FOIL AND FLOAT

A.Y.R.S. PUBLICATION No. 51

MARTIN RYLE'S Hydrofoil Craft

CONTENTS

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(Founded June, 1955)

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EDITORIAL

April, 1965.

At last, the hydrofoil breakthrough is coming about. The problems are excellently set forth by Edmond Bruce in the first article where he shows that stabilising hydrofoils are better for speeds below 2,7 $\sqrt{\text{L.W.L.}}$ while lifting hydrofoils can only be useful above this speed. Having tank tested a single outrigger with sloping hydrofoil and finding it good, he then made the craft at full scale and found that it worked.

We usually devote the April publication to trimarans and outriggers but when I gathered all the articles on these subjects, I found that they would fill two publications. Because there are several people experimenting with hydrofoils this year, I felt that the hydrofoil boats and boats on which hydrofoils had been tried should be used now, leaving the trimarans to a future publication. However, single outriggers seemed to fit this publication so I have included them.

We finish the publication with an account of the lore of the Polynesian boatbuilders' art and science of sailing, which is most informative. It is rather a pity that these methods are not used by us. I feel sure we would all enjoy having new boats built much more if this were so.

A.Y.R.S. Model Cruising Yacht Trials. On page 5 we print the rules and regulations under which we will have a competition for model yachts next year. Our best brains tell us that this competition will produce a model which can be made at full size, and be a very fine yacht. We print Edmond Bruce's letter on the subject.

Amateur Yacht Research Society.—Minutes of the First Annual General Meeting of the Amateur Yacht Research Society held at the Cedars Hotel, W.14, on the 9th January, 1965, at 11.30 a.m.

1. The Chairman read the notice convening the meeting.

2. As this is the first Annual General Meeting of the re-formed Society there are no earlier minutes to be approved.

3. The Chairman drew attention to the severe loss that the Society had suffered in the death of its President, Lord Brabazon of Tara, and reported the Committee's view which was that they did not feel the right person's name had come to mind for our next President.

4. The Chairman reported on the formation of the new Society and explained that there was still work to be done to make it a thoroughly actively operating organisation. The Committee was holding meetings each month and noticeable progress had been made in widening the activities of the Society.

5. The Treasurer's Report. The Chairman drew attention to the Accounts of the Society published in the appropriate Publication which was in the hands of Members. The Treasurer, Tom Herbert, introduced the report giving some highlights of the current financial position and asked for the report to be received and adopted. It was adopted unanimously.

6. Election of Vice Presidents. The two Vice Presidents, Mr. R. Gresham Cooke, C.B.E., M.P., and Mr. Austin Farrar, M.I.N.A., were both re-elected unanimously as Vice Presidents for 1965.

7. Election of retiring Officers. In accordance with the constitution the retiring officers at the Annual General Meeting, 1965, are the Editor, Dr. John Morwood, the Vice Chairman, Lloyd Lamble, and the Secretary; this post is currently being filled by Rogor Waddington. The re-election of these three officers to these posts was proposed by Tom Herbert and Dennis Banham and seconded by Tony Millard. They were re-elected unanimously.

8. Election of Committee. In accordance with the constitution all Ordinary members of the Committee retired at the Annual General Meeting, 1965. The following members applied for re-election: Frederick Benyon-Tinker; A. J. Millard; George Robert Dibb; Michael Henderson; Peregrine Henniker-Heaton; Dennis Banham; John Fisk; Mrs. Pat Morwood; John Hogg. The foregoing Committee Members were re-elected unanimously.

Dr. John Morwood proposed and Tony Millard seconded the election of Commander Bobby Cochrane to the Committee and he was elected unanimously.

9. The election of Auditors. The Committee made a recommendation to the Society that Auditors should be chosen who were practising in a more accessible part of the country than Folkestone. The proposal was put to the Annual General Meeting and unanimously approved. The Chairman was asked to write to the Auditors thanking them for their interest in the Society and explaining the reason for the change.

10. Dr. John Morwood proposed votes of thanks to all those who had worked so hard for the Society during the year of 1964 and mentioned the names of the Chairman, the Vice Chairman, the Boat Show Organiser, the Treasurer, Mrs. Pat Morwood, and Mrs. Hetty Tett and these votes were enthusiastically given by acclamation. The Chairman then proposed a vote of thanks to the Hon. Editor, Dr. John Morwood, and this was passed in like manner.

11. As no other subject or proposal was notified to the Secretary for inclusion on the Agenda prior to the 1st December, the meeting was closed at 12.45 p.m.

MODEL CRUISING YACHT TRIALS

Prizes. First £50. Second £20. Third £10. Five prizes of £4.

The Objectives. To improve the seaworthiness, speed and ease of handling of short handed ocean cruising yachts of any type or rig by the use of 1 inch to 1 foot scale models. Models may be designed, built or sailed by amateur or professional and will be judged from the full size point of view. They will be displayed on the Stand of the Society during the 1966 London Boat Show and the trials will take place afterwards.

The Validity of the Trials. It is hoped that the winner of these trials will be made at full scale. It is true that models and small yacths have far less stability than full sized or large yachts in the same strength of wind and this has induced makers to give their craft much greater draught and ballast than a full size yacht would have. However, if we have a wind speed which is scaled in proportion to the square root of 12, we will have a valid comparison between the models which will also hold good at full scale. We have insisted, therefore, that the models be properly scaled in all respects and intend to race them in a wind-speed of 7 m.p.h. if we can which is the scaled wind-speed of 24 m.p.h.

The Models. This first year, we have decided to have only one Class which is 36 inches maximum overall length, excluding rubber or other bumper, rudder, bowsprit and bumkin. The maximum draught is 6 inches. The actual sail area may not exceed 500 square inches which must be capable of being reefed to 350 square inches. The maximum height of any sail is 36 inches above the deck. Internal ballast of 1 lb. (representing a scale weight of 1728 lbs. of crew, stores and all gear not forming part of the vessel itself and not rigidly fixed to it) must be carried at a representative height above the keel and must be fixed in such a way that it can be taken out and checked. Inside the model must be headroom of at least 6 inches over an area of at least 24 square inches of reasonably flat floor for which the rounded hull of a catamaran would suffice.

Construction. This may be a 1 mm. plywood, fibreglass or 6-8 layers of brown paper gum strip or any other material. Frames are optional. Internal furniture, including four full length berths, galley and head, must be representatively modelled e.g., a flat sheet with rings on it would show a stove and enough of the deck must be transparent or be capable of being taken off to show this. Life lines and stanchions, the ground tackle and storm gear must be present in adequate quantities but are not to be weighed as part of the 1 lb. Anchors and metal parts, however, can be made of wood or any other substance. Any self steering gear, other than the "sheet to tiller" gears must be of the servo type using the water or wind flow to control the rudder (or, if a servo system is not used, the vane must not be larger than in the models using this system). Electric self steering may be installed if it can be shown that the battery would last 6 weeks at full scale.

The Exhibition of Models. All models must be taken to the MILESTONE HOTEL, Kensington Court, London S.W.8, (opposite the Round Pond) on the Sunday before the 1966 International Boat Show between 10 a.m. and 6 p.m. or to the A.Y.R.S. Stand at Earls Court between 10 a.m. and 1 p.m. on the Tuesday before the Boat Show and be given to the A.Y.R.S. Boat Show Organiser with a note of the make and number of the car which will take each model away after the Show. Models must be mounted on a firm base 36 inches long and the beam of the model wide on which is a 6 inch by 3 inch card giving the designer's and builder's names and addresses, the total weight of the model, including sails and saying if it is for sale. Designers are invited to attach a 12 inch by 12 inch card to the base with a short statement of the important points of the design in letters half an inch high. Overseas owner's models will be looked after by sponsors from the A.Y.R.S. but the Society will not, however, be held responsible for any loss or damage to any model in whole or in part while in transit, on exhibition or in the care of any of its members.

On the last Saturday of the Boat Show at 9 p.m., all models will be collected by their owners and sponsors and, on the following day, they will be raced on the Round Pond in Kensington Gardens. If the trials have to be postponed, owing to theweather, they will take place on the following Sunday or on such other day as is decided by the Judges.

**The Trials.* The three main prizes will be given for the three fastest boats on the following courses: (1) with wind abeam. (2) speed to windward. (3) the dead running course, without spinnaker. However, the judges may cancel any course without prior notice to competitors. Models will be raced in pairs, if possible, with full sail or reefed to 350 square inches at the discretion of the judges or owners. The lead of one boat over another on one course will be added or subtracted from its lead or lag behind the same boat on the other course or courses. If, by any chance, a model should win a prize at these trials but be of such a type that it would be impossible to build it at full scale or the trials unduly favour one type of yacht such as the multihulls, the prize may be divided by the judges in any proportions they think fit.

Five prizes of £4 each will be awarded for the following features:

1. Sea kindliness.
2. Behaviour under storm gear.
3. The construction and efficient working of the self steering gear.
4. The ease of handling of the sails, rig and ground tackle etc.
5. The elegance and general finish of the model and sails.

The last three items may be judged during the Boat Show.

How to enter. If you intend to enter for these trials, please send notice of this, giving the planned beam of the model to the address below as soon as possible but before September 1st, 1965 so that the A.Y.R.S. Boat Show Organiser can arrange exhibition space on our Stand. If this is not done, the entry may not be shown and thus will not be eligible for some of the prizes. If the number of models entered should be greater than can be shown on the Stand, the A.Y.R.S. Boat Show Sub-Committee will decide which ones will be on exhibition. Please send your letters of entry to:

The Cruising Yacht Model Trials, A.Y.R.S.,
Woodacres,
Hythe, Kent.
England.

No entrance fee. There is no entrance fee for these trials but they have to be restricted to A.Y.R.S. members. We have, however,

* The procedure of the trials will depend on the number of entries. A " pursuit race " may be held if the entry is large, for example. Members with model yacht organisational experience are asked to contact the Editor.

no qualifications for membership and anyone can join by sending £1 or $3.50 to "The Membership Secretary, A.Y.R.S." at the above address. Membership will entitle one to four publications on a variety of yachting subjects, including an assessment of these trials, a course of lectures and a sailing meeting. Our year ends on September 30th and people joining should make it clear which year they wish to include.

Judges. These will be the A.Y.R.S. Committee. On all matters, the decision of the judges will be final. The models will remain the property of their owners.

LETTER

Dear Sir,

The "Rules for Model Yacht Competition" are at hand. Such an activity should put added life into A.Y.R.S. I have noticed that members are most enthusiastic when there is something interesting to do.

This gives me an opportunity to express something regarding a model's simulation of a full size boat which I feel is a widely spread misconception. Norman L. Skene, in his book "Elements of Yacht Design," 5th Edition, stated on page 34 that if one vessel is twice the length of another similar vessel, it has 16 times the stability moment but only 8 times the heeling sail moment. He goes on to say that this is why large sailing yachts are so much stiffer than similar small ones. This has been cited to me by so-called "experienced designers" as an argument against model testing. This argument has been repeated in several books and articles written since that of Skene. These people probably had read Skene's book.

I take the position that models *do* correspond to full size, when scaled, if the scientific basic model theory has not been violated. I do not believe that the Skene statement or other similar statements are correct when *applied to scaling.*

Among similar vessels, doubling the length makes all weights proportional to L^3 or 8 times in this case. Since this weight is at the end of a doubled arm, the stability moment is certainly 16 imes as large, as Skene correctly states. However, model theory says that *all* velocities should be scaled proportional to $\sqrt{L}$. Skene did not do this in the case of the wind!

A vessel of double the length would have L^2 or 4 times the sail area. The C.E. for the sail would be twice the distance above the hull C.R. It should be in a wind $\sqrt{L}$ times as great to be compared. Since wind pressure is as the square of the wind speed, $(\sqrt{L})^2$ equals

L or 2 times greater. Thus 4 X 2 X 2=16. Therefore, the stability and heeling moments are both 16 times greater as they should be. The latter is not 8 times greater as Skene says.

Models, properly scaled, beautifully represent their full size counterparts. A known exception is in the case of the strength of materials. Suppose a square column just barely avoids being broken by it's supported weight. Doubling all linear dimensions would make all weights 8 times as much. However, the column's cross-section would be only 4 times as great. It would be broken. Models are stronger than their full-size counterparts.

Good luck with your model competition. Do not let anyone tell you that they cannot be accurately scaled to full size.

Sincerely,

EDMOND BRUCE.

Lewis Cove, Hance Road, Fair Haven, N.J. U.S.A. 07702.
February 26th, 1965.

THE 1965 LONDON BOAT SHOW

The photograph shows our stand. In the foreground to the left is Martin Ryle's "Sea sled" dinghy, which is a Siamese twin of a catamaran with twin asymmetric bows which join to a single planing stern. Below it, is mounted a transverse hydrofoil which lifts the forward part of the craft at speed—not completely as yet because of air entrainment down the lee strut. To the left of this boat on the wall is a display board showing the various types of hydrofoils, made by Ruth Evans.

Behind Martin Ryle's boat is John Partington's single outrigger, details of which are given elsewhere in this publication. We have mounted a Mill self steering gear on the aft cross beam which can just be seen below the boom of the hydrofoil boat. This was made by Norman Naish and should function well. It will be fully tried out this year.

In the background is a dish-shaped boat made by Reg Cobb with a polyurethane sail, air rudder and two twisting leeboards. Though not conforming to any known principles of hydro- or aerodynamics, it can apparently beat to windward.

The two models are of trimarans by George Dibb and Andre Kanssen and there was also a model of a hovercraft type of boat with an air propellor.

Unfortunately, our stand was placed amongst the engines and as a result we did not have the usual crowd of interested people looking over our publications. Under the circumstances, however, we were not unsatisfied.

The stand was very well laid out by Tony Millard, Hetty Tett made out the Rota and the following kind people took their turns in talking to the public and making our work known: Bruce and Dennis Banham, D. Beech, D. Beedle, Bobby Cochrane, Ruth Evans, R. E. Eyles, Mr. and Mrs. Hall, Perry and Priscilla Henniker-Heaton, Tom Herbert, Lloyd Lamble, John Partington, Martin Ryle, E. G. Scott, W. M. Scott and R. W. Taylor.

Pat Morwood, as usual, supervised the Stand, ably helped this year by Bobby Cochrane. Our thanks are due to all these good people for their work on our behalf.

OPINIONS ABOUT HYDROFOILS

BY EDMOND BRUCE

Lewis Cove, Hance Road, Fair Haven, N.J., U.S.A.

A properly oriented hydrofoil produces a large reaction component of force at right angles to its direction of motion, relative to the water. This is in addition to a drag component which opposes the motion.

A hydrofoil's use as a rudder for steering a boat is commonplace. It is used often as a lateral plane area on sailing craft to permit progress to windward. The additional possibilities of using hydrofoils, as lifters of hulls above water and for the stabilization of heeling, has appeared in a number of A.Y.R.S. writings.

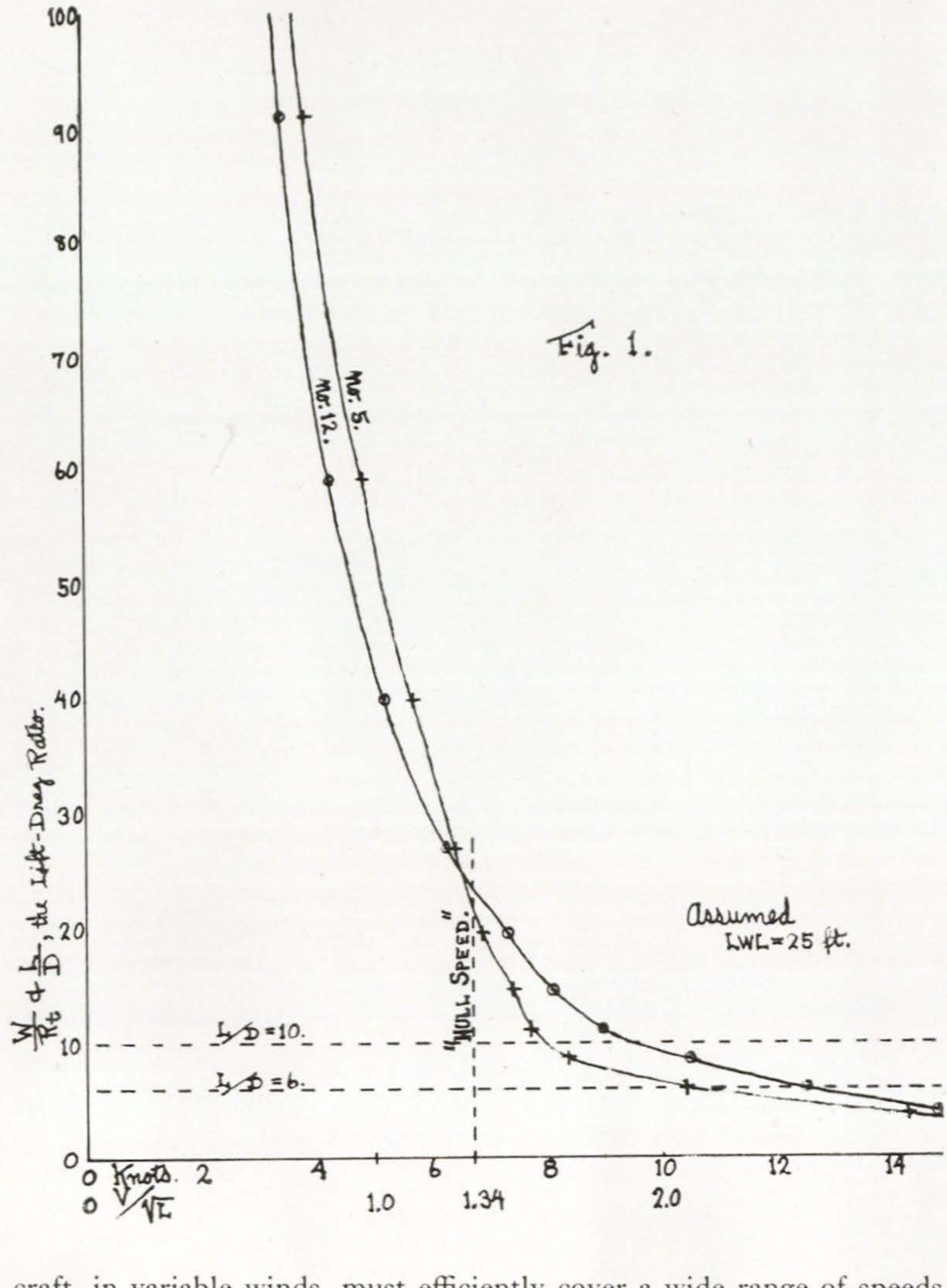
The present writer would like to express his opinion about the limitations in the use of hydrofoils as lifters of sailing hulls. Nevertheless, praise is in order for their success in avoiding heeling at all speeds, without adjustment. This was achieved in the writer's experiments, first with models and finally on a full size sail-boat.

Lifters

Lift resulting from buoyancy is free. Lift obtained from hydrofoils must be paid for by induced drag. A precise criterion as to which method is better for a boat, when employed separately, is to compare the lift-drag ratio of the hydrofoils, of adequate area, with the buoyancy-drag ratio of the displacement hull, at a given speed. The latter ratio is synonymous with the weight/resistance ratio of the hull. Buoyancy just equals weight when dynamic lift is not present. This ratio is the reciprocal of the resistance/weight ratio commonly used in performance curves plotted against, say $V/\sqrt{L}$ or $V/W.^{\frac{1}{6}}$

Referring to Fig. 1, there are graphed, as examples, the weight/resistance ratio versus $V/\sqrt{L}$ for Models No. 5 and No. 12 of the writer's article in A.Y.R.S. No. 45. The speed in knots is indicated for an assumed water-line length of 25 feet. Also appearing are dotted lines which are independent of speed, one of which represents Lift/Drag $= 10$. This is about as well as deeply immersed, lifting hydrofoils have done in the presence of strut drag, rudder drag and other limitations. The dotted line indicating Lift/Drag $= 6$ represents an exceptionally good planing hull rather than foils.

It is seen that, up to "hull speed" of $V/\sqrt{L} = 1.34$, the lifters are completely out-classed by buoyancy. Merely lifting a hull out of water does not mean success. It takes about double hull speed to make the lifters show some profit over these particular hulls. Sailing



craft, in variable winds, must efficiently cover a wide range of speeds to be satisfactory. Racing motor-boats are designed for top speed. The verdict or a compromise is up to the reader.

At this point, I would like to promote thought on some different approaches to lift. Since the wind is the source of all sailing power, it appears that hull lift could be accomplished more efficiently by properly angling the sails somewhat horizontally. An angle of attack would be provided which gives a lifting component to the sail force as well as driving and side-force components. This type of lift is familiar to ice-skate sailors. Thus sail lift would be employed rather than the indirect dynamic lift of the water. This water lift, with it's induced drag, results from the hull's forward movement with an angle of attack. Surface gravity-wave drag, which can be high in water, is substantially non-existent in the air. Therefore less drag results if the hull avoids an angle of attack with the water but uses sail lift instead.

Another type of lift, that appears intriguing, is to convert a sailing hull's side-force into lift rather than using it's precious driving force. This will be described in greater detail in a following section.

Stabilizers

Now let us turn to heeling stabilizers. Many visitors to the writer's laminar-flow towing tank, during the last four years, have seen demonstrations of a model having a special single outrigger attached to an excellent main hull. This model is completely non-heeling on any course or with any wind strength. This is obtained dynamically without the help of buoyancy or weight. It is also the highest pointing and fastest model to windward, under comparable conditions, ever tested in my tank. This includes numerous catamarans and trimarans.

Much has been written in A.Y.R.S. publications concerning different forms of righting devices to counteract heeling. Some have used buoyancy to leeward or weight to windward at the end of an arm of some sort. A few have suggested hydrofoils angled from the vertical as a combination lateral plane and heeling stabilizer. In some cases, even the sail plan has been tilted from the vertical to help achieve counter-heeling.

In re-studying the merit of these arrangements, the angled sail method was not viewed with favour except possibly to provide lift instead of reefing. The driving component, on a windward course, falls off as the *square* of the cosine of the angle of tilt from the vertical.

Buoyancy at the end of a leeward extending arm seemed inferior to out-of-water weight to windward. The latter avoids additional water drag. This is probably the reason why the Micronesians preferred keeping their single outrigger to windward.

The suggestion of an angled hydrofoil as a combination stabilizer and lateral plane was most interesting. It became the subject of the following experiments:

Single Outrigger

A sailing combination, employing a single outrigger, is shown going to windward in Fig. 2, A cross-section is drawn which is in a vertical plane containing the sail's centre of effort, C.E. This out rigger configuration has been chosen among several possibilities because of it's simplicity. Also, the need for an end-for-end reversal of hull motion when tacking, such as is associated with some single outriggers, has vanished.

Let us examine the magnitude, direction and location of the forces involved. A sail force vector, in a horizontal plane, is always countered by an equal and opposite horizontal component of the total water force, after acceleration ceases. Among the vertical components, the weight force vector is always downward. It is opposed exactly by the vector sum of the forces of buoyancy and of dynamic lift (+) or depression (—). If these forces, projected on the common sectional plane, are so positioned that the lateral heeling moments, including the sail, are just countered by the lateral righting moments of the remaining forces, no heeling would occur.

Referring again to Fig. 2, one is permitted to sum up the moments about any point whatever, within the projection plane, since the result will be the same. For simplicity, point O is used. It is at the depth of the centre-of-resistance, C.R., of the thin, flat board, assumed to dominate, but under the centre-of-gravity, C.G., of the complete hull. The moments of both weight and buoyancy disappear, for this case, since their moment arms have no length.

Note that the crew counter-balances the outrigger weight. This keeps it's floatation out of water to avoid water drag during steady progress. This floatation is used for static stability when at rest.

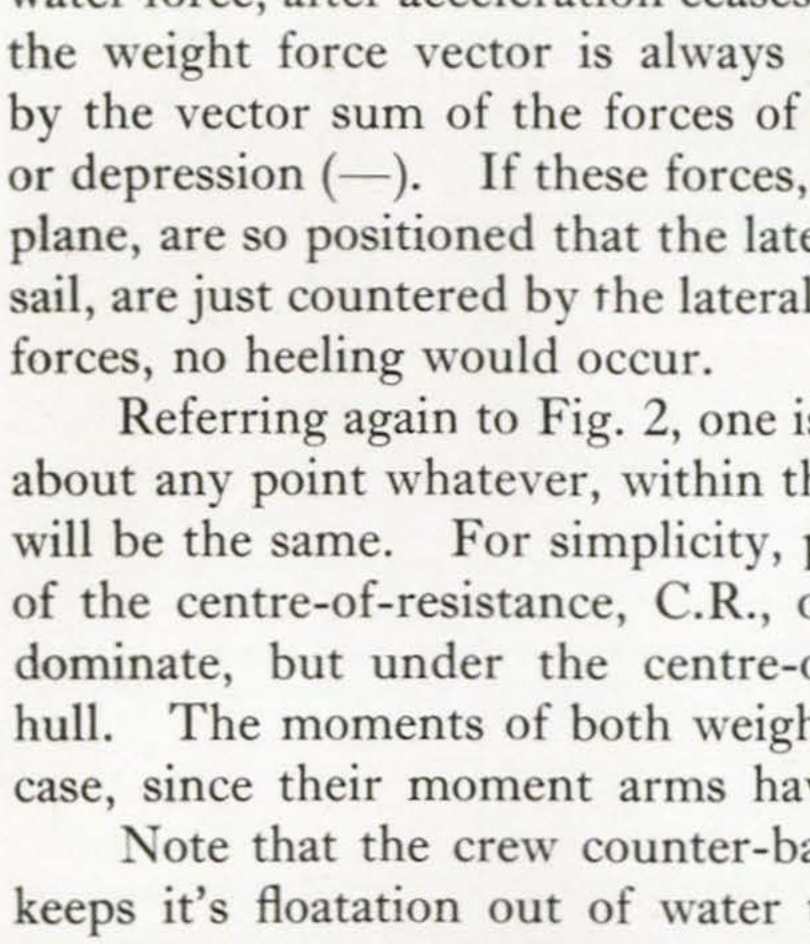


Fig. 2-A. Port Tack.

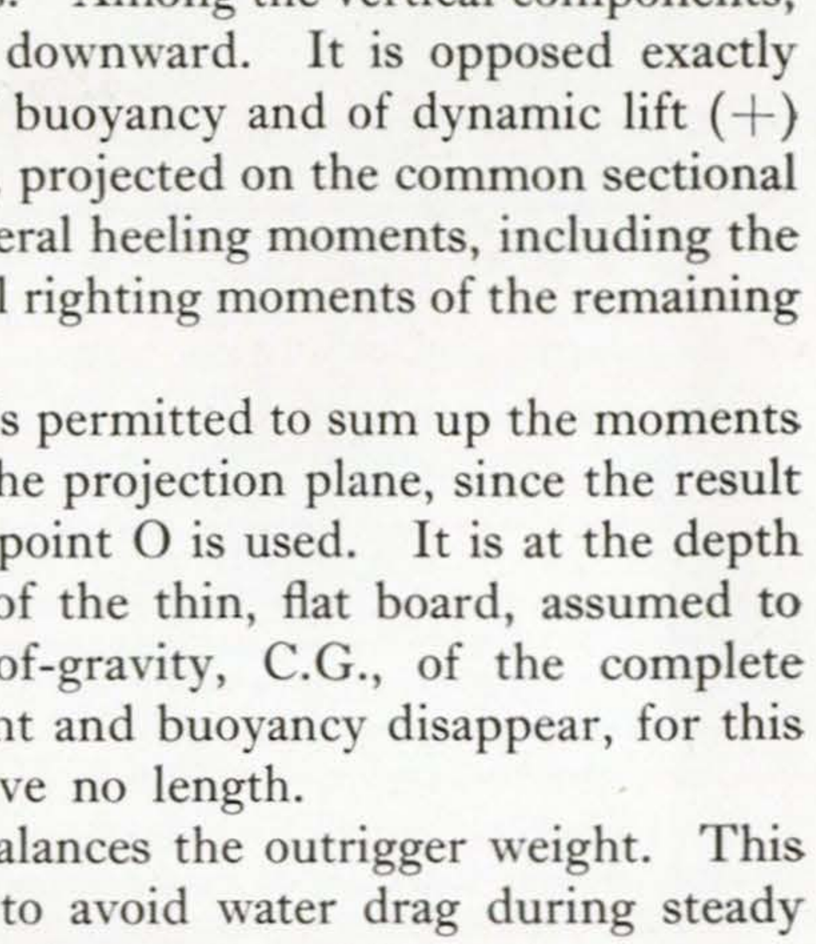


Fig. 2-B. Starboard Tack

It also makes a smaller contribution toward stability during acceleration. However, since the sideways component of steady state motion is so rapidly accomplished, no more than a slight lateral bobble would occur even if the floatation were not in the water during this period.

The board may move in and out of the water by wave action, thus changing it's immersed area over quite a range, without changing the righting force or it's moment. As the board comes out of water, it's side-slip increases. This is equivalent to a larger angle of attack in respect to the resulting direction of travel. This larger angle of attack compensates for the reduced area. The righting moment is substantially unchanged up to the point of "stalling." This does not occur until the angle of attack becomes greater than about 15-degrees. The original angle of attack should be only about 4-degrees to produce the largest lift-drag ratio of which the board is capable.

In the full size experiments, over half of the board area could come out of the water and still provide good compensation for the heeling moment of the sail. Beyond this point, the crew weight should be shifted toward the outrigger. There is ample time to do this as is the case when any small boat heels.

The solution appearing on Fig. 2-A shows the requirements for no heeling at any strength of wind or boat speed. If the board's plane angle from the vertical is 45-degrees, the horizontal distance of the board's centre-of-resistance from the hull's centre-line just equals the height of the sail's C.E. above the board's C.R. At this separation, the waves generated by the outrigger and by the main hull do not strike the opposite hull. If either did, this would result in increased resistance overall. With an arm longer than this, one would actually heel to windward, rather than to leeward, in a puff of wind.

Fig. 2-B shows that, on the opposite tack, non-heeling continues to exist. This single outrigger need not reverse it's hull travel, when tacking, as has discouraged so many admirers of such craft.

There is an odd difference between the two tacks. The whole system is slightly dynamically depressed when the outrigger is to windward. The system is slightly lifted when the outrigger is to leeward. In practice, little difference is noted between tacks. The board is a bit more efficient when it's pressure side is uppermost This largely compensates for an increased apparent weight on this tack. Water does not tend to go around the lower tip of the board from the upper high pressure side to the other side at lower pressure. It is much like dirt in a shovel. This was observed on the model with powdered rosin suspended in the water.

Note that the above mentioned lift or depression is generated from the sail's non-productive side-force. The previous criticism of lift from planing hulls and foils was based on its dissipation of the sail driving-force component. This side-force lifting concept deserves more study by all of us.

A small difference in balance between tacks appears in Fig. 3. This can be rebalanced by slightly altering the position adjustment of the pivoted board, as shown, by an opposing pair of control lines. The board's centre-of-resistance should be swung a little more forward when the outrigger is on the opposite side of the boat than the wind. Snappy tiller action is advantageous during tacking as is true for any light boat.

Surface piercing foils often have two types of difficulties. One is "cavitation" and the other is air "ventilation." A large area board is used to reduce the pressure per unit area to avoid cavitation. Air ventilation down the low pressure surface, if present, often can be blocked by a "fence." This may be obtained through slightly immersing the outrigger's buoyancy form by a shift in the crew weight toward the outrigger. Neither of these two potential difficulties has appeared either in the model or at full size. Without the reserve buoyancy in the water, the board will totally ignore the presence of waves.

