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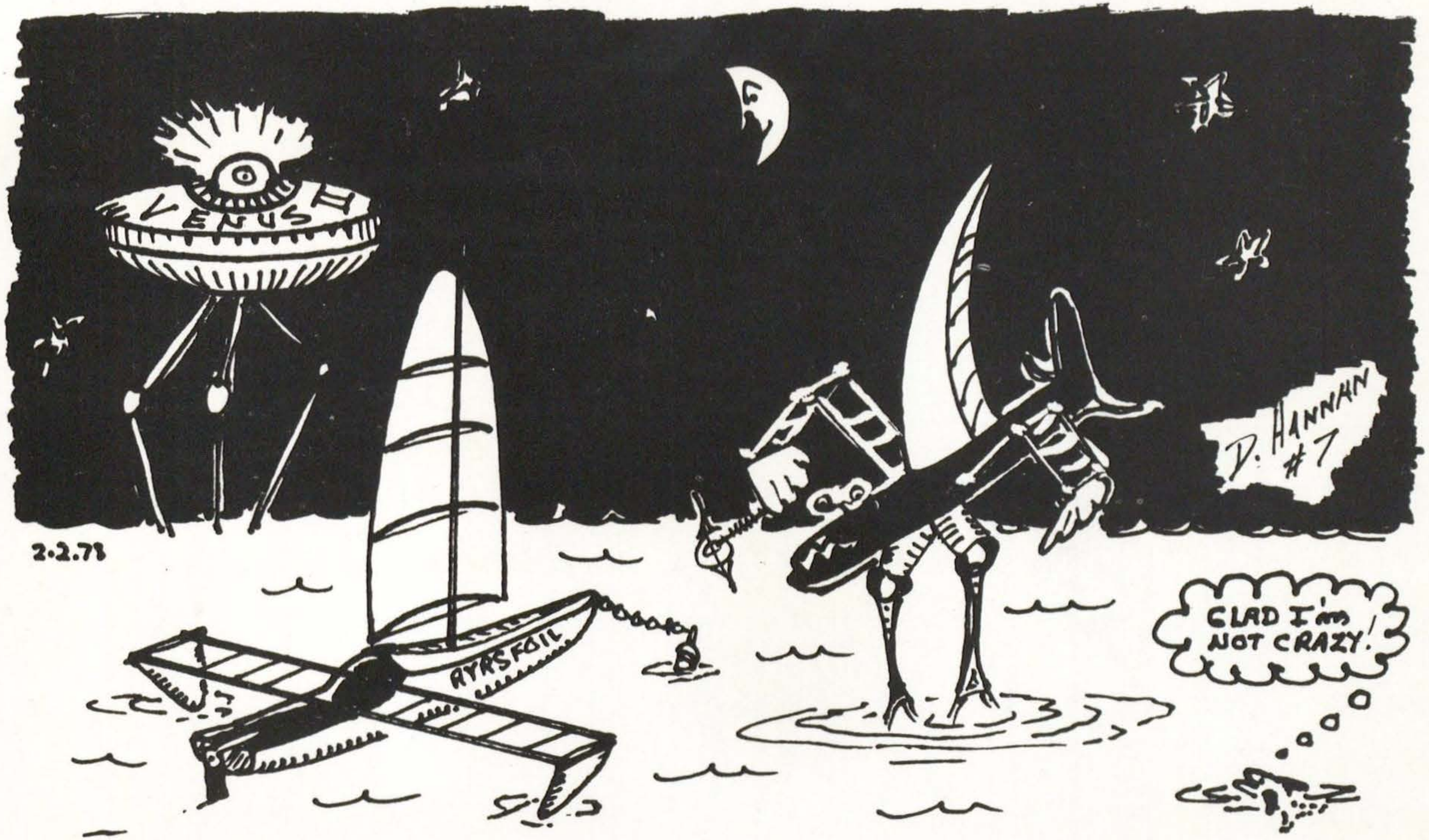
AYRS

HYDROFOIL OPTIONS



Scout IXXYZ IV reporting to base: Can not establish contact, Sir! Native appears to be in a non-arousal post mating mode.

THE AMATEUR YACHT RESEARCH SOCIETY
(Founded, June 1955 to encourage Amateur and Individual Yacht Research)

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HYDROFOIL OPTIONS

by

JOHN MORWOOD

The drawings for this article were made to help me to sort out my own ideas about hydrofoils as stabilisers and lifters. This seemed to be the right thing to do in view of my proposition that the A.Y.R.S. sponsor some sailing classes with the following rules:

1. Limited sail areas.
2. Standard hulls of fixed proportions.
3. Light alloy step ladders for cross beams.
4. Overall beam not to exceed the overall length.

My objective in proposing these classes was to get class racing going to get hydrofoils optimised. This could only be done by standardising everything except the foils. It could then be hoped that the person with the best foils would win.

My proposition was debated at an A.Y.R.S. meeting on 11th October, 1977. In the event, it was decided that only the restrictions on sail area should stand and these were decreed as 10 sq. m., 12 sq. m., 15 sq. m. and 300 sq. ft. Certain safety rules were adopted.

Despite the temporary availability of 401 cm. Kayaks at a cost to British members of £55 each, no experimental class was adopted. My suggestion of light alloy ladders for cross beams was not favourably received because of corrosion. However, they could be anodised or painted and their durability in an experimental class would be of no importance anyway.

After I had finished my drawings, I read the article by Noel Fuller, which had just come in. It is given elsewhere in this publication and describes how a kayak was used to mount stabilisers and sails which achieved about 15 knots.

My suggestion to any A.Y.R.S. members wishing to experiment with foils with a view to racing in the classes which we have adopted is to do their experimenting with 7 sq. m. (75 sq. ft.) on a kayak with an alloy ladder cross beam. Once they have discovered how to shape and place all the parts, building to the class would be much simpler. Moreover, if the foiler is intended to fly, the hull shape ceases to matter and one may as well use the lightest and cheapest.

The drawings which follow are all based on my very first idea of using a Tornado hull and 220 sq. ft. of sail area. They are, of course, equally applicable to any other hull and sails. I hope they will be of value to people striving for maximum sailing speed.

FIGURE 1.

This shows the basic geometry of a double foiler, based on a Tornado hull and sails, with a light alloy step-ladder cross beam.

With foils placed at a cant angle to the cross beam of 51°, the boat heels until the lee foil is at a cant angle to the water of 45° and the weather foil is 1 foot out of the water. In order to get this right, I had to draw the cross beam raised about 1 foot above the hull deck.

The geometry is interesting. On the beam which I allowed, the righting arm of the foil in the water is 6 feet short of the heeling arm from the centre of area of the sails to the centre of the immersed hull section. We describe this as being "Geometrically under-balanced-out." If this were so, in practice, the boat would need to be 'sat out' to keep it upright, as with dinghies. However, though I knew that this was not likely to be so in practice, I went along with the concept as far as drawing an exactly balanced-out boat in Fig. 2.

The objective of foiler design must be to produce an exactly balanced-out boat in which the driver can sit anywhere he likes in the hull when either using the craft as a displacement boat or when flying with the hull off the water.

