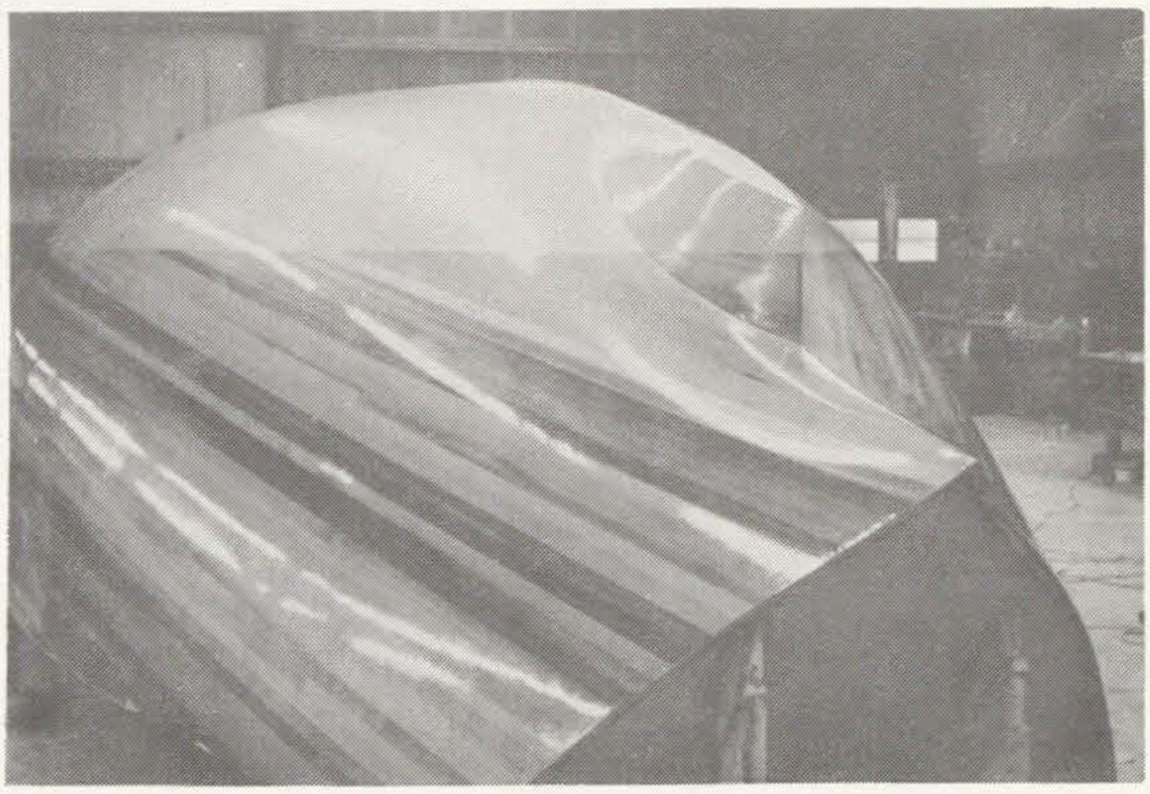


Fig. 5

Although most staples are left in the hull, we have worked out a method to remove them quickly. We just staple through 40 mil polyethylene sheet. An edge of the sheet can be grabbed and the staples removed quickly. For the final layer, we staple through scrap veneer strips into the outside layer. When we pull them, the only damage done is to the scrap strip - not the hull. When the hull is cleaned off, there are no dents and gouges, and the staple holes are barely visible. We then use an old cabinet maker's trick and wet out the last layer of cedar with water - the wood expands and the holes close. We let the hull sit for some weeks to dry out thoroughly and then apply the epoxy coatings.

Some have complained of the difficulty in sanding epoxy-coated surfaces, and perhaps some epoxies are more difficult than others. The type we market is relatively easy to sand. We cure a coated surface for three days in our well-heated shop before sanding and have found that washing the surface first with water and a rough towel often helps. The fastest method is with a foam pad on a disc sander. We also use Rockwell 205 vibrator sanders at 10,000 RPM. The best technique we have found is to use air-operated wet sanding machines with 220 grit paper and 3/4" (19 mm) travel. They are incredibly fast and produce extremely smooth hull surfaces ready to paint. We use a belt sander only on bare wood to trim material.

INTERIOR.

In Fig. 6, (below), the hull is being rolled over, and it can be seen that all the bulkheads are already installed. The inside of the hull is also epoxy coated and varnished - very clean and beautiful. For a racing boat, she was outstandingly liveable. Figs. 7 and 8 (below) show the interior in the process of installation. All of the interior is designed to be structural. We first look at a bunk from the standpoint of being a good place to sleep, and then we consider it as being part of the structure and supporting a portion of the skin area. For example, in Fig. 7, one lower bunk runs from an aft bulkhead to another bulkhead which is further connected to a forward bulkhead by the galley area.

Fig. 6

Fig. 8

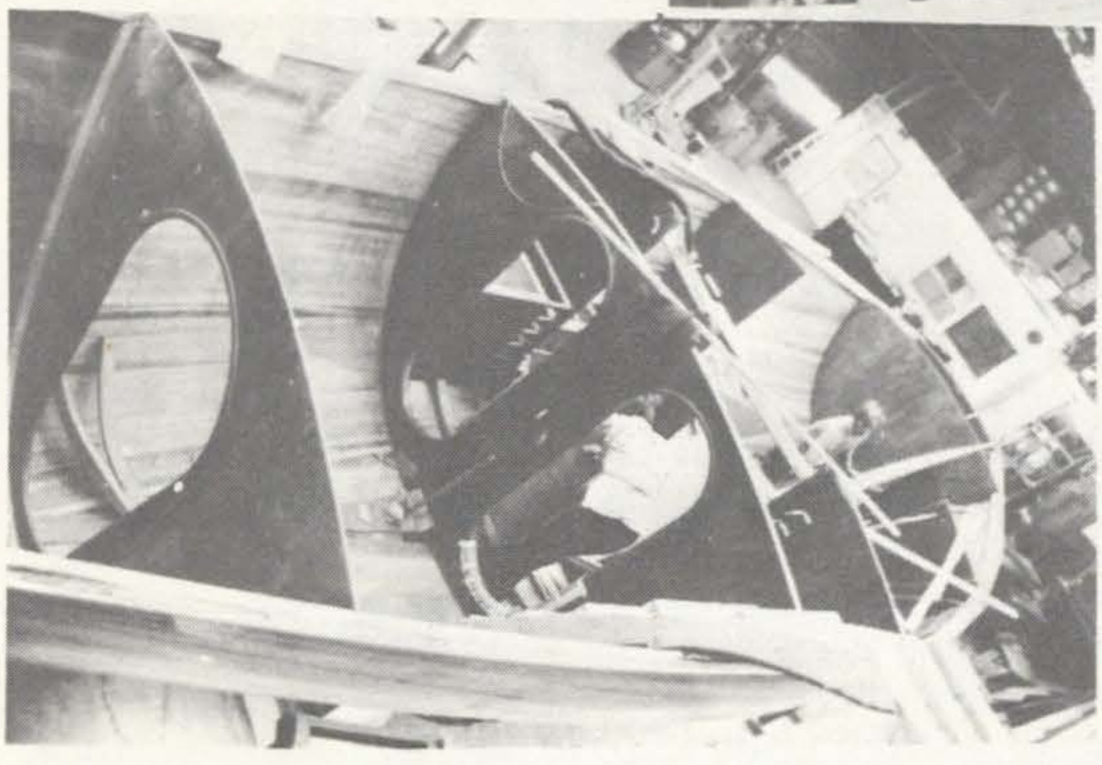


Fig. 7

Just about everything put inside the boat is pre-finished - sanded and coated with epoxy ready for final finishing. It is so much easier to do all of these bulkheads, bunk fronts, etc. out on the floor rather than having to finish them inside the hull.

VARNISHED HULL.

One of the big eye-catchers with GOLDEN DAZY is her total natural finish inside and outside. Varnish work outside is usually very difficult to keep up - two years at best and three years in our climate before replacement is necessary. With our method of using varnish over epoxy, we estimate that it will be six years before actual deterioration takes place. Both epoxy and polyester resins deteriorate at about the same rate in sunlight. Therefore, after putting on three coats of WEST epoxy, we apply two coats of the 10-15 Captain's Varnish.

When we talk about breakdown in a natural-finished wood, two things actually happen: one is that the wood cells change chemically and have a tendency to kick off the coating. Epoxy sticks longer than varnish to bare wood. The other factor is that the coating material, the varnish, loses weight. When 5 to 6% of the weight is lost due to ultra-violet attack, the coating begins to lose enough of its physical properties so that it starts to chalk and eventually flake off.

DECK.

Figs. 9 and 10 (below) show the longitudinal and thwartships members, the former used primarily for headstay tension, as they come in for considerable compression load. The crucial point here is that the deck must be totally load bearing to maintain the stiffness of the hull. Notice along the sheer/gunwale that we have a full four inches (10.2 cm) of gluing area to connect the sheer with the plywood deck, and the thwartships members are notched deeply into the sheer. This is a very important joint in our opinion. Gussets are used in some critical areas. We used a system of filleting inside the joint after the deck was on to increase the gluing area even further and to distribute the loads. The deck was laminated of two layers of 4 x 8 foot (1.2 x 2.4 m) 5 ply 1/4" (6 mm) marine mahogany plywood. We applied one layer with all butt joints on stringers so no seams showed below. The inside surface was precoated with epoxy and sanded for ease of later varnishing and appearance. Excess glue is carefully wiped from below as the sheets are applied. The second layer of plywood is glued with joints staggered and covered with two layers of epoxy resin. We see no need for tedious scarphing of these sheets as the deck is primarily a compression member, and the butt joints are carefully edge-glued.