The entire outrigger should be as light as size and ruggedness dictate. While not employed in these tests, an inflated vinylized nylon shape might be excellent as the outrigger's light-weight reserve

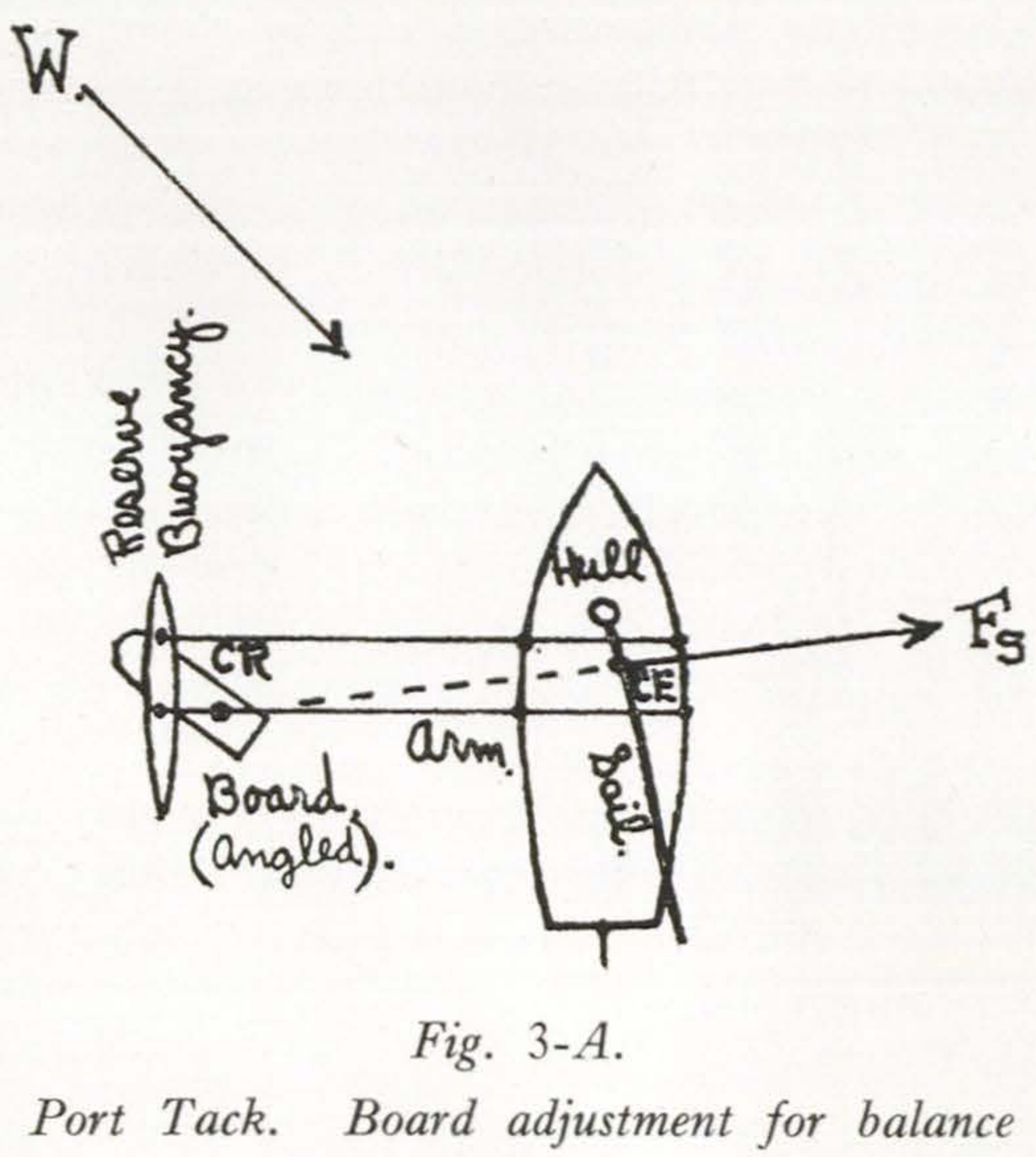


Fig. 3-A.
Port Tack. Board adjustment for balance

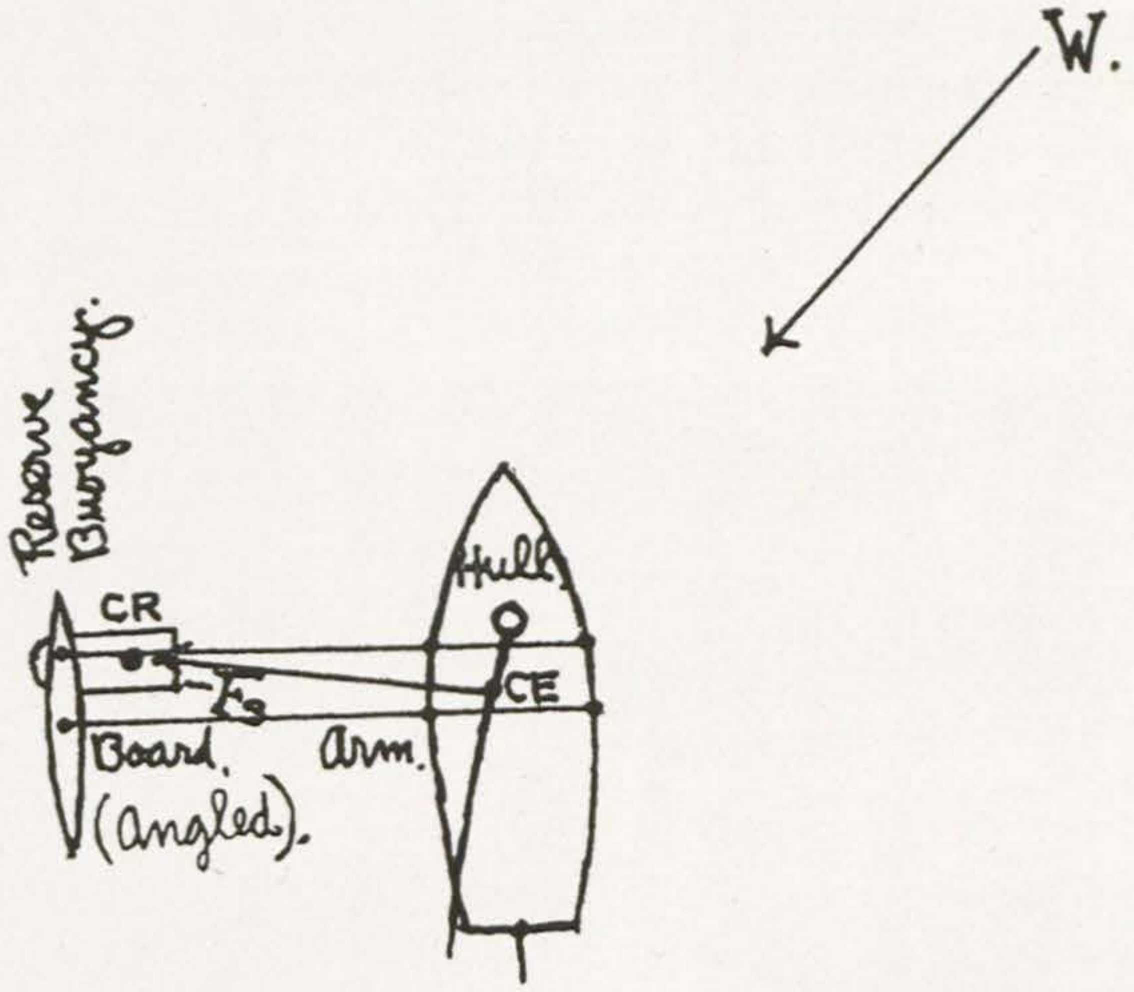


Fig. 3-*B*.

Starboard Tack. Board adjustment for balance

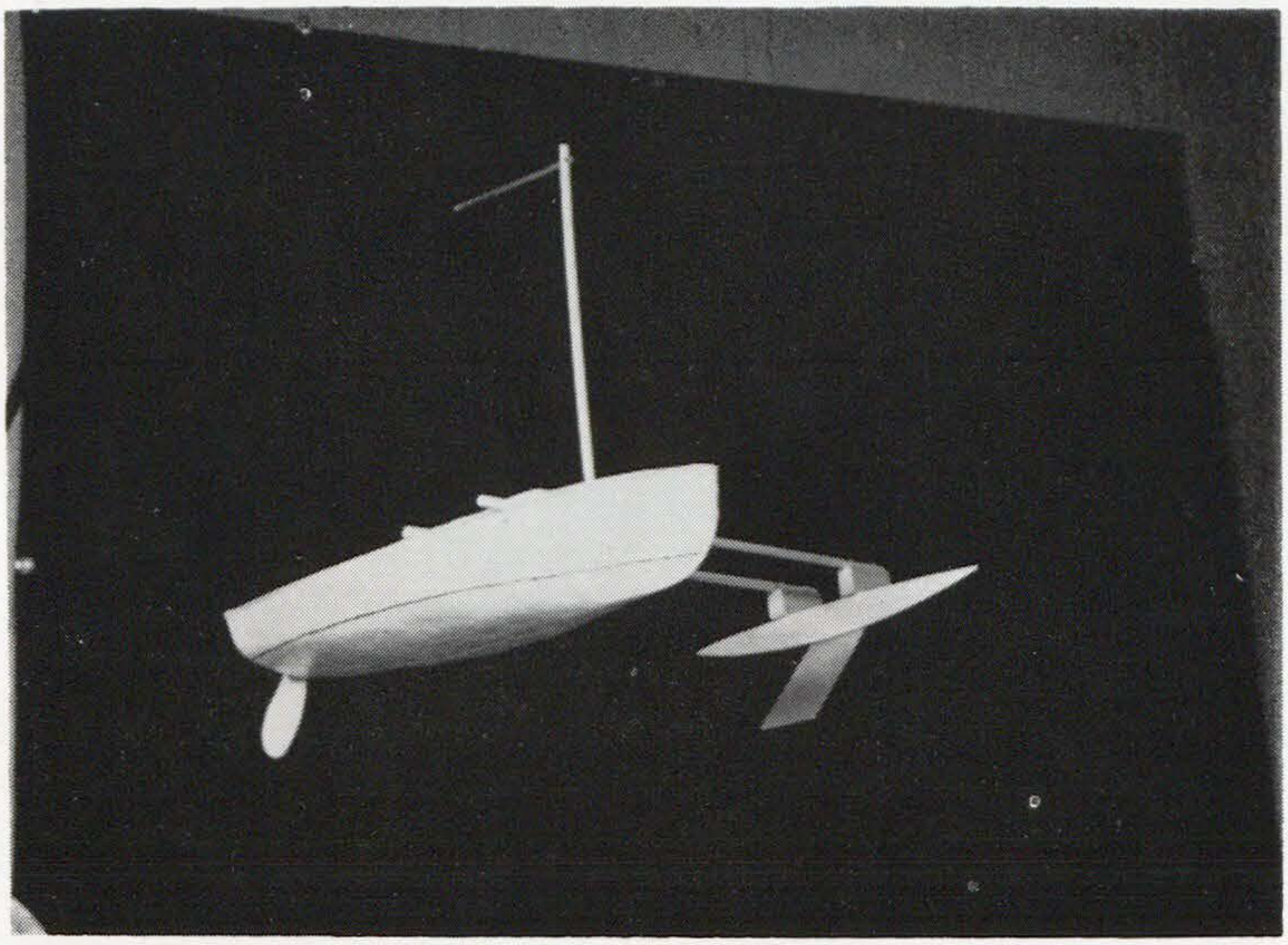
floatation. As to size, I believe that the buoyancy form should be small enough to allow large waves to gently break over it rather than absorbing the shocks of riding the wave profiles. The float, used in the present experiment, was larger than appropriate for racing. A cruiser, insisting on complete safety off-shore, may desire a large outrigger. It's totally-immersed effective buoyancy might be made equal to it's out-of-water weight to provide the same degree of stability on a lateral roll toward either side when dynamic stabilization is not available.

For practical reasons of lateral spread, John Stoddart has kindly suggested that users may want to make the outrigger's arm a hinged, folding pantograph. This would be useful in entering slips or when auxiliary power is employed in narrow channels.

I will not burden this writing with the extensive details of tank test data. Model work led to a full size trial on the International 12-foot Dinghy described by the writer in A.Y.R.S. No. 40. This was chosen because of the extensive data that exists on this hull. Any sailing craft could have been used. One having a high value of length over beam would be preferable for speed since main hull lateral stability is no longer important.

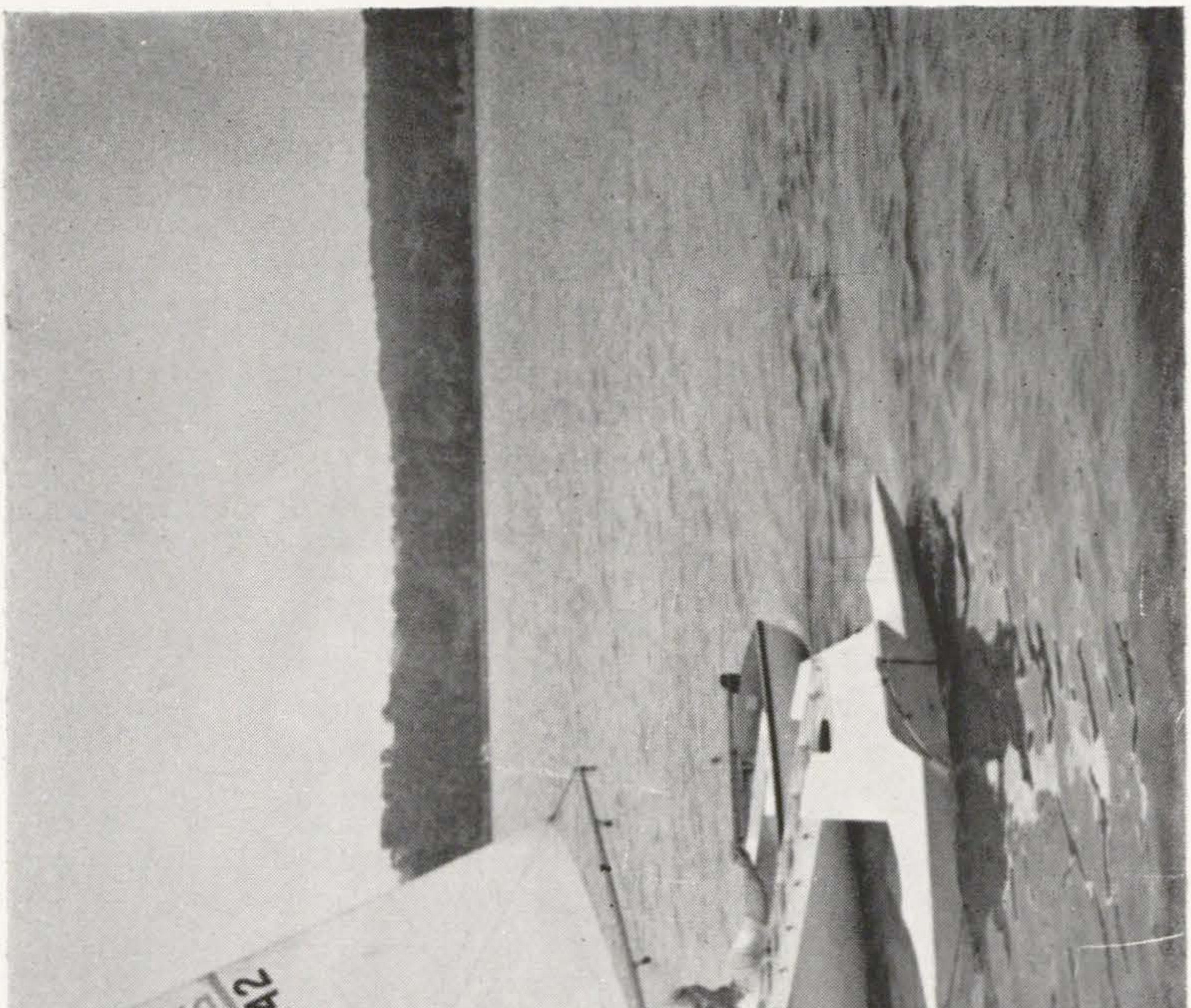
Every performance characteristic of the model, including increased speed to windward and when reaching, was confirmed at full size. Fig. 4 is a photograph of the dinghy model with outrigger.

Fig. 5 is a photo, including a smile of success, of it's full size counterpart under sail and using a 13-pound aluminium ladder as the outrigger arm. The reserve-buoyancy form and the board, for this experiment, were made of water-proof plywood. The hull's regular centre-board was not used.



The principal gain in speed seems to result from increased sail drive through non-heeling. For example, if a conventional, strong-wind, windward heel of, say, 20-degrees is avoided, the sail drive would be greater by approximately 13 per cent. A 30-degree heel avoidance would gain 33 per cent. These gains are far larger than possible reductions in hull resistance through being sailed upright. Avoiding wave-interference between main hull and outrigger is worth something in speed. Also, a minimum of increased weight and wetted surface is tolerated when only a single small outrigger is used. All of these factors give the structure advantages over catamarans and trimarans.

My hesitance in showing the tank curves, of the original boat versus this hull and sail with the added non-heeling outrigger, is that, for best windward sailing, the original boat had a centre-board which tested to be too small. This was rectified in the outrigger with a startling improvement. For this reason, a comparison would appear to be excessively optimistic.



I must mention the only criticism I have heard about this outrigger project. A teenager remarked, "What are you trying to do, ruin sailing? I like to heel."

Future Experiments

Since sails with curvature are better than flat sails, the same should be true of boards. This has been the experience in two of my other tank projects, one of which is now being observed in full size tests. As a result of model work, a study at full size of curved, thin-plate, angled boards on outriggers is planned for the future.

Two boards, each shaped for a particular tack, will be used one at a time. These will be located at each end of a self-sliding, lateral arm. Each will have its own separate reserve buoyancy. This is because self-buoyant, *thick* foils, in water (also in air), are known to "stall" too easily at sail-boat speeds, thus ruining their lift-drag ratios.

The above thick foil "stalling" or "separation" is revealed in low-speed wind tunnels. In high-speed wind tunnels or in aeronautics, this does not occur so easily. A model airplane with the thick wings of its full size counterpart probably will not fly. Thin wings must be substituted. Nature provides insects and the smaller birds with thin wings. Fish have thin fins except the largest.

With the above automatic sliding outriggers, a high degree of directional stability will exist since the board in use will be extended with its resistance far to windward on either tack. The sail force will lead away from this centre of water resistance, not toward it.

Even if A.Y.R.S. members like to heel, as did the mentioned teenager, the improved speed to windward and especially when close-reaching, for the same sail area, should prove interesting. With the heeling stability that has been achieved, one wonders what is the upper area limit for an enlarged sail plan.

HYDROFOILS

BY JOHN MORWOOD

The progress towards the best possible hydrofoil configuration is painfully slow. Progress, however, is being made. *International Aquavion* are at least using the three foil system which we in the A.Y.R.S. have shown to be correct. The main weight is taken on a surface-piercing foil system such as is commonly used for forward foils, while two forward surface-skipping foils which can dive through waves are used to give longitudinal trim. A supplementary after foil damps the pitching moments. This craft seems to me to be a distinct advance on the orthodox foil craft but it is unable to fly anything like as high as the Hook *Hydrofin*. The two points about the craft which could be improved are:

1. The "fussiness" and high resistance of the forward surface-skimming foils which tend to pull up the boat when they enter a wave.
2. The main foils, which merely trail along, could be replaced by inverted T foils which were fully submerged and set at an angle of about 20° of dihedral. This would save enormous expense and resistance.

The progress of original thought is desperately slow. Very few people indeed have the facility in any worth while degree. The number of times which we in the A.Y.R.S. have sorted and re-sorted out hydrofoil ideas is a case in point. If only one of us really had the facility for original thought, the answer would have been present almost at the beginning. Nor is it any good for governments or private individuals to try and bribe original thought from anyone by millions of pounds or dollars. Our good Professor Parkinson has clearly shown how absolutely stupid that is. Governments can only buy mechanics, not original ideas.

The ultimate hydrofoil system. Millions of tax-payers money have been put out on hydrofoils and some hydrofoil craft are working. Anyone, however, can see that they are "wrong" by their fusiness and limitations. In essence, they are the triumph of mechanics over insuperable difficulties. To date, only one hydrofoil craft has been any good and that is the Hook *Hydrofin*. Right in its beginning, it was a true piece of original thought and the mechanics which it ultimately needed were negligible.

The *Hydrofin* is as obviously "right" as other foil systems are obviously "wrong." The only improvement and simplification is to have a "canard" arrangement with a single foil forward with a surface "feeler" and two inverted T foils to take the main weight. With this, one would have the ideal and final hydrofoil arrangement suitable for sail or power. The mechanical and practical modifications, can be left to mechanics.

The politics of hydrofoils. In the nineteenth century, when a man invented a machine, he built it if he could. If he had money, he made it and sold it. If he had not, he tried to get some manufacturer to make it for him and pay him royalties. Nowadays, he is forced to try to sell it to his government. Now, civil servants and civil servant scientists are not the people to understand a piece of original thought. They thus obstruct the adoption of the device, or if they accept it, they will happily spend a few millions on it, after which they will consider that their job is done. They will not have seen the need for the device or even carried out the trials in any way which could have shown the need.

During the last war and shortly after it, governments spent vast sums on hydrofoil craft absolutely blindly and some mighty weird monsters were produced. However, because the motives were those of civil service expertise and not the right ones of producing a hydrofoil craft which worked, the process very soon ground to a standstill. The objectives were firstly to spend as much money as possible to enhance the prestige of their civil service departments and secondly to show that the inventions of their own subjects were better than those of the "foreigner." On the whole, from the public interest, I prefer the nineteenth century system, though it produced some very poor and disgruntled inventors.

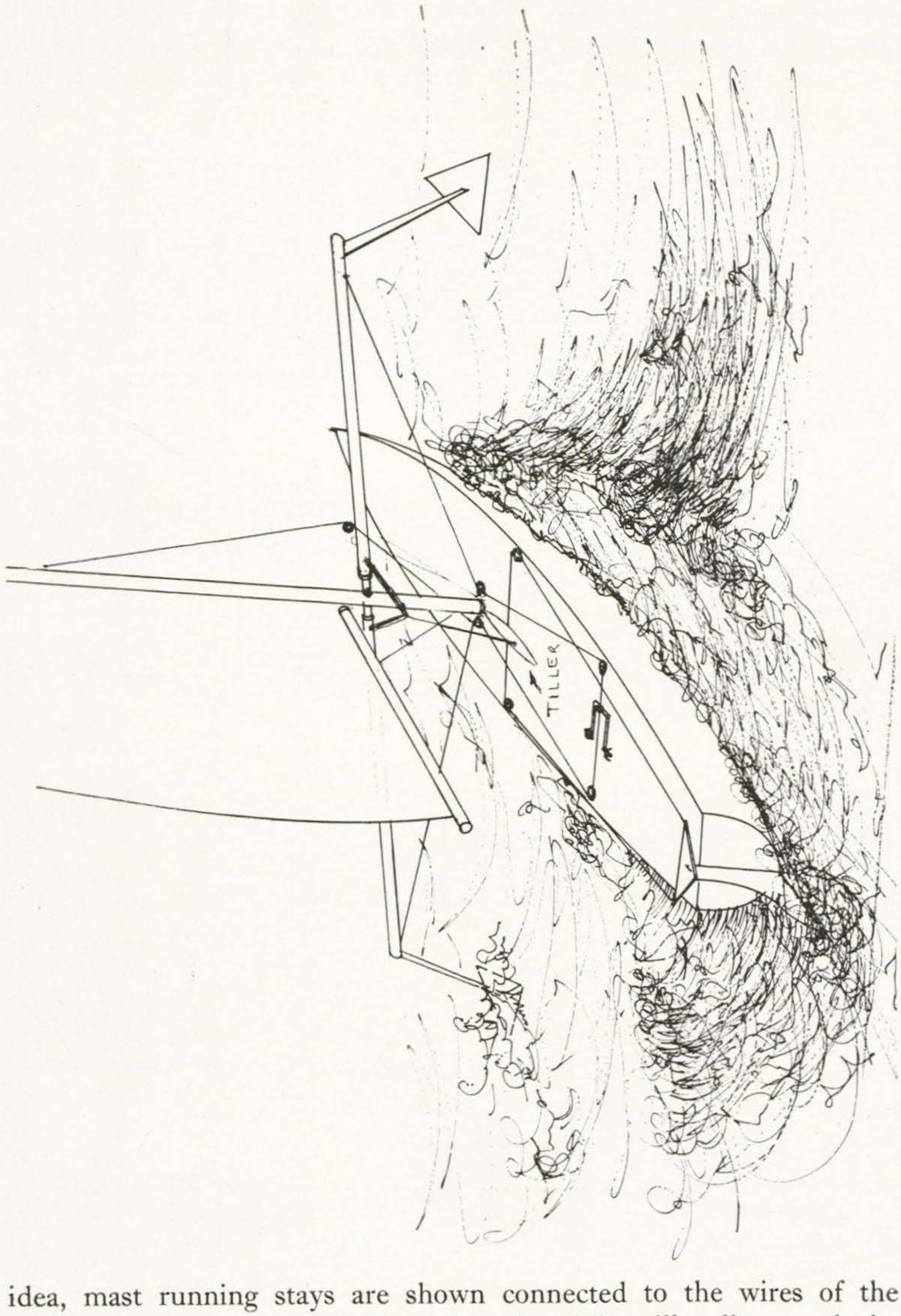
The history of the Hydrofin. Just after the war, Christopher Hook joined the hydrofoil circus with the *Hydrofin* to find Sachsenberg, Carl and Baker in the field against him. The Europeans were committed to Sachsenberg. Carl and Baker were Americans. The U.S. Navy spent £500,000 on a *Hydrofin* landing craft but should have ironed out the mechanical side with a 16 foot craft. By their very nature, hydrofoils are priced out of the private market unless the foils are made of wood and fibreglass and so far, no one has used anything but light alloy or steel for the larger sizes. The only field where hydrofoils have had even a limited success is in the passenger ferry services and somehow, the *Hydrofin* has never managed to get in. The reason for this in my opinion is that Christopher Hook has never allowed the mechanics to "play" with the *Hydrofin*. If any firm was to use the *Hydrofin*, Christopher insisted on having control on what was built and, as the technical boys were not going to have their fun out of it, they refused to accept it at all. However, as all the main patents have run out, we are free to make *Hydrofins* and A.Y.R.S. members could well try some models to see if they can come up with a good answer to the problem.

Summary. Several different hydrofoil systems have been made to work but in my opinion, the Hook system but in a "Canard" form, will ultimately prove to be the hydrofoil system of choice.

HYDROFOIL STABILISERS

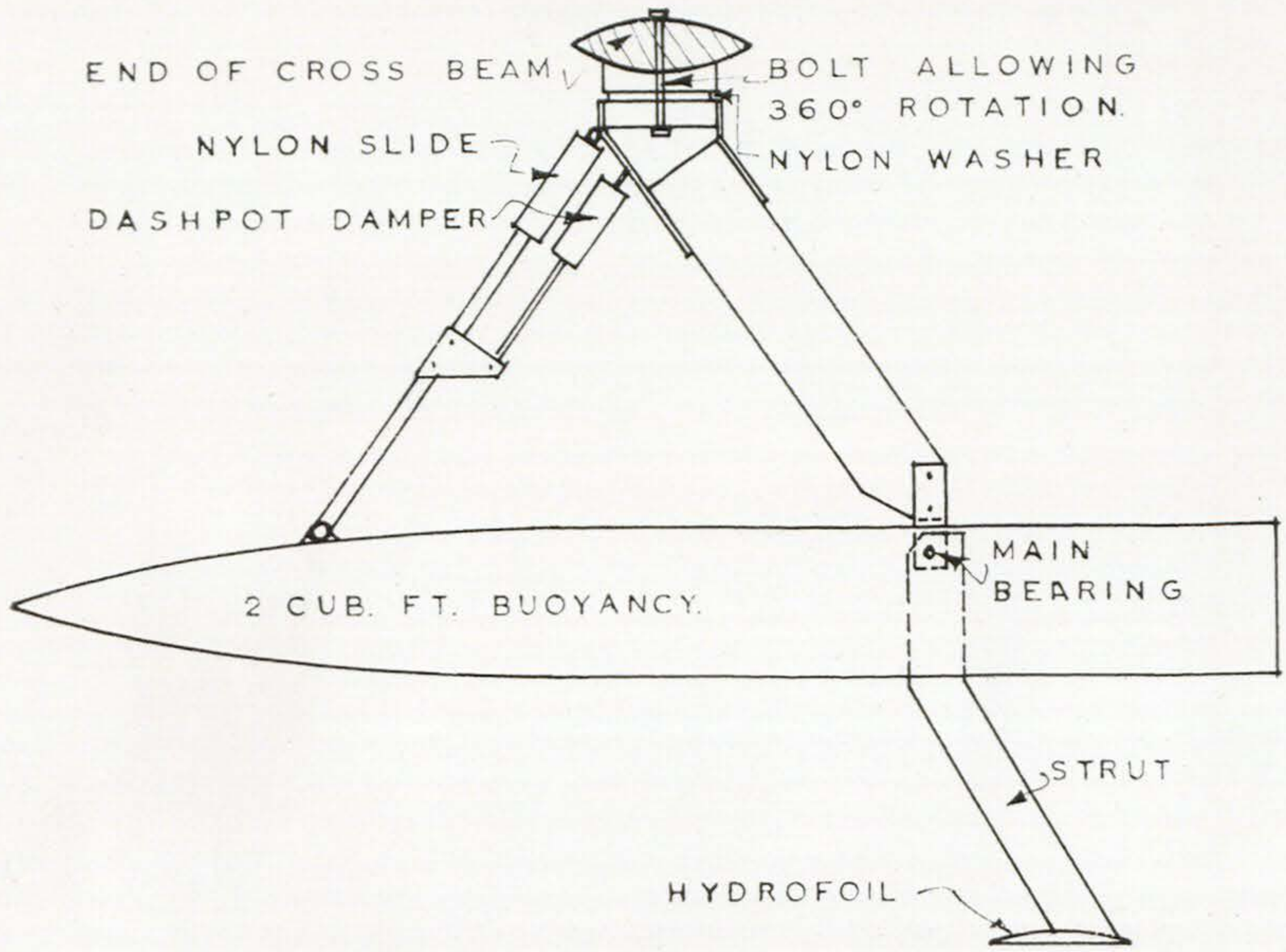
BY JOHN MORWOOD

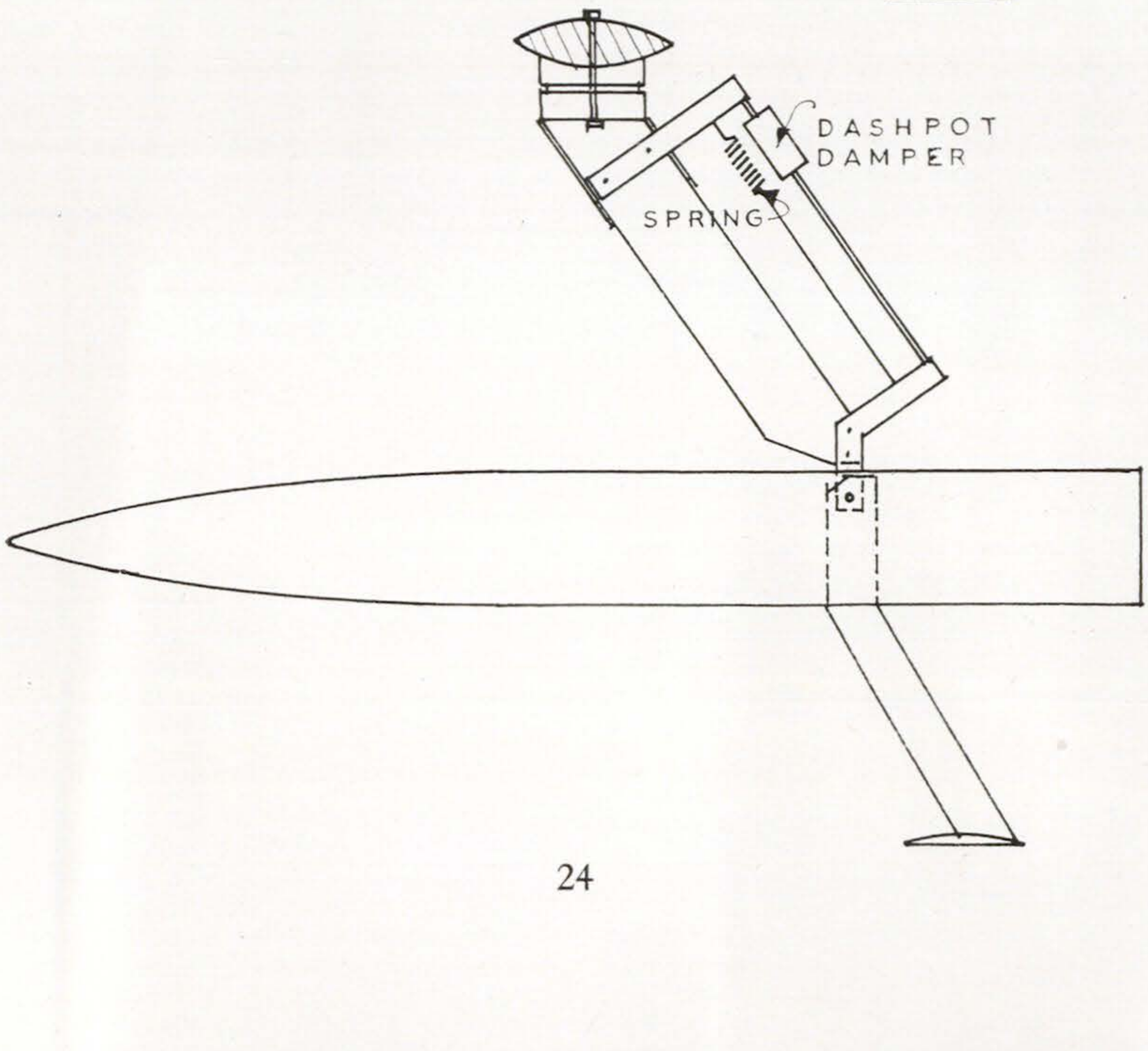
It appears that the stabilisers of my *Rysa* design are not quite clear. The drawing shows how the angle of the thwartships beam is controlled by two wires and an overcentre strut. To complete the