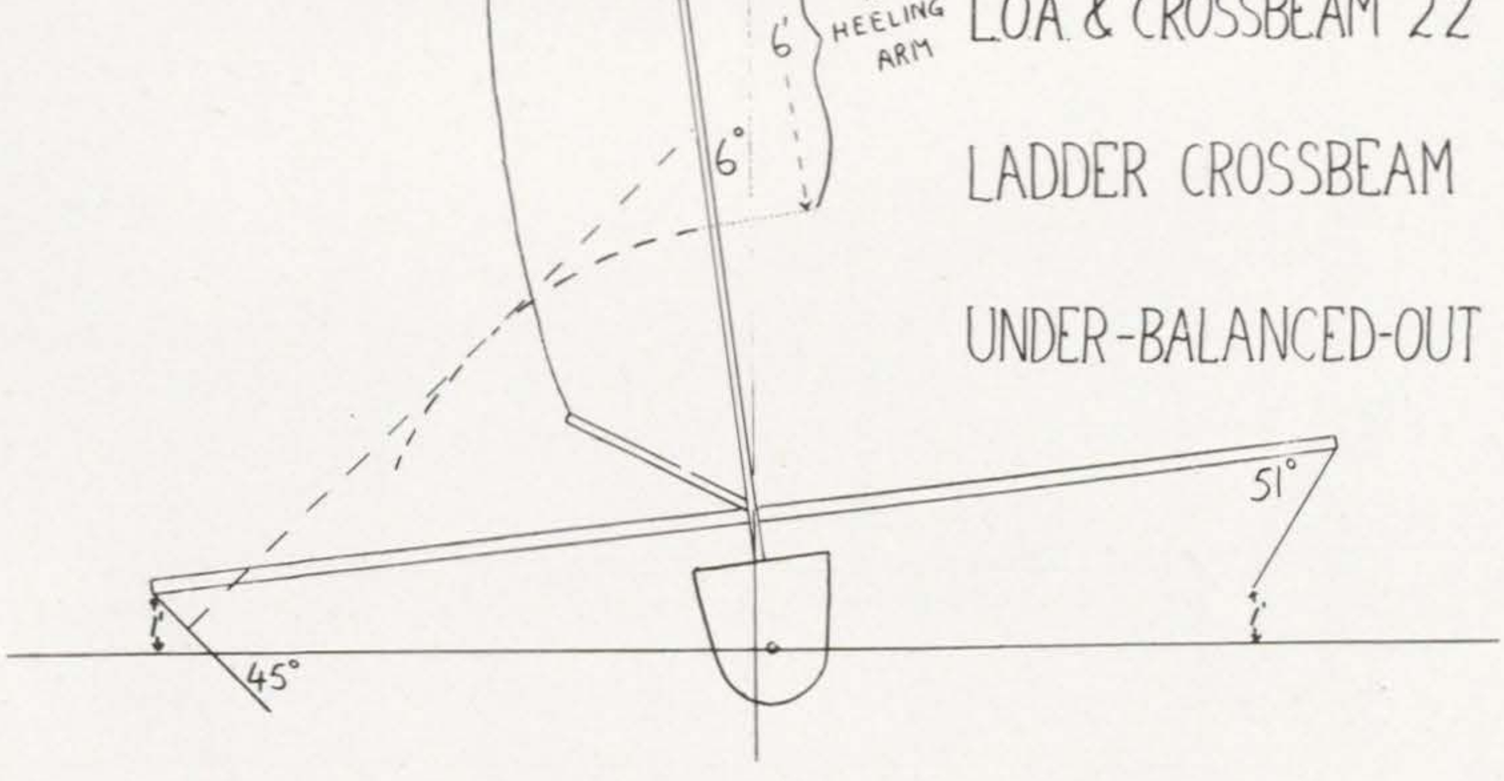


FIGURE 2.

This shows the effect of putting the cross beam all on one side when it becomes a Bruce foiler. When the allowed 22 feet of cross arm is used, the boat is geometrically OVER-BALANCED-OUT. This would mean in practice that, when the foil was to weather, it would give too much stability and would dig in, making the boat slower. On the other hand, when the foil was to lee, it would not dig in enough, thus losing lateral resistance. Again, the boat would be slower.

For optimum performance, the foil must exactly counter the sail force with no heeling (once the foil is working). As a result of the above geometry, I next drew a vertical foil to see how the idea of variable foil cant angle appealed to me.

It will be obvious to all that the only way to make such a foiler work is to have variable cant angle of the foil. As drawn, and depending on the ACTUAL centre of effort of the sails, as compared with the GEOMETRICAL centre of effort, the foil would need to be more vertical than the 45^{0} drawn. As such, it would be more efficient in producing lateral resistance than the 45^{0} cant angle. However, the longer cross beam would produce more windage, especially if it were a ladder though the bare round pole which many people seem to favour, is a shocker for wind resistance in low windspeeds. I think it may well be worse than a ladder.