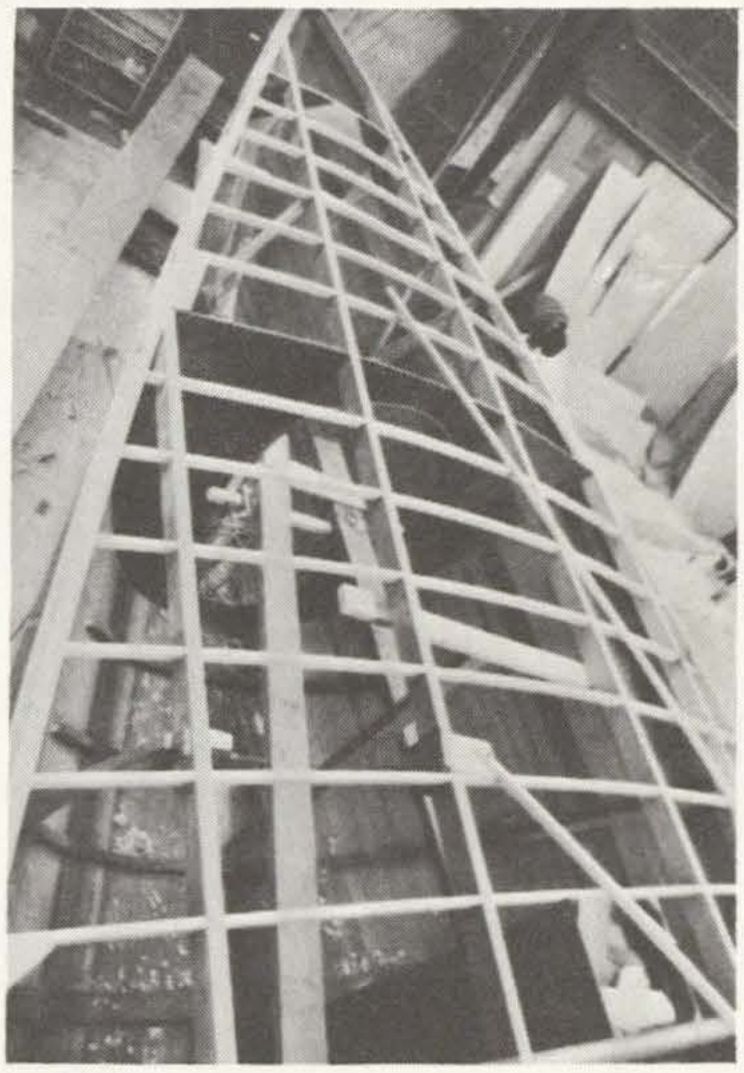


Fig. 9

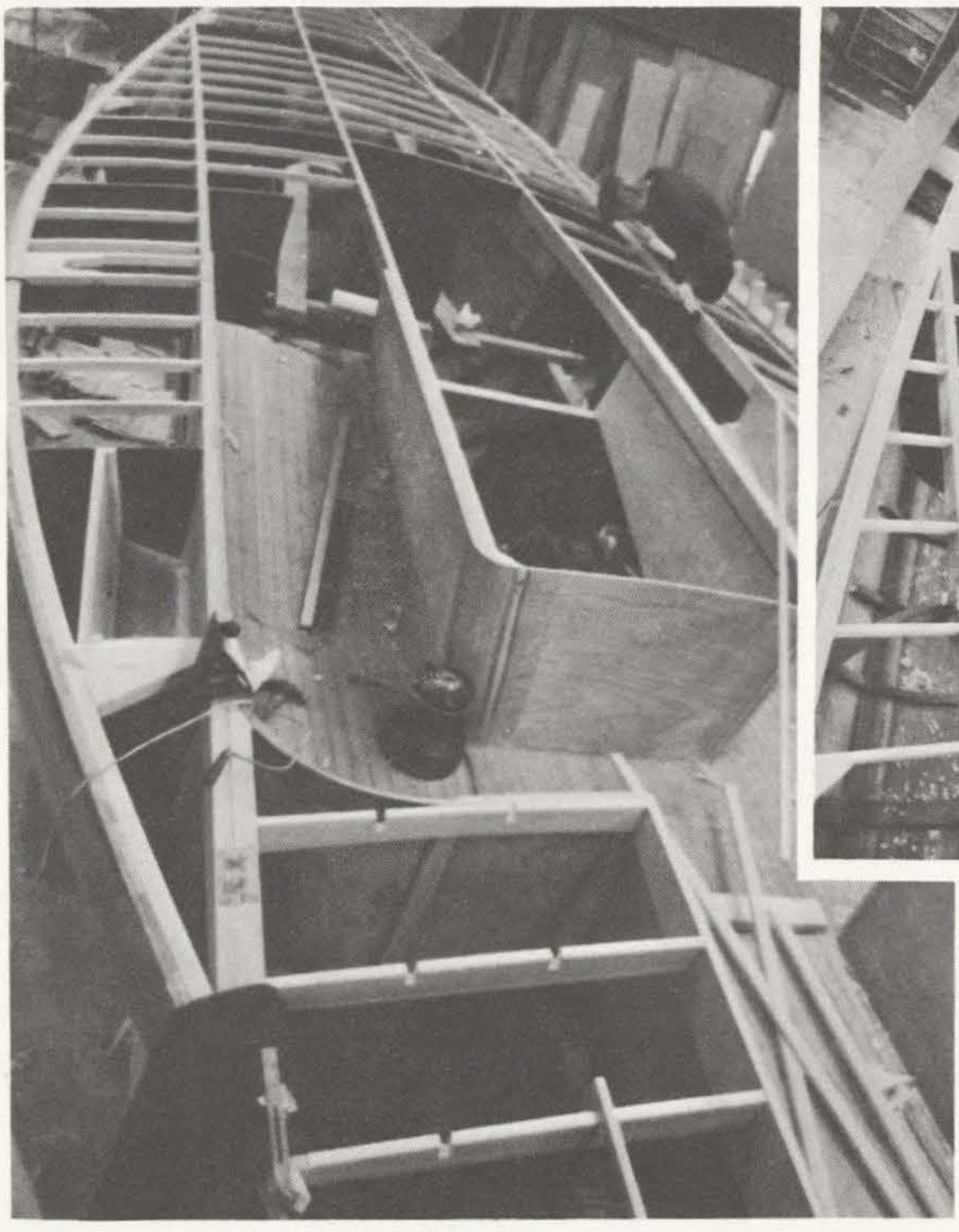


Fig. 10

We then glued and bronze-stapled 1/8" (3 mm) by approximately 1 3/4" (45 mm) teak planks and left the traditional gaps between the side edges. Instead of using the old thiokol compound, we filled these gaps with epoxy colored black with graphite to make a good sun screen. It really looked terrible! We thought we had made a big mistake. It was black all over with glue and staples sticking up, and it really looked bad. But, at this point, we got a floor sander, hoisted it up on deck and sanded the whole thing smooth easily. The result was one of the prettiest, maintenance-free and easiest to work on decks I have ever seen. We tested this deck lay-up for 18 months in our humidity chest before building GOLDEN DAZY and encountered no problems.

COCKPIT.

Fig. 10 (above) shows the slingshot cockpit in place. This Y-shaped cockpit with double hatches was conceived by the owner Dr. Gerald Murphy and proved very successful in racing conditions. It was a terrific construction problem, because it had to float in the middle of the boat but had to be made tough to be a really sound structural unit. The way we did it was to make the cockpit sole a two inch (51 mm) thick cored laminate. The core was a rigid Hexcell plastic like a honeycomb. The sole was laminated first on the floor of our shop with teak planks applied and sides joined.

ACCOMODATIONS.

GOLDEN DAZY has a double galley arrangement on each side of the boat built-in for structural reasons and six built-in berths. She was well-equipped with: electric range, oven and refrigeration; double sink; water tank; and plenty of cupboard space. This more than repaid the cost in weight because in racing there were always good things to eat down below, and this kept the crew morale up. The crew noticed two outstanding things about GOLDEN DAZY: natural insulation of wood and lack of internal framework clutter. She is a very quiet boat which facilitates sleeping and the general mental well-being of off-watch sailors. She is warm and shows a complete lack of condensation on the hull. This is important on the Great Lakes, because our waters rarely warm up above 50 degrees F (10 degrees C) and in the summer, air temperatures are between 70-80 degrees F (21-27 degrees C) during the day. This causes tremendous condensation on the insides of most hulls which makes for very damp boats. The multi-laminate system opens up a lot more hull volume for useable space and facilitates the practical matter of cleaning the boat.

WEIGHT, COST AND BOAT LUMBER.

The basic hull structure of GOLDEN DAZY weighed 4200 - 4300 lbs (1932 kg) including deck and hull prior to the installation of deck hardware. Approximately 800-850 lbs (375 kg) of this is WEST epoxy resin, so we're running roughtly 20% - 80% ratio of epoxy to wood which is a reasonable matrix. The wood and epoxy on this boat cost just a little over $5000 (£2440), and the total, final cost of GOLDEN DAZY in racing condition was $110,000 (£53,660). Labor cost was around $55,000 (£26,830). The remainder was spent on very expensive hardware, instruments, winches, rigging, hydraulics, sails, engine and the varied equipment and amenities of a high performance racer.

Note that total shell (hull + deck) materials cost was less than 5% of the total cost and 9% of the cost excluding labor. It seems to be a little-understood fact that hull materials cost is such a small fraction of the total. Thus, many base their decision of what kind of boat to build on hull materials cost, as those who choose ferro-cement without considering other factors. This is absurd and ridiculous. It just does not make sense to try to save a few dollars on a $100,000 boat by using cheap lumber or cheap anything. That is why the wood itself is a real bargain. You hear a lot of griping about the high cost of plywood and the high cost of good lumber, but in fact I can recall ten years ago paying $600 (£293) per thousand board feet for spruce, and we are now paying $900 (£439) per thousand. Everything else has doubled since then - cars, houses, groceries - so I think wood in today's market is one hell of a buy and to us it is an insignificant part of quoting a boat. We used to figure up to the last stick when estimating cost. We don't do that anymore. We figure on a per sq. ft. hull area basis in attacking the lumber costs. We could be off a few hundred dollars either way, but it is pretty hard to err a thousand dollars (£488) on a boat like this.

STRENGTH AND COMPARISON WITH OTHER MATERIALS.

I would like to point out that what is really unique about GOLDEN DAZY'S hull is that it is 1 1/8" (29 mm) thick, and what we have is a five-laminate hull with a weight of 2.31 lbs. per sq. ft. (11.3 kg per sq. m). The complete hull weighed only 1730 lbs (780 kg). Where we made out was that the hull was rigid because of its thickness, and we achieved this combination by using Western Red Cedar as our base material which has a weight between 22 and 24 lbs. per cu. ft. (0.37 gm per cc). The entire matrix using WEST epoxy has a density of 30 lbs. per cu. ft. (0.48 gm per cc). The significance of this can be emphasized by comparing with our competition.

Aluminum has a density of 270 lbs per cu. ft. (4.33 gm per cc), nine times that of the WEST matrix, so in effect we are about the same weight as a 1/8" (3 mm) aluminum skin. The aluminum is extremely strong and rigid, and we certainly are not any stronger than 1/8" (3 mm) aluminum. However, where we start to win out is where they need some support for that thin skin, because the skin is <u>not</u> self-supporting and will buckle under much lower compression loads. These frames and stringers and associated structures run the weight up considerably. Builders do go to a 3/32" (2 mm) plate and have some advantages, but basically they have very much difficulty in maintaining the stiffness we do in hulls under 40 ft. (12.2 m). Aluminum starts to shine in the 60 ft. (18.3 m) and up range where 3/16" (5 mm) plate is used. This plating is terrifically stiff, and the framework is pretty reasonable on a weight to size ratio. It is hard for me to compare at that size, because we just have not yet built that big a boat. Someday we will, and we will have these answers.