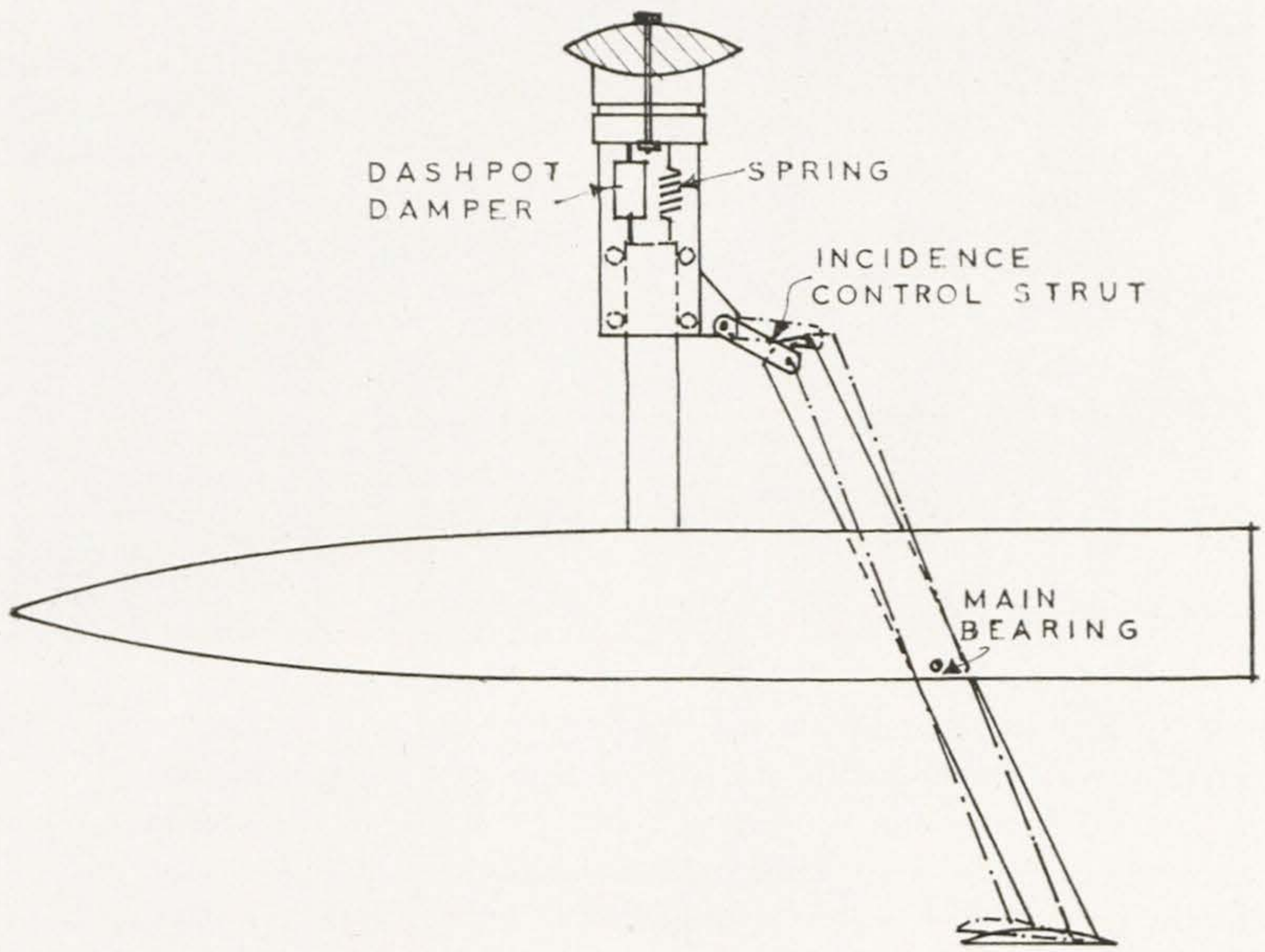


idea, mast running stays are shown connected to the wires of the opposite sides, thus abolishing shrouds. The tiller lines and the incidence control of cross beam are controlled by a single horizontal "joy stick."

In my opinion, outrigged buoyancy will not be necessary for light winds because the capsizing rate will be slow enough to let the crew balance the craft upright. However, at least some people diagree with this and so I show three different methods of combining outrigged buoyancy with an incidence control mechanism which might be suitable for cruisers.





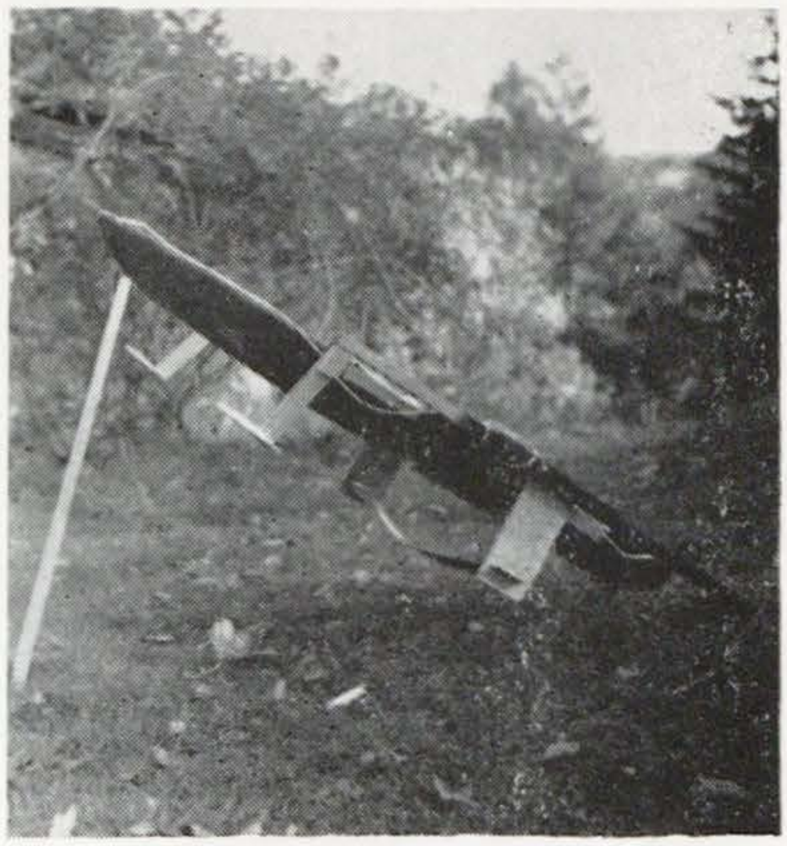


Dear Sir,

Since writing to you for information on the ideal shape of hydrofoils, I have surveyed as much research literature as I could procure on the topic. I subsequently designed and built a model hydrofoil craft 4 feet in length. It had fixed foils, two at the front, and the main load carrying foil aft of the C of G of the boat. The two front foils were designed to work initially as hydrofoils and later at full speed as planing surfaces. The change of incidence on all foils is due entirely to the attitude of the craft, although they have some initial positive incidence when at rest. The main foil which runs underneath the craft is designed solely as a hydrofoil with the immersed area varying with speed, i.e. as the lift increases, the boat rises and removes some of the foil from the water.

The progress of the model is as follows:

1. At rest.
2. The front foils produce lift and change the attitude of the hull. This increases the angle of attack of the main foil.
3. The main foil lifts the rear end of the model.
4. The front foils now plane on the surface completely clear of the water, the immersion of the main foil being dependent on the model speed.

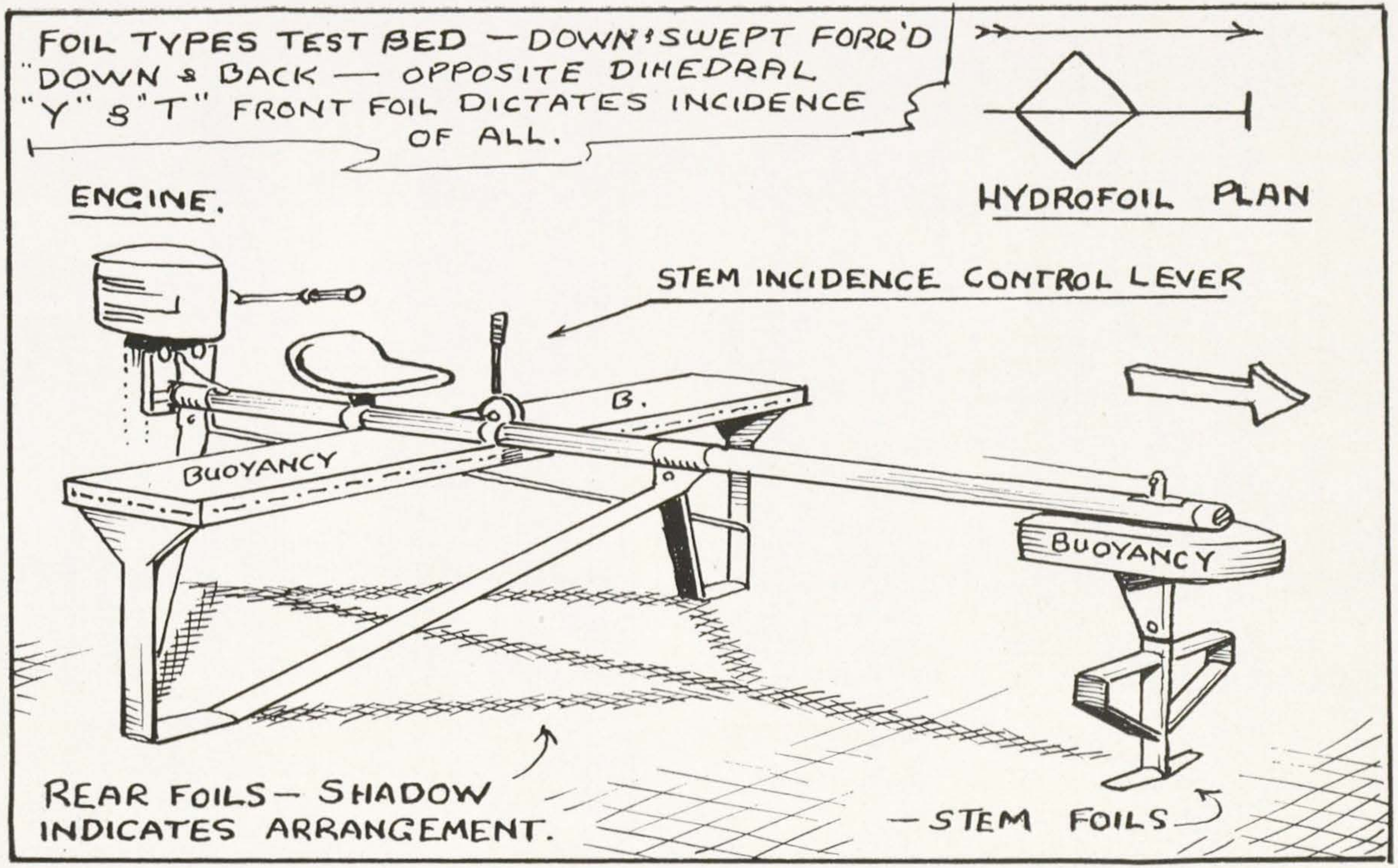
The model was driven by an air propellor and it was towed. It seemed very stable during the limited testing it was given. It suffered a lot of damage due to hitting rocks on its tests runs, which were carried out on the river Esk. However, the tests give some confidence in the proposed hydrofoil configuration, particularly motor propelled. By altering the line of thrust of the air propellor, I managed to produce a reasonable heeling moment which went some way towards simulating the effect of sails. (The motor driven propellor was mounted on a pylon 12 in. above the deck). This, of course, opened up a rather larger test programme and points to future development as under conditions of "motor at full power and boat at rest" the side force caused too much heel as, apart from the wooden support structure for the foils, I had no buoyancy in what would be the float position on a trimaran. However, if the boat was towed off before applying full power to the propellor, it heeled but continued to stay foil borne. At the present time, I have not continued development on this model. If you consider that yourself or any members mighr be interested, I am prepared to discuss the design in more detail and even continue with the development, when I have finished my current model which is intended to be a cruising trimaran.

ANDREW NORTON.

c/o A.Y.R.S., Woodacres, Hythe, Kent.

Dear Sir,

I am afraid my hydrofoil experiment petered out after considerable work and expense. It was probably too ambitious and complex for both my capabilities and my pocket! It was a test bed of different foil arrangements with no hull and an unorthodox approach.



ABOUT 15 FOOT

I had a single foil on the stem which anticipated one or two I've seen since and which was adjustable in pitch. I hoped this incidence would be transmitted to all the craft and the rear fixed foils and this seemed to be so but the experiments didn't continue long enough to confirm it completely. The forward foil shape was as in the drawing.

The "Hull" was a mast and the foils were attached using a "Dexian" wing of the plan view shown. Plastic buoyancy floats were fixed below the "Dexian."

The object was to study (1) sweep forward sloping foils, (2) sweep back sloping foils, (3) the normal high speed foils and (4) the front climbing foil. I had the lot plus the unusual front single foil arrangement.

The craft was tried out in Montrose basin over a course of two months and we ran into a series of difficulties and mishaps. I tested it with a diving suit on in case of capsize but the craft was certainly stable even at 1 knot. The main trouble came from the engine mounting and adjusting mechanism as the engine would not function fixed because of the back pressure on the exhaust when too deeply immersed. This necessitated a method of raising and lowering the engine as the craft rose or fell on the foils—we could not then afford to get a long shaft engine which was suitable.

I was stranded, swept away, dowsed and frozen on my off days which were few. The attending boat twice was holed and repaired and eventually sank when returning to Arbroath—fortunately my pals were picked up by the Montrose lifeboat. While awaiting a suitable engine we once tried towing the craft against the fast rip on the Esk and the whole thing came up on the foils at a very low speed (it was unmanned) and taught me that the best way to test hydrofoils is in a fast river tied to a bridge and unmanned—in this way it can be studied at leisure. We ran out of time and money and my pals (understandably) ran out of patience. We used a *Seagull* 4½ h.p. mainly and I hadn't the money to buy a more powerful one.

Despite our failures, I still believe the arrangement was sound though we didn't get a real chance to assess its capabilities or study the foil arrangements. I believed that a foil sloping down and forward into the flow would minimise bubble interference but did not carry on long enough to be able to do any proper observations.

I learnt a lot the hard, cold way. Now I believe that the minimum and simplest of foil arrangements are best and that the way to achieve this is to have adjustable telescopic foils which reduce appropriately in size with speed increase. This can be achieved by a device similar to the demand valve of an aqualung breathing apparatus—at depth, air pressure activated by deeper water pressure opens out the foils and the foils contract as they near the surface because of decreasing water pressure. It would be tricky mechanically but effective and automatic.

Well, there's the sad story and I hope Sir that I've entertained you if not enlightened you in any way.

Other foil ideas

1. Would not a Venetian blind arrangement of foils fixed across a dock entrance break down waves in bad weather and be much cheaper than dock gates or breakwaters? It may be better to have inverted foils to disintegrate waves upward in spray. It is worth a thought.

2. Another idea is to use small foils on fishing nets to keep the trawling bags open by pulling outwards without the use of poles or stiffeners of any sort.

3. I haven't seen a foil yet with a tail plane stabiliser as on aircraft. This could be useful for certain purposes.

4. I also worked out a method of foil propulsion that you may enlarge on. It is difficult to illustrate but is based on the flapping foil except that a number of foils flap not up and down but across and are complementary to each other. This arrangement could be set along the transom and be protected inside a "box." The fluctuating foils suck in and squeeze out water at high speed. This is rather complicated mechanically and may not be worth experiment.

BILL HOLROYD.

"Larn," Montrose Road, Arbroath, Angus, Scotland.

Dear Sir,

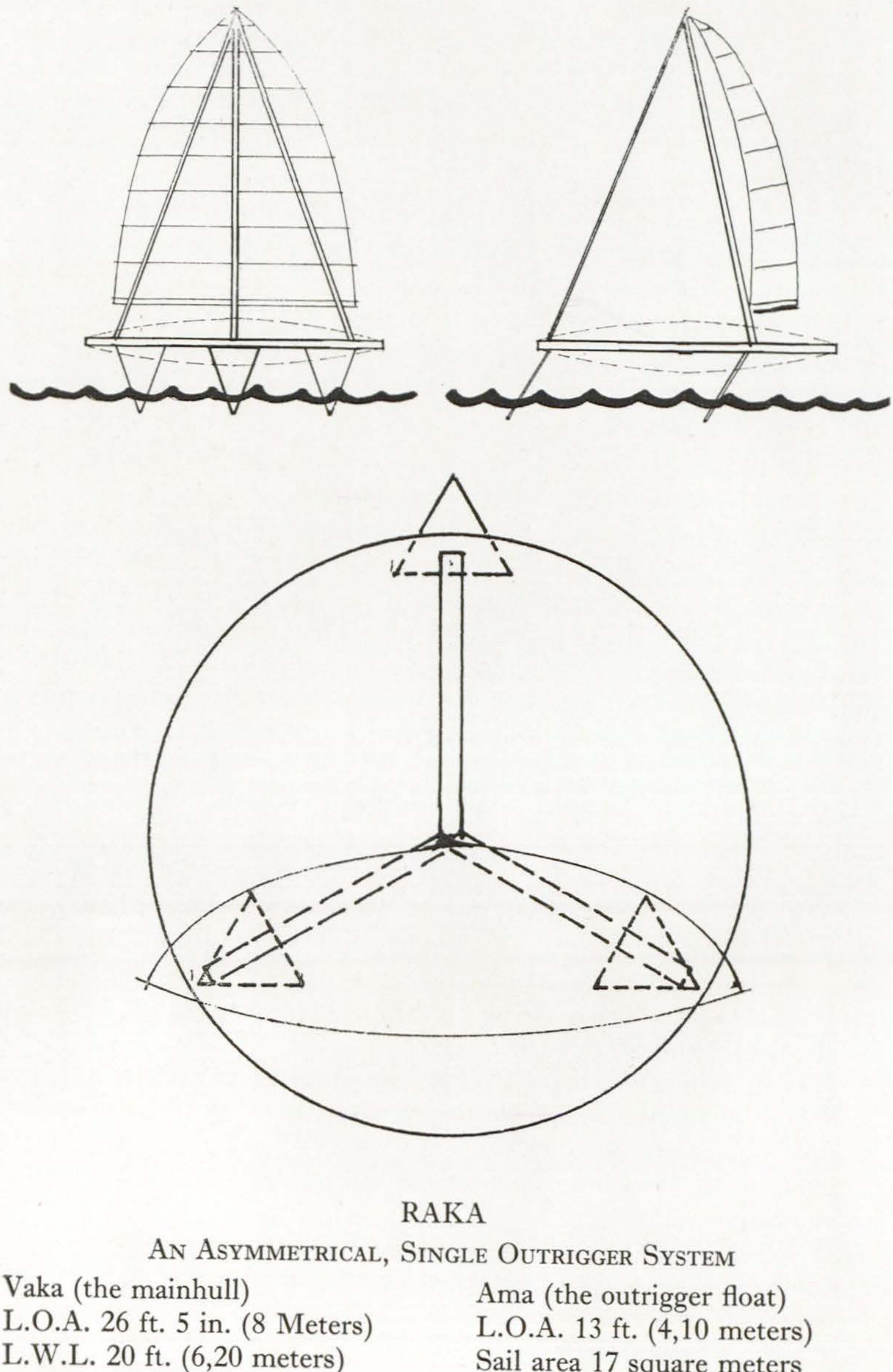
Dozing by the fire—when the new baby isn't crying—I have come to the conclusion that the simplest design for trying out aero- and hydro-foils would be something like the "Flying Flounder" shown on the enclosed sketch. Being no drawer of drawings, as Chesterton would say, I must resort to words.

This thing consists of a circular frame, 3 hydrofoils, a tripod mast and an A.Y.R.S. sail. On the periphery of the frame is an endless track—split tube—in which runs the "boom" and the boom sheets, which leave the track inwards at the point of the windward foil. Further, there are two sheets for the sail to adjust inclination and angle, or let fly. Whether of the cruising or racing type, this design would give me a lot of space, of which I'm very fond. Can you give me any ideas on suitable proportions for sail and foils.

P.S.—Alternative name, if successful, could be "Soaring Sole."

HELGE INGEBERG.

Eiksveien 52, Oslo 7, Norway.



RAKA

AN ASYMMETRICAL, SINGLE OUTRIGGER SYSTEM

Vaka (the mainhull)
L.O.A. 26 ft. 5 in. (8 Meters)
L.W.L. 20 ft. (6,20 meters)
Total beam 4 meters
Draught 1 ft. 2 in.

Ama (the outrigger float)
L.O.A. 13 ft. (4,10 meters)
Sail area 17 square meters

Designers and Owners: B. and E. Andersen, Holback, Denmark.

Taking its origin from what they call the "true" single outrigger of the Pacific, the Danish modernizing experiments have again blossomed out in the building of the 8 meters asymmetric single outrigger *Raka*, designed and completely home built by the twin brothers Andersen, Bent, the mechanic and Erik, the joiner with appropriate instructions in principles by A. E. Bierburg of Lyngby.

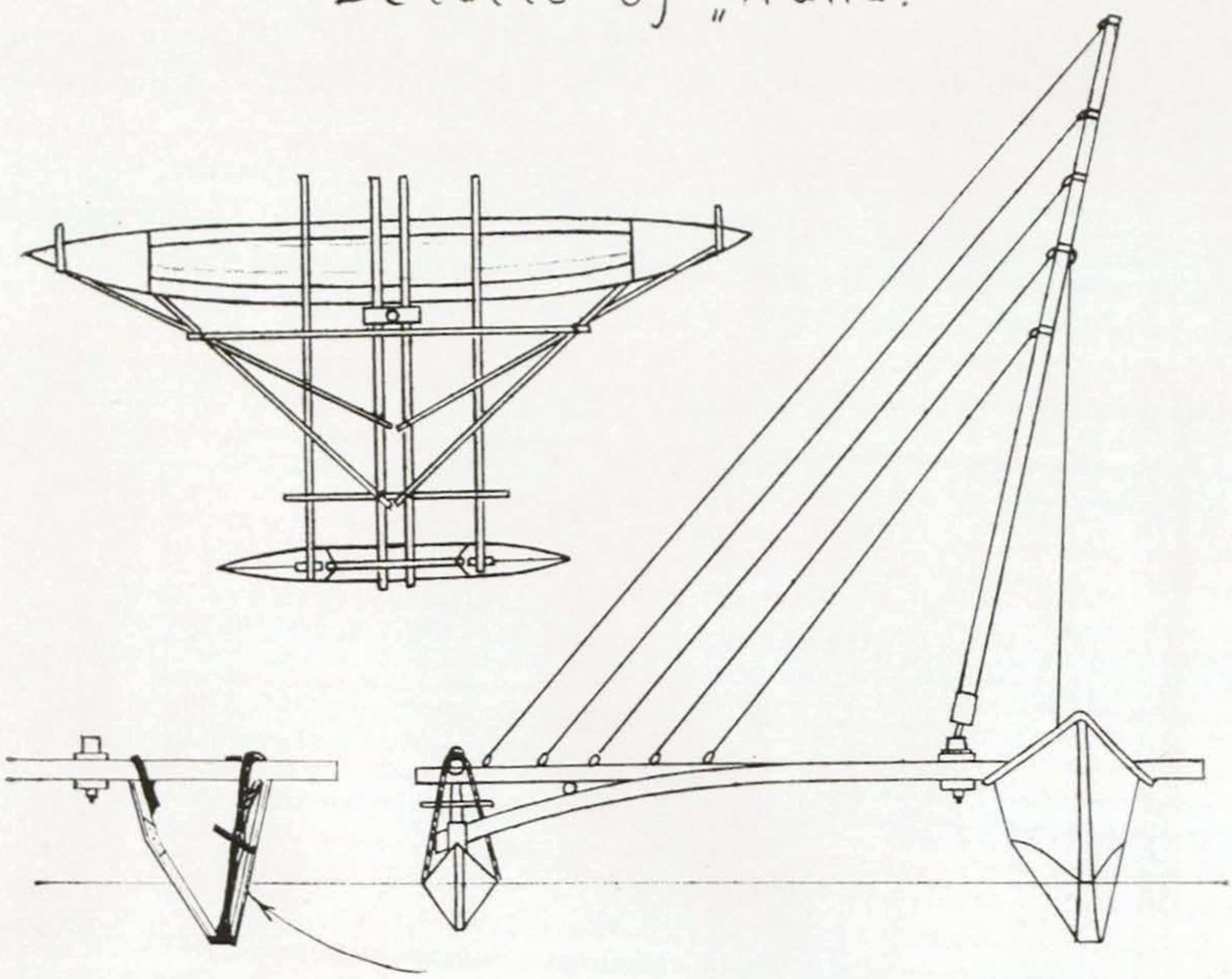
The Vaka (mainhull) is planked with waterproof plywood (Bodex) on frames and with chines. Both ends are decked with watertight bulkheads to make the craft unsinkable.

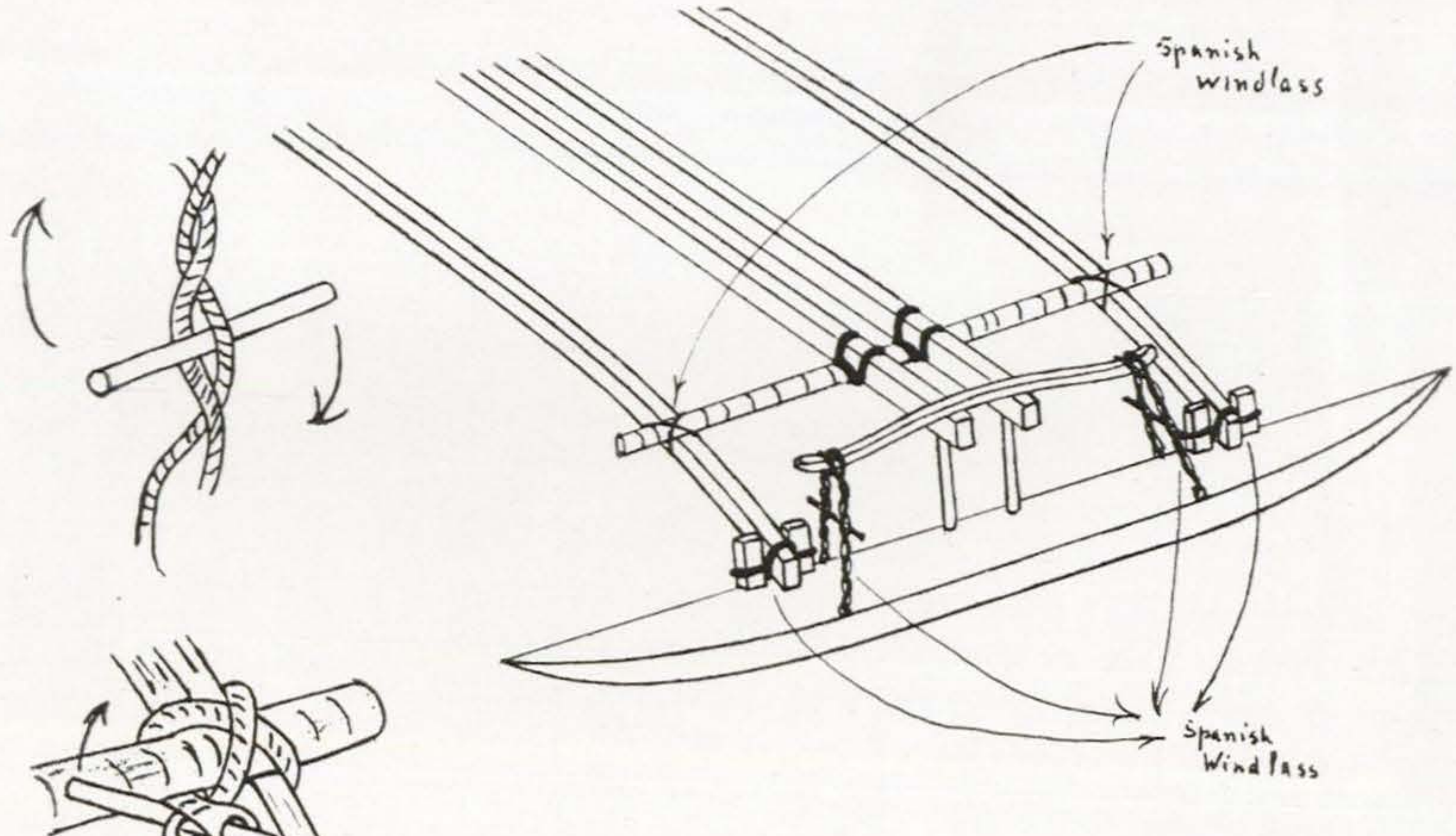
RAKA

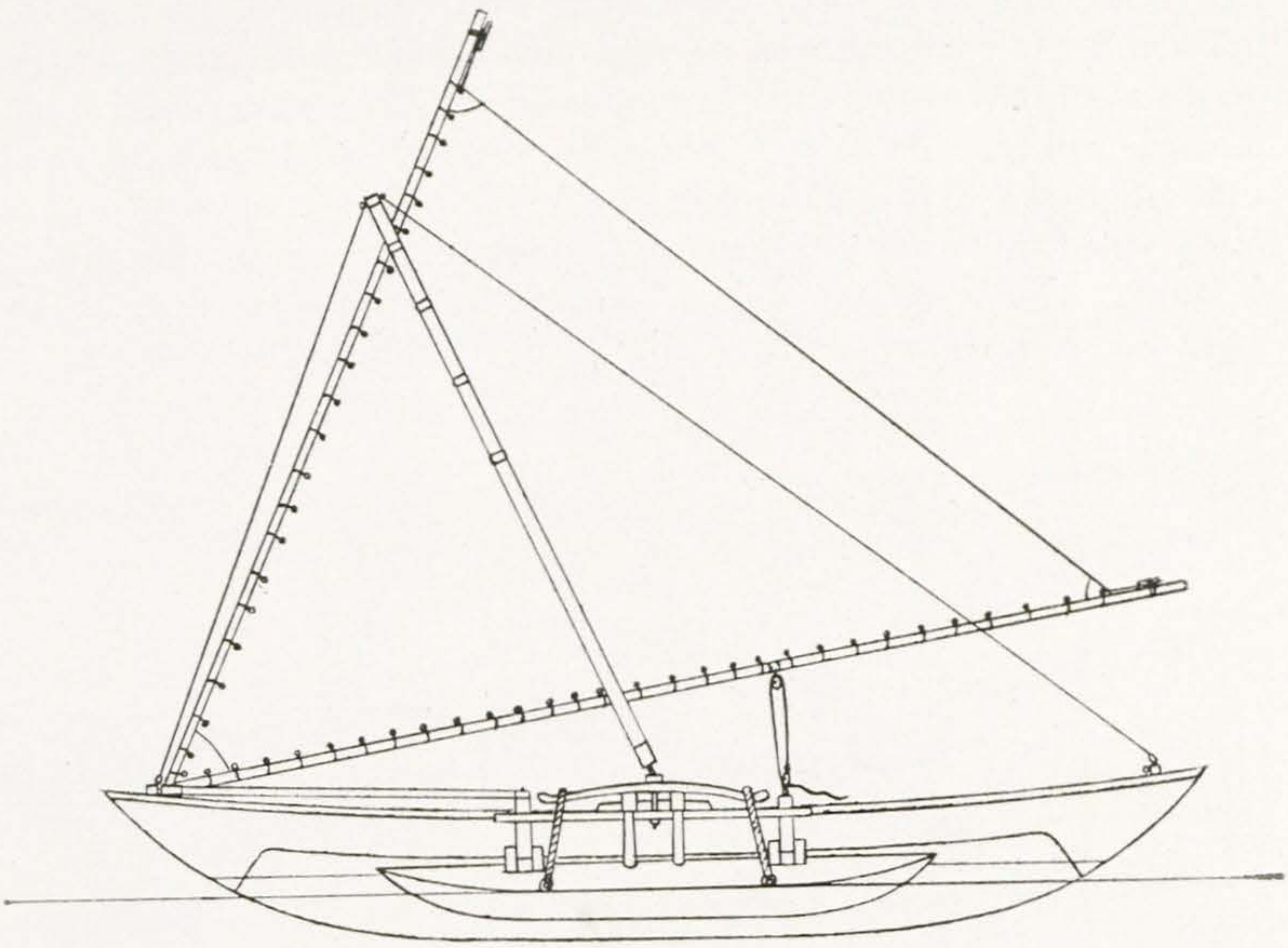
The Ama is planked in the same way but it is solid below the waterline to give weight while there is a lot of reserve buoyancy above this in case the wind should catch the sail on the "wrong side" and try to drive the Ama under.