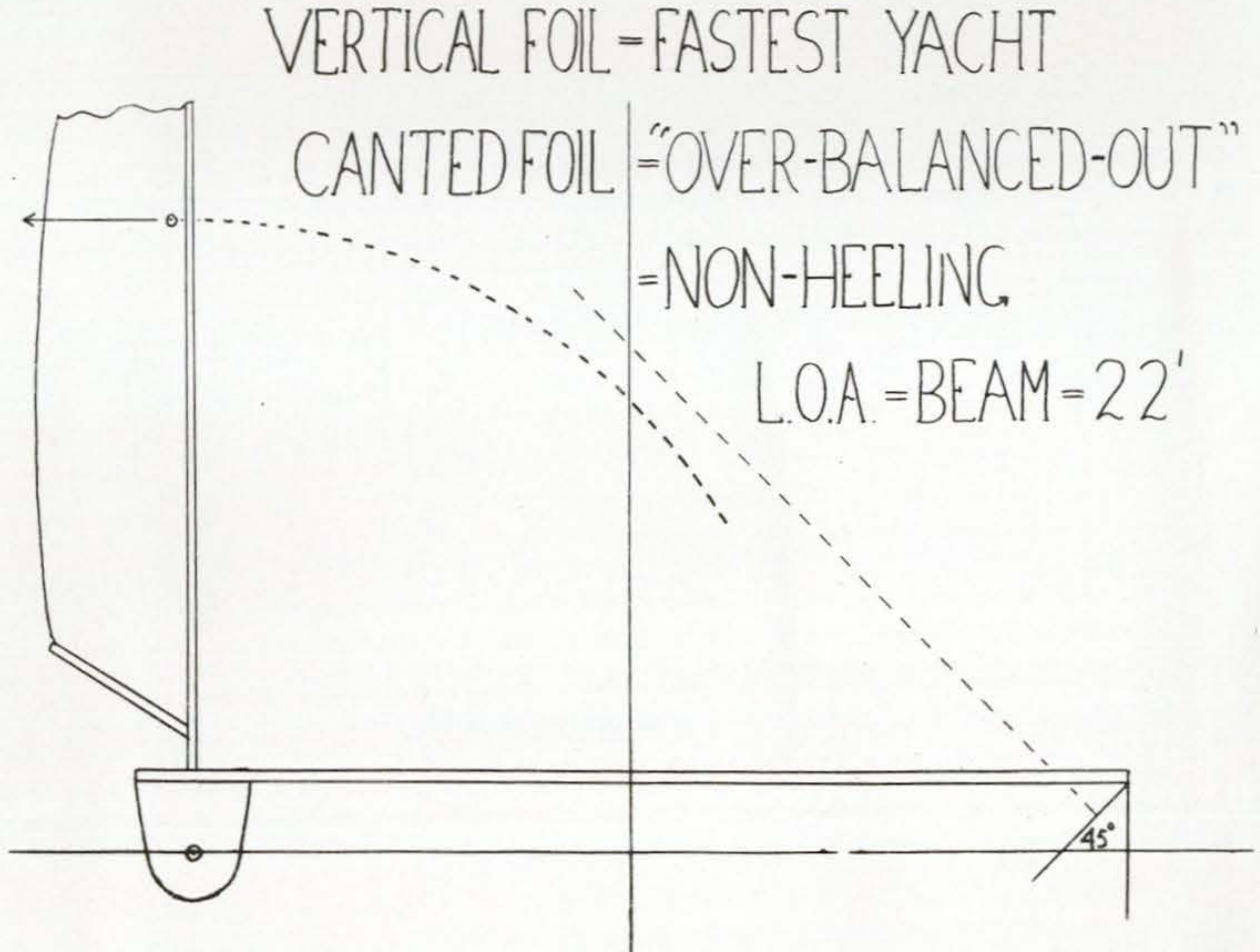


FIGURE 3. & 3A.

Despite all criticism, I firmly believe in the light alloy step-ladder as a cross beam. There is nothing quite so strong as an I section extrusion, in the sense in which we want it. Moreover, a ladder which I bought years ago as a cross beam for a trimaran worked well and still exists in constant use (for climbing things). It is good in tortional strength, too, which would occasionally be needed. Edmond Bruce also used a ladder cross beam.

By contrast with the ladder, round poles seem to be very bendy and need to be stayed down to near the water surface. When these stays meet waves, they produce fine spray which soaks the crew and hold the boat back. As already stated, they have a lot of wind resistance.

Edmond Bruce has clearly shown the ruinous effect of hull windage on performance. Obviously, we cannot add the windage of cross beams to this. All cross beams must be streamlined, especially bare round poles.

Fig 3 shows three types of fairing for an alloy ladder. The top one is designed to touch the water surface from time to time so I call it a "Water skidder." With a 5° angle of attack, it should not dig in. Perhaps, I have not drawn the nose long enough. "Aerodynamic Ballast" is a term coined by Taylor in Australia to indicate that the wind, meeting an appropriate shape, will push it down. If it is out to the weather side of the mid-line, it will increase stability. If to lee, it will push up. giving negative aerodynamic ballast. I have drawn it as a simple symmetrical section. Finally, the ladder fairing may be a "Lifting section," if such is wanted.

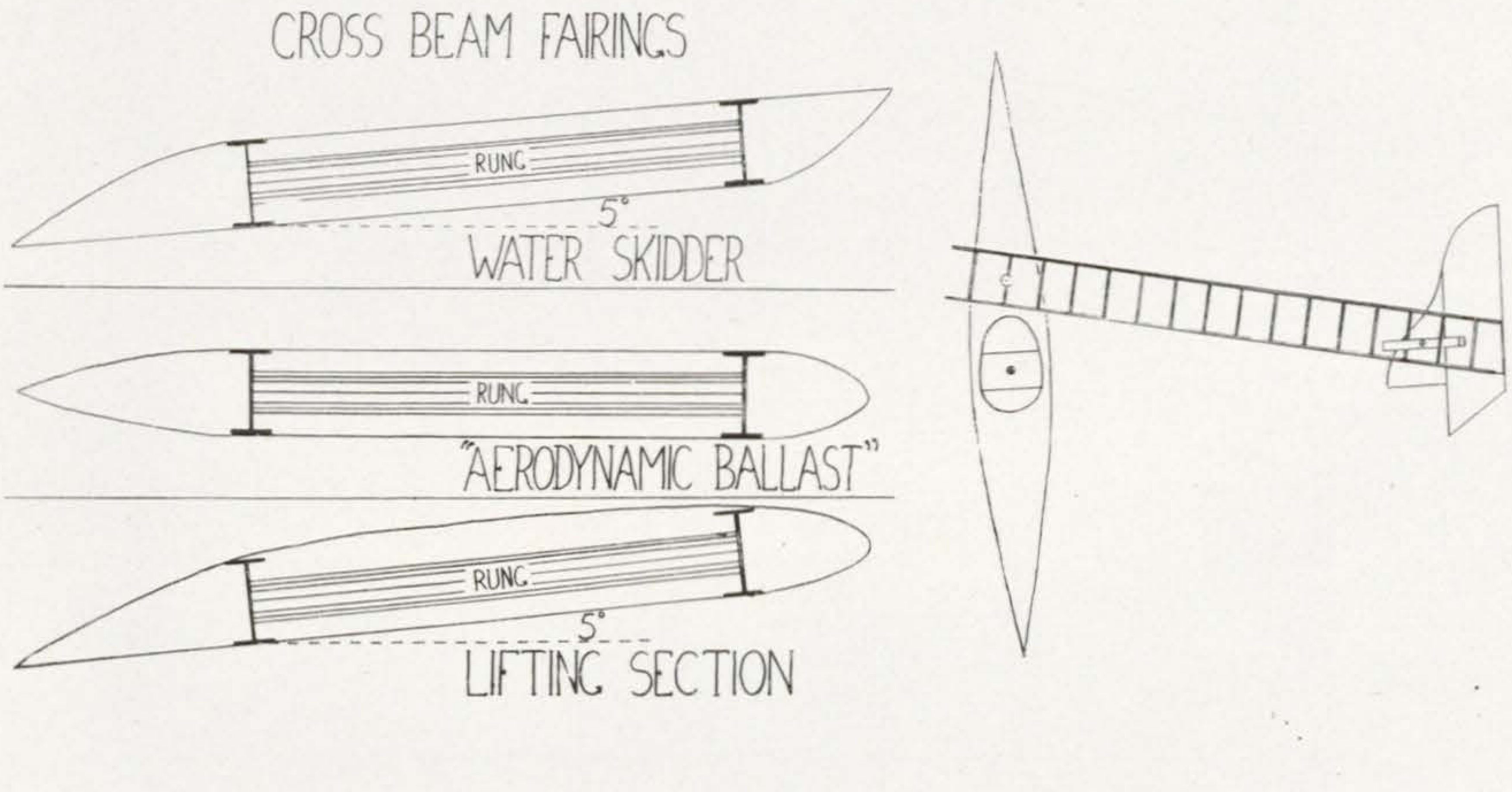


FIGURE 4.

This diagram shows one way in which "Aerodynamic Ballast" can work. General Parham showed that this was most simply achieved by using anhedral in the cross wings.

Because of the slope down at the ends of the cross beams, the wind strikes the upper surface on the weather side and the lower surface to lee, pushing them down and up respectively. The reverse of this happens in the wings nearer the hull but there is less leverage there. By having appropriate angles of anhedral, the angles of attack of the wind on the wing can be made more or less what one wants, though I must confess that I have not worked this out in any detail. Nor do I really know if such a system as I have drawn would be either wanted or be of any value to a foiler.