The fibreglass-polyester matrix runs from 100 to 110 lbs. per cu. ft. (1.68 gm per cc) - a bit over three times our density - which equates to only a 5/16" (8 mm) skin. Balsa and Airex cores are used to get around this problem to separate the skins, and an acceptable solution usually results. They try to achieve the same thing we can easily do - i.e. go to a thick hull to obtain tremendous panel stiffness. The problem is that they have to add a material in the middle that is non-structural. A core material is dead weight. All it does is act to separate two skin materials that are acting as the strength bearing members, whereas in our laminate, every piece of that hull is load bearing and doing work. This may be significant, say, in a balsa core boat where 200 - 300 lbs. (91 - 136 kg) of balsa is used that itself absorbs a certain amount of resin. There have been problems with some core materials with inner and outer skin movement which can lead to eventual delamination unless it is sufficiently flexible. Airex has been successful in overcoming this problem.

Because of the success of keel boats built with the WEST system, we have become more and more advocates of true monocoque construction with less hull framework and more skin. I think the advantages, even for multihulls, are great. In our early days, we believed in very intricate frameworks and thin skins. This approach was very successful, and all of our earlier boats had good structural integrity and reasonable lives. But, there are some problems with thin skins such as their ease of puncture, early distortion when loads are applied, and racking which sometimes shows up as skin wrinkling. The same things happen on fibreglass boats.

<u>MULTIHULLS</u>.

In applying this approach to multihulls, I see nothing wrong in going to 1.1 lbs. per sq. ft. (5.38 kg per sq. m) and have a four-laminate 1/2" (12.5 mm) thick main hull in even a 30 - 35 footer (9.1 - 10.7 m). Now, two layers of 1/8" (3 mm) are used over a rather heavy framework, and there is only a 1/4" (6 mm) skin. I think they may be going in the wrong direction, and it might be better to put some of that framework into the skin and let it become much more load bearing than it is, rather than trying to transfer loads through frames, which take up three inches or so of hull space on each side. We are tending more and more to the thick skin method in our construction of multihulls.

<u>NEW DEVELOPMENTS</u>.

Even with saturation of the outer layer with three coats of epoxy resin, cedar is quite soft. For a practical cruising boat designed to withstand a lot of dock abrasion, it might be better to substitute a very high density veneer as Honduras mahogany for the cedar on the outside layer. We are currently experimenting with some laminates where the first few layers would be cedar, and then we would go to balsa cut from balsa plank. For the outside layers, we would switch back to cedar and use heavy Honduras for the final outside veneer. We think we could come up with a skin that would weigh the same as that of GOLDEN DAZY but be 1 1/2" (38 mm) thick. This would increase stiffness very considerably, and the balsa planks would be load bearing and not just sit there as in the end-grain balsa coring. Balsa is a reasonable material on a strength to weight basis.

ADVICE TO THE AMATEUR BUILDER.

Although it may be possible to devise jigs for one man to strip plank alone, it is much better to hire someone or impress a son or daughter to hold one end of each strip as it is applied. The only source of veneers we have found in this country willing to supply in small quantities is: The Dean Company; 519 N.W. 10th Drive; Gresham, OR 97030; U.S.A. Their price for Western Red Cedar at $200 per thousand sq. ft. comes out to 20¢ per sq. ft. (£1.05 per sq. m) which compared to 1/8" plywood at 55 - 65¢ per sq. ft. (£3.15 per sq. m) is a real bargain. For our purposes, the cedar-veneer is stronger than the plywood because all the grain runs in one direction. Other veneer suppliers cut lumber for the plywood industry and are just not organized for small orders. Their prices are extremely reasonable, but unless you can use 50,000 sq. ft. (4645 sq. m) or so, they will not talk to you. Most of their veneers are thinner than the 1/8" we like to use. Sawing the veneers yourself is not recommended. We have found waste up to 60 to 70% when trying this. The Dean Company also supplies Sitka Spruce and Douglas Fir veneers.

Editor's Note: The preceding was transcribed and edited from a tape kindly supplied by Meade Gougeon at my request and another tape and questionnaire replying to some of my questions. Therefore, if anyone has goofed on this, and if errors of fact or intent have crept in, this is most likely my fault and not Meade's. It was my good fortune to be able to visit GOLDEN DAZY when she was here at nearby St. Petersburg. My thanks to Dr. Murphy, the owner, and Mr. Mowers, the ship's captain, for this privilege. I can affirm that she is a real beauty both outside and below-decks. It is hard to beat the attractiveness of a varnished, natural hull. It is a sad commentary on our times that many at the yacht club thought she was a plastic boat with simulated wood grain. (See additional photo on front cover.)

The WEST system is a further development of the early pioneering work of Koopman and Lord in this field. In these days of scarce, traditional boat lumber, it makes possible the construction of long-lived, high-strength yachts from the less expensive grades of wood. For the amateur builder, it is one of the least expensive boatbuilding methods. The resulting boat shell is a combination of epoxy and wood, resulting in a substance which is not quite synthetic and not quite natural but combining many of the best properties of each. As far as I am aware, the combining of two well-known boatbuilding techniques in one hull: strip planking and cold-moulded, is an original development of the Gougeon Brothers.

About a year ago, I was given a small, experimental amount of the Gougeon epoxy resin and some Western Red Cedar by a local AYRS Member building in this medium. I glued up eight samples of double and triple diagonal, using both the Gougeon and a "leading brand" of epoxy glue. Samples were labelled with letters and the key put away. After curing, I sectioned and polished each sample and examined them under seven power optical comparator. The "leading brand" showed numerous voids and some evidence of delamination/non-adhesion. All samples using the Gougeon epoxy showed few voids - some none - and no evidence of non-adhesion. With a resolution of about 0.0001", I saw no particular penetration by either epoxy except that the Gougeon variety completely filled the "hills and valleys" of the wood surface and appeared to provide a very solid toothed bond. This is a crude test and does not take into account: strength, stiffness, longevity etc.

What is not brought out in Meade's account is that the epoxy itself adds considerably to the stiffness of the wood. It is quite striking to compare the bending properties of a piece of bare cedar to one that has been coated with epoxy. Remember too that sealing wood accomplishes other purposes: the wood is kept dry and hence strong - wet wood is weak*; worms are kept out and rot has no chance to get started as both air and moisture are prevented from entering the wood cells.

(*The American Plywood Association recommends for plywood with a moisture content of 16% or more that allowable stresses be reduced by 61 to 84%.)

It is only fair to state that there may be a difference of opinion with Meade on which method results in a lighter cold-moulded boat: thick skin with only bulkheads and small laminated frames, or thin skin with an elaborate system of frames, bulkheads and stringers. AYRS Member, Prof. Walter Castles recently told me that the old-time aircraft rule-of-thumb was affirmed not long ago in a very elaborate and sophisticated computer study: the lightest aircraft results when a thin skin is used supported by an internal framework. Stringer spacing should be 30 times the skin thickness, and half the material should be in the stringers and half in the skin on a strength-weight basis. Walter also mentioned that stringers should always be edge-on to the hull planking and that some designers have erred here in putting the wide side against the hull.

There can be no doubt that the thick skin Meade advocates is more resistant to being holed, and that it results in a stiffer shell. Some may argue that the strip planking itself is a series of stringers with zero spacing, but I believe that this may be an easier and faster technique than the usual cold-moulded process. A good discussion of strip planking and suggested home-built clamps which might make it possible for the amateur to handle this alone are contained in Reference 9. A modified version of scantling recommendations are originally published in Reference 10 is given in Fig. 11, (See Page 32).

Meade is a Member of the AYRS and our AYRS-FCCG. He is the author with Ty Knoy of the book: The Evolution of Modern Sailboat Design, and with his brothers of The WEST System. (Ref. 8). The Gougeon Brothers are suppliers of epoxy resin and hardener systems for commercial and amateur builders and a variety of additives including: microballoons, graphite fibers, asbestos fibers etc. The WEST manual (Ref. 8) provides complete information on the use of these systems together with some intriguing remarks on restoration of old hulls and repairing areas of older wooden boats attacked by dry rot. The Gougeon epoxies are exported to other countries by individual order.

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8. "WEST System," by Jan, Joe and Meade Gougeon; Copyright 1973: Gougeon Bros.; 706 Martin St.; Bay City, MI 48706; USA - $2.00.
9. Boatbuilding in Your Own Backyard; S. S. Rabl; Cornell Maritime Press; 1958.
10. "Cold-Molded Construction (a critique)." by J.W. Shortall III; "The Woodenboat," V.2; No. 7; 1975: p. 50.

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WATERPROOF ADHESIVES.

Letter from: Ephraim C.S. Clark; P.O. Box 152; Horseshoe Beach, Florida 32648.

Dear Jack,

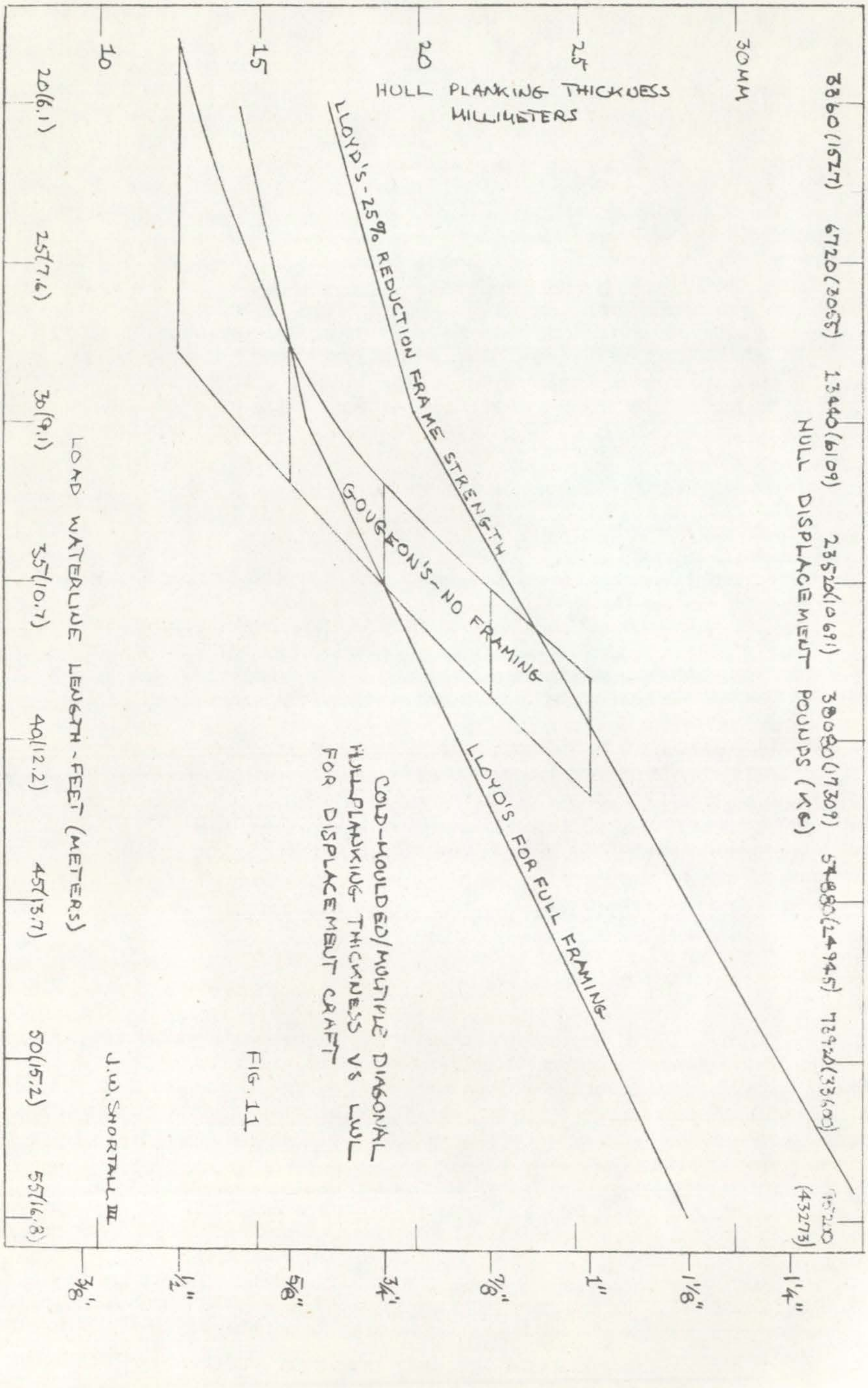
Some of the early waterproof adhesives were bay and bee's wax, and later pitch and gum from trees. Pitch from the conifers was used so extensively that it became known as naval stores for the wooden navies. The Indians covered their birchbark canoes with pitch and usually carried some in the boat for emergency repairs. Most of the early wooden boats were covered with cloth and sealed with pitch. (Ed.: as in the Welsh and Irish Curragh.)