The mast is spruce; the curved outrigger beams are ash and the middle beams are pine. The sail yard and boom are of bamboo. The running stays and all the lashings are in nylon, tightened by the traditional Spanish windlass systems. The connection between

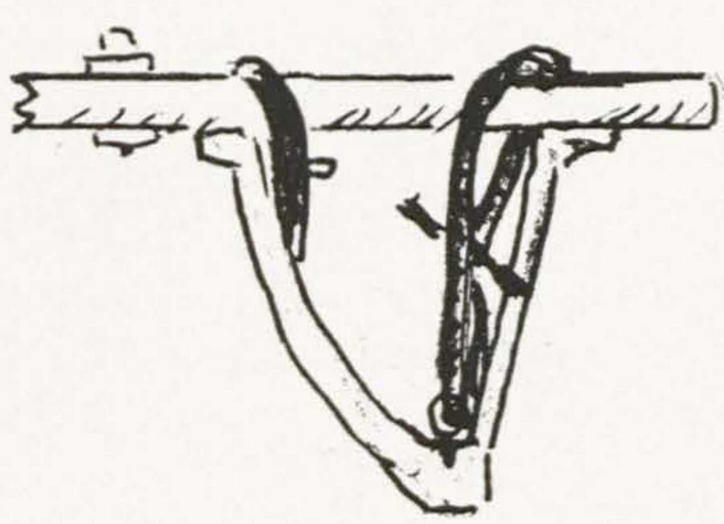
Details of „Raka."







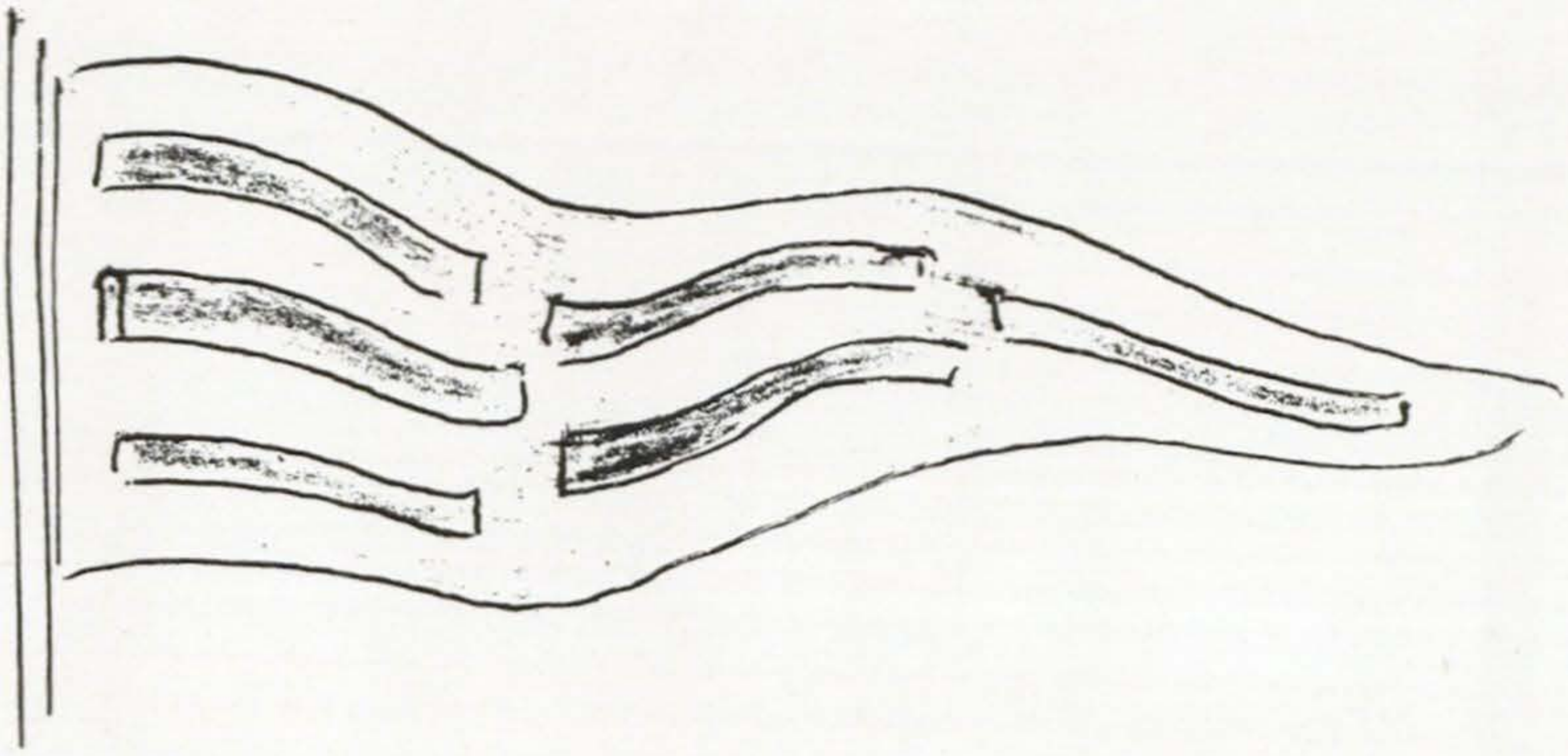
Vaka and Ama is a combination of the strong and elastic construction still in use by the sea-going canoes of Micronesia (Yap and Marshall Islands).



The ingenious Micronesian sail (apex down), the long and narrow asymmetrical mainhull with the straight, flat lee-side (very efficient against leeway) make the craft a fine and fast boat, sailing very effectively close hauled.

The outrigger float is kept always to windward and in order to change tack, the boat is stopped and the tack of the sail is carried from one end of the boat to the other end, the steersman also changes ends and the boat then sails off in the opposite direction to which she was sailing before. The manoeuvre takes normally but 30 to 40 seconds as described in A.Y.R.S. Nos. 29, 33 (*Itata*) and in 47 (The Prout Proa).

The trials with *Raka* were made over a distance of 18-20 sea miles under full sail and with a man on the middle part of the outrigger beams as an extra counterweight on all courses from close on the wind, through wind abeam to a near running course. In spite of the high and rough sea, the boat took in no water. With the wind astern, *Raka* sailed more steadily than the ordinary sailer in the same force of wind. Owing to the unique sailplan and the high sheer, *Raka* lifted her stern successfully.



The pennant of the Dansk Catamaran Klub

Raka is not made for real racing but for a long cruise on the open sea, so the sail area is not the maximum. Nevertheless, she does 15 to 16 knots (on an average 10 knots but at moments 20 knots).

With a well trained crew of 2-3 men, *Raka* will show herself to be a worthy member of the newly founded "Dansk Catamaran Klub" (Outriggers, trimarans and catamarans) when she will show her characteristic and symbolic pennant along the coasts.

TABUARIKI

A Polynesian Outrigger Sailing Canoe

Main Hull L.O.A. 14 ft. 1 in.	Outrigger Hull L.O.A. 11 ft. 7 in.
Main Hull Beam 2 ft. 5 in.	Outrigger Hull Beam 10 in.
Main Hull Draught 6 in.	Outrigger Hull Draught 4 in.
Draught, Daggerboard down 2 ft. 5 in.	Beam O.A. 7 ft. 1 in.
	Rig, Lateen Gunter
Sail Area 64 sq. ft.	Total Weight Rigged 172 lbs.

Designed and built by: John Partington, 34a Station Approach, Chipstead, Surrey.

Tabuariki, Weir Wood, October, 1964

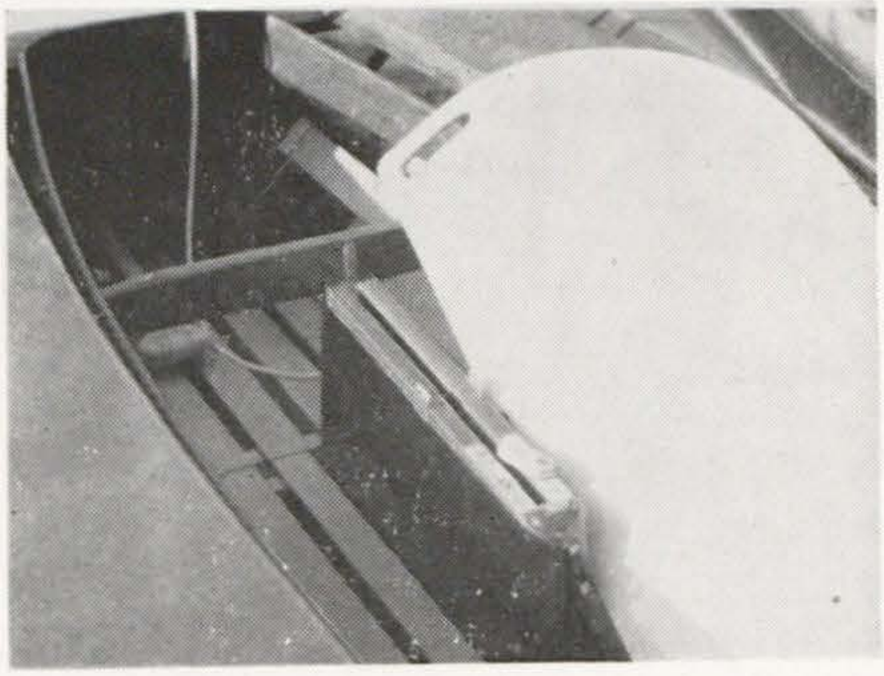
The decision to build a Polynesian Outrigger was made after studying as many A.Y.R.S. publications as possible that gave any relevant information on single outrigger craft. It was apparent from these that very few sailing outriggers on the Polynesian principle have in fact been designed and built to date, and of these the majority have originated in American waters. There appears to be no logical reason why this type of craft has been so neglected, especially in Europe, as the reports of the America boats built have attributed them with extremely good performances (Malibu A.Y.R.S. 29, Islander A.Y.R.S. 23, Ron Tiki A.Y.R.S. 16).

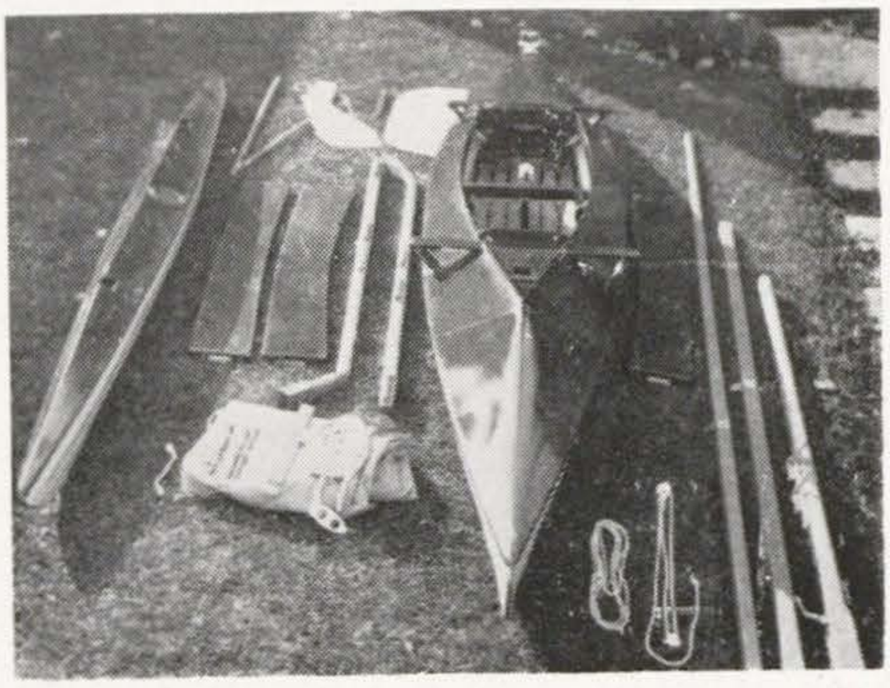
The single Outrigger has several distinct advantages over the equal hulled catamaran, especially with regard to simplifying construction and thus a saving on weight. Most of these factors have already been covered in John Morwood's article on "The Unequal Hulled Catamaran" (A.Y.R.S. 50) and had already proved to be true in the construction of *Tabuariki*. The mast is stepped to the hog and a single dagger board case fitted into the main hull, this incidentally simplifies handling having only one dagger board to raise and lower. Another advantage is that only a single tiller and rudder are needed thus eliminating the necessity of many feet of linkages and tiller extensions usually to be found on most Catamarans.

Tabuariki was based on a standard rigid framed PVC/canvas skinned canoe which had been built the previous year. The main reasons for this were to keep the cost and building time down to a minimum on a type of craft where there is such a limited design data available. It also gave a secondary purpose to the experiment to find out if this type of construction, which is basically light and strong, is suitable for a fast sailing craft.

After determining the basic dimensions required for the outrigger hull and overall beam of the boat, the first step was to strip the canvas decking from the canoe hull. This was considered to be too vulnerable to damage, and also by using 4 mm. marine ply for the deck the hull was made more robust. Before the new decking was fitted the hull had to be strengthened to take the mast step, daggerboard case and outrigger beam support frames. This was done by adding a $\frac{3}{8}$ in. ply false bottom across the hog and bottom stringers in three places, to take the thrust from these three major components.

The outrigger support frames were made of $2\frac{1}{2}$ in. by $\frac{3}{4}$ in. mahogany in the form of an inverted triangle, so that the top cross member came above the decking to allow the outrigger beams to be bolted to them. The daggerboard case was of standard construction except for the provision to take a rotating daggerboard, this was considered necessary with the canoe type of hull construction used, and my thanks go to W. Almond for this idea (A.Y.R.S. 47). However, it has been found in practice that the shear pin dowel tends to break too easily, especially if the daggerboard is pushed down too hard, with the result that the whole board disappears when most needed to say nothing of the fun and games retrieving it. If the dowel is made too strong





Tabuariki

Right: Showing separate components before assembly. Left: Main hull before decking, showing the strengthening struts, outrigger support frames and buoyancy

then it does not break when the daggerboard hits anything, also the broken dowel has a strange attraction for the daggerboard case slot, jambing the whole contraption solid! This problem was overcome by fitting a turnbuckle on top of the case to turn through the lifting hand hold on the daggerboard, and held in position by a ball catch. In the event of the daggerboard grounding the turnbuckle is forced off and the board is free to rotate under the keel, giving another foot of clearance to get out of trouble with, and with no resultant damage to the hull.

The outrigger hull is built on exactly the same principle as the main canoe hull, but with double frames to take the outrigger beam ends. Also about 75 per cent of its volume is filled with expanded polystyrene to give buoyancy should the PVC/Canvas skin get damaged. Polystyrene buoyancy is also built into the bow and stern of the main hull for this same reason.

The outrigger beams are made of $2\frac{1}{2}$ in. by $1\frac{7}{8}$ in. solid ash, each beam being shaped and tapered to an angled joint, with the outer end held into its recess in the outrigger hull deck by a single $\frac{1}{2}$ in. brass bolt. Two 1 in. bolts are also used to fasten each of the beams to its respective support frame on the main hull. Ash was selected for these beams, as although it made them 2 lbs. heavier than if they were made from alloy tubing, it simplified the method of attachment to the hulls and its natural flexibility is a great asset in allowing the outrigger hull to work in a seaway. Each beam projects beyond the main hull on the opposite side to the outrigger hull, i.e. the port side, to facilitate the fixing of a side deck between them. Two side decks are fixed between the beams on the outrigger side of the main hull.

Originally it was intended to use a lateen rig of about 65 sq. ft., the main reasons for this being simplicity, the sail could be carried rolled on the boom and spar ready for rigging, and the unstayed mast quick to rig. It was however found that the mast required would be too long to carry inside the main hull, and also the long boom and general inefficiency of this type of rig decided on the use of a modified form of lateen which I have called, for want of a better description a "Lateen Gunter." The boom is shorter and carried on the mast by a gooseneck as is the spar also on a gooseneck at the tack, this arrangement permits the use of a shorter stub mast and was generally considered to be more efficient, and easier to handle than the standard lateen rig. I must however admit that the idea was prompted by the rig used on the Californian Malibu outrigger.

It was found almost impossible during construction to get the outrigger hull levelled in relation to the main hull, and this was eventually overcome by completing the outrigger beams except for the angled joint, and then taking the complete boat up to the Thames and cramping the beams together. This allowed adjustment of the angle and length of the beams whilst on the water until the correct relationship was found between the two hulls under various load conditions, this exercise brought several amazed looks and a near ducking when one of the G-cramps slipped.

As the rig was completely non-standard it was decided to have a shot at making the sail. Terylene sail cloth is not the easiest of materials to work with and 65 sq. ft. of it in a living room, fighting to keep it straight through a domestic sewing machine is not recommended as the best way to continue a happy marriage. However we eventually ended up with a large amount of terylene resembling the shape of a sail, which considering that all the seams were stuck together with copydex adhesive to keep them straight while sewing, the sail sets remarkably well.

Tabuariki was completed by the end of August, and the car roof rack modified to take the two hulls. Transportation is easy as all parts stow inside the main hull, with the exception of the boom and spar which go between the two hulls. Assembly time from car top to water is about 20 minutes. Because of the late completion sailing experience obtained so far is limited, however several obvious conclusions were drawn from this so far. Performance of the hulls in a seaway is good, with very little water being taken into the cockpit even when a hull goes clean through a wave, this can mainly be attributed to the shape of the canoe style deck which throws the water off and also cuts the windage to an absolute minimum. Stability and balance obtained were adequate for the sail area carried, the draught of the outrigger hull being easily controlled by sitting out on the portside deck. When on the other tack no difficulty was found in preventing the outrigger hull flying, even though the side decks are only halfway out on the outrigger beams.

There are however several modifications needed to obtain the maximum performance and make the boat safer. The canoe stern is a disadvantage in that it sits down in the water with the aft deck nearly awash once any speed is reached, this gives a very turbulant wave form from the aft sections of the hull. It has also been established that considerably more sail can be carried and that more buoyancy is needed in the main hull, as in the event of a capsize although the boat is easily righted the main hull is completely awash and cannot be bailed out.

Modifications to rectify these faults are being carried out and it is hoped to have them completed for this coming season. The main hull lines are being modified by reducing the overall length and building in a transom, this will give more buoyancy aft and it is hoped improve the wave form. Buoyancy compartments will be built into the complete bow and stern sections and the rig changed to a sloop with fully battened mainsail and jib to give a total sail area of about 110 sq. ft. The addition of a jib should improve the boats ability to go about. It is also likely that a sliding seat will be fitted to enable the helmsman to use the full beam to sit out over the outrigger hull, this will then give practically the same stability as a cat having a 7 ft. 6 in. beam.

It would be interesting to establish whether in fact a single outrigger classifies as a catamaran under the I.Y.R.U. rules, as *Tabuariki* is within the restrictions of the "A" Class ruling and nothing states that the hulls must be of equal size. One final advantage of *Tabuariki* is that on days when there is no wind, the main hull can still be used as a paddling canoe, also for those who are less interested in speed this type of craft would make an ideal camping canoe, being sailed when conditions allow, the outrigger being detached and left behind, reverting to a standard paddling canoe for narrow or shallow waters.

G. Sirkett's Proa

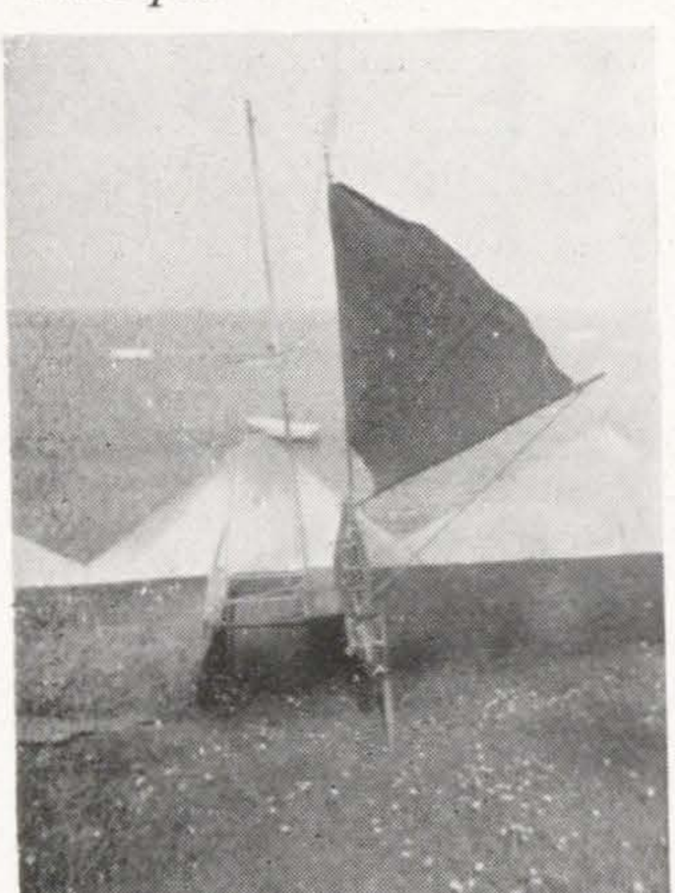
Dear Sir,

I enclose a photograph of a model flying proa which I have made and am sailing. I made it to scale as nearly as I could to correspond to

Taylor's design of 1962 in A.Y.R.S. No. 47 but using a 5 foot long hull like the Prout proa mentioned in the same bulletin, as I had, it so happened, made the latter already from copies of the same native design reproduced in H. C. Folkard's "The Sailing Boat: A Treatise on English and Foreign Boats and Yachts," a very interesting old book published in 1870.

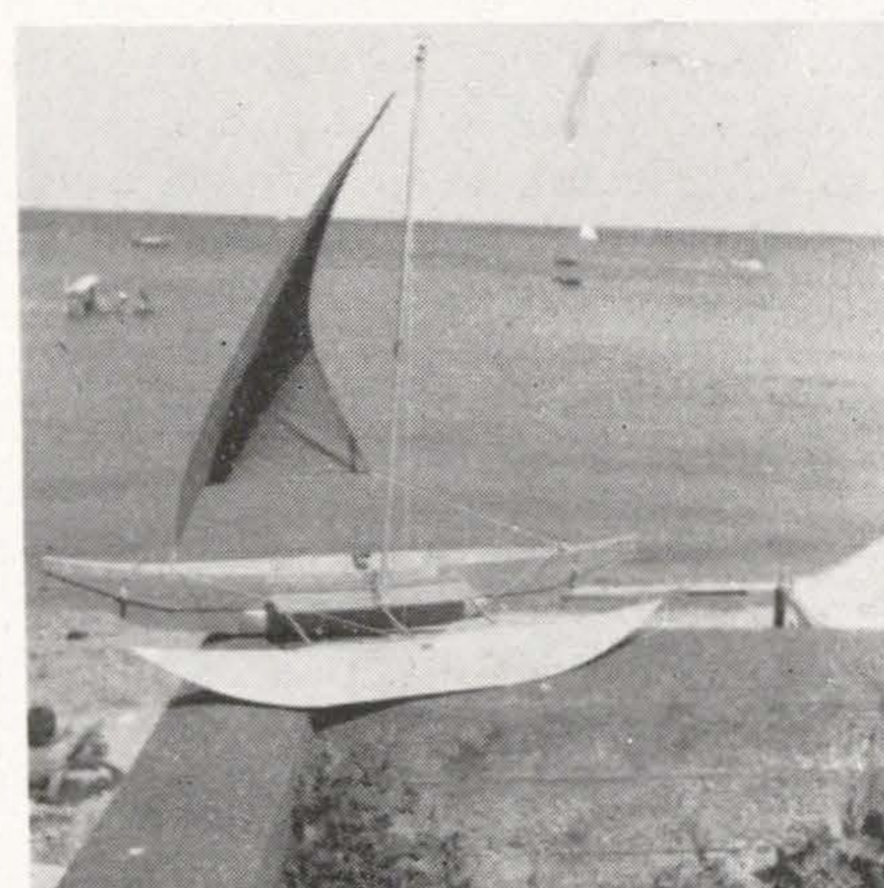
With all due respect to J. S. Taylor, whose full scale versions he says perform so well, I can only say that I was not so fortunate with the model. As quite moderate gusts capsized the boat in spite of the aerodynamic outrigger, I reduced the height of the mast by 20 per cent and cut off the bottom of the sail. She still capsizes now. Also, possibly because my home made sail to Taylor's design is badly cut, she would not sail to windward. I remedied this by giving it a boom: with this the performance, both on and off the wind, was fast and about equal to that with a native lateen-type sail as used in the Prout-built proa. My lateen is shown in the enclosed photograph (I fitted two Chinese-type bamboo battens which I think improved its performance slightly. With this sail too, however, the boat still capsizes in quite moderate gusts).

Note paddle rudder at stern



After reducing mast

Paddle-rudder amidships



Before reducing mast and sail

In fairness to Taylor, I should point out that he may have himself abandoned his claims that his aerodynamic outrigger makes capsizes impossible for at the head of an article by him in "Yachts & Yachting" for 23rd August, 1963, there is a note (possibly Editorial) to the effect that it is unwise to attempt to fly the outrigger, and this was presumably written later than the article about Taylor's 1962 design reprinted in A.Y.R.S. No. 47 which advocated the practice. For my part, I think I gave the outrigger every chance of proving itself the equal of the wind-on-the-sail, as can be seen from its size as shown in my three photographs (enclosed herewith). To correct excessive weather helm, I had to move the Taylor-type sail about six inches nearer to amidships than shown in the photographs. Steering is good with the paddle-rudder at the stern.

G. BIRKETT.

Yellow Door, Seagrove Bay, Seaview, Isle of Wight.

Dear Sir,

Since the end of the sailing season for this year, I've had time to evaluate and put into coherent order, my thoughts and memories of sailing in my 20 ft. Hydrofoil stabilised Trifoil.

"Fancy-Free" was home-built with the help of one or two friends, to Erick Manners' design, using $\frac{1}{4}$ in. marine ply, $\frac{1}{2}$ in. marine ply ribs, Oregon pine for stringers, keel, etc., and exterior ply for non-essential parts. Graceful is the first word that springs to mind as I picture her sailing. She glides over the water as a skater over a rink, and a fast skater at that. In the early mid-summer days of sailing, the winds were kind and gave me a chance to become used to the craft.

Watchers find it easier to judge speed than those sailing in "Fancy-Free." I found, on one occasion, in a light to moderate wind, even with three hefty adults and a schoolgirl on board, we attained a speed of 10 knots, checked by a helpful speedboat alongside. Yet so stable is this boat that we had the impression of sailing at no more than 3 knots. Another time, we sailed her to West Hartlepool and back in very steep and choppy northerly seas, with a small spanner standing on its edge on deck throughout the round trip of eight miles. The journey took just under the hour.

Steering is so light under all conditions that this has impressed everyone who has sailed in the boat. Her characteristics are similar to those of M. G. Dibbs' Trimaran except that there is no air entrainment visible from the foils. The type of foil used, appears to me to have a really great future, since it does not produce the sharp, jerky movement evident on the conventional trimaran.

I would say that the partially submerged float has great scope for development and a compromise between the two extremes would probably give high speeds combined with good behaviour at sea.

On reflection, the most telling comment I can make is to say that I'm now counting the days to Easter . . . R. HARBRON.

26 Station Road, Stokesley, Yorkshire.

Dear Sir,

We continued to make trials this past season of various rigs to be used for sailing small canoes as "proas"—either end as the bow. The trials were made in various weathers on a mountain lake and on a shoal tidal river known for its steep chops.

It now seems very clear to us that a small craft which can change tacks *with* the force of wind and wave, rather than against them, is a very sure and safe one in blowing weather. This is particularly true of canoes and multihulls which are too light to carry around by momentum and too narrow to spin around. And in the case of a paddling canoe, there is no rocker to the keel line. Yet the manoeuvre is sure each time.

On the other hand, there is some question about the concept of keeping but one side always to windward. What if the wind swings suddenly around to what was "leeward" just an instant before? This can and does occur on waters near high ground.

With the Oceanic lateen sail having the tack fixed to the deck and a mast and usually stays next the sail, what happens is that the sail blows back against the standing rigging. Pressure cannot be relieved. The craft is out of control and in trouble. It starts to capsize over the float now to lee, or the rig fails, or one gets it around with an oar—to be caught again as the wind swings back.

With the square sail of symmetrical form, backwinding tends to throw the craft into sudden reverse. On one occasion with such a sail, we were tossed too and fro considerably. (Except for this problem it was a wonderful sail and in light steady air was very powerful).