In this diagram, I have drawn BOTH foils in the water and working at the same time. This has been tried by Gerald Holtom, David Chinery and Josef Dusek. All have claimed that the system gives far greater stability than a single foil and, in a seaway, the weather foil seems to grab the water to such an extent that the lee foil can be left free of water by a wave and the boat stays upright, without a lunge to lee which would otherwise occur. Gerald Holtom thought the system was slower than a single foil to lee, the other two did not seem to notice this to any great extent. A careful comparison with half-sized foils on each side seems in order.

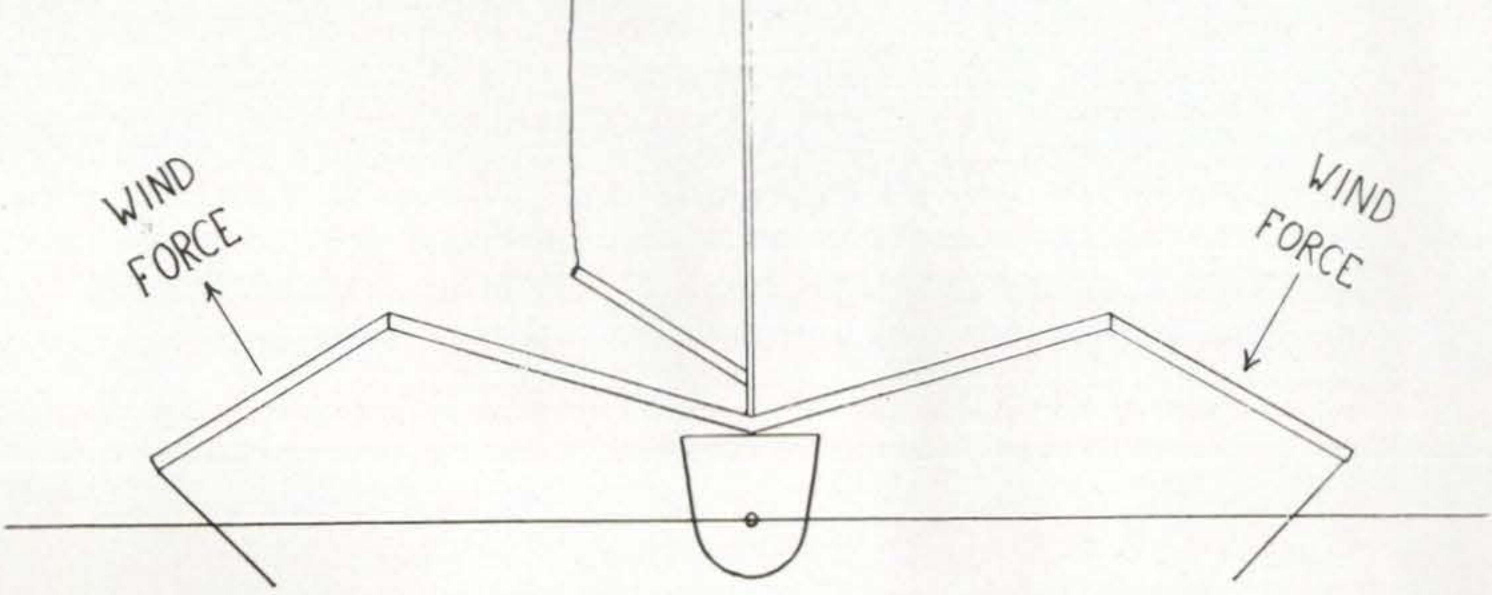


FIGURE 5.

I have sailed in Gerald Holtom's foiler and found a beautifully behaved under-balanced-out boat with a centreboard for best windward performance. This figure shows the geometry with considerable under-balancing. I explained this as due to the sail twist as well as the losses in sail power at the peak of the mainsail.

Then Noel Fuller's account came in. At one time, he tried a sail with a wishbone boom across the sail as with the Windsurfer sail. With this, he noted better windward performance but also more heeling. Obviously, the sail had a higher true centre of effort much nearer the geometrical centre of area than occurs with the usual triangular sail.

In this diagram, I have drawn two angles of heel. However, the greater angle is not used and the cross beam ends never dip in the water from normal wind pressure alone. Even the larger heel angle, however, does not geometrically balance the sails.

My conclusion from this was that the usual rig was a pretty poor performer and the sooner the semi-ellipse was used, the better. All subsequent diagrams are therefore drawn with the semi-ellipse sail or sails.

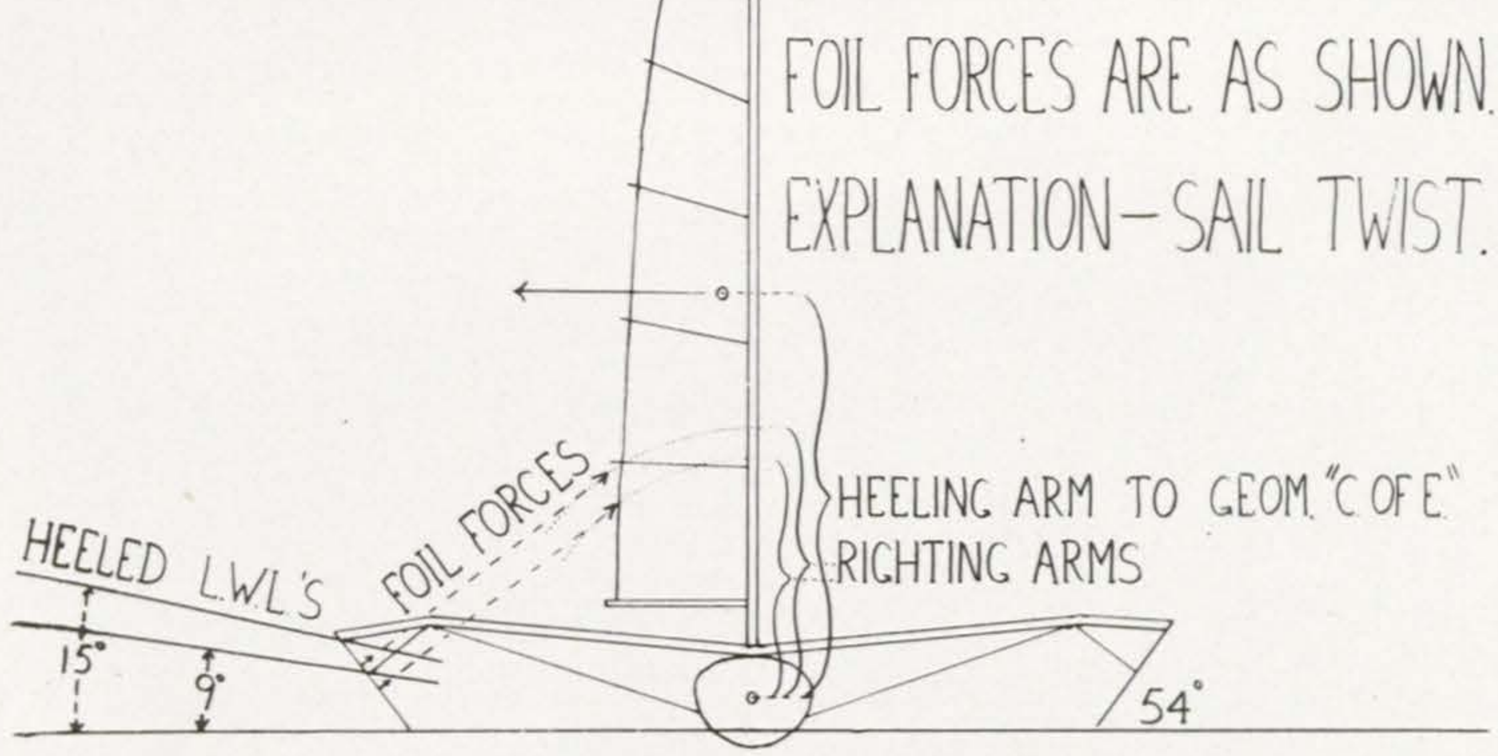


FIGURE 6.