One of the early wood-to-wood waterproof adhesives was Portland cement. This had advantages and disadvantages compared to pitches and gums. It was harder and longer-lived, but the long curing period slowed construction except of boats built of rough-sawed green lumber which were immediately put into service.

"Stick it with chewing gum," came from the days when we chewed spruce gum. Then Mr. McIntosh used the gum of the rubber tree to stick two pieces of cloth together to make waterproof clothing. This was the fore-runner of our synthetic rubber adhesives.

(Please turn to page 33.)

Figure 11 - Building GOLDEN DAZY.
See Page 31.



(WATERPROOF ADHESIVES - Continued from page 31.)

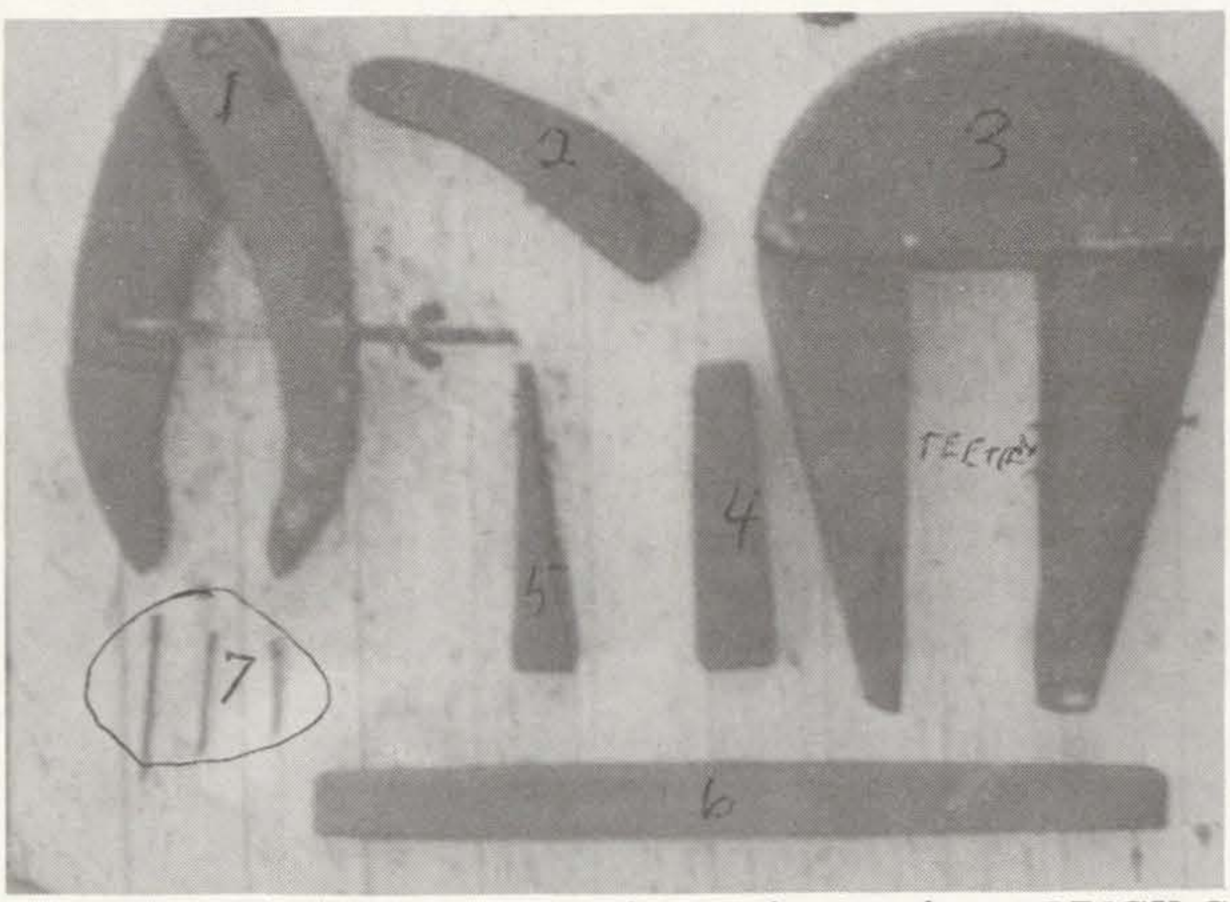
Now we have better hardeners for animal and fish based glues that make them more waterproof and stronger. As adhesive history seems to repeat itself, we use the ancient waxes along with many new ones to make our strongest and most waterproof glues: the epoxies.

I have used resorcinol glue the most. It has good holding power on all kinds of wood, is reasonably priced, especially when purchased in large lots from the factory, but the resin has to be kept in a refrigerator in the summer in Florida. I simplify the complicated open and closed times for different working temperatures by putting a small dab of glue on a vertical surface at the start of application and pencil-marking the bottom every few minutes. When it stops running down, it is time to apply pressure to the job. Resorcinol shows dark through almost all oil paints. I found aluminum paint to be best to overcome this problem and seal off the dark color.

Epoxies are better for the amateur, as they have no complicated open and closed times and do not need so much pressure. They do not show through paint, do not shrink much and stick to almost everything except pitchy pine.

The picture shows some of my home-made clamps for gluing. No. 1 is used mostly for laminating frames and opens to 7 inches (18 cm). No. 2 is the wrench for tightening this clamp. No. 3 is for parallel laminated planks and strip planks to two inches (5 cm) thick. The jaws are beveled to fit the taper of the wedges shown in No. 4 and 5. No. 6 is convex on four sides. A pair of them are used for scarphs in plywood and wide planks with a clamp at each end. No. 7 are double-headed nails also called scaffold nails. The four inch (10 cm) ones are used to laminate keels of 2" x 6" (5 x 15 cm) stock, and the two inch (5 cm) nails are used to laminate stems 1/2 x 3/4 inches (12.5 x 19 mm). By pulling them out with short strokes, they will not be bent and can be used many times over. I have also used many sizes and shapes of rubber bands cut from tire inner-tubes for clamping. Blocks are inserted for flat and concave areas. (See picture below).

Adhesives have made it easier to build lighter, stronger and longer-lived boats of wood, particularly because of their preservative effects of filling and sealing against rot.

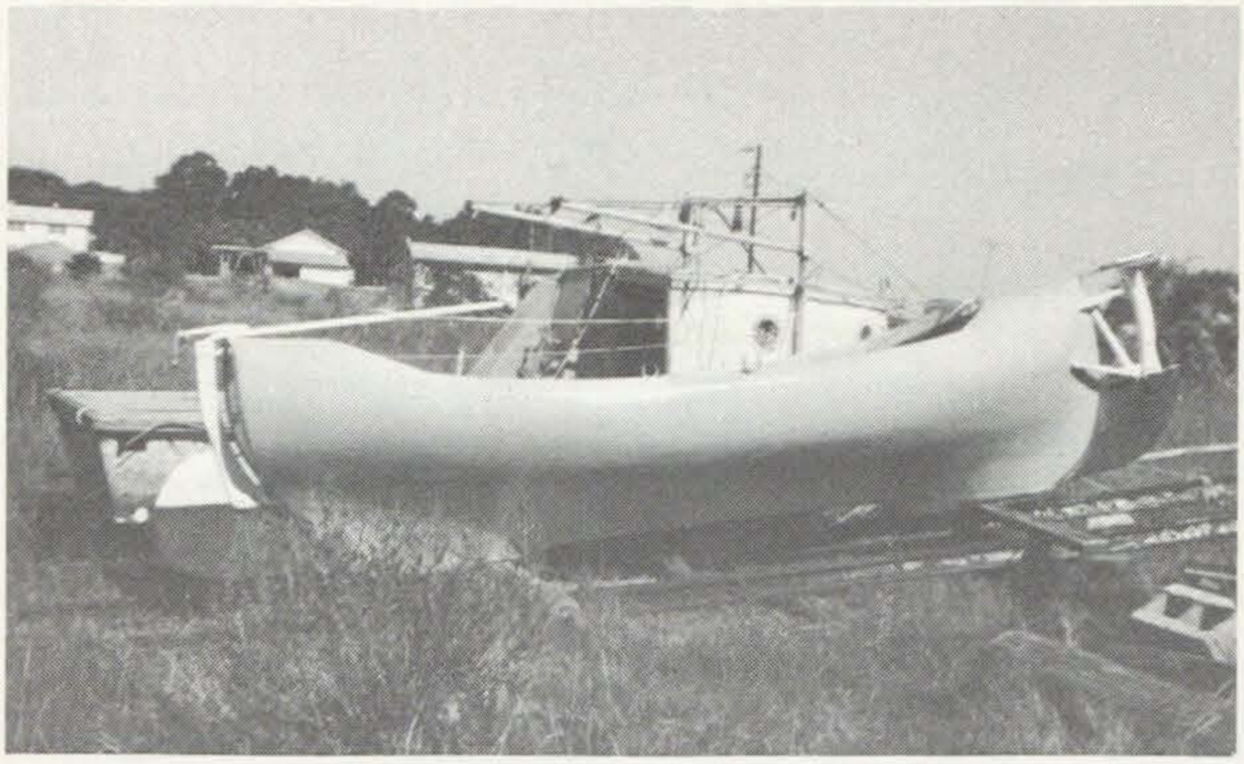


Sincerely,
Ephraim Clark

Editor's Note: The second picture from Ephraim shows BEACH COAMBER which was described in AYRS AIRS 9 pp. 33 to 38 and some of his many experiments on her. She is intended to be the tender for the 45 foot motor sailer he is now building, and to serve as a lifeboat as well. Ephraim has experimented with a variety of rudder positions and sail rig arrangements including a kite sail, rotating mast, ballast (sand), and a wishbone mast. The picture shows BEACH COAMBER with the bow rudder in the same place as before but the rudder post moved 10 inches (25 cm) ahead. Without the bow rudder, the mast is stepped too far forward. Ephraim writes: "If this does not work out satisfactorily, I may put on a bulbous bow similar to the Australians."