It seems to us at this point that the general asymmetrical configuration of a Micronesian proa is not so useful for a small canoe to be sailed in turbulent air flows. It will perhaps be more practical to have a freely weathercocking sail rig and a craft able—like most any other—to sail with the wind from either side.

In tacking such a craft by changing ends, we have found the manoeuvre to be quick and economical of space in narrow water. One makes a 90 degree turn from one tack to the other in this manner: the sail is swung around by a pull on the other sheet. The craft at once stops, restarts in reverse, and makes the turn as the sheet comes in—all with a fine swoop and rush. RICHARD L. ANDREWS.

25 Audubon Drive, Ossining, New York, U.S.A.

THE DEVELOPMENT OF THE SHARK V TRIMARAN

L.O.A. 13 Feet 10 Inches

by J. R. Anderson

59 Penhill Road, Lancing, Sussex

This article is complementary to the description given in A.Y.R.S. Publication No. 43

In the four years since the Prototype of the *Shark V* was first sailed in December 1960, intensive development and testing has been carried out on five hull shapes, with a host of deck arrangements; six centreboard shapes and sizes; six rudder shapes and sizes; fourteen types of floats; eight different masts with variations in rig on each mast; nine different sails, which in themselves, have been recut and flowed a good number of times; and some of the most promising permutations of the above.

The result is a Trimaran which will point as high as, and go as fast to windward as, the average racing dinghy of similar length, whilst being considerably faster off the wind. This has been accomplished without loss of manoeuvreability, for example, the craft can tack up tide, up wind, on the river Adur at Shoreham as easily as a dinghy.

The reason for all this development before putting the craft into production, was to kill the bogey "that Trimarans won't go to windward," and to ensure that purchasers would obtain the high performance the Trimaran configuration offers, in thoroughly tested craft.

In this connection thanks are due to the Sussex Yacht Club for their foresight in adopting the Class, and becoming the first to race Trimarans in this country.

Thanks also to the Catamaran Yacht Club which includes Class racing for the Trimarans during their International Catamaran week. They have given us some exceptionally good racing in all types of condition. On one occasion at last season's meeting, although the Class was started last, the first Trimaran got through the fleet when the wind dropped, held its position when the wind rose, and finished with only the four C Class Cats and four of the B Class Cats ahead of it.

Space does not permit the full description of all the combinations tested at full scale under racing conditions, and the following is a brief precis.

Hulls. Considering first the centre hull, the "sewer" section was selected as the basic profile. This section theoretically gives the best buoyancy/wetted area ratio for a vessel, and the A.Y.R.S. Publications on hull shapes and some tank tests on hull shapes, were instrumental in making this selection. This optimum profile is only ob-

Photograph 1. Prototype in its original form

tained when the hull is not heeled, and one of the aims now, when sailing the craft, is to keep the mast as near vertical as possible.

To save time and expense, the prototype was a double chine construction, "cutting the rounds" off a "sewer" section.

Bearing in mind that the craft must be manoeuvreable, and not be over long for stowage and home construction, a length of 13 ft. 2 ½in. was used, and the appropriate dimensions of the sewer section to give a displacement for a complete boat weight of two hundred pounds plus crew, were determined.

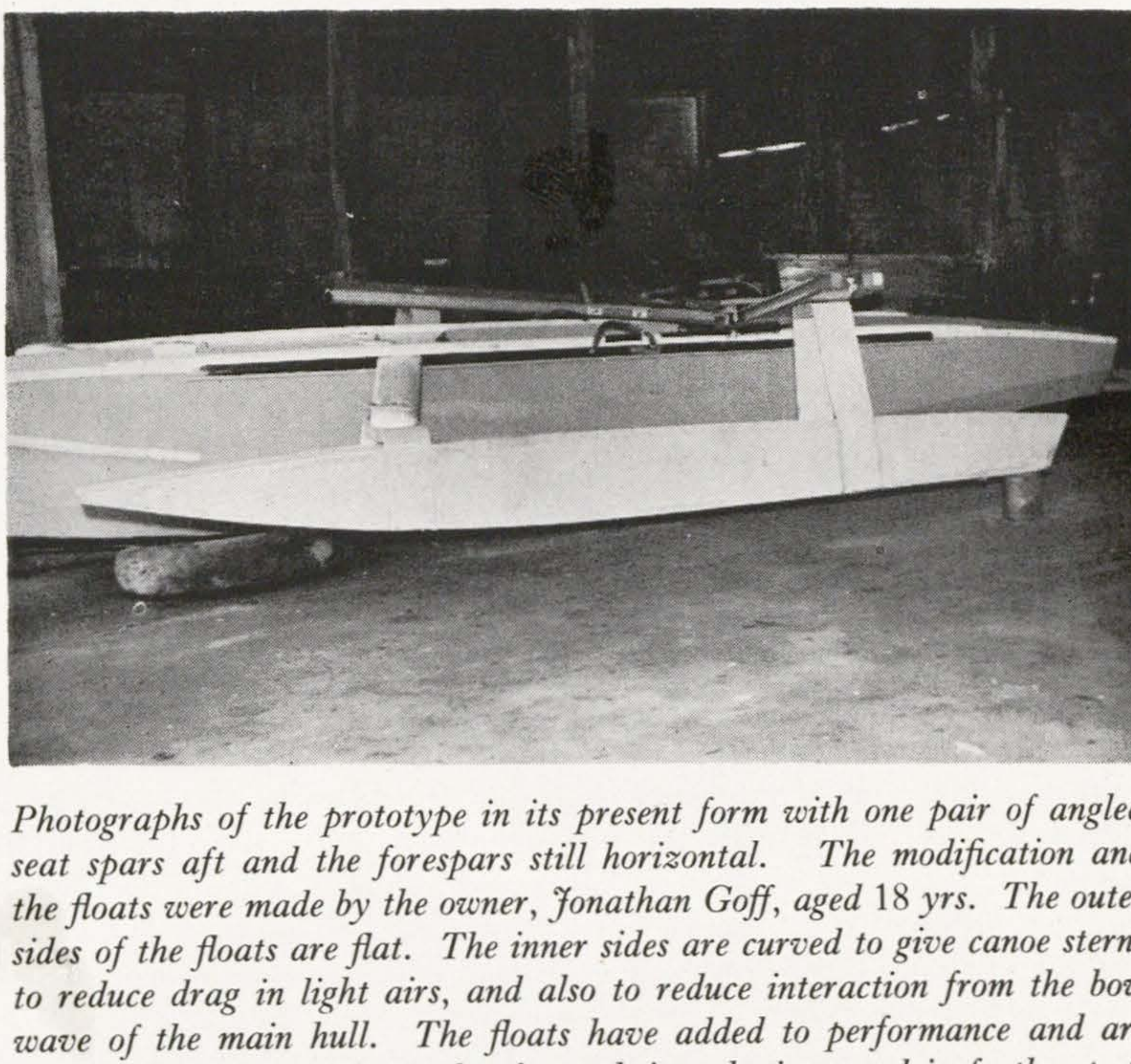
The prototype in its original form is shown in photograph 1.

No centreboard was fitted at this stage, instead, the first floats were a narrow V, the basic section being 15 in. high by 9 in. wide at the top. The outrigger arms were horizontal, and both floats were in the water when the craft was upright. The leeway when going to windward, was unacceptable, even when the float side area immersed was greater than that of the centreboard of a dinghy with comparable sail area. The aspect ratio of the foil was too low. A centreboard was fitted and an immediate improvement was effected.

The centreboard was increased by stages in the next four craft, and they were carefully sailed in comparison with top class dinghies, until the shape and size used in *Shark V* gave comparable pointing ability. When the prototype was sailed off the wind in force 4 and above, there was a tendency for the bow of the main hull to dip momentarily due to the sail force in heavy gusts. Although in flat water conditions this would have been acceptable, the conditions at Shoreham are such that with any wind except the infrequent North, we have very high seas. The length of *Shark II* was, therefore, increased to 13 ft. 10 in., the depth forward was increased and the hull given a finer entry. The fining forward modification was continued, and frozen at *Shark V*.

The result is an extremely seaworthy boat. For example, as reported on the front page of the daily press, on one occasion last season, practically every dinghy racing with our Club capsized at one time or another. The five single handed Trimarans out that day never looked like doing so, and had a fantastically fast and exhilarating ride. One was sailed by a lad of fifteen years in his first season of helming any boat.

Referring now to the outrigger and seating system, photograph 2 shows the prototype with the centre outrigger spars removed and a pair of sliding seats fitted on angled arms. With the original system of spars and trampoline, the helmsman could not move readily enough to control heel accurately, and sometimes had to scramble uphill. Initially, the seat spars were rotatable about their inboard ends, and a roller skate was fitted to each outer end to run on the flat top of the float. The skates were held in contact with the float by means of shockcord. By using his feet on the gunwales to angle the arms, the helmsman could move his weight fore and aft. This system enabled the best compromise positions for the seat arms to be found. It felt a little "dicey" in big wave formations, however. The arms were then fixed in the determined positions, and tested on *Shark II's* modified hull. To reduce weight and complexity, *Shark III* was designed with two pairs of spars angled upward, and with the sliding seats



Photographs of the prototype in its present form with one pair of angled seat spars aft and the forespars still horizontal. The modification and the floats were made by the owner, Jonathan Goff, aged 18 *yrs. The outer sides of the floats are flat. The inner sides are curved to give canoe sterns to reduce drag in light airs, and also to reduce interaction from the bow wave of the main hull. The floats have added to performance and are easy to construct. The angle of attack is to be increased in further tests*

running on the aft spars. Various anti-friction materials for the seats were experimented with, and discarded in favour of rollers.

Floats. The first floats on the prototype were of deep V sections with spade bows to provide lift when heeled. They were quite effective in moderate to high wind speeds, their disadvantage being that their drag was excessive in light airs as both floats were in the water. One could see water being pushed in front of the spade.

In the higher winds the angle of attack of the whole craft was decreased due to the sail force, and the angle of attack of the spade was decreased, so that the spade bows worked quite well. This change of angle of attack of the craft due to sail forces, and the change of angle due to wave pattern, are problems to be mastered before foil craft can come into general use.

The floats were modified to a normal stem, and light air windward performance was improved. In moderate and high winds, however, the floats tended to bury. Angled strips 1 ft. 6 in. long, and 1 in. wide, were fitted at the stems high up to provide additional lift. These effected an improvement although in short choppy seas they could cause unnecessary drag.

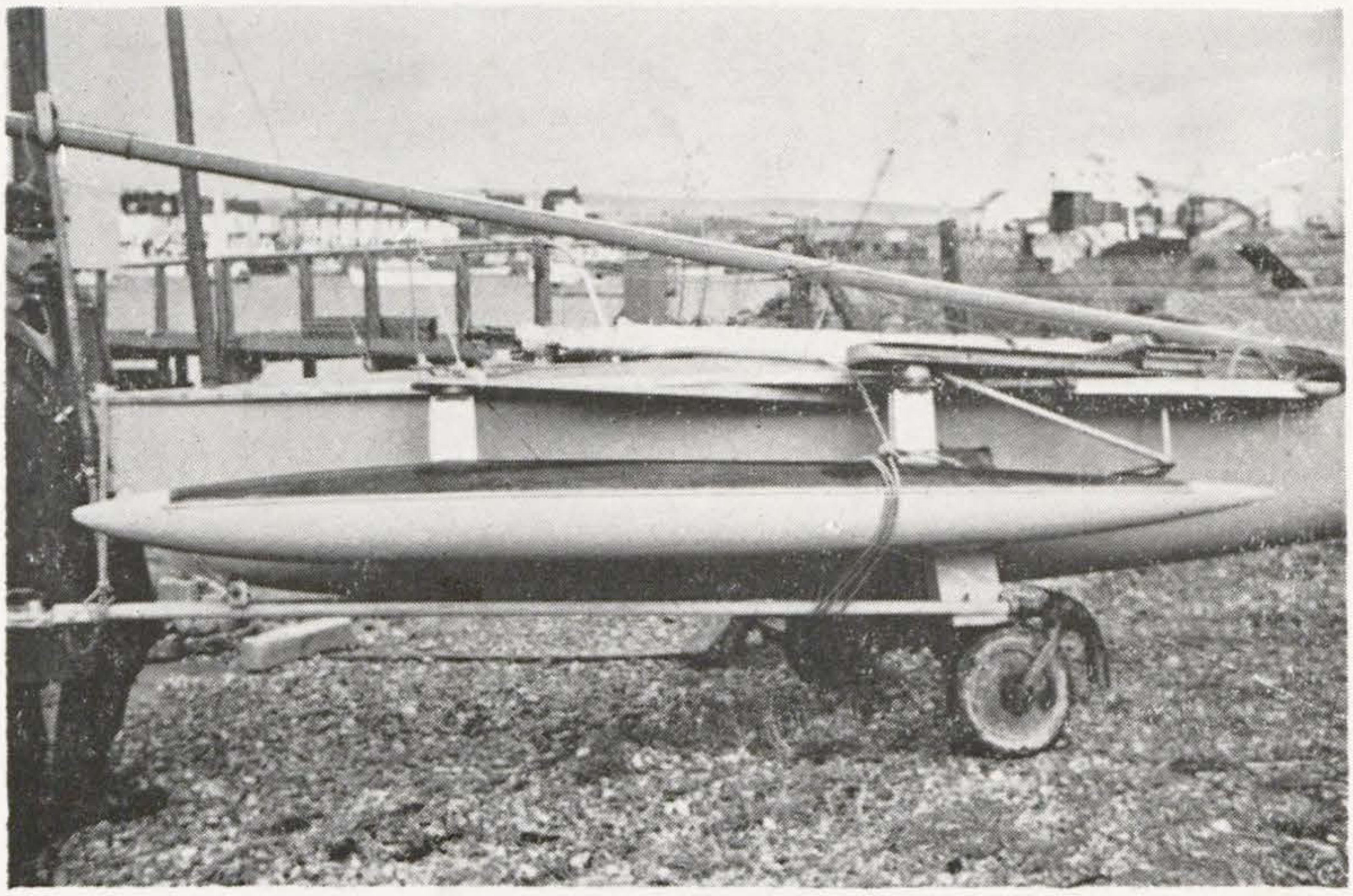
On *Shark II*, flat topped sewer section floats with canoe sterns were fitted. Their buoyancy/drag ratio was high, the disadvantages being that there was no dynamic lift, and they were difficult and expensive to make in wood.

Shark II was faster to windward than, and pointed higher than the prototype in any conditions. Off the wind in light airs the prototype was marginally faster. This was due to the wetted area of the sewer type floats being greater than that for the Vee type, as the floats for each of these two craft were equally immersed when sailed with masts vertical. The floats on *Shark II* were unloading the centre hull, which was undesirable in light airs. *Shark II* was sold to an enterprising young lady at Sheppey, and after three months testing, no further comparisons were possible.

It was clear that improved performance should be gained by sailing with the floats out of the water, and this proved to be the case when *Shark III* was made with the outrigger arms angled, and with the seats running on the aft spars. This saved weight, work, and windage, as the number of spars was reduced to two pair. The floats had to be fitted on pylons, and this was an advantage as in high wave formations, the forespars were kept clear of the water.

The floats first used on *Shark III* were of vee section, with a rounded top, and were to a design by our Class Secretary, R. C. Garrett; to whom thanks are due for financing the prototype, and for his solid work and enthusiasm which has made this development possible.

The floats on *Shark IV*, which craft was built by Rodney Garrett, had a slightly flatter V section and smaller transoms. These are standard as given in the production drawings. The floats are easy to make, there are no compound curvatures in the ply; the rounded top alloys the water to clear readily when the float goes through a



Photograph 3. Showing the Garrett fibreglass float in elevation.

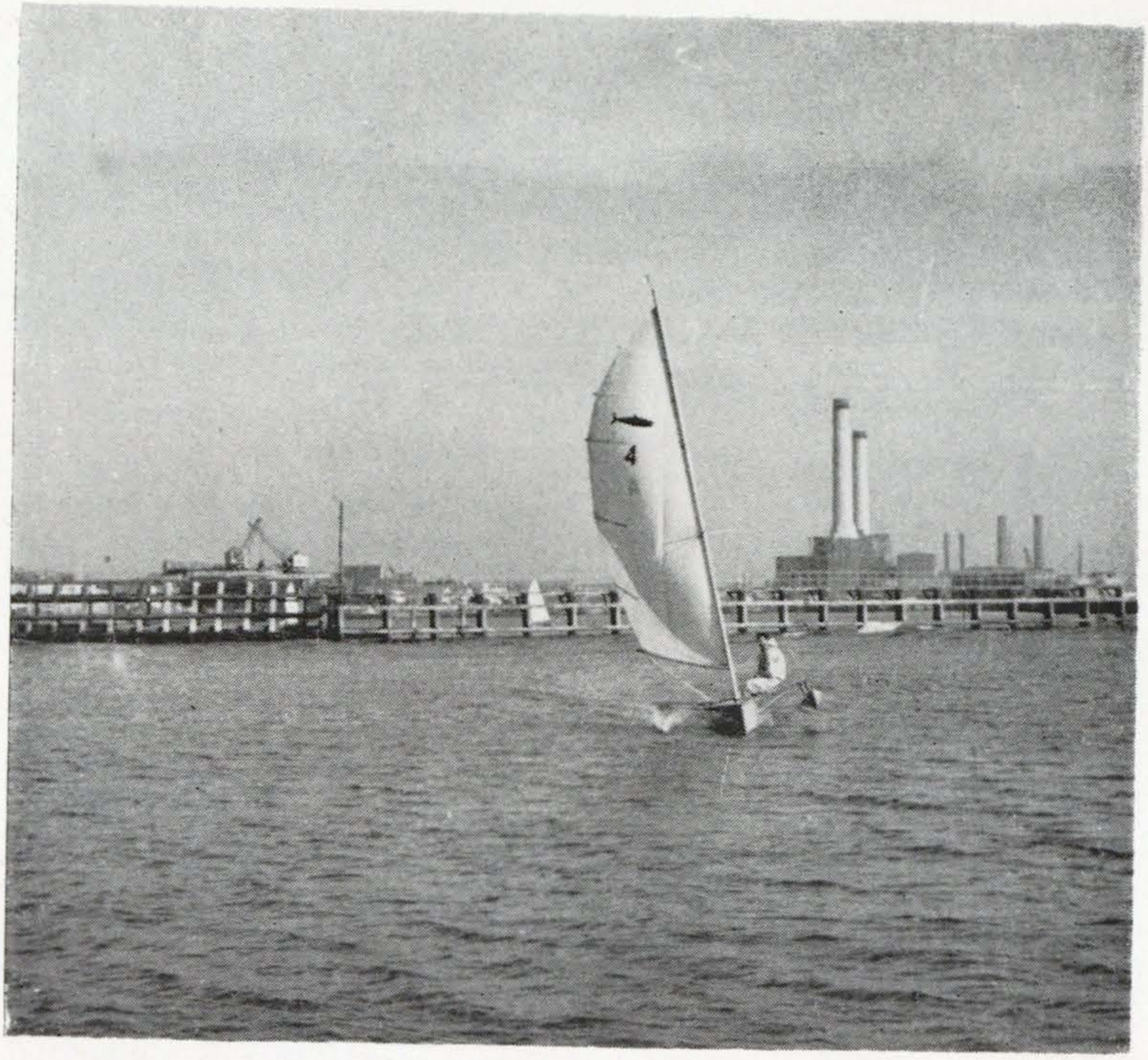
wave, they look well, and have given the best all round performance thus far.

The maximum length of the floats, as laid down in the Rules, is eight feet, so that they can easily be made from standard ply sheets, and so that there is an incentive to derive the best shape of float or float/foil combination within this length. Herein lies the exciting future of the racing Trimaran.

Considering buoyancy only, which is limited in the *Shark V* to a maximum of 150 lbs., it is clear that a longer finer float of appropriate shape may provide less overall drag when submerged. In fact this has proved to be the case with the floats shown in photographs 3. These were made in fibre glass, with marine ply tops, by Rodney Garrett, and are 9 ft. 6 in. long.

When beating in high wind and sea conditions, the floats may spend a good deal of time going through waves, and these floats have generally given better results. Off the wind, where speeds are higher and the craft can be sailed more upright, they have shown no gain over the standard float which derives dynamic lift from its Vee section.

The craft when beating in such conditions are heeled at a considerable angle, which is undesirable. Three separate ways come to mind to rectify this. Firstly, to reduce sail by reefing when going to wind-



Photograph 3A. *The rounded float is the lee float shown in the photograph. The windward float is a standard*

ward, and unreefing off the wind. The disadvantage is the loss of time while this is being effected. Secondly, by sail flattening with a bendy mast, and by the moving clew system automatically operated by the main sheet, which has been pioneered on the *Shark V* by Anderson Aerosails. Thirdly, by providing foils below the floats.

The first two methods are dealt with later when sails and masts are discussed, and in my view the third method should take precedence. In other words, given a certain sail area, let us find the floats and techniques which will enable us to use this area to the full at all times. It is more convenient to do this on Trimarans than on other types types of craft.

It is important to stress that this part of the article refers to beating in wind strengths of 4 and above, together with relatively short seas of approximately 5 ft. from trough to peak, and higher.

In flat seas and lower wind speeds, the floats can be held out of the water for quite long periods when beating, and the high ratio of sail power/weight, with the low drag centre hull, gives the craft an exceptional performance.

In medium conditions the *Shark V* can also give a good account of itself, for example, in the Worthing Inter Club Race on 27th September, 1964, in which ninety one craft of practically all the well known types competed, only five Catamarans, a Jolly boat, and an Osprey were ahead of the first *Shark V* Trimaran to finish. Those behind included F.D. 505, Hornet, Osprey, Merlin, Fireball, Scorpion, Shearwater III, etc. The race commenced in winds of force 3-4 with white capped seas, which eased slightly, and the course was virtually a beat and a run. Had the course included a reach, the *Shark V* would have shown an even better performance. This Trimaran was fitted with standard floats and a low rig bendy mast, the sail being also capable of further flattening by means of the auto-

The helmsman is right out and the craft is heeled to obtain assistance from the float. A foil below the float would correct the heel and be more efficient

Photograph 4. Soft-footed sail (radial cut), Clew outhaul system

matic mainsheet-clew outhaul. Even so, when beating in the race, a certain amount of assistance to hold up the boat had to be obtained from the lee float. This assistance was from float buoyancy. The craft have to be heeled at a considerable angle before it takes effect; which is undesirable for sail efficiency.

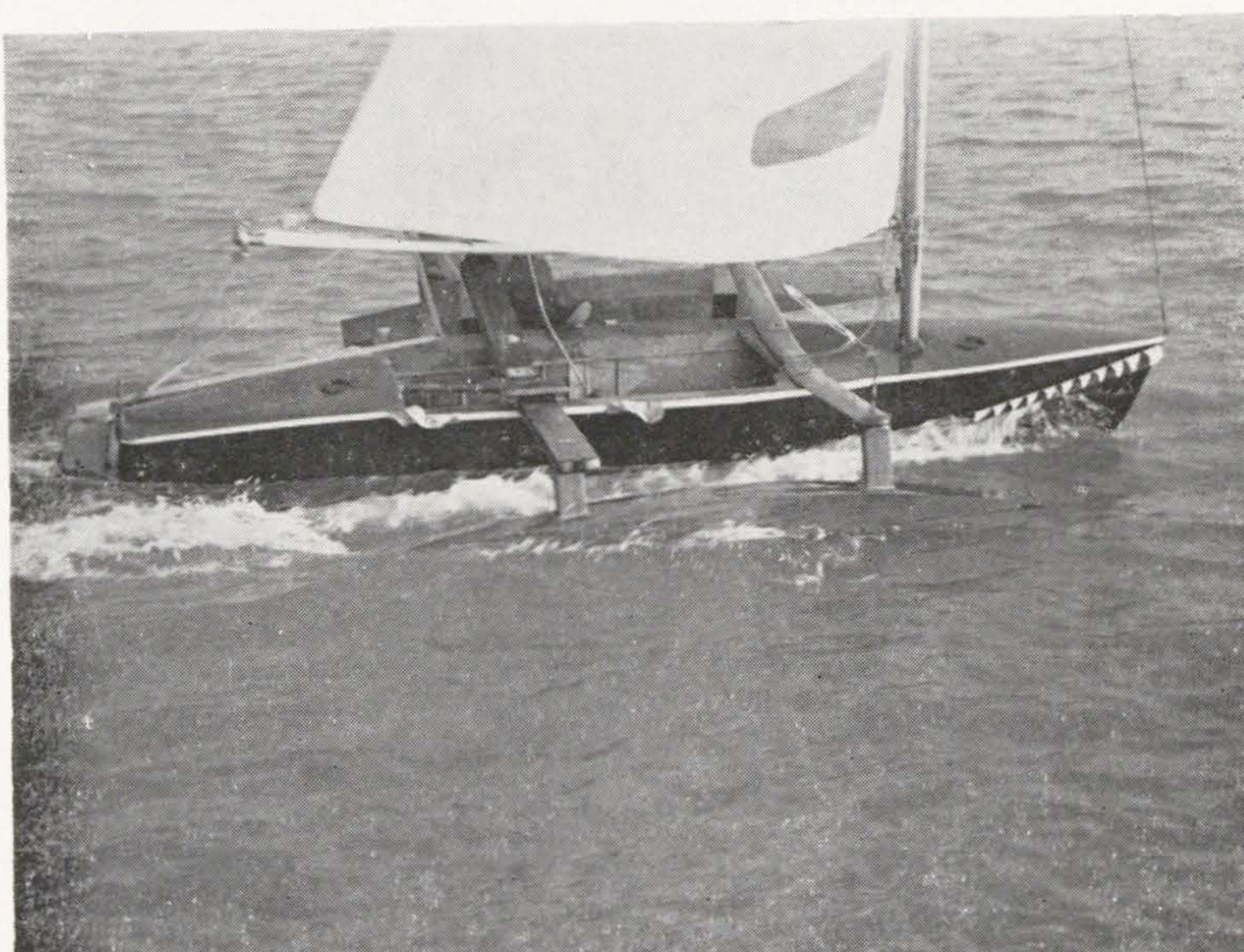
The use of a foil beneath the float would be more efficient hydrodynamically, the mast would be held more upright, and the foil would provide a damping effect should there be a "hole" in the wind.

To increase float lift at beating speeds in high wind conditions, flat bottomed floats as in photograph 4 have been tested. The first float was flat underneath and cambered on its top surface. The intention was, that normally lift should be provided by the flat bottom; and that when the float submerged, additional lift should be derived from the cambered top surface. When sailed in flat water this worked very well and when submerged the flow over the top surface appeared to be excellent, excepting that it was broken by the central pylons.

Another float was made with a slightly cambered undersurface, and cambered upper surface using light alloy hoops fastened to the sides, as pylons. The flow over the top surface was then unbroken.

When the craft was sailed in the open sea in high wave conditions, it was found necessary to progressively increase the angle of attack of the floats because of the change in angle of attack of the whole craft due to the sail force when running, and because of the direction of water flow when sailing down into a trough and cutting into the rising water of the next wave.

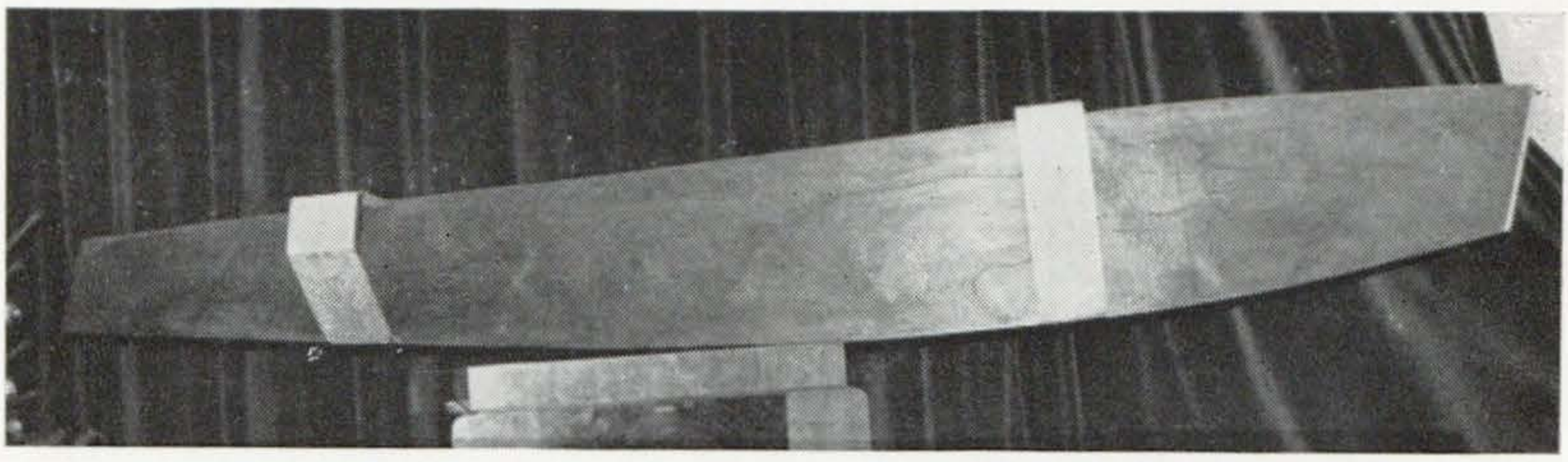
When an adequate angle of attack had been found by trial and error and a few capsizes caused by the float pulling itself down, it was found to be too large for efficiency in normal conditions. The

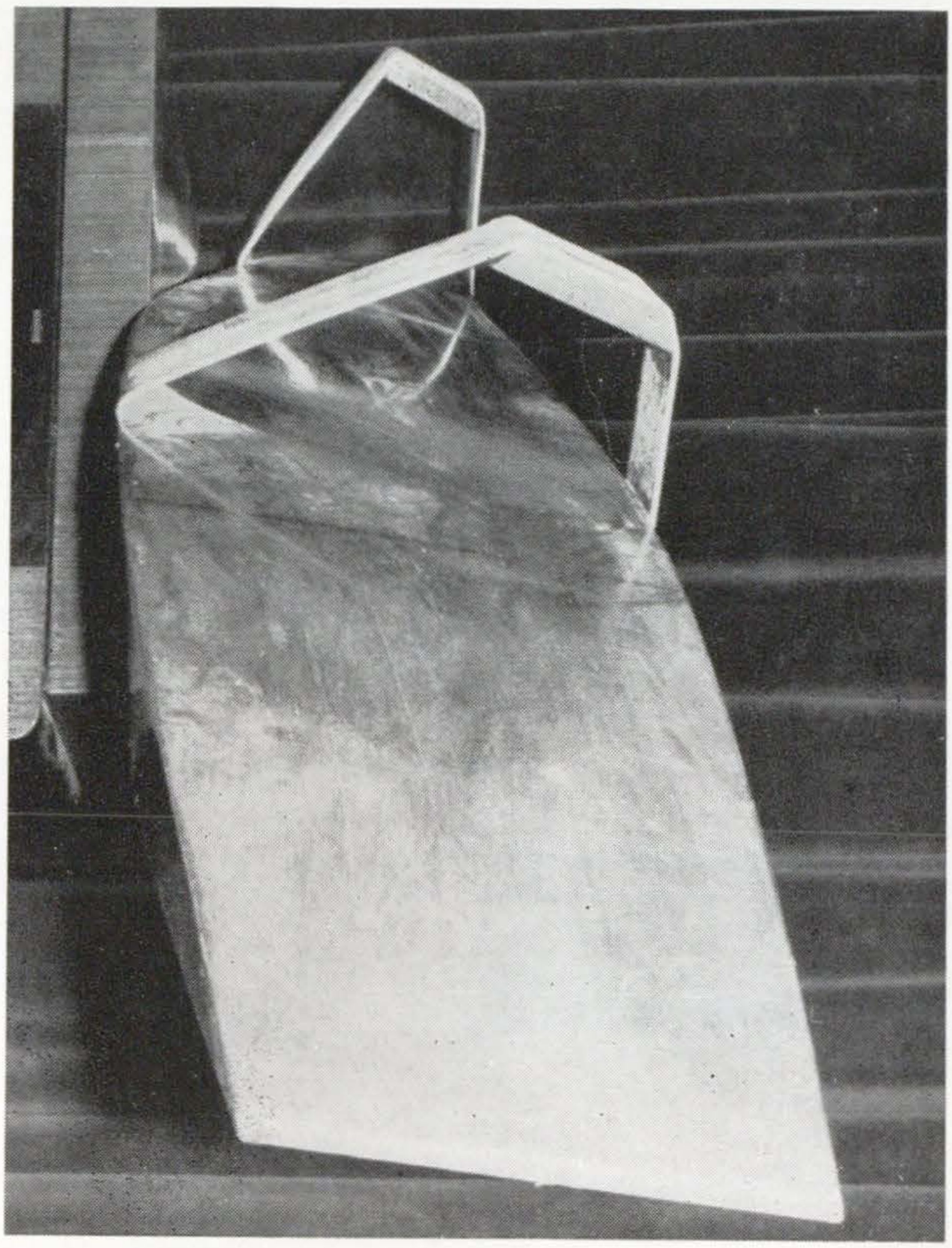


Photograph 5. *"Flat-bottomed floats," "Rooster tails." This is Shark III hull; Shark V hull is a good deal finer forward*

sterns of the floats were too close to the water in flat conditions, with the result that quite large rooster tails were formed, as seen in photograph 5.