At the Weymouth Speed Trials, the Holtam foiler performed to the admiration of all. She consistently achieved 17 knots, planing on the aft part of her hull. This begs the question as to what would have happened if she had had an inverted T foil aft, and thus become a flyer.

In this drawing, I have suggested an A.Y.R.S. "Flyfoiler" with one foil working to lee and an inverted T aft. One can fly the weather hull of a catamaran for quite long periods. Surely, therefore, one could equally well fly on two foils only. The cross beam has a lifting section and tilts to keep the sail rig upright. Both of these are surely beneficial.

The sail is the semi-ellipse with a lower centre of area than a triangular plan form, but, if its true C. of E. is at its geometrical centre, there is considerable under-balancing.

The semi-ellipse, with downhauls to its tack and clew and its true centre of effort just aft of the mast, should have small sheet forces. In order to make flying on two foils easier, a shock cord sheet would be worth while trying. Variations in wind strength would then be taken up by varying angles of attack on the sail while the heeling moment stayed constant.

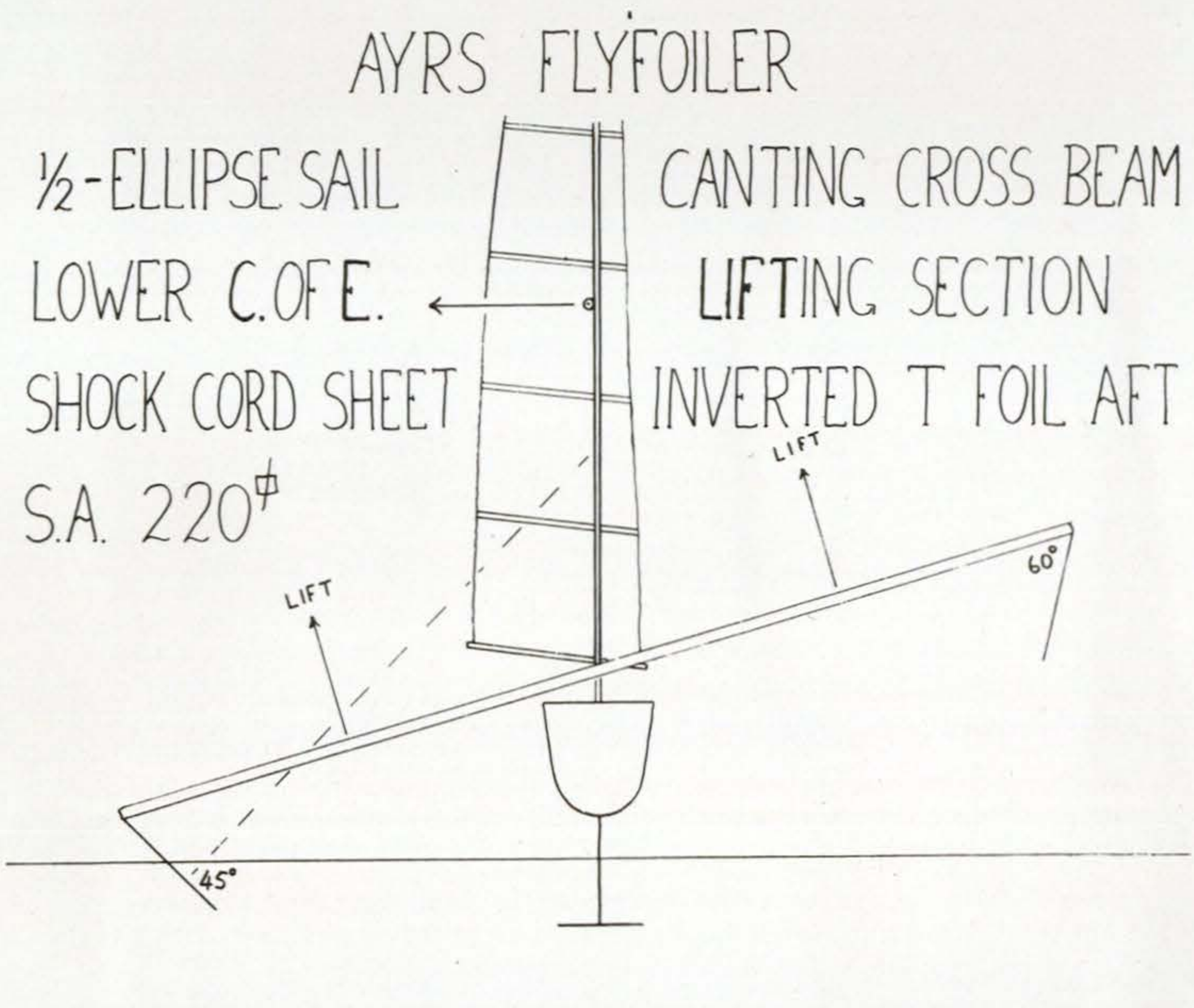


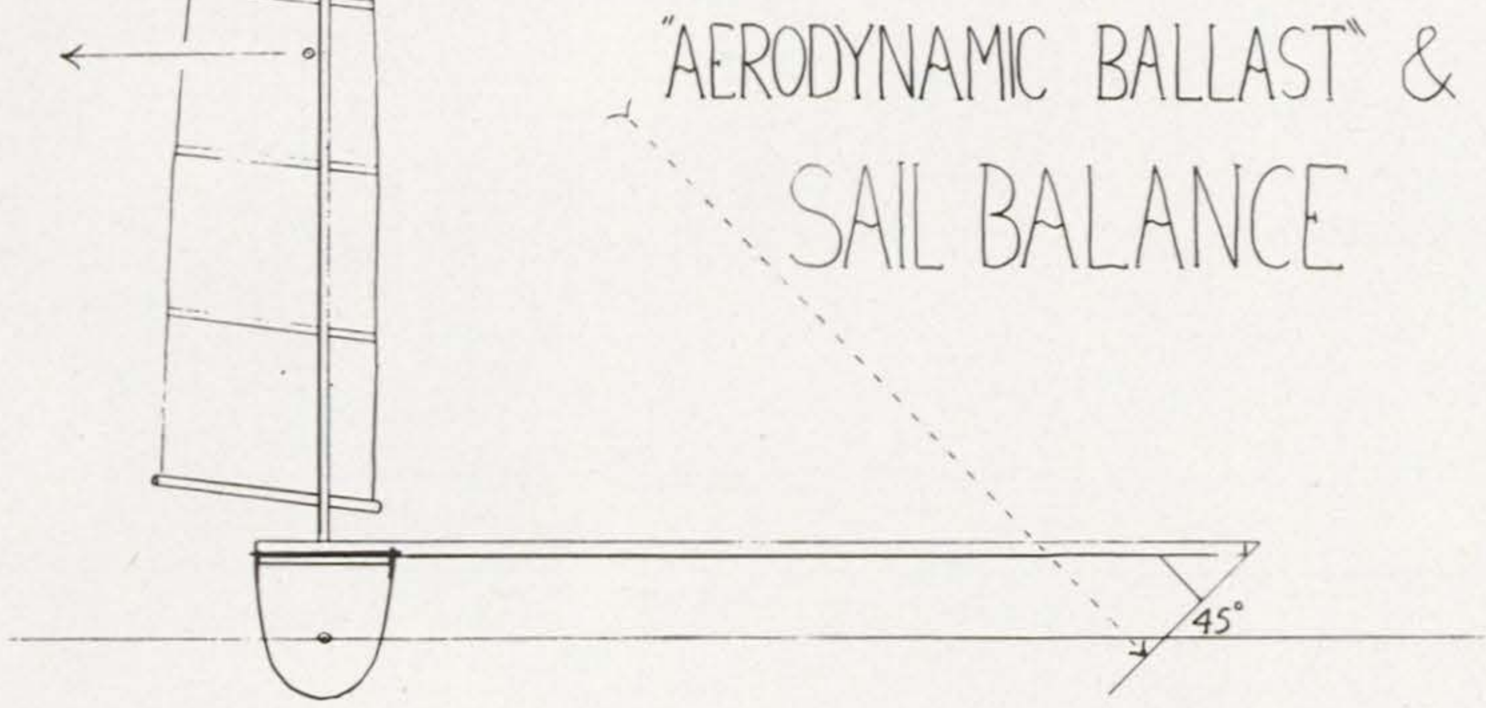
FIGURE 7 & FIGURE 8

All double foilers have a parasitic foil to weather solely for use on the other tack. It only contributes to weight and windage. Edmond Bruce showed that, not only could the weather foil be abolished but that a canted foil to weather pulling the weather side down was actually more efficient than one to leeward. His boat was faster with the foil to weather.

Gerard Horgan and others have tried this and found that it works. However, occasionally, when sailing with the foil to weather, the foil will come unstuck from the water and a near capsize will result. Gerard thinks this easily counterable and is currently making a 50 foot Bruce foiler. Others have not been too enthusiastic about it.