There are a good many hints in Ephraim's article on adhesives for Fifty Dollar

Regatta entries. John Morwood has written that a good idea for such might be the Irish or Welsh curragh.



BEACH COAMBER

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KEVLAR* 49 PRICE COMPARISON WITH OTHER SYNTHETIC LAMINATING MATERIALS.

A U.S. mail order company has just announced in its 1976 catalog the availability of Kevlar 49-5 oz. per sq. yd., 10.0 mil fabric. (Defender Industries, Inc.; 255 Main St.; New Rochelle, N.Y. 10801; U.S.A. $1.00). The following table compares the prices of Kevlar 49 with other laminating/covering materials offered by this company. The price given is for small quantities of Kevlar 49 only - obviously the price would be less in quantity - while prices shown for the other fabrics are for both small and large amounts.

Material:	Cost per sq. ft. - U.S. $ x 100	(British pence)
1. 10 oz. Fiberglass Cloth	11.5¢ - 18.0¢	(6p - 9p)
2. 4 oz. Fiberglass Cloth	8.5¢ - 10.6¢	(4p - 5p)
3. 4.3 oz. Polyporpylene (VECTRA)	15.6¢ - 22.0¢	(8p - 11p)
4. DYNEL	16.0¢ - 21.3¢	(8p - 11p)
5. KEVLAR 49 - 5 oz. 10 mil (17 x 17) 50" wide.	76.0¢	(38p)

Defender Industries also sells C-Flex Fiberglass at $ 1.05 to $1.25 (50p - 62p) per sq. ft.; PVC Foam, 3/8" thick: $1.39 (69p) per sq. ft; and AIREX foam at various thicknesses ranging in price from $1.33 to $2.50 (66p - £ 1.25) per sq. ft; and a variety of polyester and epoxy resins with instructions on the applications of each type including a new underwater epoxy glue at $31.50 (£15.44) per gallon.

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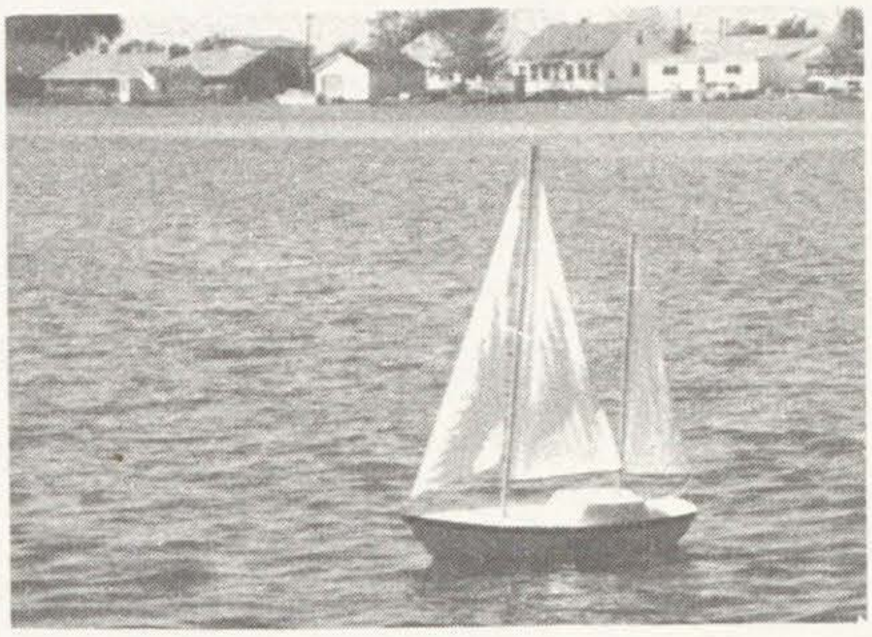
SOURCES OF BARE HULLS AND KIT BOATS.

As stated in previous issues, we continue to list sources of bare hulls and kits because many potential amateur boatbuilders are put off by the difficulty of building the hull or hulls and then facing up to being only one-quarter or one-fifth finished. I have had no personal experience with any of these boats or firms and would welcome comment from them or those who have. AYRS Member, Harold Stilson, Jr., President of Harstil Industries, was kind enough to write me with details of his KAULUA 31 and SEA EXPLORER 46, described below, and to answer my followup questions.

Recently, I was pleased to read the book: Fiberglass Kit Boats, by Jack Wiley; International Marine Publishing Co.; 174 pp; 1973; $9.95. For anyone considering buying a bare hull or a kit boat, I would urge that they obtain a copy of this volume. While the prices and some of the firms are no longer valid, there are many useful tips, references to other books and the names and addresses of firms which supply hulls and kits from: England, Canada, Hong Kong and the U.S.A.

1. SEA EXPLORER 46. Harstil Industries, Inc.; 17150 Fifteen Mile Road; Fraser, Michigan 48026. U.S.A.

The almost-47 ft (14.2 m) SEA EXPLORER 46 is a heavy displacement ruggedly-designed and built cruising ketch. The first boat was completed for a Sea Scout Post to U.S. Coast Guard Rules and Regulations for Small Passenger Vessels, and she received full approval by the U.S. Coast Guard. Layup of this fibreglass hull varies from 7/16" (11 mm) thick at the topsides to over 1" (25 mm) at the keel. Several different accomodation plans are available for the yacht version. Bare hull price is \$16,625 (£8110) plus a fee of \$395 (£193) to the designer: AYRS Member Nils Lucander. Other components are available as: stringers, bulkheads, deck, shaft log, rudder, engine beds, tanks, etc. Of particular interest is that Harstil Industries also manufacturers a 1/10 scale sailing model of this yacht with hull, deck and cabin trunk moulded in FRP with rudder cut to shape and sail plan and deck layout drawings. The model, shown sailing under radio control, sells for \$113 (£55.1).



2. KAULUA 31 Catamaran. Harstil Industries, Inc. (Address as above.)

The KAULUA 31 is described elsewhere in this issue. She is a fast cruising catamaran with a Bruce No. of about 1.5 maximum, DLR about 73 minimum, and L/B of her hulls is 12.9. She is manufactured in two models: cabin and overnighter. The "Overnighter" can be disassembled for trailering and reassembled by two people, each operation taking about six hours. Kit price for a pair of hulls complete with decks, daggerboard trunks, four bulkheads, sole supports, berth tops, steps, rudders and skegs, hatches, etc. is \$9436 (£4603). Other components and assemblies are also available.

3. INGRID - Atkins Double Ender. Blue Water Boats, Inc.; P.O. Box 625C; Woodenville, Washington 98072. U.S.A.

This firm advertises the 38 foot ketch INGRID at a bare hull price in FRP of about \$8000 (£3900). Other components may also be purchased: interior, deck, ballast, etc.

4. FLICKA 20 and ANASTASIA 32. North Star Fiberglass Yachts; 800 Cacique, Santa Barbara, Ca 93103. U.S.A.

These are two of Bruce Binghams' designs and are furnished in RFP from bare hulls to finished craft. Hulls only are \$2450 (£1195) and \$5600 (£2732) respectively, and partial kits are available. Brochure: \$1.00.

5. SEARAKER 50. Windward Marine, Inc.; 3310 South Union; Tacoma, Wa 98409. U.S.A.

This is a 17 ton, Monk-designed, cutter or ketch furnished at any stage of construction. She has an unusually strong, hand-laminated hull of 17 layers of woven roving, mat and cloth at the sheer ranging to 44 layers at the bottom of the full keel.

6. STEEL AND ALUMINUM HULLS. Kellahan Marine Ventures, Inc.; P.O. Box 2173; New Westminster, BC, Canada.

The manufacturer claims that hulls in steel or aluminum may be built from 14 to 40 feet (4.3 - 12.2 m) in little time - a 28 ft. (8.5 m) hull in two days! Brochure \$2.00.

7. LEAD KEELS. General Metals and Smelting Co.; 47 Topeka St.; Roxbury, Ma 02118

Lead keels and shapes are poured in all sizes.

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CRUISING

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PROGRESS WITH HYDROFOIL SAILING by David A. Keiper; P.O. Box 181; Honeoye, New York, 14471.

WILLIWAW - The 31' 4" (9.5 m) Hydrofoil Cruising Trimaran.

Very little has appeared in the pages of AYRS on WILLIWAW since the publication of AYRS 74: Sailing Hydrofoils. At that time, she had just completed a voyage from California to Hawaii in September, 1970. As of the end of 1975, she had logged 14,000 miles (22,500 km) of voyaging and was in New Zealand.

After cruising the Hawaiian Islands extensively and operating as a charter yacht, WILLIWAW was sailed back to California in July, 1971. That was a 22 day upwind voyage, mainly in light airs, and the foils were used on only three days. For the next three years, WILLIWAW was only used for summer afternoon sailing on San Francisco Bay while I was busy experimenting with hydrofoils for small boats and running my firm: DAK Hydrofoils. In 1974, when stocks of the two inch chord aluminum hydrofoil extrusions ran out, and the country was in the grips of recession, inflation and Watergate, I retreated to WILLIWAW and made some modifications. The changes were very successful, and I almost sailed off in late 1974 with a crew woman for the South Seas. However, a friend talked me out of this, and we produced a 14 minute movie on WILLIWAW and began to plan a new hydrofoil entry for the multihull Transpacific Race. Promised funds did not materialize, so in June, 1975, I sailed for Hawaii and returned to the charter business.

In November, 1975, I sailed WILLIWAW for New Zealand with stopovers in Samoa and Tonga. During one ten day period of moderate trades, she covered 1650 miles (2655 km) and the foils were in use continuously. Overall, WILLIWAW sailed 4000 (6436 km) in 33 days using only the working sails with myself and one crew member. She self-steered a reasonable amount of the time with the helm tied.