To reduce the angle of attack of the after ends, yet still have a sufficient angle of attack forward for high wind conditions, the floats were turned upside down and tested at varying angles. This improved matters a little, but the inefficient rooster remained with us. The





Photograph 6 *showing the third Calkin float in plan; and Photograph* 6*A*, *showing it in front elevation*

floats were turned end for end, to increase water clearance. There was a further slight improvement, but as the overall performance was inferior to that of the standard float, tests were discontinued.

In light airs and ghosting conditions it is convenient to sail the

Shark heeled to keep the sail in shape. The drag of the flat aft sections of the floats when so doing, was sufficient to make the craft definitely slower than those with standard floats.

The lesson pressed home was the criticality of the angle of attack of any foil due to the change of angle of attack of the whole craft, and also due to the changing angle of the water flow, in high wind, high sea conditions.

In the writer's view, the next step is the development of a hydrodynamically balanced foil which is retractable into or onto the float or forward outrigger arm. It needs to be retractable for beaching the craft, and also because in light airs, it would be unnecessary drag. The adjustment of angle of attack needs to be automatic, because the helmsman has enough to do already.

The enthusiast has ample scope for his talents, in developing such foils, and the one design of the hull shape for the *Shark V* provides a basis for truly comparative results.

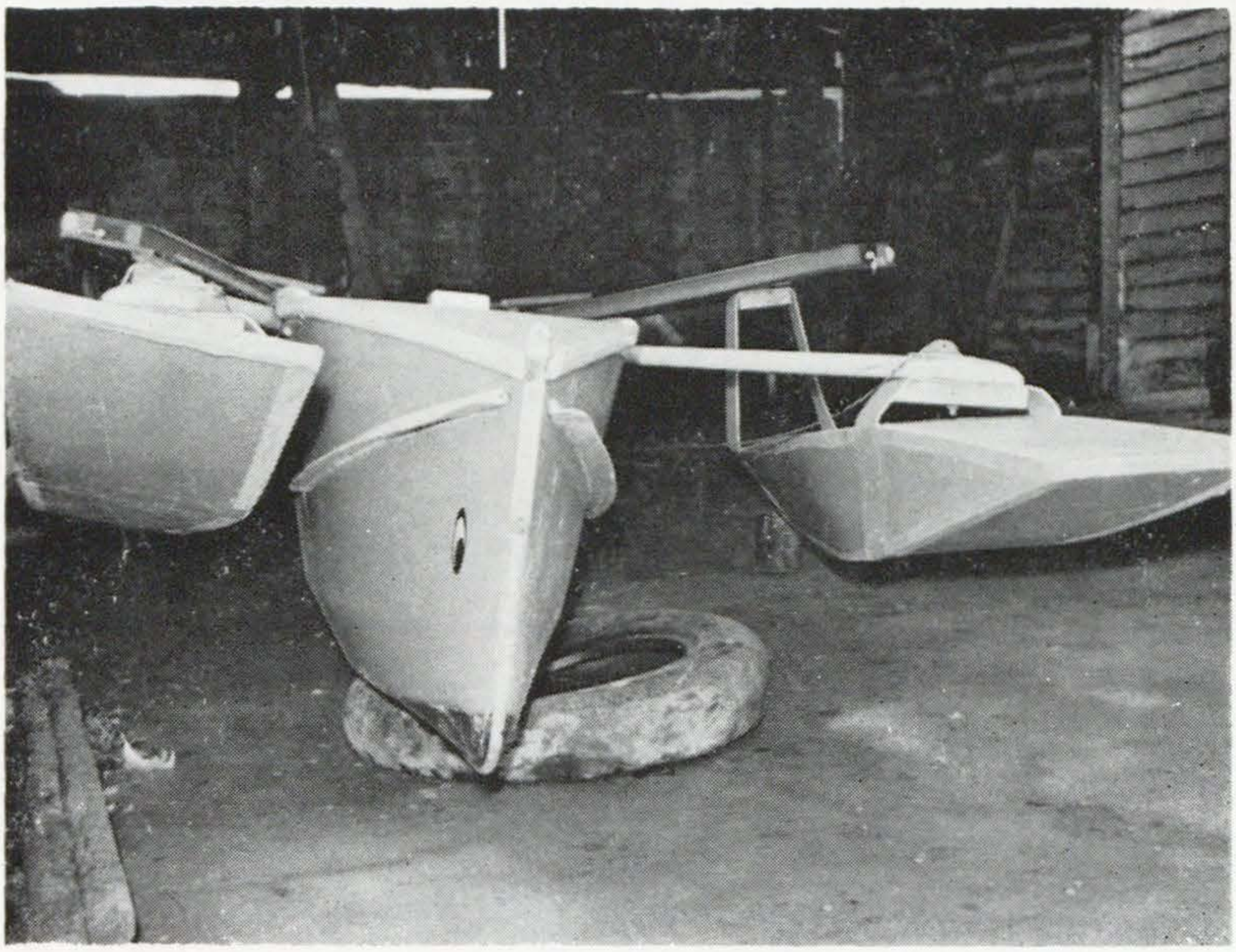
Parallel to the above testing, another enthusiast, one Peter Calkin, designed, made and tested floats, the third of which is shown in photograph 6 and 6A. The first was designed for submerged operation at all times, the buoyancy was very low, and the aim was hydrodynamic lift, both to counteract sail side force, and to reduce the water load on the centreboard. The floats were angled for this reason.

While the craft was stable enough when moving, the lack of buoyancy made the craft rather capsizable when the forward speed was low. Buoyancy bags had to be fitted above the floats between the outrigger spars. He then made two further floats with increases of buoyancy, and tested these with their centrelines parallel to the centreline of the craft, and at varying angles of toe in.

His valuable conclusions confirmed those given above for the flat bottomed floats, and as the overall performance was not as good as with the standard floats, the tests were discontinued.

Sail and masts. The only sail restrictions are that there shall be only one, that its area shall not exceed 115 square feet, and that the maximum mast height be 21 foot eight inches above deck level.

The first sails were made with three full length top battens, to give shape, and hold out considerable roach. They were fitted to wood masts of varying degrees of stiffness, and one light alloy mast. A number of shroud-spreader-diamond combinations were tested. The sails were recut and modified to obtain optimum performance, and the clew out-haul-mainsheet system was developed because a simple inexpensive reefing-while-racing arrangement was not forthcoming.



Shark floats

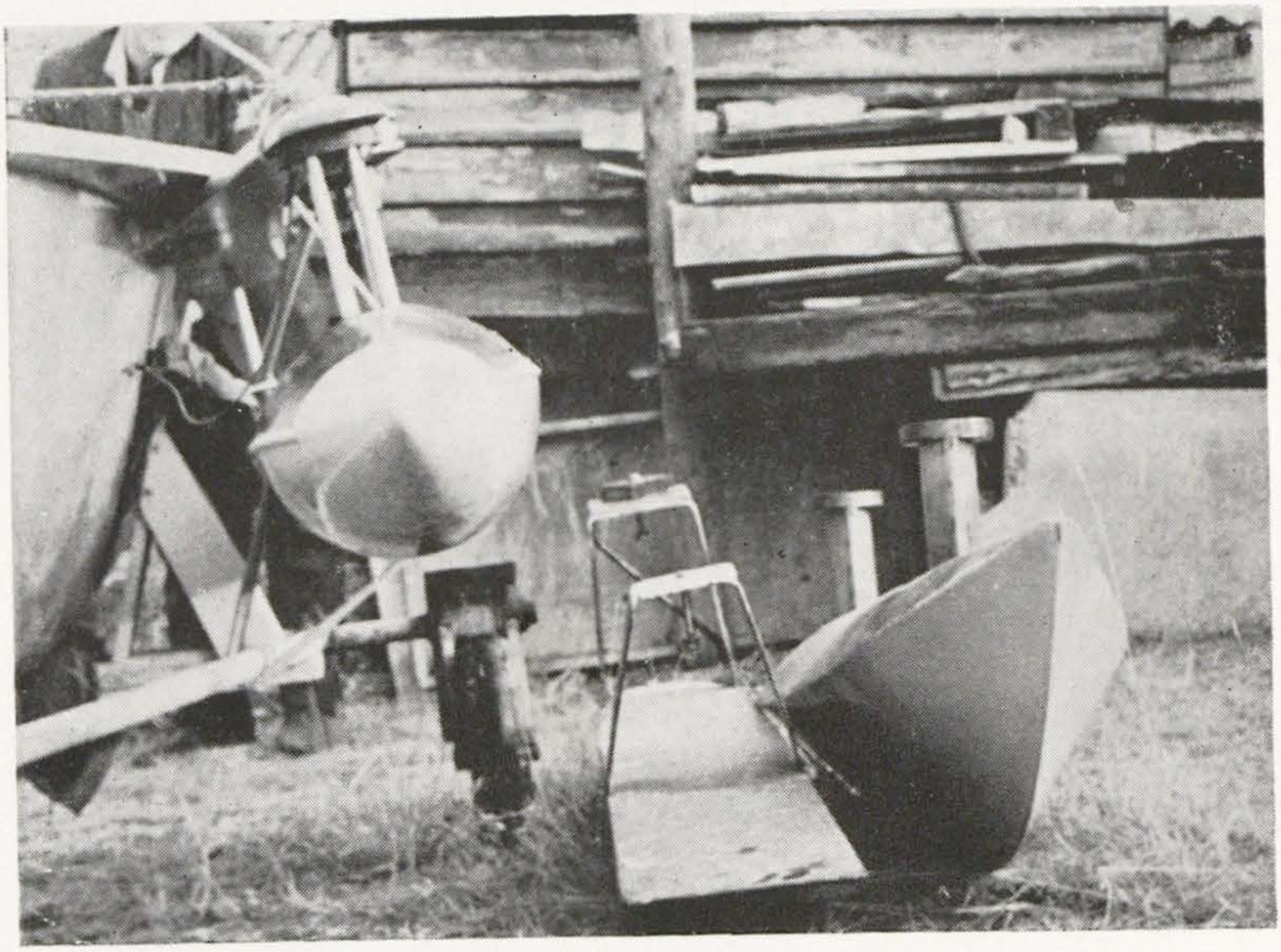
In the absence of a jib, a normal roller reefing gear is provided for emergency use. Suitably reefed, the craft can be sailed in practically any conditions.

Two of the sails had special soft feet, fitted with shock cord so that the basic curvature, and curvature means drive, can be continued right down to the foot. One of these sails can be seen in photograph 5 which also illustrates the outhaul system.

This soft foot is another development by Anderson Aerosails, and is used on most of their sails for other classes, where the rules permit.

So far, no one on any other class has had the temerity to make full use of the system as used on the *Shark* Trimaran despite its obvious advantages. Instead, the shock cord foot rope has been pulled into the boom groove in the usual way.

When the Shark V Owners Association decided that the Catamaran method of measuring sails should be adopted, the area of the soft foot shelf had to be included. As it is more efficient to add the shelf area to the basic area of the sail to give drive, rather than have it in the plane of the airflow where its only use can be to reduce vortices at the foot of the sail, the shelf has been eliminated in the latest sails. The basic curvature of the sail can still be continued down to the foot



More floats

if the sail be cut correctly. We have used and proved the cut for several years; firstly on Peter Shaw's Shearwater III Catamarans. This year he used this type of loose footed mainsail on *Thunder*, his C. Class Catamaran.

Whilst the clew outhaul—mainsheet system was effective in flattening the bottom of the sail and controlling its basic curvature, it could not flatten completely the top section with its full length battens and large roach. A further approach was necessary, and to this end a bendy mast with hounds fitting at half height has been developed; the roach has been reduced; and the foot lengthened to accommodate the area. The mast comprises a light alloy tube to which a track and fittings are secured with adhesives. There are no holes whatever in the working section of the mast, it is completely sealed and buoyant, and is as strong in side bend as it is in fore and aft bend. It costs considerably less than one made from the usual mast extrusion. A simple and effective hook up masthead is standard, to prevent wrinkling of the luff when the mast bends. The use of the mast has improved performance considerably.

For those who want the fastest and most exhilarating practical single handed sailing craft, and who also desire scope for their ingenuity and skill, the *Shark V* drawings, kits, and part built components are now available.

MANUREVA (FLYING BIRD)

AN EXPERIMENTAL TRIMARAN

BY A. JEFFREY
101, Milngavie Road, Bearsden, Glasgow

L.O.A. 27 ft.
L.W.L. 25 ft.
Main hull beam w.l. 2 ft.
Max. designed displacement 1700 lbs.
Beam O.A. 16 ft.
Sail area 200 sq. ft. Main 130 sq. ft. Jib. 70 sq. ft.

Floats: L.O.A. and L.W.L. 12 ft.
Section 12 in. by 8 in.
Buoyancy 200 lbs.

Manureva was built singlehanded during the first four months of 1964 in a rented garage 18 ft. by 9 ft. The garage was fitted with electric light but had no heating or power point, thus the use of hand tools not only was a necessity to carry out the construction but was also a help in combating the lack of heating.

The floats were constructed first, painted and stored outside. The plywood skin is 3 mm. exterior grade ply to B.S. 1088, the chines and gunwales are of $\frac{3}{4}$ in. by $\frac{1}{2}$ in. whitewood, the deck is of 6 mm. ply and the whole is filled with polyurethane expanded in situ (a very simple operation which no one should be in doubt about undertaking).

The main hull was constructed on frames spaced at 4 foot intervals from 6 mm. exterior grade ply on 1 inch by $\frac{3}{4}$ inch whitewood chines and gunwales. The whole was fastened with Gripfast nails and glued with "One Shot" Cascamite throughout.

The fore part of the hull was made first up to station 19, the 8 foot stern portion only being partially assembled. This was to let the bow part be decked and painted to spend the last month in the fresh air while the stern was being finished.

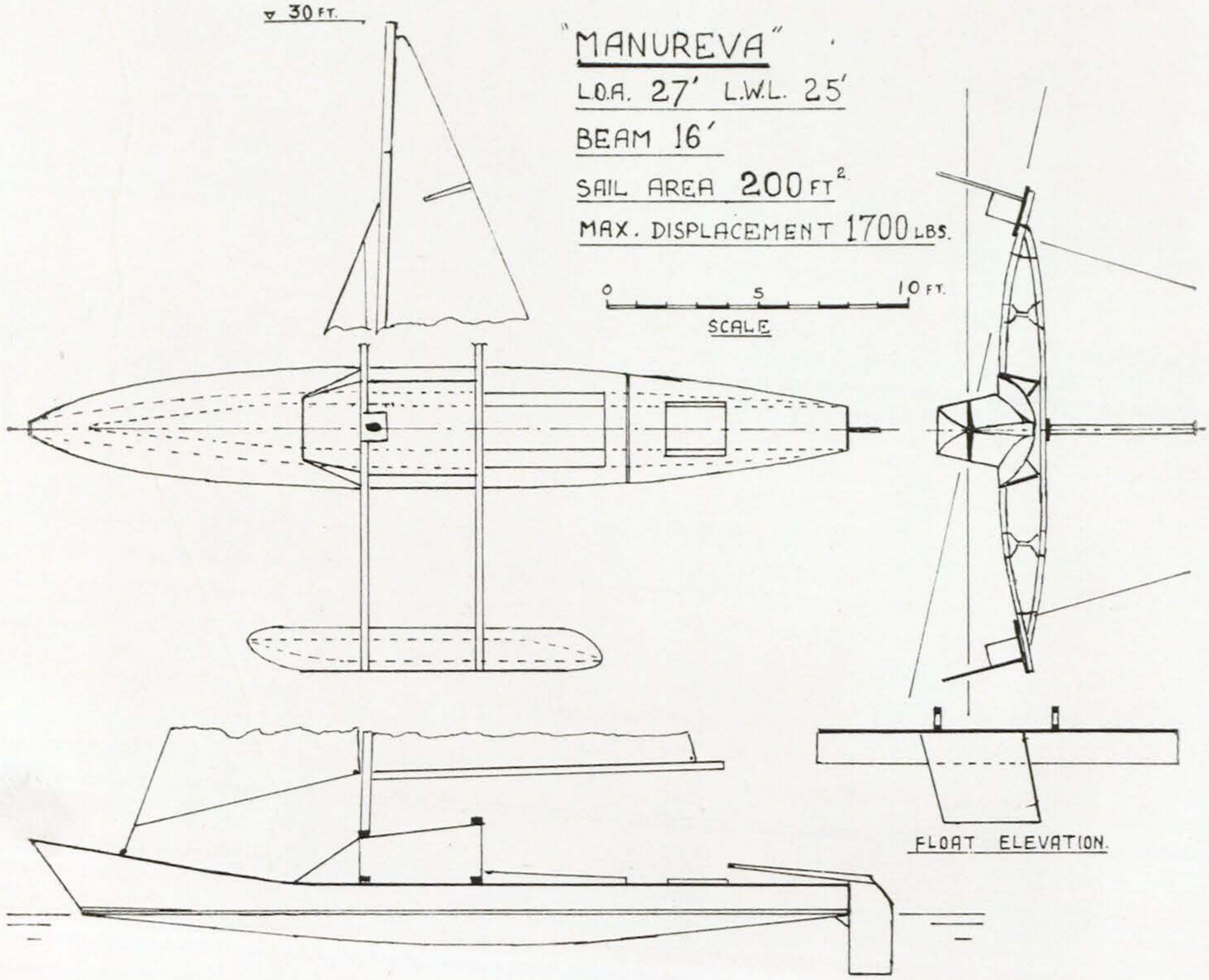
The hull was painted inside with two coats of aluminium paint and outside with one coat of metallic primer, two coats of undercoat and two coats of enamel. The boat is so easily beached and scrubbed that it was not found necessary to use anti-fouling.

The total cost of the complete boat was a little over £100, including secondhand but unused terylene sails, stainless steel rudder blade, stainless steel standing rigging and synthetic running rigging. This cost would have been much greater if I had not been given an alloy mast which was broken at about 50 per cent height which I repaired with a 2 foot long timber insert, stainless sheeting on the exterior and five stainless straps put on with a tension of over 20 tons per square inch.

Centre Hull. The shape has been devised over a long period basically to a mathematical formula, as was the development of the

Manureva

sides. It was simple to construct, light in weight. It is easy in its motion and produces very little fuss. The wide overhung decks give dry sailing under all conditions. The main hull dimensions are: bottom beam is a sine curve to 55 per cent L.W.L. thereafter parallel at 18 inches to the transom. Bottom depth is a sine curve to the maximum draught at 55 per cent L.W.L. and sine curve from transom to the same point. This gives the centre of buoyancy at 13.25 feet



L.W.L. The length to beam ratio is 12 to 1 and the beam to draught ratio is 2 to 1. The bottom is flat and the sides slope at 15° (1 in 4) to the deck level. The displacement curve conforms to a versed sine-trochoid.

Floats. These have a built in incidence to windward of 3° to counteract leeway and have the deck extended 4 inches to each side to act as additional surfaces to provide dynamic lift at speed.

After launching the boat and putting it out to moorings, a storm arose which lasted off and on for two weeks which brought out three important points:

1. The four cross beams, each made from two lengths of 2 inch by $1\frac{1}{8}$ inch ash, were too flexible and were stiffened by two 1 inch by 1 inch by $\frac{1}{8}$ inch angles along the top edges of each top beam.

2. Owing to the design intentionally having only one float in the water at any one time, the boat slapped from side to side when at

anchor, each time shaking the floats and mast structures. This was cured by fixing a 10 lbs. weight to the outermost point of one float. Now, even in the wildest weather, the unweighted float very rarely touches the water.

3. Due to the flexibility of the cross beams, the floats moved about their lateral axes so two additional stays, one to each float were run to the mast at 50 per cent height which makes the whole structure rigid.

Before sailing trials, I fitted a 2 square feet surface piercing hydrofoil to the port float with approximately 2° incidence. With the outboard giving 7 knots in choppy conditions, the hydrofoil was only able to operate about half the time but when it did, there was a wonderful sensation with the centre hull running level and neither it nor the hydrofoil caused any fuss. It was also steady compared to a displacement type power craft running alongside. I feel that a hydrofoil of about 6 square feet of area set at an incidence of 4° to 5° on each float would be ideal.

Sailing. *Manureva* is designed to displace 1700 lbs. but only weighs some 750 lbs. so a crew of 4 or 5 is needed to bring the boat down to her L.W.L. With a light crew (my daughter 7 stones and self 11 stones) she rides with her stern 3 inches out of the water, thus upsetting both lateral area and rudder area. It is then most difficult to come about in anything stronger than force 3 or 4. On the reach with the light crew, *Manureva* went very well at 10 to 12 knots and the leeward float had enough static and dynamic balance to stay on top of the water.

Close hauled with the light crew, speeds were equal to those of a deep keeled boat of medium size up to force 3 to 4 but in stronger winds, the lee float buried and the sheets had to be eased. Also, the lee float had not enough area (12 sq. ft.) to counteract leeway. With a heavier crew, (36 stones), she sailed very well and could be steered with hands off the helm by moving one of the crew fore and aft. She seemed to sail just as well with the weather float in the water as with the lee one and by doing this when going about, tacking was made certain whereas it was only 50 per cent certain with the lee float in the water.

In July the following minor adjustments were made:

1. The mast was restepped 8 inches further aft to give more weather helm.

2. The floats were made vertical. They had about 30° of slope out previously.

3. The floats were given 2° of positive incidence.

4. Lee boards of approximately 6 sq. ft. were fitted to each float.

The drawings and photographs show *Minureva* after these modifications.

These modifications made the floats ride over the water rather than cutting through it as before. The lee boards of $\frac{1}{2}$ inch plywood made very little disturbance under the outboard and the wake of the leeboards and floats met about 10 feet behind the stern of the main hull. Sailing was also improved with *Manureva* pointing as well as any racing keel boat. She is well balanced with slight weather helm. The floats are better but I feel that curving up the fore ends of their decks about 4 inches or so as in a water ski would give more dynamic lift and be useful.

Conclusions. (a) With a light crew, the floats could be 50 per cent larger to give 300 lbs. of buoyancy. (b) With the heavy crew (36 stones), the floats were the correct size for the capsizing moment can easily be counterbalanced.

The A.Y.R.S. exists for the free exchange of details and experiences to advance the science of sailing and I shall be very pleased to hear from any interested members who may want more details of the building or sailing of *Manureva*.

Dear Sir,

In answer to your leaflet in hand, why don't we have more stories and less $\frac{a^2}{\sqrt{x1}} = ab + y = x$. What happened to the Great Piver for the Trans-Atlantic race? Why not a write-up about that $1\frac{1}{2}$ ton outrigger by its owner?

In answer to part 5, may I state that your book is too technical and for that reason, if it does not improve in 1965, I shall have to withdraw my support. Maybe I am just a drop in the ocean but how many people who buy your bulletins can work out $\frac{a}{\sqrt{bc}} \times 5 - Z = x$, for I can't and would not try? But how many do?

Did you know that the red and green railway lights on signals have a paraffin light but can be seen better than your ship lights (small). These are some of the things we want to have but you have no readers' pages. Buy the *Sun* daily paper and see how people have a say in *their* paper. It is *my* book not *yours*.

W. Goodwin.

44, Shakerley Road, Tyldesley, Lancs.

Editor: Mr. Goodwin expresses quite a common view here. I myself don't bother to study involved equations and very few people do. However, we always get a few people writing in to say how much they enjoy this kind of article. On the whole, about the same number of people say our bulletins are too technical as want to have the technical level raised. But we please everyone (I hope) by descriptions of actual boats, whether usual or experimental. People who want the publications *less* technical can skip the odd technical article and those who want the publications *more* technical and filled with performance figures will at least have to wait till these have been acquired.

Dear Sir,

The more I see, hear, and read about, the endlessly fascinating business of sailing, the more I am impressed with the desirability of having more quantitative data and more precise understanding about it. Therefore I write to ask you to consider doing two things in the A.Y.R.S. publication.

(1) To appeal to the members and other readers to make and report measurements of the performance of their boats. You are the one to do this.

(2) To solicit, through the bulletin, and publish ideas about instruments useful to the foregoing.

Together, these constitute a big and valuable project, one which could run for a long time. You might consider sections entitled something like "data sheets" and "instrument corner" for publication as often as the editor had anything worth inclusion.

If you decide to do this, you will probably wish to start off with rather careful statements of the problems. What to measure? What degree of accuracy? What form of reporting for easiest digestion and comparison of information from many sources?

To me this appeals as a significant, long-range programme of work which might well be sponsored by the A.Y.R.S.

Henry A. Morss, Jr.

10 Otis Place, Boston, Mass., 02108, U.S.A.

MULTIHULLS AND MONOHULLS OF THE SOUTH SEAS

by Te Kupe Rangi

Waiheke Hauraki, Islands of Aotearoa
New Zealand

Introduction

In old times there were few Europeans who did not disgust the Islanders. They were pirates, whalers, blackbirders, militarists and religious zealots whose cruelty, stupidity and rapacity had to be experienced to be believed. It's true the Islanders had a few tough guys but it was chief to chief, village to village. They did not aspire to wipe out the whole of the island community. The Gilbertese were the only ones to develop armour and weapons designed to inflict ghastly wounds with the maximum efficiency (shark tooth spears etc.).

The N.Z. Maori when he invented a word to describe the white man used Pakeha (white lice). It is not surprising then that the Rangiteria were reluctant to impart the knowledge of centuries to these gentry. Often, I suspect, to get out of a tight corner they told a little less than the truth

In modern times each successive year sees a fresh influx of know-it-all charlies. Bright fresh young people who must have something to put in some half baked thesis.

After all, there are worse places than the islands to have a thinly veiled holiday at somebody else's expense. A good man with a good mind is ever welcome no matter his race or creed. Man is best judged with his clothes off.

I am trying to tell you something of the Canoe builders art. To do this I find I have to describe the man. To describe the man I have to describe his environment. I will try not to bore you nor to be over technical. Throughout the islands local conditions influence the design and construction of these craft and what I have set down is a summary of the shapes and methods. Whether the craft had hulls of similar and dissimilar sizes or not I am not concerned except that either of the hulls, no matter its length, will be of the average proportions of which I have drawn up. Fashions, misconceptions, trends etc. are not the sole monopoly of the European.

Intelligence is a matter of hereditary and is confined to no particular classes. Nor can money buy it. In fact money and intelligence are poor bed companions. Education, it is said, blunts intelligence and develops memory as a poor substitute. Limited the education of the islanders may be in the European sense, but their intelligence is by no means lacking.

The islanders know far more about the natural sciences etc. than is generally realized. "Mana," that mystical "something nothing"; Churchill, a great Rangitira, also Rutherford, Darwin, Cook, Kelvin, Pasteur, Nelson, all had "mana." Compare two men. Nelson was a great sea war chief—he had "mana" for killing and destruction. Captain Cook had "mana" of the sea. Navigation astronomy, the art of improvisation and enquiries etc. He did not like killing and destruction. The old ones had this mana. Just as you can close your eyes and find your way about your own house, so could these people find the way across the oceans. They knew and could read the signs.

The last of the Island trading schooners, the Tiare Tapora, left for the last time the N.Z. shores. This fine vessel in 1958 had the misfortune to be caught in a cyclone for 3 days. The wind boxed the compass every 4 hours. Neither sun nor stars could be seen. The captain sailed onward, and the night before we were due to make a landfall, he quietly went to his cabin for a couple of hours, "to think his mana." He emerged and said: "In the morning at 7 a.m., we will be in the pass at Takaroa."

Came the morning. Fog aplenty. 5 a.m., 6 a.m., 7 a.m.—no land. 7.10 a.m. Land-ho! and there we were a mile offshore, the surf crashing on the reef.

This man is a Tahitian and carried 40 years of sailing in his head. The basic skills he had been taught—his "mana" is something no book can teach.

The fingers of the European are probing, grasping, feeling, changing, controlling. The skin is clean, supple and unbroken. The wheel has a long journey to turn its circle. The Great canoes no longer bathe in Tangaroa's mana.

Our young seek not the wisdom of their ancestors nor claim their birthright. No sons are to follow me—no children are there to teach.

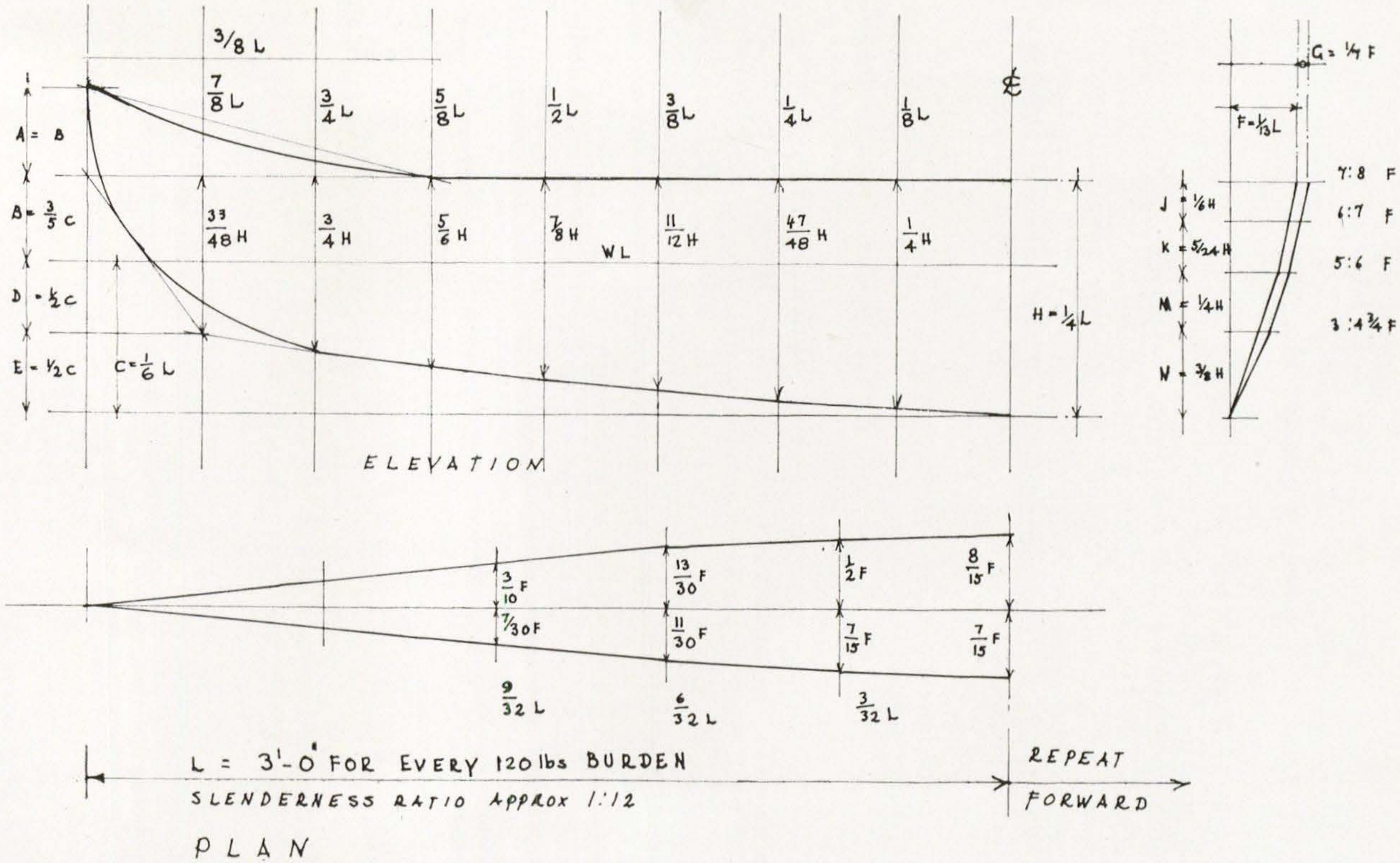
The great canoe is no longer of economic, social or military value. Now freed of shame I place the gifts of the old ones on the mat, and whenever a glance is cast upon my charge, it is not without honour I reveal its glory and its nakedness.