This drawing shows a Bruce foiler with the foil to weather, a semi-elliptical sail and possibly a shock cord sheet. It is the only configuration which gives the exactly balanced-out geometry within the beam limitation of the length of the boat when the true centre of effort is at the geometrical centre.

My only thought for this boat is to have the cross arm rocking on an athwartships axis. If the cross beam is a wing with a symmetrical section, there can then be aerodynamic lift and depression when it is to lee or to weather. Also, there is a difference in sail balance between the two tacks.



When the foil is to lee, it has to be a bit farther forward than when it is to weather. This is also achieved by rocking the cross beam. In practice, however, Gerard Horgan finds that the rudder can take up this difference without trouble so the principle is only important for racing speeds.

Figure 8 shows the Bruce foiler with the foil to lee and needs no comment because what applies to all other foilers applies to it.

It will be noted that the Bruce foiler does not heel so that the sail or sails are always working to their best effect. The boat and cross beam are lighter and have less wind resistance than that of the double foilers. Moreover, the aerodynamic ballast will work to its best effect. In all, the Bruce foiler is the best possible displacement boat for speed which has yet been made.

There is an undertone in all foiler considerations that one is really designing to win the Weymouth Speed Trials. At the very least, one is trying to design a boat which will be faster than that of anyone else in the whole world. Despite the possibility of capsize when the foiler is to weather, it is surprising that no one has yet brought a Bruce foiler to Weymouth.

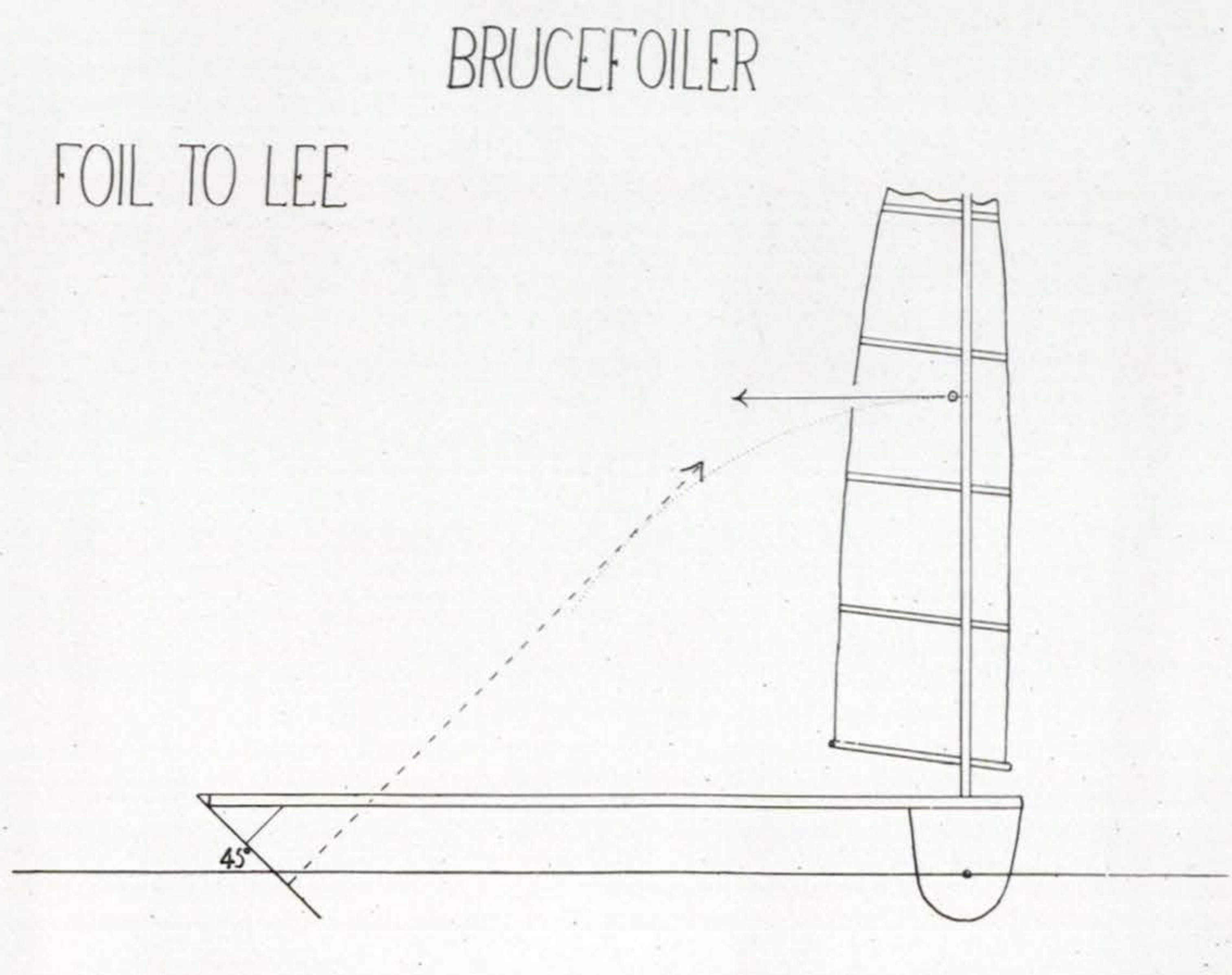


FIGURE 9 & FIGURE 10.