I would rate WILLIWAW as an ideal sort of ocean cruiser. Her seakindliness with the foils set is truly phenomenal. On the foils, one gets the feeling of utter and absolute stability and control, even in heavy seas. In squalls, she goes like an express train on rails, and therefore the squalls always seem to be of short duration. In light winds, she is a fast trimaran with foils retracted and finds some incredibly beautiful anchorages with her 1 1/2 ft (0.46 m) draft. She is extremely strong and tough, for we went onto a coral reef on a lee shore and pounded up and down for about an hour before getting off with minimum damage. She is comfortable to live aboard for two people, although there are berths for three. Foil setting or retraction is fairly easy and only requires heaving to for about five minutes. Solo sailing is easy.

Now that the designer has fully tested WILLIWAW, he wishes to find someone else to take her over, so that he can get on to some other foil designs that are running through his head. Her price, fully equipped, delivered to any major port in the world is $19,500 (£9512) or any reasonable offer.

Performance data on WILLIWAW.

In the Spring of 1975, WILLIWAW was entered in the Pacific Multihull Association speed trials. Competing boats included one other hydrofoil sailboat and racing catamarans from 14 to 38 ft. (4.3 - 11.6 m). The other hydrofoil boat dropped out due to structural failure. The catamarans were stripped racing versions with sail area to displacement ratios twice that of WILLIWAW, and we were loaded with many years accumulation of junk. However, we did take fourth place on speed and were clocked at 17.5 knots over the 250 yard course in 17 knots of wind. Later on, with stronger, but very gusty winds and a short chop averaging 1 1/2 feet (0.46 m), she made a run of 18.5 knots. What really amazed the catamaraners was that under these conditions, the three crew members on WILLIWAW were standing up on the deck and only lightly holding the windward shrouds. Catamaran crews had to lie down and hold on for dear life to avoid being pitched overboard. The catamarans were continually burying their bows, and two capsized. WILLIWAW's foils always stabilized her perfectly, and she kept her nose high.

Once, in 1973, WILLIWAW met a strong wind and flat water conditions in San Francisco Bay behind Angel Island. She lifted off and did at least 30 knots for a few hundred yards. She was raised very high off the water. As she streaked across the Bay, there was no feeling of motion or even force on the tiller. The water looked like a blur beneath the boat, probably because of a thin layer of pulverized water just above the surface. Typically, in the summer afternoon winds on San Francisco Bay, WILLIWAW would average about 18 knots. Usually she flew for miles until she either ran out of wind or water.

At sea, she usually does not average such speeds, although she may come down waves at 35 knots or so. With a squall chasing her at sea, she is likely to average 15 knots and outrun the squall. For all day at sea, in strong winds, she is likely to average 12 knots. WILLIWAW has never met the ideal speed condition at sea of a strong, prolonged gale aft. She might make 400 miles (644 km) per day in such conditions. (I am very much a realist and refuse to take over Art Piver's early dreams of 1,000 miles (1600 km) per day!)

FINAL SOLUTION OF THE MULTIHULL CAPSIZE PROBLEM.

Early trimaran designers swept the capsize problem under the rug, but trimaran capsizes left messy evidence floating around. Keel boat designers did not have this problem, as evidence of their disasters sank out of sight to the bottom. Granted, trimaran capsize is rare, probably no more common than keel boat sinkings, but that is no consolation to the trimaraner who suddenly finds his trimaran flipped over at sea.

On our voyages, WILLIWAW has always been well-laden with stores, and in 14,000 miles (22,500 km) has never been close to capsize. However, she is narrow and somewhat lightweight and so could possibly be capsized while stopped by a sudden vicious gust. She exhibits tremendous stability when moving on foils even when only half foil-bourne.

In early experiments with small pontoons, WILLIWAW did capsize on San Francisco Bay. Once with the present pontoon size, masthead float, and unladen; she also capsized on the Bay. Both occurred with the boat stopped or moving very slowly when caught by strong wind gusts. In the last capsize, I feel that the masthead float contributed to this through its weight and windage. The float then failed to keep the boat from going upside down in a wind of about Force 8 (33-39 knots).

Upside down, I sat inside and contemplated. Lo and behold, the water only came up six inches inside that boat. The fore-hatch had been well dogged down, and so an air-lock had formed. Then I imagined a pair of baffle plates which could be placed in the tops of the doorways fore and aft of the cockpit. They could keep all the water out. Then I pictured the stern foil retracted and forming an excellent rudder blade with the boat upside down. The hull lines upside down were those of a shallow draft, broad-beamed monohull because of the flush deck with reverse sheer and sloping to the sides. The oval mast forms a 34 foot deep centerboard. The boom could be removed and stepped in the head outlet hole to form a jury-rig mast. One doesn't need to sit there and die. Sail on! (At reduced speed, of course.) If the wind gets too light to sail this queer-looking boat, then the seas also flatten out, and one can do a righting procedure with a rubber inflatable raft hauling at the masthead.

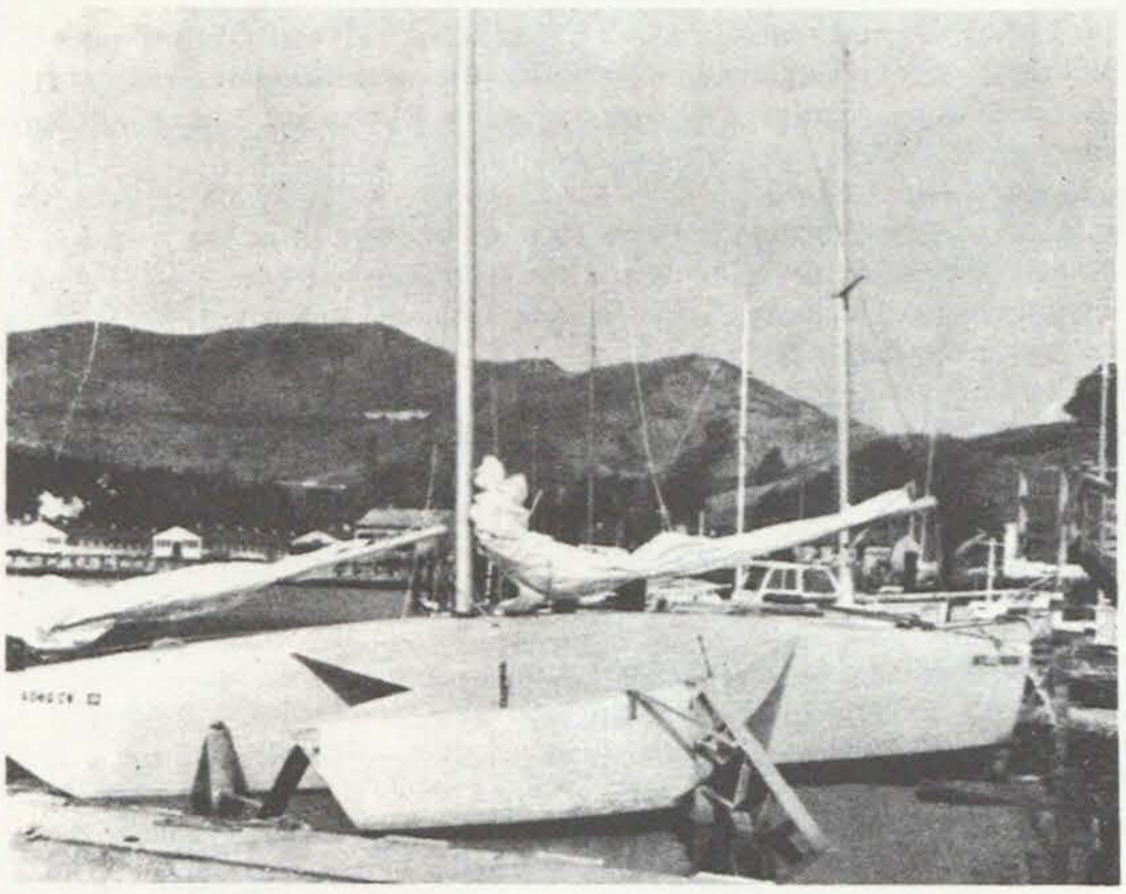
For the past 7,000 miles (11,300 km) of cruising, I have had the baffle plates handy, but the seas or winds have not forced me into using them. Perhaps I'll do the experiment in protected water to see if this is an effective solution to the multihull capsize problem. While WILLIWAW is well suited to this means for survival, many trimarans would not be suitable, and their cabin designs would present problems. If a trimaran partially fills with water after capsize, the interior of the boat becomes unliveable because of water sloshing around. Boat weight is increased by the amount of water that has gotten inside, and this might prevent a boat from being sailed effectively upside down. It would be very difficult to right a capsized trimaran in heavy seas.

FOILS FOR SMALL BOATS - Sailing Multihulls and Outboard Power Craft.

During 1973 and 1974, I test-marketed hydrofoil kits for various daysailing catamarans, trimarans and outboard power boats under the name: DAK Hydrofoils. The kits utilized 2 inch (51 mm) chord hydrofoil lifters and struts extruded from aluminum. Plans and cutting patterns were supplied with the foils. The ladder foil elements were joined together with tapped screws and epoxy. In all, about two dozen kits were sold to experimenters before the extrusion stocks ran out. Some of the kits were rather experimental, while others were reasonably tested. Some of the boats worked well with foils and some did not. The best success seemed to be with lightweight 14 and 15 foot (4.3 - 4.5 m) sailing catamarans and lightweight power boats. It was decided that the heavier boats needed a slightly larger chord length extrusion.

People interested in having hydrofoil kits should write me at the above address. When there appears to be sufficient interest, so I can avoid losing money, DAK Hydrofoils will be reactivated. Designs will be the latest state-of-the-art, incorporating improvements made over the past few years. Kits will be far easier to build next time. This was perhaps one of the biggest problems with our previous kits. Prospective purchasers will be advised if I feel a proposed project may be successful. Kit prices will be kept as low as possible, and minimum price will be about \$300 (£146).

It is a real thrill to fly across the water on hydrofoils and especially so using windpower. Powerboaters who do not want to wait for the wind can cut their fuel consumption by one-half, or get more speed, or use a lower horsepower engine or get freedom from pounding in waves.



Dave Keiper's WILLIWAW showing bow and main foils

Editor's Note: Many AYRS Members will be happy to learn that David has been so successful with WILLIWAW in proving that a first generation hydrofoil trimaran can cruise the Pacific safely and in comfort. Dave is a research physicist who quit his work to undertake the design of hydrofoil craft. His sailing background began in 1961 with the ownership of a 20 ft (6.1 m) keel-centreboard sloop. In about 1964 he purchased Arthur Piver's NIMBLE No. 1 and took an eight month, 11,000 mile (17,700 km) cruise through the Pacific. WILLIWAW was first flown on hydrofoils in early 1968, after her late 1967 launching. Dave is the first to take a hydrofoil-equipped cruising sailboat offshore.

As originally launched, WILLIWAW had an LOA of 31'4" (9.5 m) LWL of 28' (8.5 m) and with foils in place a beam of 23'6" (7.2 m) and draft of 4'0" to 2'0" at high speed (1.2 - 0.6 m). With foils retracted, the beam is 15' (4.6 m) and draft 1'4" (0.4 m). Her sail area was 380 sq. ft. (35.3 sq. m) and displacement 3,000 lbs (1361 kg). Bruce No. = 1.35 and DLR = 61.