The multihulls which you are building now stand in the footsteps and graves of our dead. Your technological resources and skills will enable you to quickly bridge the passing of great ages and so to set your feet upon this bridge. I have written this that you may know from where to start your voyage

CHAPTER I

The early Europeans who entered the realms of the Maori, i.e. Polynesia, Micronesia and Melanesia, were more concerned with saving the souls of the heathen or shipping them off as Kanaka labour to distant shores than making a scientific study of their naval architecture, cartography and sea lore. Consequently most of this information has been lost to us. There is an odd "Tahonga of the sea in Melanesia" (Man savvy true belonga sea) and also in the Gilbert Islands in Polynesia. To make an intelligent approach to this subject, you need to know the type of man the Tahonga was and his environment.

The Tahonga is something of a man and intellect. He is first and foremost a naval architect and mathematician, an extremely skilful


3/8 L
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℄
A = B
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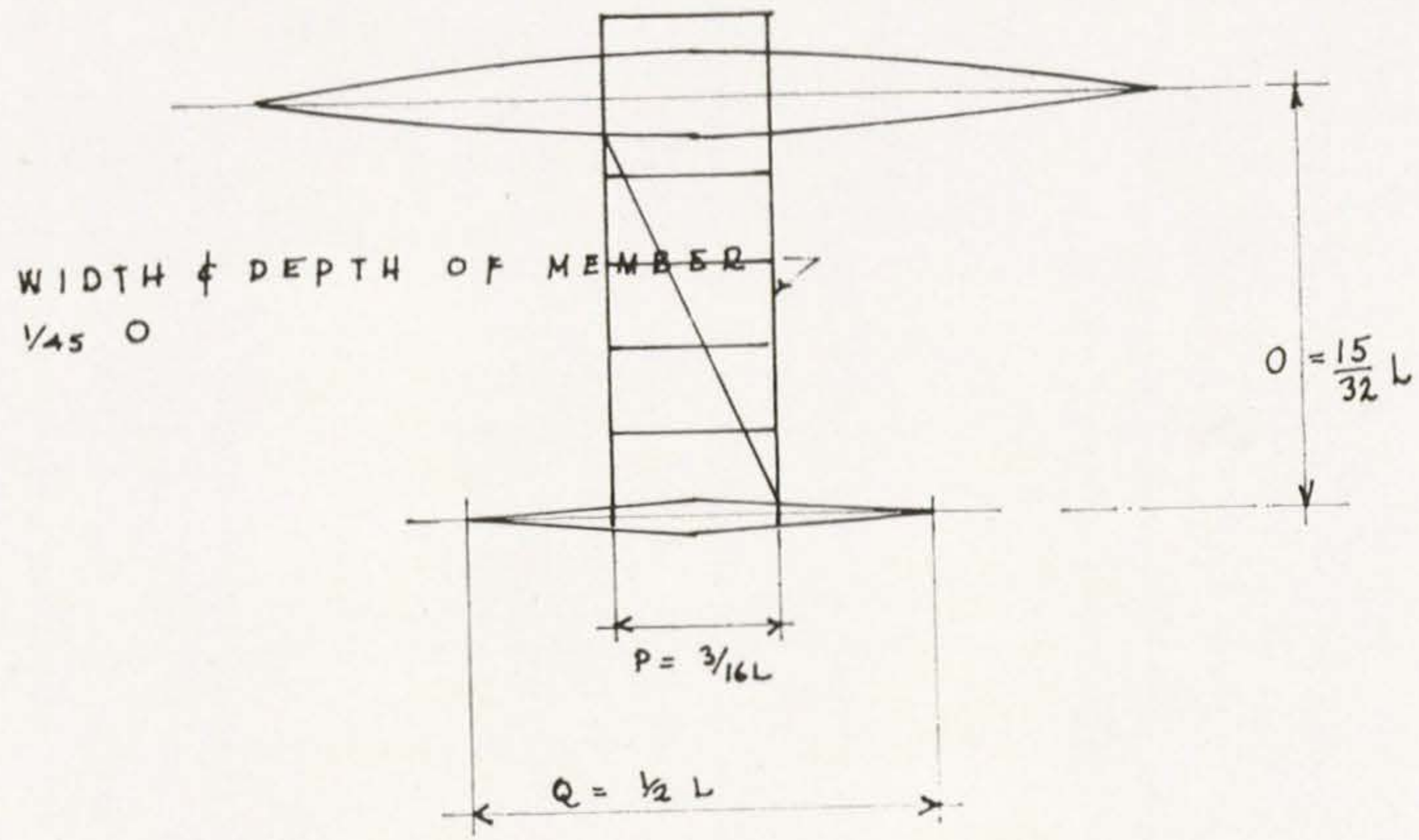
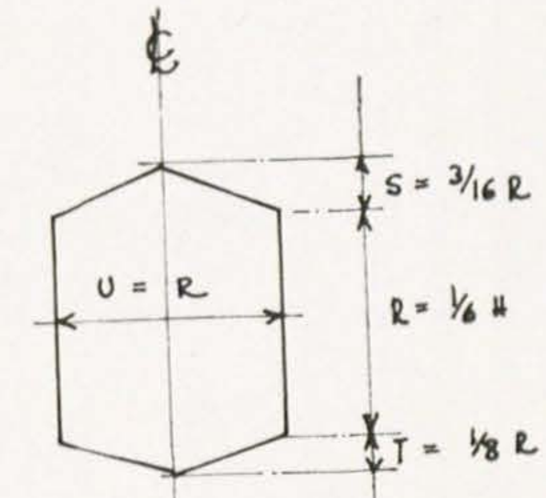
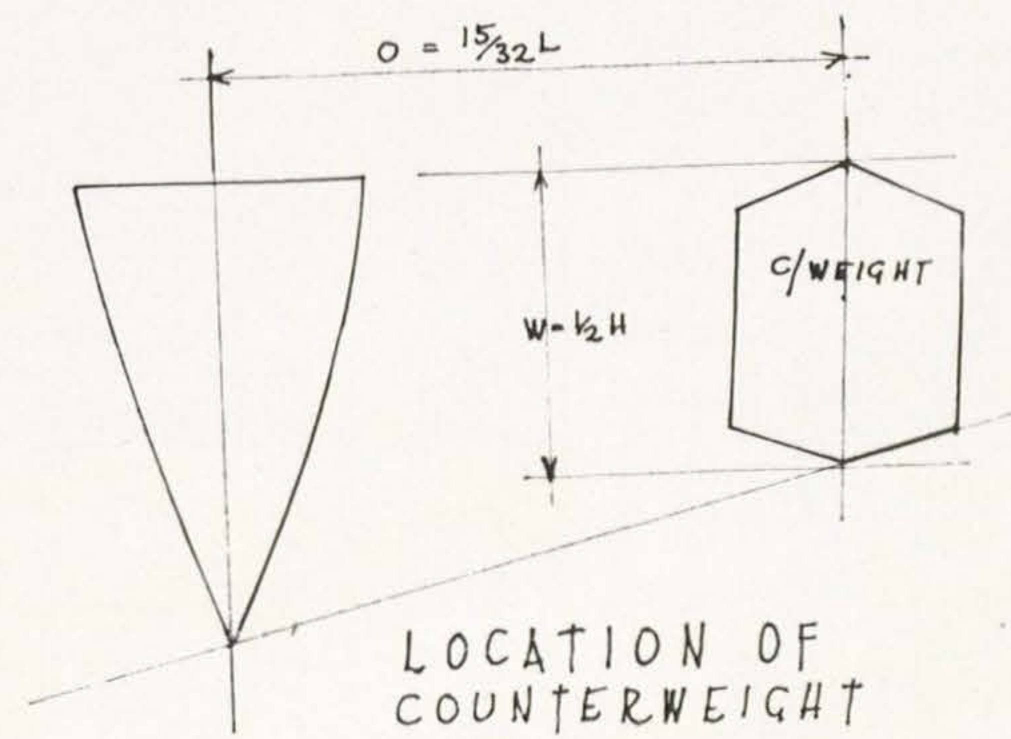
D = 1/2 C
E = 1/2 C
C = 1/6 L
33/48 H
3/4 H
5/6 H
7/8 H
WL
11/12 H
47/48 H
1/4 H
H = 1/4 L
ELEVATION
G = 1/4 F
F = 1/13 L
J = 1/6 H
K = 5/24 H
M = 1/4 H
N = 3/8 H
7:8 F
6:7 F
5:6 F
3:4 3/4 F
3/10 F
7/30 F
13/30 F
11/30 F
1/2 F
7/15 F
8/15 F
7/15 F
9/32 L
6/32 L
3/32 L
L = 3'-0" FOR EVERY 120 lbs BURDEN
SLENDERNESS RATIO APPROX 1:12
REPEAT
FORWARD
PLAN





A/S OF COUNTERWEIGHTS
WEIGHT = 10 lb FOR EVERY
120 lbs BURDEN

RUDDER AREA = 1 SQ INCH FOR EVERY 1" LOW
SAIL AREA = 3 SQ FT FOR EVERY FT. LOW
MAST HT. 2/3 L



LOCATION OF
COUNTERWEIGHT

shipwright, a seaman and also a first class astronomer and navigator. A canoe can therefore be made by one of these men or by the local carpenter. Consequently there is a big difference between an ocean-going-craft and the lagoon hack. The lagoon hack is generally a round bilge weight carrier made to get the best out of the log to hand, or in some areas where there are no sizeable trees, out of odds and ends to the most economical shape.

To turn to the ocean-going-craft the sketch gives the basic shape in a proportionate scale.

Leeway is well understood and it is for this reason the hulls are asymmetrical. Centre boards are a death trap over reefs.

The basic measurement of distance is the space required to use a paddle, approximately 3 ft. per man. A man averages about 9 stone, so each 3 ft. of length equals 120 lbs. burden. It should be noted that Fijians, Tongans and Hawaiians are more bulky and so are their trees, and craft. The Gilbertese are smaller stature, have smaller trees and planked craft. It is purely a question of related environment and resources. The smallest practical sailing crew is four persons, so the craft will be 12 ft. long. Added to this, allowance has to be made for the distance they have to travel. "Sea days" a man requires in food and water etc. about 1/6th of his body weight per day—say 20 lbs. So for a 20 day journey you need 400 lbs.—equals say another 9 ft. per man so four men equals 36 ft. giving a total of 48 ft. overall length; approximately 25 ft. per hull. The slenderness ratio is roughly 1 to 12. On a 24 ft. L.W.L. = 2 ft. which is just about the space required to sit down in. 25 ft. is considered to be the smallest practicable ocean-going-craft. Craft up to 40 ft. are usually outriggers ("Monohulls") and above that Multihulls. Mother Nature is a knowledgeable old dame and trees are about the proportion of 12 to 1 height to diameter ratio. The higher ratio species usually grow in the wetter, windier places. There must be a reason for this.

The beams and Asymmetrical Scales are set out in sketch. Canoes are double ended, the reason for this is both religion and practicableness. Such effort is required to manufacture one of these craft and their military significance (naval power) that they are accorded the dignity of a diety. It is bad manners to push a God's nose into the beach and its often a dicey business making a landing stern first in surf. Also the rigging and the method of changing tack dictates that the prows be high, roughly equal to the freeboard, to prevent tripping.

The rocker is about half the draft, its maximum being amidships. The method of sailing and rigging dictates this. I have used craft with the rocker point both fore and aft of this position and they have all been cranky. I will describe the method of building the hulls further on.

Connectives between hulls/counterweight. These must be correctly spaced and flexible. The sketch gives the sizes. The depth and width of connectives in 1/45th of their length between hulls. On outriggers they overhang the hull by 9 in. to give footway either side of the mast. When changing tack one takes a line one side and another crew member the other. I know from experience the force of impact between two bodies even over so short a distance is sufficient to raise a bump about the size of an ostrich egg. The stiffeners require to be carefully spaced as you have to run up them like a ladder. You mark time on the spot and measure the height the sole of your foot goes above the floor, 1-1/6th times this distance is the correct spacing. It's an interesting experience to fall between them. The diagonal brace sits on top of the stiffeners, so you have a build up of three members, one on top of another which form a beam the depth of which adds to 1/15th of its span. Islanders know their stresses and strains.

Counterweights are of a fairly heavy timber, about 50 lbs. per cubic foot and are designed to burst the wavetops when they are flown just skimming the crests. The expertise comes in the ability to do this and accounts for over half the speed (very little friction or drag.)

Multihulls *do not* fly hulls. That is not intentionally. Sharks also have intentions.

Sail area = 3 sq. ft. for every foot of waterline and is often an equilateral triangle. The mast height is $\frac{2}{3}$ the L.W.L. It is said that the wind blows harder or steadier the higher you go up the mast. So if you put a greater amount of sail at the top of the mast and can shorten the mast to reduce the height of the C.E., the overturning moment is less and the drive is at its greatest. This is exactly what the islanders do.

Rudder. A sweep is best for manoeuvering 1 sq. in. for every 1 in. L.W.L. or is a custom made paddle. It is also used as sea anchor.

CHAPTER II

The Construction of a Canoe or Multihull

There are two methods of construction: (1) by planks and (2) by hollowing and forming a log.

To deal with the log and more usual type first: the log needs to be of lightweight, water and borer resistant, easy to burn and cut, ductile, slit resistant and structurally strong, straight and round, free from low branches. You need luck to find something with all these virtues and still greater luck to find one growing in an accessible place. The high islands are very precipitous. The English lake district would be described as relatively flat ground by comparison. The place to look is on a Bluff overlooking a damable stream in which there is a fairly dry beach with working space and close to cultivatable land where a garden can be started. It should be clearly realized that steel tools are not all that superior to stone. Steel's principle virtue is that it sharpens easily and can be shaped to make for good shafting. The tree must fall clear and free so a space has to be cleared for it to fall into. You try to smash up as much of the top as you can on the falling. Slices are cut out of the bowl low down and fires started in them. They are controlled and tended 24 hours a day until the tree falls. You now get busy and have a corker bonfire of the top branches etc. Simultaneously a handy site is being cleared and small village built and gardens started by the women. It is here the master Tahonga and his assistants will live and work for the first phase. Surplus wood is burnt out and chopped off to lighten the log for transportation to the boatyard. Meanwhile the tribal civil engineers are making a road, erecting dams in the stream in readiness for this operation. Ropes are being made from coconut fibre by the school for seamen. The carpenters are making rollers and erecting snagging posts. The log has been measured and a building is being built to house it. The floor of the building is dug over and sometimes several inches of sand is laid. A tax is levied of animal dripping, usually pig fat for roller grease and core firing. Candlenuts are sometimes used but they don't give off sufficient heat for a decent core fire. There is a junk, built in Hong Kong and sailed to here via the Great Barrier Reef, called the Golden Lotus whose timbers about three years ago were shaped and cut by fire. I was interested to see the knots in the pine-wood planks had been core fired out and tingles fitted in exactly the same manner as the Islanders use.

Before declaring a log ready for moving the choice of times are important. A large labour force is required so it must be just after the harvest is gathered to ensure a food supply. If water transportation is involved there must be sufficient water built up and expectations of a further supply quickly forthcoming, but not too much to bring the streams to flooding. So you give a party to gather the labour force together at the appropriate time. Sometimes it is many parties spread over several years. All goes well and the logs are in the shipyard safely and the major work begins. The shipyard is sighted so that the logs can hear the sea but not see it. This is so that they know the smell of the land and to ensure that they return to land.

After all there is no point in taking chances that a big expensive boat is stuck out in the ocean. Actually there is a little more to it than that and it is of a religious nature.

Tools are varied, so are methods, but the results are the same. The length of the log is divided into an equal number of parts, roughly $2\frac{1}{2}$ times the number of men it has to carry. So if it has to carry four men there will be 10 divisions. The minimum practical length of a hull is 10 steps. A step is about the distance you require to sit down in. The factor of ten is the basic figure, you have ten fingers and ten toes. If you turn to the Table of Proportions the proportional cross sections of the hull are given at these points. Pegs are driven into the ground at these cross section points, about two hand spans away from either side of the log. The full size cross section is drawn out on one side of the log at each of these points. The datum points being pegs driven into the ground. These pegs will stay there just as long as the job lasts.

There is a ceremony—the giving of the pegs. Each crew member and apprentice is given a peg as a momento at the craft's first launching. Each peg is carved with the Tahonga's insignia and matches the one carved inside the hull (the Tahonga's trade mark). Stout stakes are made about 3 in. x 3 in. of requisite length through which holes are drilled and the cross section points N.M.J.K. These are driven into the ground each side of the log at the ten cross section points. Sticks are fed through the horizontal holes to trace out the profile. The surplus wood is removed by burning or adze. It is always finished with adze. Sometimes the log is long enough, but of insufficient diameter to work in the rocker. The log has then to be bent to give the rocker. This is the tricky part and you only make one misjudgement. At either end of the log at points where normally the stem, cutwater and keel join, you place logs or cut stones the same height as H. at position 33/48 H. & E. The log is now lifted up on the supports (another party day). Other spacers are inserted at B. & E. heights in their appropriate places so that if the log were pressed down these spacers would support it at the correct profile.

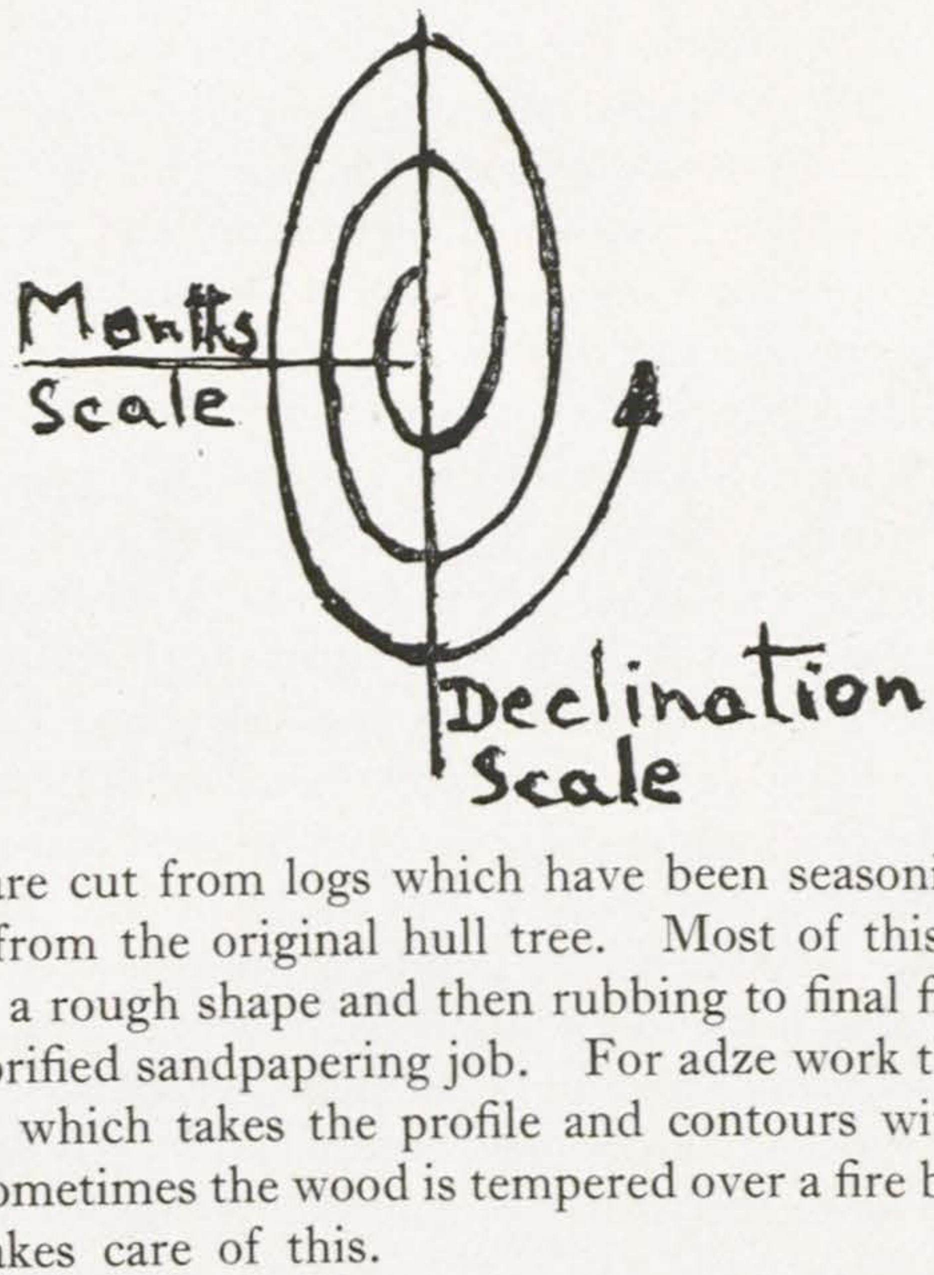
The log which is roughly hollowed is filled with water and red hot stones are thrown into it. The water boils and the log sags just a little. It is allowed two days to cool and the water is bailed out. After all this bonfire making, stone heating etc., everybody has just about had it and a holiday is declared for about a week. This is a week of blood, sweat and tears for the Tahonga in case the log splits. Work resumes and the walls are thinned both by fire and adze. It is refilled with water and repeat performance goes on. It is experience that dictates the number of thinnings and fillings which will be required. You learn this the hard way. As the walls get progressively thinner less and less fire and water can be used, and a partial filling of hot sand has to go in immediately the water is baled out.

This checks the cracking and its weight helps the bending to be even. When the walls are thin enough to tune by tapping the work to an even thickness, (lumpy spots are fatal). The sides are pulled to fare to give the needle like form. This is an awful dicey business and you don't do any more pulling than you have to. You build up a wall of sand along the outside of the hull up to the gunwales. The hull is filled with water and heated. The water is kept about 180° by swapping hot stones for cold. You now drive gently, so very very gently, wedges along the gunwale until you get a nice fair shape. If you are lucky that is. You now don't press your luck any further and go on holiday for about a month. You try to work this to coincide with the fishing or hunting season. Never with the gardening, that's women's work.

You reluctantly resume work and get the stones out but leave the water in and see if the hull has lifted up from its profile. A log has life as it's called and the best hulls have plenty of elasticity in their hulls. You top up with water until it sinks down again. You should now catch on to why the first two hull supports were made to height H. If the log has a lot of life you have room to take it beyond it's profile so that when it springs back it comes to the right shape. You also have room to get underneath to work if necessary. Eventually you reach a compromise with the log and bale the water out. The log has to be slowly dried. This is a moment of grief. The boatshed roof is removed and the sun allowed to do its work. It's a great joy to pick the rainy season for this as it is effortlessly part filled and emptied and is all to the good. The wall of sand or earth must not be removed from along the outside of the hull until the hull is completely dry. You then demolish this wall at the rate of 2 inches per day as the winds rate of evaporation would be too fast and the hull would crack particularly where a limb has been and the resultant change of grain. You now go walkabout after re-roofing the boatshed. With a bit of luck you may get a sea trip to visit some other boatbuilder on another island (poor mug). It is not unusual to cover 1000 miles island hopping.

The fine work now commences. The making of the stern and prow carvings. The carving is usually cut by a specialist carver, but is marked out by the canoe builder. For in fact, the detachable stern is a horizontal and vertical sextant. The flat head of the prow mask is drilled to accommodate sighting sticks. The carving on the stem sides are specialized nautical almanacs and sun tables, sometimes for both N & S latitudes.

The declination of the sun is set out on a vertical scale and the months on the horizontal by starting at the centre a spiral is cut which is proportional and interpolations can be made. The same goes for stars etc. and the form can be varied by using varying scales. These are the secret writings you hear about and are somewhat personal to the Tahonga and his school. There are horizontal holes poked through the stem usually four sided and measuring sticks can be slipped through them. The sticks are graduated and can be read over an arc of 100°. The vertical spacing is at 10° intervals and often an extra hole is added for some special purpose. The sighting spot is marked on the sides of the hull often a little nitch in which is placed a stick as a headrest whilst sighting. Wash strakes and odd bits and pieces are cut out for carving. The hull is drilled for their ties.

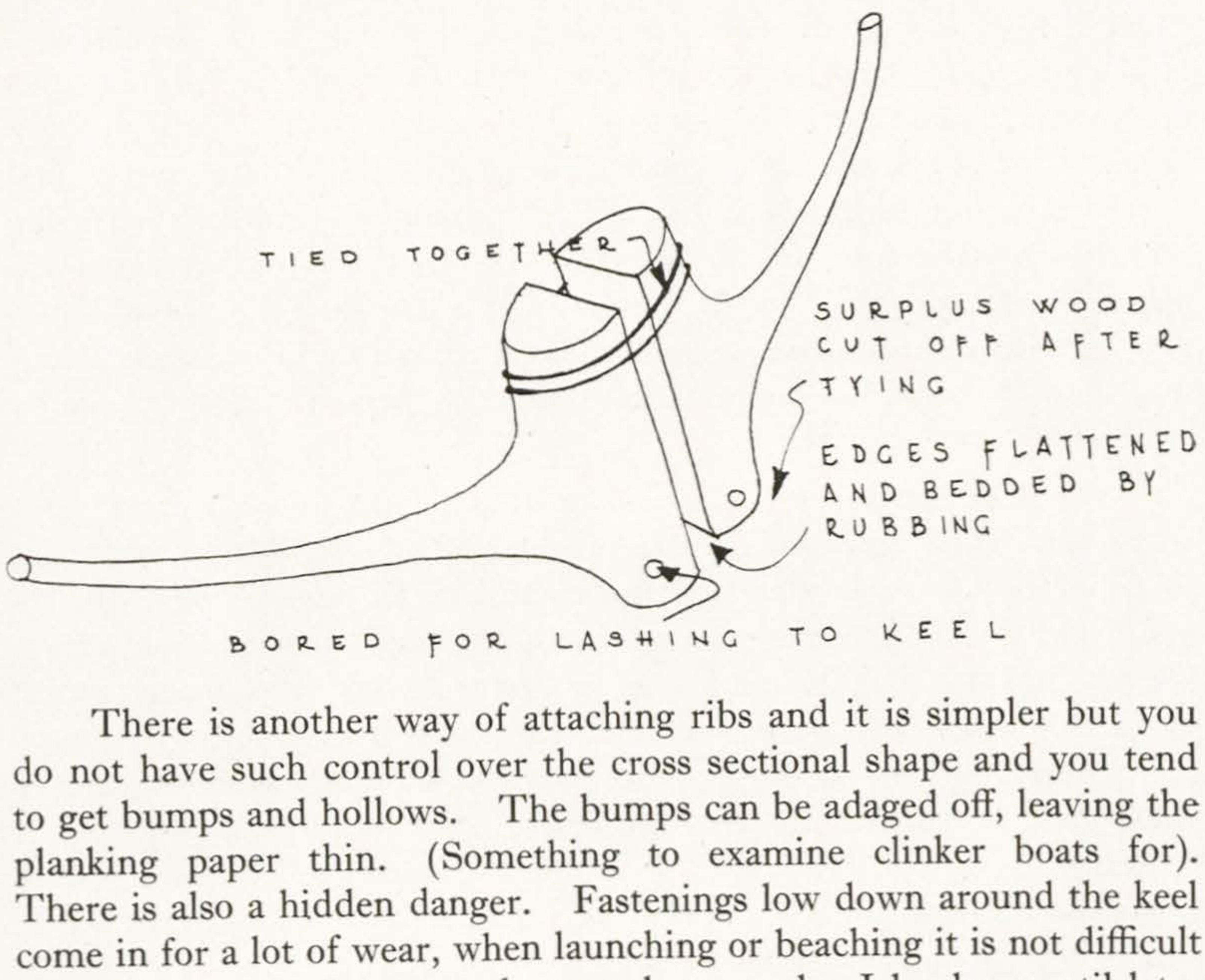


The paddles are cut from logs which have been seasoning, often they are branches from the original hull tree. Most of this work is done by burning to a rough shape and then rubbing to final finish on coarse stones. A glorified sandpapering job. For adze work they are pegged down in sand which takes the profile and contours without breaking the wood. Sometimes the wood is tempered over a fire but the burning out usually takes care of this.

The Building of a Planked Craft

First get your planks. In some places this is not over difficult. Trees in the warmer climes often grow quickly to great sizes and are short grained. Many will work both with and against the grain. These trees split relatively easily into long thin planks. Some need to be cut green, others old and dry. Some improve by being exposed to salt winds, others not. In these days cedar is used, but this is a poor choice as it soaks water and is difficult to fasten. In New Zealand they have Totara, Kauri, Kiaheketia, Tawa. The Maori of N.Z. soon forget the art of making sailing vessels and of navigation. True, they made some great paddling canoes from their mighty trees which alas the New Zealanders still ruthlessly destroy and even the very land itself. Great works are their carvings, but long forgotten are the carvings of the seamen and navigators. It is as they never existed. Perhaps the greatest naval architects from a technical sense are the Gilbertese. Planked Canoes are usually in the smaller sizes and tend to be a family ownership. The building site is dug over to get rid of lurking snakes, centipedes, scorpions etc. and to pack it down again what is better than a good stamping. A dance is just the thing, a down payment. So all is ready. The planks are cut and dried. The rib branches have been cut and matched. The sennet lashings are made, the anchor stones are grooved. The drill points have been reset and cut. All the tools have to be at their sharpest as in this fine work you cannot strike a heavy blow. The distance the canoe has to travel, it's burden etc. has all been fixed and worked out. So, as with the dugouts, the dimensions are paced out and pegged in the ground, and so also are the frames but this time they are kept away from the working space. The curvature of the keel has first to be established. 10 logs, brain corals or stones of varying heights are pegged to the ground. Unless it is a very large craft the stern, keel etc. is all from the one piece of timber and is a flexible triangular section knifed edged. It is made by splitting with stones and rubbing away to a finish on rocks. Sandstone and scoria are the best. These stones are prized and often acquired from different island groups where the good type of stones appear as a natural feature. To make the keel strip flexible it is buried 3 in. deep in wet sand and a long fire lit on top of it. When it is removed from the sand it is too hot to handle. In this state to facilitate its handling handfulls of damp seaweed are used and the hot keelstrip is forced down on the ten profiling stones or logs and pegged into position. It is important to ensure a nice fair curve which is done by means of the pegs. By now you have a good collection of burns on your hands, arms and legs so you take a couple of days holiday and leave it alone. This job is better done in shorts than skirts.