This drawing shows what happens if a Bruce foiler is made so that the hull is heeled slightly to leeward and the foil cant angle is increased to 50°. Because of the increased cant angle, the overall beam is increased slightly.

The increased cant angle should make the foil work a little more efficiently and the cross beam is a little more raised above the water. Its end has marked anhedral, thus increasing the lift and depressive forces from the wind. A rocking cross arm is assumed, though it has not been drawn.

The heeled sail has some advantages. Because the sail force falls off by the square of the cosine of the angle of heel, the heeling force will fall away much faster when the foil surfaces and rises. This may make capsizing a little less likely.

Fig. 9 on its own probably does not make much sense. It might or might not produce worthwhile advantages. However, the boat becomes completely transformed on the opposite tack, as Figure 10 shows.

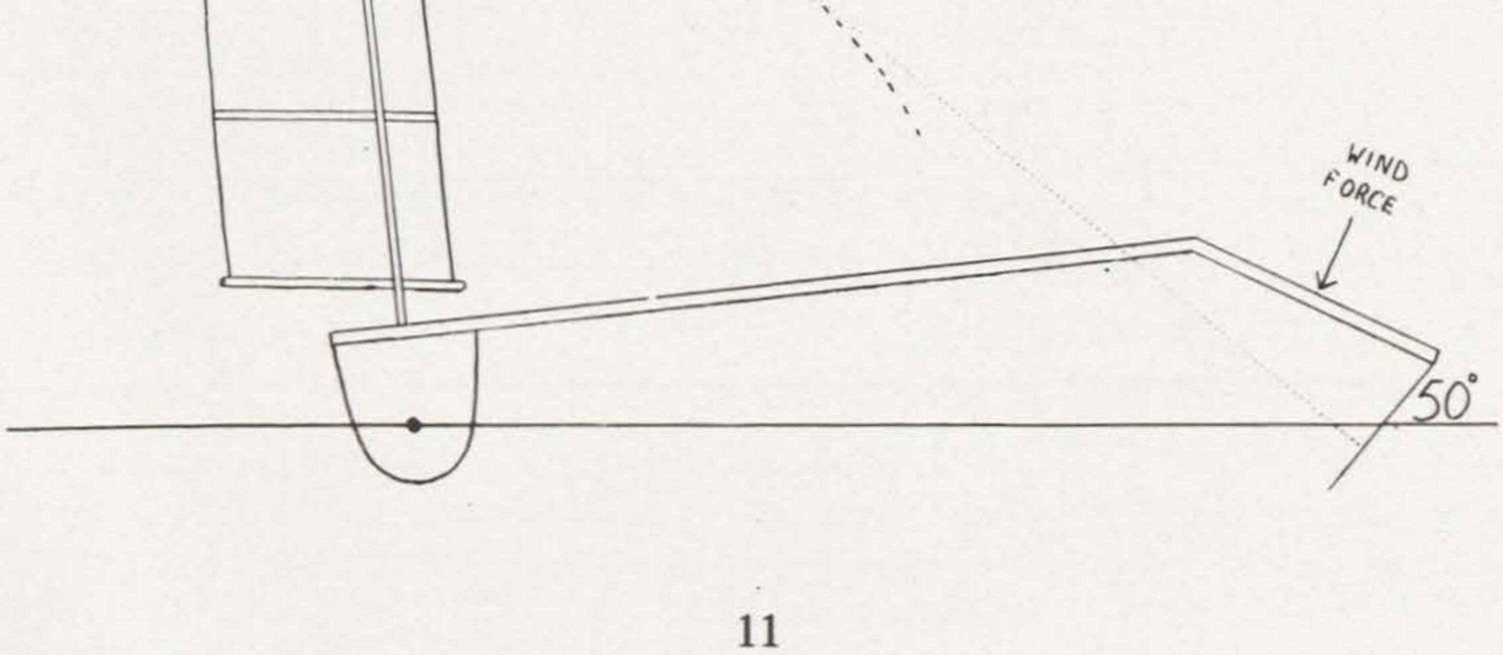
Fig. 10 is a flying foiler (I call it a "Flyfoil"). The foil now is set at a cant angle of 45°. The cross beam gives aerodynamic lift all along its length but has more at the anhedral of its outer end.

HEELED HULL BRUCEFOILER

EXACTLY "BALANCED OUT"

220#, ½-ELLIPSE, ⅛TH CAMBERSAIL

AERODYNAMIC BALLAST



There is an inverted T foil aft to support the stern and steer. It should be pointed out that the rudders of all foilers, flying or otherwise, should be set across the boat at an angle of 7^{o} when the foil cant angle is 45^{o}. This gives an angle of attack on the foil of 5^{o} which was shown by Edmond Bruce to be an optimum in his test tank. Actually, Edmond showed a clear optimum in his test figures for a canted foil angle of leeway of 7^{o}. Thus, all foilers should sail at their optima with a lee helm of 7^{o} which is not the practice with any other boat.

The geometry shows the boat as exactly balanced-out to a semi-elliptical sail. With a shock cord sheet, the boat should be able to be kept flying along a straight course for long periods of time on its two foils.

In so much as the ordinary Bruce foiler must be faster than any double foiler, this boat must also be faster than any other craft in the displacement mode when it is indeed an ordinary Bruce foiler, though with a foil cant angle of 50^{o}. If however, lifting the boat from the water on the foils improves speed, as would seem to be the case with relatively heavy and high windage craft, like Mayfly and Icarus of Hansford and Grogono, it is likely to be even more worthwhile with such a light and low windage craft like this.