Dave is the author of two papers presented at the AIAA annual Symposia on the "AER/Hydronautics of Sailing," the Third and Sixth respectively, and his letters and reports have been published in AYRS 55, 58, 62, 66 and 74. For a good discussion on the capsize problem and an examination of the factors involved in living in an upside-down yacht, see Jim Brown's article "MERIDIAN - Isle of Survival, Part II," in "Multihulls," Winter, 1976, pp. 12-17.

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CONCEPTS FOR LIGHT AIR, HIGH STABILITY SAILING IN SWITZERLAND.

Letter to: Michael Ellison from: Oscar Abegg-Sarasin; Hohenstrasse 6a; 9302 Kronbuhl; Switzerland.

Dear Michael,

May I bring to your attention some of my ideas concerning small fast craft. In my area, Lake Constance, winds are mostly Force 1 (1-2 knots) or less and for weeks hardly exceed Force 3 (6-9 knots). A catamaran therefore, most of the time cannot sail at its ultimate speed flying one hull. In addition, I have never liked the idea of having to wait for help in case of a capsize. Now I am looking out for a design to unite the advantages of a catamaran (speed), a yacht (self-righting capabilities) and a wind-surfer (space requirement and ease of transportation). Take the hull of a UNICORN or a boat with somewhat fuller lines. Add a very deep keel of 5 to 6 feet (1.5 - 1.8 m) of minimum weight in a bulb of 50 to 100 lbs (23 - 45 kg). Add the mast of a LASER or a similar boat but with trapezing capabilities. Such a boat must be faster than a wind-surfer, have fewer capsizes, be self-righting and be unsinkable. As an option, foils may be added to windward.

Sincerely, Oscar Abegg

Letter from: Michael Ellison

Dear Mr. Abegg-Sarasin,

I think you are working on the right lines. The area of your keel does not want to be too great, and the keel will have to be stiff. In the past, there have been problems with narrow, deep centreboards because they twist. The deeper your keel, the greater will be the leverage to heel the boat, but your ballast will be lower. Personally, I would suggest that the hydrofoil replace the keel, but then you have a proa, and these have considerable problems in shunting.

Sincerely, Michael Ellison

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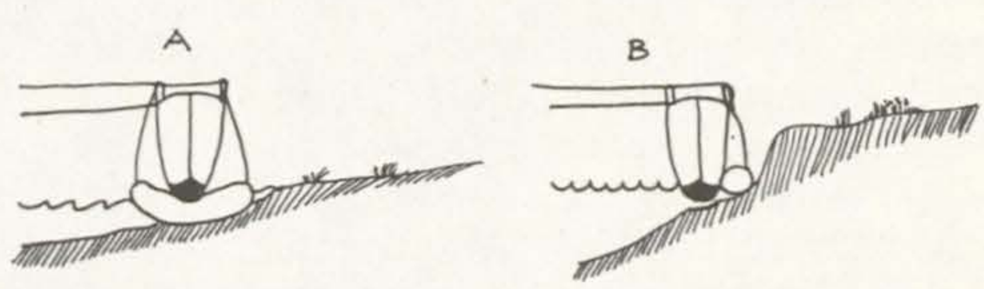
PINTA TRIMARAN IN SWEDEN.

Letter to: Michael Ellison: From: Bjöm Engvist; Karlbergs v. 65 (V) 11335 Stockholm, Sweden.

Dear Michael,

Enclosed are two pictures of our Ib Nielsen-designed PINTA trimaran. 20 have now been built in Sweden. The first, plus the enclosed sketches show how a trimaran is moored in the archipelago where there is no tide. During six weeks of cruising, we anchored only three times. The second picture shows our method of hauling our trimaran out.

Sincerely, Bjöm Engvist



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TELSTAR 26 IN SCANDINAVIA.

Letter to: Michael Ellison; From: Ing. Helge Ingeberg; Postboks 2644; St. Hans-haugen; Oslo 1, Norway.

Dear Michael,

Thanks for AYRS AIRS 11, most full and varied. I read your: "1000 Miles by TELSTAR," with special care. A casual reading might give a bad impression of TELSTAR, because the good points are drowned in the stories on Yamaha + fire and electrolytic corrosion of the speed sensor, all of which have nothing to do with TELSTAR performance. Over here, TELSTAR is well accepted. Over the past two and one-half years, I have sold 9 of the TELSTAR 26 trimarans in Norway and 3 in Sweden. Seven of these were sailed home, and the best crossing of the North Sea is three and one-half days. From Sandwich, Kent to Kristiansand S. is a distance of 480 nm which gives an average of 137 nm per day. This is pretty good for a 26 ft. (7.9 m) LOA BOAT. Highest wind on that trip was Force 8 (33-39 knots). Two of the boats were sailed home last summer by father & mother + small kids via Holland and Denmark. Last September, seven TELSTAR 26 trimarans competed in the 70 nm Hollender Race. 76 boats completed the race with six of our TELSTAR's. The best TELSTAR was number 11 over the line together with the 3/4 ton IOR racing boats, and we did not carry spinnakers. Our opinion is that the TELSTAR 26 is a good, high performance, comfortable and versatile family boat.

Our NFS sailing club now has 43 members and 25 boats. Our first meeting was in September with films, slides and report on our August series of three races. In October, we had thorough coverage of self steering. I have made up some 50 slides giving the history, principles and descriptions of available gears. At our November meeting, we covered: keels, rudders and leeboards. In January, we will have three speakers on: practical experience in sandwich construction.

Sincerely, Helge Ingeberg

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VAL - HIGH SPEED NEWICK TRIMARAN. Designer & Builder: Dick Newick, R.F.D.; Vineyard Haven, MA 02568. U.S.A.

On December 14, 1975, the latest of Dick Newick's, very fast creations, was launched: VAL - a 31 foot high performance trimaran. "She handled superbly in Force 2 winds (3 - 5 knots) on launching day, and the next day with Force 7 (28 - 32 knots), she gave us a memorable ride under double-reefed main and a few square feet of jib." Particulars: LOA: 31'2" (9.5 m); LWL: 27'10" (8.5 m); BOA: 25' (7.6 m); BWL: 2'8" (0.8 m); Draft: 17" - 72" (0.4 - 1.8 m); LWL/BWL: 10.4. Sail Area: 440 - 560 sq. ft. (40.9 - 58.0 sq. m); Displacement: W = 2800 lbs (racing) (1270 kg) or 3200 lbs. (cruising) (1452 kg); Weight: 2200 lbs (1000 kg); Bruce No.; Br = 1.49-1.68 (racing) 1.42-1.61 (cruising); Disp-Length Ratio: DLR = 58 - 66 (racing vs cruising); Auxiliary Propulsion: outboard or yuloh. See photos, page 41 and front cover.

VAL is designed with solo transatlantic race capability, and four of the first seven sold are entered in the 1976 OSTAR (Observer Single-handed Trans-Atlantic Race). She will accomodate up to six for day sailing, weekending for four, and spartan cruising for two. She is demountable for transport or storage. Construction varies at owner preference and pocketbook from fiberglass with Airex foam top stringer to the more expensive kevlar, Airex and carbon fibers.

VAL was a solo racing layout, rotating mast, fully-battened double slabreefing jib. Her daggerboard trunk has a foam safety cushion to minimize or prevent damage in the event of grounding, and the skeg-rudder pivots up out of the water. Sailaway price is $24,000 (£12,000) which is reduced to $12,000 (£6,000) for the basic hulls, decks, crossarms and centerboard for owner assembly.

There is no doubt that with her simple and efficient sloop rig, low DLR and high BR, that VAL will be a very fast and easily-handled sailing yacht. Dick Newick is one of very few designers who publishes the lines of his body sections. His philosophy of design is very refreshing. He produces sailing yachts which are intended above all other considerations to sail efficiently, easily and well. His attitude seems to be that if your primary concern is a dinette, large diesel engine, generator, elaborate galley and head, dish- and clothes-washers and the like, better invest in a beach cottage or buy a houseboat. By concentrating exclusively on the sailing qualities of his creations, he does not have to make the usual compromises which result in the modern cruiser being a rather poor power boat and not a very good sailer. VAL is a beautiful boat, very easily driven and probably quite easy to sail. She is one of the first of what we might call fourth generation trimarans. One of many things I like about her is her topsides streamlining with much attention paid to minimizing wind resistance - oft neglected by designers.

If she were mine, I would use yuloh propulsion and would expect to be able to move her at a steady two to four knots without effort. A more complete description of VAL appears in the Winter '76 issue of "MULTIHULLS."

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KAULUA 31 CRUISING CATAMARAN. Harstil Industries, Inc.; 17150 Fifteen Mile Road; Fraser, MI 48026. U.S.A.

Particulars: LOA: 31' (9.4 m); LWL: 29' (8.8 m); BOA: 14' (4.3 m); BWL 2'3" (0.7 m). Draft: 1'8" - 4'2" (0.5 - 1.3 m); Payload: 2450 lbs (1111 kg); Displacement: 6050 lbs. (2744 kg); Weight: 3600 lbs. (1633 kg); Sail Area: 412 - 556 sq. ft. (38-52 Sq. m); Bruce No.: Br = 1.1 - 1.3 (full load); Displacement-Length Ratio: DLR = 111 (Full Load).

KAULUA 31 is a fast cruising catamaran laid up in FRP with balsa core used in decks and hull topsides. She was designed and model-tested over a five year period by Harold Stilson, Jr. and Robert Williams who state that she was intended to perform well in the predominately light airs of the Great Lakes on all points of sailing. The combination of proper weight distribution plus very fine entry and exit angles has been successful for tacking and reduction of pitching in short, choppy seas. She is available in three forms: bare shell and kits as described elsewhere in this issue; over-nighter with accomodations in the hulls for two; and cabin model with roomy and comfortable accomodations for five. The over-nighter is priced at $19,000 (£ 9268) and the cabin model at $24,000 (£ 11,707) plus sails and minimum 15 hp outboard motor, but with a reasonably complete inventory. The "Over Nighter" model can be converted to the "Cabin Cruising" model at any time with a kit which may be purchased later. See "Multihulls," Winter '76; Vol. 2; No. 2; p. 57 for more details. (See photo on rear cover.)

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The AYRS-FCCG is composed of 107 AYRS Members having a sailing interest in Southern waters including the Caribbean Sea and the Gulf of Mexico. Most of the AYRS-FCCG Members live in the southeast U.S. from Virginia to Florida to Texas and on islands and countries in the Caribbean. An annual fee of $2.00 is requested from those wishing to take part in our activities or contribute to same. Write the Editor.