It is not good practice to have much rise fore and aft in the planking as it stresses the planks too much and reduces their ability to withstand a blow. You pick out the wider and better planks for the Garboards and lower ones. Each plank has to be bedded and matched to the other. The edges are not square but have a varying bevel which is dictated by the profile formed by the frames. How well this is done decides the quality of the craft. The planks sit on the edges of each other and are bound in place. (European clinker boats—the planks overlap each other which is a simpler way of doing the job but it also makes the craft 30 per cent heavier and has a greater drag). Some canoes are clinker built and sewn together, the sight of which makes a Tahonga's lip curl. The Frames, which become later ribs, have next to be fixed to the keel. The frames are made from small branches which are split at their junction to the main tree limb and tied to the other as sketched.



There is another way of attaching ribs and it is simpler but you do not have such control over the cross sectional shape and you tend to get bumps and hollows. The bumps can be adaged off, leaving the planking paper thin. (Something to examine clinker boats for). There is also a hidden danger. Fastenings low down around the keel come in for a lot of wear, when launching or beaching it is not difficult to partially cut a line on a sharp rock or coral. Islanders, until later years, have not used metal fastenings as metal ores and their requisite fuels etc. are not generally to be found, and where they are present, something has always been at a loss, hence metals have never been much developed. Pottery clay with its appropriate fuel is another commodity that has had little development. However, if one thing is not available another is. I have two pearl shell plates that have seen many places and have given great service. The great gold lipped shell and its companion, the Black one, are objects of great beauty besides utility. We do have flax, cabbage tree and coconut fibres which are very useful and strong but they cut. If you put to sea with a line of partially cut fastenings you will get sufficiently from shore to be in great danger. This happened to the writer. I was fishing and boated a small tuna, an extremely vigorous and powerful fish. To stop it leaping out of the canoe I stepped quickly and heavily on to the bottom and pushed the Garboard strake away. My foot went between the Garboard and the keel. It is extremely difficult to swim with a canoe attached to ones ankle, take my word for it. The alternative is to tie the Garboard to the keel; drill a small hole in the keel and poke the rib end into the keel and then the rib to the planks. My choice is a well made frame secured to the keel and planks. Have the frames fixed to the keel and securely braced. The planks are now affixed. They are carefully drawn in and bevelled to sit one on top of the other by rubbing on stones or adzing. The planks are then removed and the fastening holes countersunk ready for the next job of shrinking the planks. Companion holes are not drilled in the ribs/frames but notches are cut about the thickness of the plank below the level of the holes. The diameter of the fastenings (string) is roughly half the thickness of the planks. The planking is carefully buried edgewise in sand about 3 in. below the surface. Not less than two but not more than an hour's work of tying. Usually you settle for three planks.

You light a fire on top of the buried planks and the heat dries them out. They are quickly siezed edgewise to each other and drawn to frames. One man ties to frames and one to edges. You need a good rabbits foot at this moment in case the planks split. Sometimes the lashings are tied shrunk if they are large. You have to be careful about this as when the planks are wet they expand and exert a tremendous pressure on the lashing. It is to avoid sheering them off and to draw them down that the ribs/frames are notched and not drilled. It is humiliating upon launching to watch the planks fall off on a brand new boat. If the job is well done the hull will be tight and full of life.

CHAPTER III

Pros and Cons of an Ocean Voyage

Cooking. What you cook and what with, is largely a matter of what is available on the islands where you come from. In the olden days for a fire place (primus stoves had yet to appear) we used a woven mat of Pandanus covered with sand or earth slung between the hull's connectives. Earth is the better as it keep cooler than sand.

Not infrequently some silly mug sets the mat alight or loses the earth to the sea. Earth weighs about 120 lbs. per cubic foot and you need at least 1 cubic foot to do any good, which, if it were food, would be more useful. Alternatively a hollowed-out brain coral is used. (It must be very dead otherwise the stench is unbearable). It's lighter and so long as the fire is kept low it stays whole. It also floats away. Giant Clams. Tridacna. The shells of these are tremendously heavy and on outriggers you have to fit a very buoyant float to the counterweight to compensate for this.

If you can get one and the chances are you won't, they are handy as serving a dual role of bowl to wash your face in, etc. With the advent of oil companies, has come the 40 gallon drum. This split lengthways is ideal and you have no idea the things you can do in half an oil drum.

For instance, you can keep a slow fire going and drape your wet clothes over it, which, apart from drying out, often acquire additional ventilation.

It is an interesting experience to land at a port minus the backside of your only pants. Lava lavas always seem to come to grief at about the same place. Grass skirts are reasonably waterproof and dry quickly, but oh boy, do they get warm when they catch alight! Somehow you can never get the simplest knot undone when you are in a hurry . . .

Food. You allow about $2\frac{1}{2}$ lbs. per person per day plus whatever comes to hand on the journey in the way of fish which is usually not very much. Taro is something like dirty potatoes and take a lot of boiling.

You don't usually have a lot of fuel to spare to bake anything. Yams are like watery potatoes slightly sweetened when boiled. Kumaras are the best—they boil and bake easily, taste good and keep fairly well. The raw skins rubbed on scratches seem to do some good. Pineapples take two years to grow and never seem to be ready at sailing times. They are ideal to get rid of the taste of the sea and a morale booster. They bruise badly and the spine often causes painful festers. Breadfruit are fillers, but you soon get fed up with it. Rock oysters in their shells are good keepers. These oysters grow on rocks similar to mussels or barnacles and are chipped off with a hammer. Cuts are plentiful on this job and they are heavy to carry. They keep well bottled but uncooked trailed in the water to keep cool. It then becomes a question of who gets them first, you or the sharks. Care has to be taken with their collection not to include damaged shells.

Fish and various shell fish are usually carried dried and smoked which in turn become nicely wet and smelly as the trip proceeds.

The multihulls score on the point as there is room to hang them around the walls or in the rafters. Lemons are carried for soaking raw fish in. It gives the fish a smoked taste and look, and in the process is some way or other half-pie cooked. Anyhow, it's good tucker.

Meat is dried and smoked or stored in pots of lard. Chickens are often carried alive. Piglets are a darned nuisance and eat too much. Chickens often die of fright early in the voyage; the survivors get more skinny as time goes by. They can also be difficult to catch. On multihulls the rafters are their domain and a hazard they are, too. Fowl dirt baked with earth makes a fair hearth. Not all foods are available throughout the various island.

When God made coconuts, He had a brainwave. The nuts are collected at various stages of growth suited to the purposes for which they are required, some for drinking—for eating, for boiling, burning, buoyancy, caulking, rope, sunburn, home brew and salt sores. They substitute for crockery, navigational instruments, etc.

Three shells make a water still and the husks make a good fire. If the worst happens and you sink, you and the nuts come ashore at about the same place, if at all. If you have a means of opening them, you can have a snack en route. They are particularly difficult to open by banging them on your head though.

Launching

The craft are dragged into a shady place ready for launching and loading. Coconuts, chosen for their smallness and ripeness are loaded. These are for fuel and buoyancy, the meat of which is for sunburn and eating. Next the green drinking nuts and so on. You always make sure you have a good shaped nut to sit upon. The green ones keep dryer and the choice is by trial and error. The shell fish in the prows and stern on top of the anchor stones let air circulate under them. Water in Gourds tastes mouldy. Thank heavens for bottles. The Fijians had pottery. The ration is 1 drinking nut and 1 meat nut per day per person, the husks of which are just about sufficient fuel to cook anything you have, when coming off night watch, cold, wet and miserable in those dragging hours before sunrise. The noble sacrifice is to forego cooked food for the day in exchange for a fire in the oildrum on which you sit or drape yourself between hot spots to get warm. Your always curse your choice when the sun comes up and you are trying to keep cool or are tenderly nursing a juicy burn on some tender spot.

The fruit, meat and all the gear is on hand on the big day which is in the particular sailing season and always seems to clash with every other chore. So you have a party after which when you have departed a tucker tally is taken. Those ashore are not beachcoming but are digging furiously.

A multihull, say 50 ft. long, weighs about 4 tons all up. This is something of a weight to shift and it's unlikely that sufficient manpower would be available in any one place at the right moment to launch it without a slap up party. So the party (Sing Song) is a necessity and unless you have about 200 pushers and pullers you are going to sweat some. These 200 eager beavers are going to eat about a ton of food and somebody has to look after the girls whilst you are away, which is usually about a year from one sailing season to the next.

The Dance of the Tahonga

Islanders are just about the only crews that put to sea cold sober. The time of departure is usually half an hour before the sun touches the western horizon for the navigational reason that the time has to be measured between the sun on the horizon and the first appearance of the especial navigational stars. Three hours before this the fleet's (craft's) Commander walks into the dancing area and pushes the craft steering oar into the ground. The Tahonga of the sea who is staying at home, walks into the area and sits down in front of the oar. He is immediately flanked by his assistants (apprentices). The departing Commander Tahonga sits down in front of them and is given advice from the old man staying at home and generally is wished farewell from one seaman to another. The departing Commander recites his sailing directions and makes known his plans and also undergoes a stiff verbal examination at the hands of the old man. If the old man is dissatisfied with his answers he will seize the steer oar and break it and the voyage is off. The departing Commander stands a very good chance of being beaten to death at the hands of the women for risking the lives of their menfolk due to his incompetence at this stage. Once this hurdle is over the departee dances and chants his way around the area, passing on to his crew the advice given him by the old man and also urging his crew to be strong and stay away from the girls and liquor as their testing hour is at hand. (The crew are sailors not Tahonga). The girls then come to the fore and dance temptingly around the Commander trying to tempt him into shame (you don't know what temptation is until you have been through this). The Commander plays aloof and hard to get and eventually the girls turn their bottoms upon him and sit down. The old man then sends his assistants (apprentices) to fetch the Commander to sit beside him in front of the steer oar. The assistants charge the Commander (rugby has nothing on these kids) and frogmarch him to the old man. The

Commander must not cry out or show pain despite the generous collection of bruises he is now sporting, as he will be deemed unmanly and the trip would be off. This same Commander has probably been giving these kids sailing tuition with the aid of a rope end prior to his departure and the kids take the opportunity to even up the score. Next it's the crews turn. They dance around and declare they, and sometimes their women, will protect and obey the Tahonga (Commander), be loyal to his officers (senior apprentices undergoing sea instruction), will fight on land and sea and protect their ship and crew with their lives. They vow to kill each other with the intention of protection of the others (in case of madness) if need be. The girls come forward again and get on with the tempting act. The crew are required to stand and hold their ground and be indifferent to the girls embraces etc. until the girls get fed up with the job. If a man falters the girls will give him a beating of a lifetime and he is out. If there is a volunteer or a spare crewman he is sworn in and goes through the ropes. This is a really tough assignment as this chap is something of a novelty and gets the full treatment with all the trimmings. It is from these men that fight Chiefs and Officers are often chosen. They are not required to have the mental ability of a Tahonga but they are well above average.

It is a pity that these old traditions and customs are passing from memory. The cold fish demeanor of the European is a poor exchange for the warm-blooded life of yesteryear.

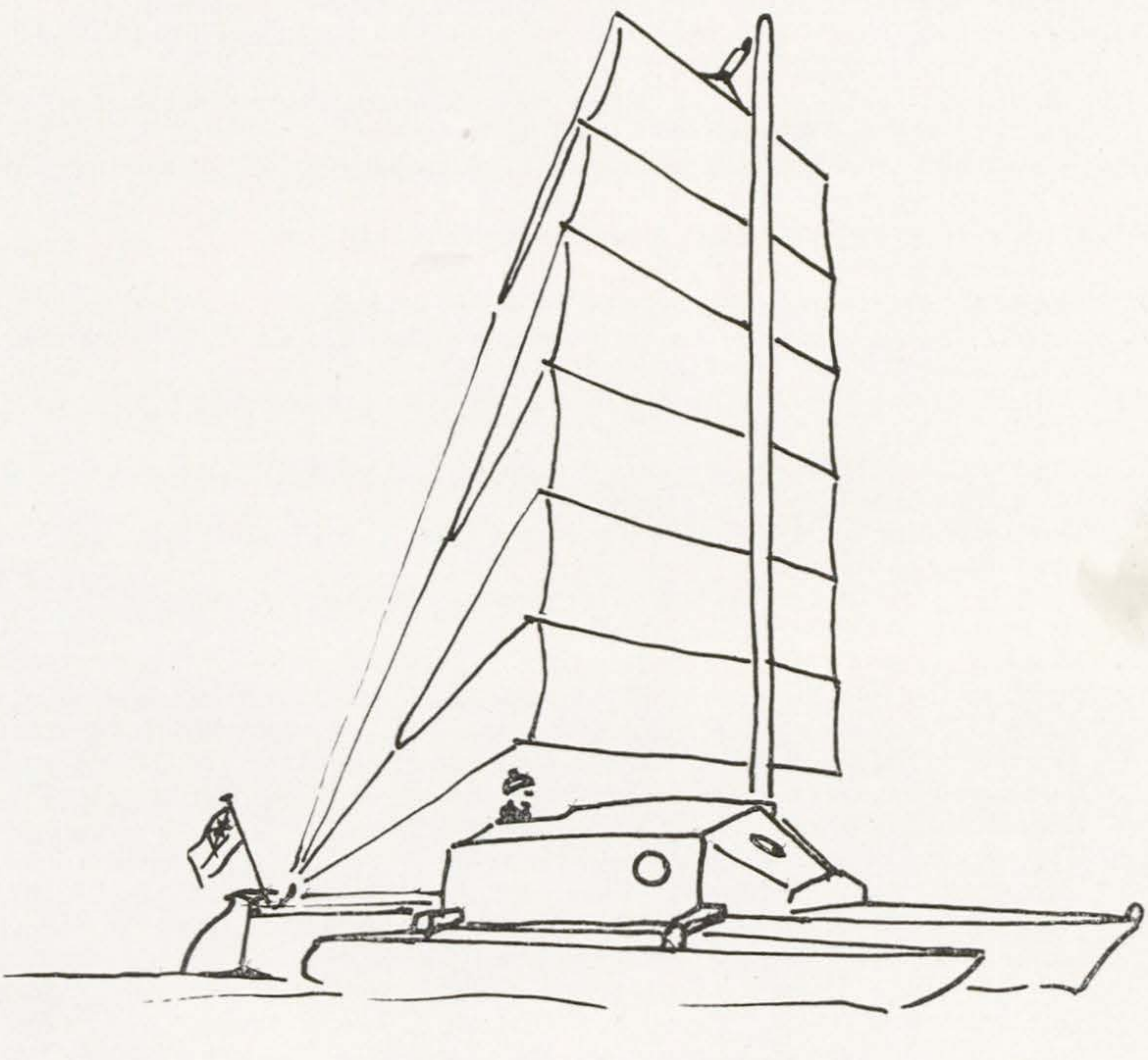
The Commander and crew take no part in the actual launching. This is the province of the assistants (apprentices). It is their responsibility to see that every fastening is tight and every ounce of gear and stores is aboard. Once the craft is waterborn the apprentices hold the craft steady and the crew carry the Commander face down to the waters edge so that he may remember well the sight of his native land and not get lost. The old man then joins the Commander up to their knees in the sea and asks for the blessing of Tane and Tangarea, the sea Gods for the venture. Other Tahongas in their respective spheres also ask for the blessing of the other Gods at this stage and in turn enter the water. The crew climb aboard and make an inspection of the craft. This is far from casual and woe betide the apprentice whose work is at fault. The chief officer then carries the Commander aboard on his shoulders. He must not stumble or fall although he may have the assistance of the other officers if he feels unequal to the task. The purpose of this is to show the Commander off to the crew so that there can be no mistake as to his identity and the Commander in turn shows his trust in his officers by entrusting his person into their care. If the Commander is dropped in the sea it is taken that the officers are unworthy of their Commander and the voyage is off, and the crew promptly set upon the offending officer with the paddles. The crew in turn must not break a paddle on the offender, not only to preserve their skills but paddles are laborious to make. Something like trooping the colour. The principle chief/king removes the steer oar from the ground and hands it to the Commander and everybody sings a farewell song, as the crew pick up the paddles. The apprentices now waist deep in water dive and swim under the craft as a gesture of their confidence in their work that the craft will sail and hold together so long as breath shall last.

This ceremony varies from place to place like others.

There is one more ritual which is performed at sea, and it is tabu to speak of, in the case of a large fleet, particularly if it's a war party. The fleet is laying together offshore close enough to pass from one craft to another. The Commander has just finished taking navigational bearings and worked out his course and all is stowed ready for sea. He then names a series of successors if he or they should fall in battle or get drowned. The crew and officers are on equal footing for this occasion and can challenge the Commander's choice. They must say why they object and the Commander can either modify his choice or the company will call for a choosing of the champions. The rejected and the champions will submit to a verbal examination by the ship's company on seamanship navigation, military tactics, shipwrighting, sailmaking etc. The Company will then vote on who gets the job. The Commander can take no part in this and can either accept the companies decision or be put ashore and a new leader selected in his place. If the Commander accepts the company's decision and then makes difficulties for the champion the company will kill the Commander by lowering him head downwards into the sea through the hulls connectives until he drowns. This is to wash the evil from his mouth before he meets the spirits that he may speak truly to them. The entire company, women included, cut their hair short to show their shame for having such a dubious Commander and to indicate to the Gods that they are in especial need of care and protection. In these circumstances the new Commander, if he's wise, will make for the nearest acceptable land and stay there until their hair has grown neck length and their shame is by then covered, otherwise the venture gets off to a very poor start.

Washday at sea. This is when it rains. The mast is unshipped and sail and spars are lashed over the connectives. The canvas/matting sags between the connectives and makes a convenient water catchment from which the water bottles are refilled. This has to be done before clothes washing starts. Simultaneously there is a great soaping and rubbing off of caked salt. The soap used to be melted coconut mixed with herbs. The recipes are local—some work but most are poor. Lever Bros. now have the monopoly of this business. The day's toilet takes place after breakfast when the fire is put out a little after day break before the craft spread out over a wide front for the day's sail. (They come together at night and heave to 1 hour before dawn to about 1 hour after). Bodies are preserved from the salt, wind and sun by a massage with warmed, scented coconut fat. It is repeated after evening meal at sundown. I would recommend this to all yachties and the girls get particular pleasure from this. The saying goes it makes 40 feel like 14 (it does too, if you rub it on thick and heavy). I have often laughed at tourists in rented cottages when they find out about this. The next morning there's mum flat out washing the sheets. Sometimes we quietly slip a finely woven mat between the sheets. Mum is quick to catch on and usually returns home with the mat, her greatest treasure and it's about the only thing Pop willingly pays for.

Rough weather drill. The craft come together; the outriggers lash together, hull to hull and form a trimaran. The fleet take a line astern formation. Masts are unstepped and the mast, spars and sails are lashed over the hulls to form a tent to give some protection. The steer oar is trailed on a warp. It is arranged that the oar is off balanced and dragged through the water and is trailed from the connectives. The last thing an apprentice makes ashore is a *bailer*. This he must have before he is allowed to sea training afloat. This is carefully designed to scoop up the greatest amount of water without spilling or being tiring to use. The trick is to get the right set on the handle. It looks something like a sugar scoop with the handle on top. These are difficult to make and are usually carved. The bailer now becomes the most important chap in the craft and he is certainly the busiest. The masts are about $\frac{2}{3}$ the L.W.L. This leaves a space at bow and stern. The bailer is in the bow and a steersman in the stern who is controlling the storm sweep. The sweep is set up in a crutch and a line is attached to the sweep. Sticks/lines are erected across the hull under which the steerman puts his legs. This prevents him from being swept or thrown out and he can get clear if he has to. The coconuts are put into netting bags, each crewman sitting between bags. These will form a liferaft if the worst happens. You now put on a necklace of dried shell fish—tucker strings. The bailer is similarly fixed up and he ties the bailer to the hull. He may get thrown out but if the canoe is intact with a bailer you can right a capsized or waterlogged craft. Usually they swamp if anything is going to happen at all. On the multihulls the crew repair to the cabin after closing the hulls over, leaving two steersmen and two bailers on watch. It has to be really bad before they go to this procedure. Usually they reduce sail and keep going. The biggest problem in these circumstances is to keep the speed down to suit the sea. Quite often the sail and spar is furled to the mast and you find yourself tearing along like bats out of hell. It is then difficult to get the mast down and this is when the casualty list starts. Sometimes in desperation a bag of coconuts is towed to slow things up.



METIS

METIS is a 24 ft. junk rigged plywood trimaran. She has been arranged so that one man can sail her from the cockpit, and reef, hoist sail and anchor without leaving it.

Main particulars are:

Hulls and Floats to Nugget design by Piver, sheathed bottom, sides and top with fibreglass. Cabin with 3 berths, Sumlog speedo and log, compass. Rig to H. G. Hasler's drawings of 'Jester.' Hollow spruce mast built by Clarke & Carter of W. Mersea. 240 sq. ft. tan terylene sail Jeckylls of Wroxham.

Main dimensions: length 24ft., draught 20in., centre-board up, breadth 14 ft. but cross arms are hinged and floats can easily be folded or removed leaving hull about 8 ft. 6 in. wide. **£350**

Squadron Leader A. E. Barton, Lynch Green, Hethersett, NOR 42 X, Norfolk.

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IN THE CURRENT ISSUE (APRIL 1965):

From Australia: The racing Trimaran "Jabawock"—the Kraken class Trimaran.

From California: Racing and cruising Trimarans—the 26 ft. "Caravel"—34 ft. "Manta"—38 ft. "Off Soundings"—19 ft. "Skol"—25 ft. "Trilogy"—32 ft. "Trialar"—39 ft. "Valhalla"—42 ft. "Madrigal"—all new classes.

From Portugal: Mason and Barry (Constructors de Embarcacoes) Limitada's cruising Trimarans.

From England: The 33 ft. Triple Ripple Tricraft cruiser with full buoyancy in each hull and 6 ft. headroom.

Also: Catamaran workboats for fishing, etc. A Catalogue List of craft on the market, with prices.

JANUARY 1965 ISSUE HAD THE FOLLOWING:

1. Catamaran Car Ferry from Japan.
2. Photo of Catamaran sailing clear of the water on foils.
3. Largest single Catamaran class in the world—the Aqua-Cat "12," with over 2,000 sailing.
4. New Bipod rig Catamarans, the Aqua-Cat "18" and the Fiji "12" and Fiji "16."
5. Construction photos of 10 metre 6/7 berth "take apart" CataCruiser that you can build at home in a garage.
6. Twelve photos for the "Little America's Cup" races, with "close-ups" of gear, mast, rudders, etc.
7. Trimaran news from designers—Brown and McQueen, Jefferies, Marina, Jay Kantola, Doblet, Hedley Nicol.
8. News of a new Trimaran magazine from Sydney, Australia.
9. News of the following multihull national and international associations: Aqua-Cat Catamaran S.A. L'Assoc. des Prop. de Catamaran Francais. Australian Catamaran Assoc. Assoc. for International Racing of Catamarans. Canadian Catamaran Assoc. Catamaran Assoc. of W.A. Catamaran S.A. Eastern Multihull S.A. Flying Kitten Owners Assoc. International Cougar Catamaran Assoc. International Multihull Boat Racing Assoc. Irish Catamaran Assoc. Mercury Class Assoc. Midway Catamaran Assoc. National Shearwater Catamaran Owners Assoc. N.S.W. Catamaran Assoc. North American Multihull S.A. N.Z. Multihull Society. North American Shark Assoc. Ontario Catamaran Assoc. Pacific Catamaran Assoc. Shark Owners Assoc. Shark V. Trimaran Owners Assoc. Shearwater International Racing Assoc. Sveriges Catamaran Seglare. Tiger Cat Assoc. Trimaran Assoc. of Australia.
10. A Catamaran at the London Boat Show, ready to sail for £130 ($400.00) or can be built from a kit with sails and spars complete for less than £100 ($300.00).

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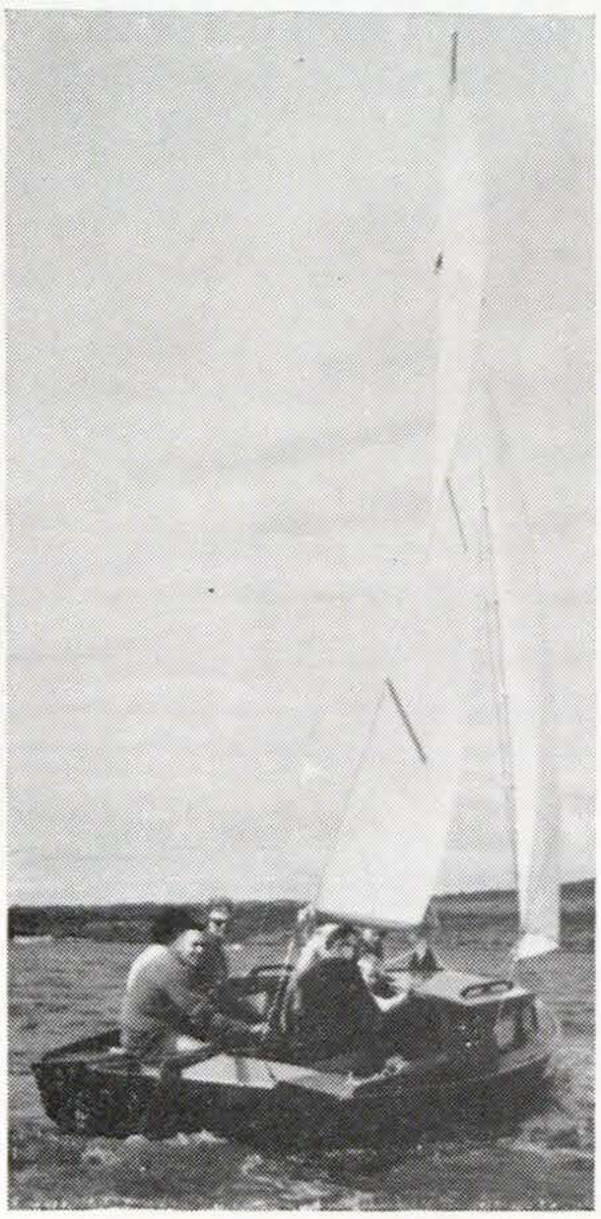

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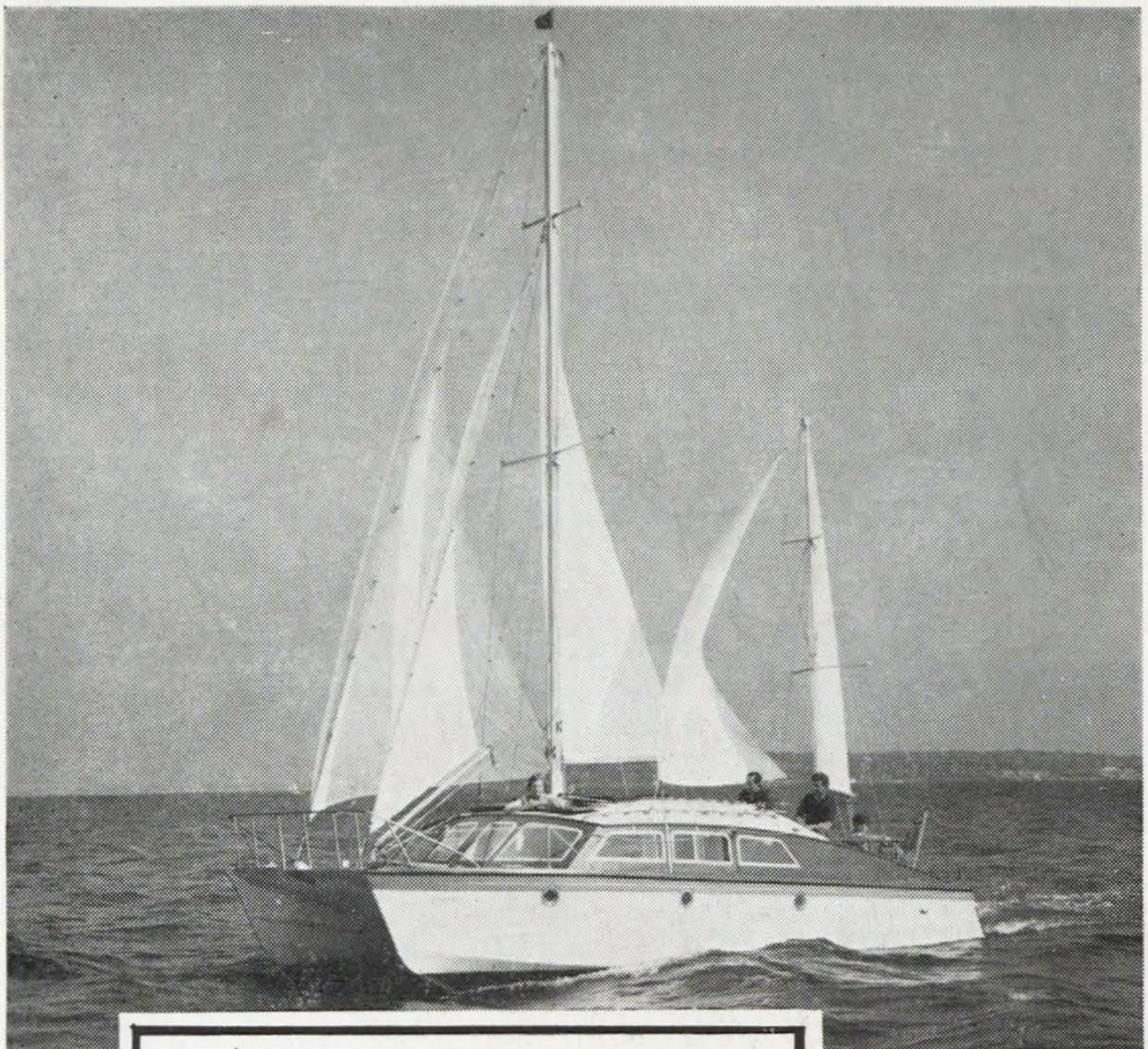

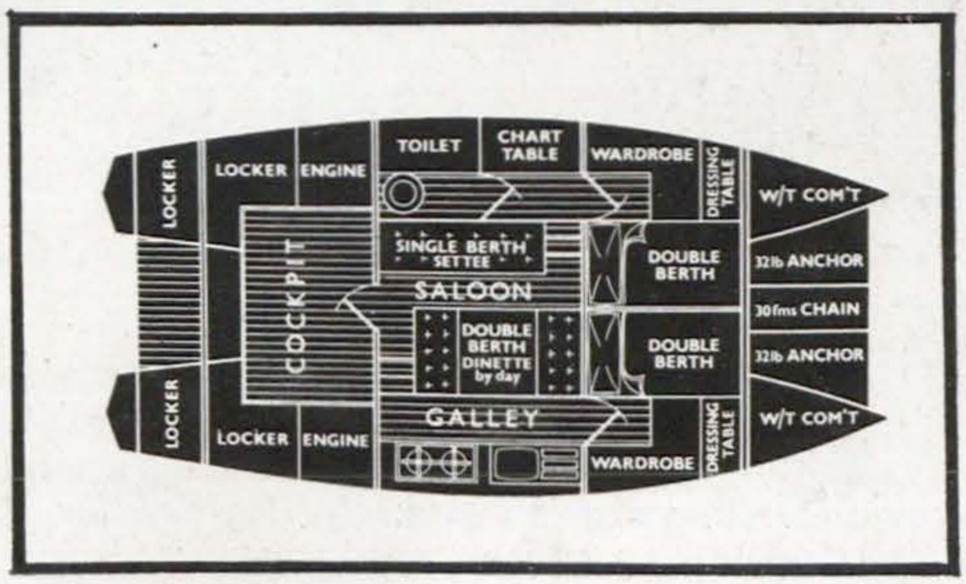

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