SAILING MEETING NO. 2 - FOURTH FIFTY DOLLAR REGATTA - April 24, 1976. Write to: Prof. Edwin Doran, Jr.; 1114 Langford; College Station, Texas 77840. Telephone (713) 846-6679.

As originally conceived by AYRS Member Joe Gray, the Fourth $50 Regatta will be held in Texas on the above date. Restriction on boats participating is that the estimated fair market value of all materials used in construction must not exceed $65 (£32) - inflationary hike. All boats will be examined prior to racing round the buoys to determine that this criterion has been met. The designer-builder need not be the helmsperson.

SAILING MEETING NO. 3 - May 15 and 16, 1976. Location: At the home of: Warren Noden; 331 Palermo Circle; Fort Myers Beach, Florida 33931. Tel. (813) 463-9547. Write to the Editor for more information.

Both AYRS and prospective AYRS Members are invited to SM-3. Those who are not AYRS-FCCG Members are asked to contribute $2.00. Warren has a waterfront home, and Members and other participants are encouraged to sail or trail their boats here. Up to 20 cruising and racing sailboats have been docked or moored in front of Warren's home. This is off-season in Florida, and there are many motels within walking distance. We hope for a Florida $50 Regatta here. A working model of the RVG self-steering gear will be exhibited, and Gordon Gillett will give a demonstration of kite sails. Members and others are encouraged to bring boats, models, drawings, films, slides and any other examples of their work and interests.

The AYRS is an informal organization, and we hope to have a good deal of fun as well as idea exchanges. We will hold panel discussions - round tables on the following topics which were selected as being of majority interest from the questionnaires returned with the $2.00 AYRS-FCCG Membership fee:

(1) Saturday Morning - May 15, 1976.
Long Distance and Short-Handed Sailing and Yacht Cruising - Bruce DuClos and Neal Henderson.
(2) Saturday Afternoon - May 15, 1976.
Advanced Materials, Boatbuilding Applications, Multihulls - Meade Gougeon.
(3) Sunday Morning - May 16, 1976.
Long distance Cruising for Women - Ms. Penny DuClos.
(4) Sunday Afternoon - May 16, 1976.
Sailing Yacht Research - Design for High Speed Sailing - Joseph Norwood, Jr.

There will be no formal papers as such, and it is hoped that many will come prepared to contribute to these sessions with ideas as well as questions.

Among the larger of the boats promised are: Concordia 40 yawl with RVG self-steering; Kantola 42 trimaran; Susman 11.5 meter fast catamaran; and various smaller craft including some trailerables and possibly the Editor's trimaran CATA if she gets a new bottom job by then.

WORLD MULTIHULL SYMPOSIUM - June 14-17, 1976 - Toronto, Canada.

Charles Chiodi, Editor and Publisher of MULTIHULLS, 91 Newbury Ave.; No. Quincy, MA 02171; is organizing this meeting with the cooperation of Canadian Multihull Services. Write Charles to register. Details are given in the Winter '76 issue of MULTIHULLS.

AYRS-FCCG Member, Prof. Frank Sciadini, has suggested that if enough Florida and Caribbean Members are interested, group transportation to and from Toronto could be arranged, and Charles Chiodi confirms this. Write Frank if interested at: 3011 N.E. 10th Drive; Gainesville, FL 32601.

INEXPENSIVE FIBREGLASS CLOTH AND STAINLESS STEEL PARTS.

Leland Hardy; 4426 Leola Lane; Orlando, FL 32806; writes that he obtains reprocessed industrial quality bolts of fibreglass cloth from: Fiberglass; 201 N. 2nd Ave.; Alpena, MI 49707; at $9.50 for the first bolt and $9.00 for each additional bolt. These are three feet wide and 30 feet long. Leland cuts two and three inch tape from these by sawing with a fine-toothed saw through a portion covered with masking tape to prevent unraveling, or by using a fine stainless steel fishing leader wire with an electric current running through it. Leland also uses stainless steel leader wire and motorcycle spokes for pins, threaded bolts and ice picks.

GALVANIZED RIGGING AVAILABILITY IN U.S.

A local AYRS Member has located a good source of economically-priced, hot-dipped galvanized hardware and rigging wire at: Standard Marine Supply Co.; Hooker Point; Tampa, FL 33602, with similar stores in many seaport cities in the U.S. 3/8 inch (9.5 mm) diameter plough steel galvanized rigging cable with a breaking strength of 5 tons costs only $37 (£18) per hundred feet. Turnbuckles to suit are $8 (£4) each. The 6 x 7 wire is easily spliced over a thimble by cutting out the center hemp core and opening the wire into two parts of three strands each. An overhand knot is tied, and the strands are re-layed into a loop. Then the ends are potted in epoxy and served.

BARBADOS QUERY ON WEST, BOTECOTE, UNITEX 2, and CALAHAN SEAPRENE.

AYRS-FCCG Member Ian A. Reid; 32 Golf Club Road; Worthing Post Office; Barbados, West Indies; writes to ask about various coverings for plywood hulls including the above. Anyone with experience in the last three items is asked to write. Ian has sailed in small boats since his youth and has cruised in the last eight years in the Caribbean, particularly in Antigua, Barbados, Grenada, Grenadines. He has plans for a 41 ft. Wharram catamaran NARAI and hopes to begin building this year.

QUESTION ON LIFE EXPECTANCY OF FIBERGLASS.

AYRS Member, Ms. Marilyn Oppenheim; 2904 Farmington Drive; Alexandria, Va 22303; has a problem she wishes to throw open for replies. She is selecting a boat 30 to 35 ft. long to go on a very long cruise. She expects to encounter rough seas and wants a very sturdy craft. It must be simple to maintain as she will be traveling alone. She will be buying a used boat and wants to know whether it will still be seaworthy at the end, say, of 20 years of hard use. She would like to know which areas will be most stressed and what preventive maintenance one person can reasonably expect to accomplish.

LENMEN HIGH PERFORMANCE CATAMARANS AND TRIMARANS.

Leonard Susman of Lenman Industries, Inc.; P.O. Box 689; Cape Coral, Fl 33904; will have some of his very fast production trimarans and his 11.5 meter SUNRISE catamaran at SM-3. His 34 ft. TRIKINI D built in Airex foam sandwich, whose picture is shown, has a displacement of 1100 lbs and sail area of 500 sq. ft. for a Bruce No. of 2.0 with two crew.

DO-IT-YOURSELF BOATYARD.

Lemon Bay Marina; Mr. Charles R. Dehayes, Manager; P.O. Box 1028; Englewood, FL 33533; just off Marker "30" on the Intracoastal Waterway, south of Venice, has a fine do-it-yourself boatyard where the skipper can live aboard his boat after hauling. Prices are very modest. A new bottom job on CATA, my 32 ft. trimaran, would cost $161 (£80) if painted myself, and $225 (£110) if done by the boatyard - both much less than having her hauled by crane as in the past.

COMPUTER AVAILABILITY.

Prof. J.A. Llewellyn; 3010 St. Charles Drive; Tampa, FL 33618; is an AYRS Member and has a computer which: "could help anyone who has a problem that can use that sort of service."

AMATEUR YACHT RESEARCH SOCIETY
John W. Shortall III - AYRS Editor
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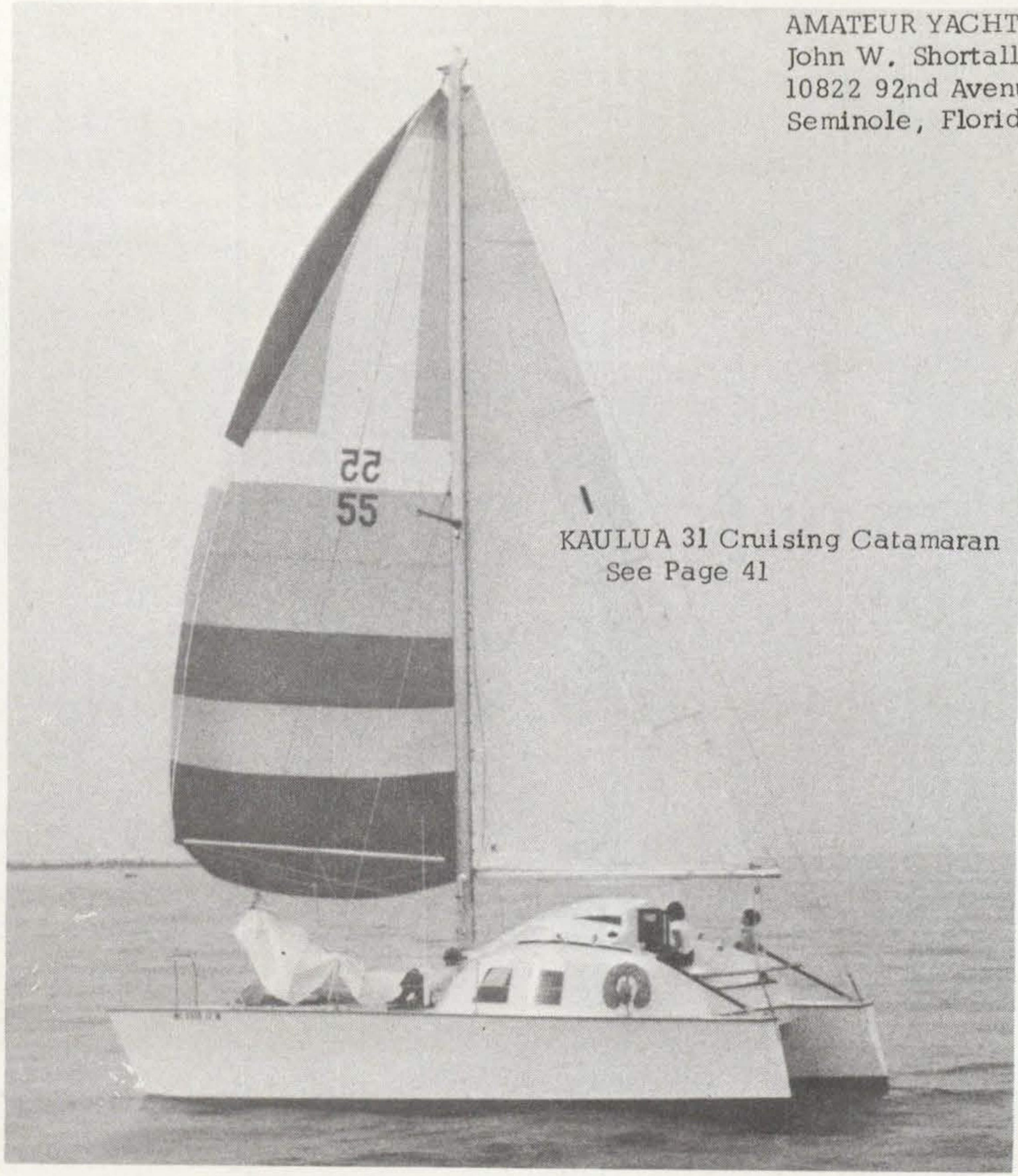

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