FASTEST AYRS FLYFOIL

SAME AS PREVIOUS BUT OPPOSITE TACK

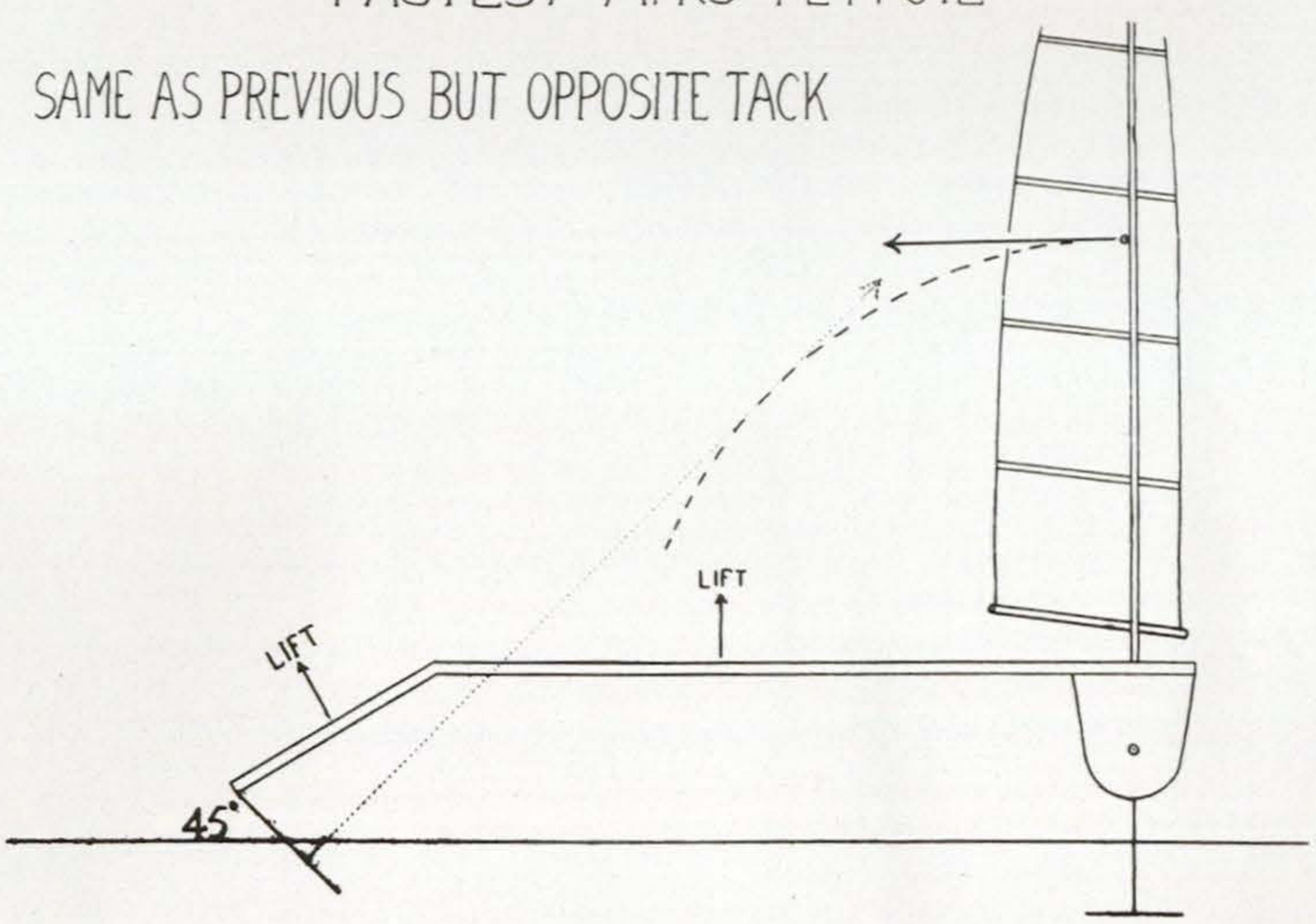


FIGURE 11.

This is what I call a "Tandem Bruce Foiler." The idea was suggested by Edmond Bruce to counter the criticism that the foil could surface when to weather and the boat capsize. With two foils in the water, the chances of both coming free at the same time would be much reduced. Jock Burrough has been an exponent of this system in several unpublished designs.

In order to reduce the possibility of capsize even further, I have suggested the use of 20^{o} of slope down and out for the beam connecting the two foils. This was J. S. Taylor's original concept of "Aerodynamic Ballast" in a Micronesian canoe design. To this, I have added the possible use of rocking cross beams which will still further increase the hold down on the weather side – and also give lift when the foils are to lee. One becomes exceptionally worried when the cross beam of a Bruce foiler is faired to a streamlined shape because, when the foil and cross beam lifts, the wind can get underneath it and help the capsize even more.

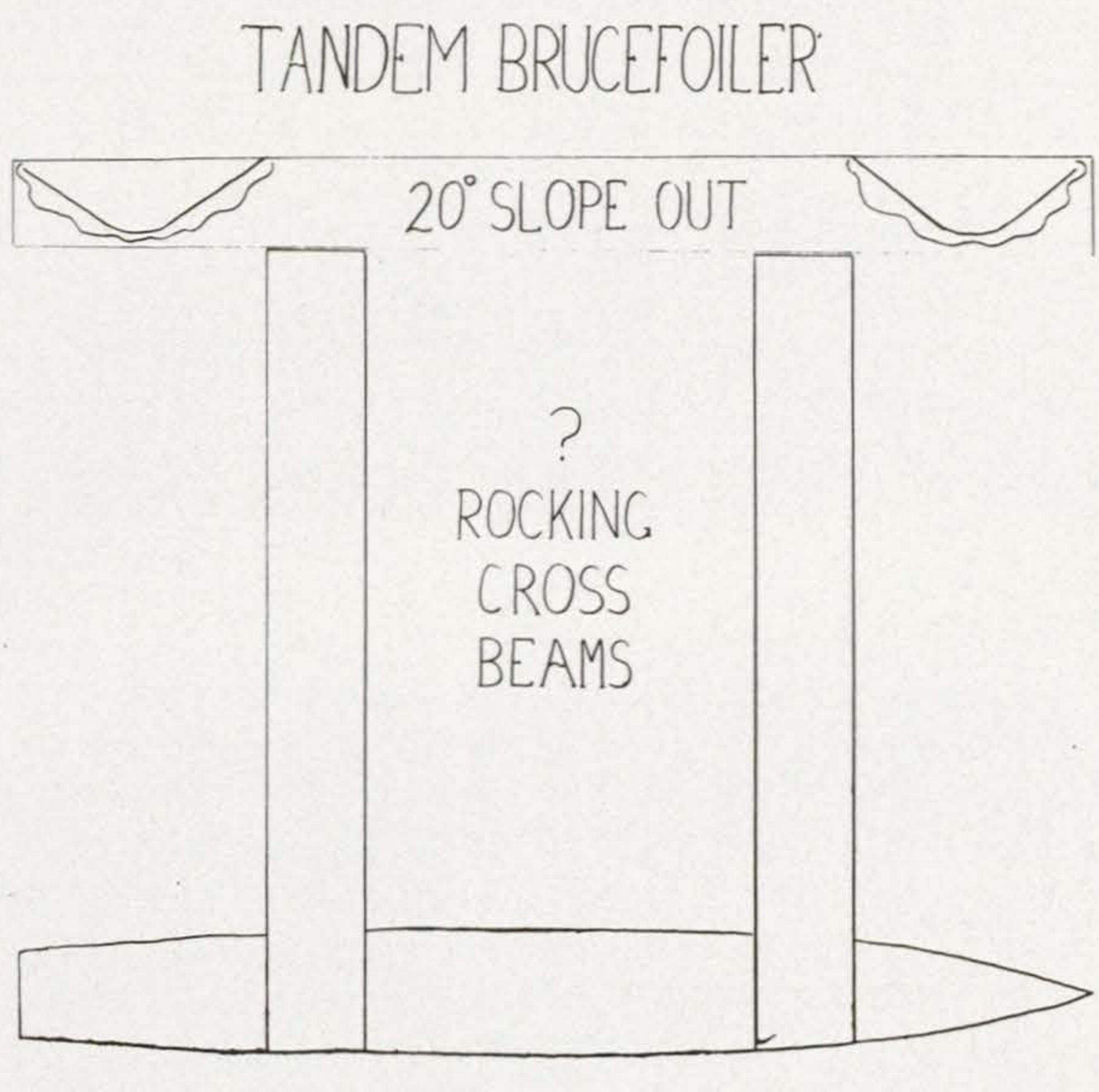


FIGURE 12.

My first contact with a yachting inventor was with Commander Fawcett. He was sailing around Dover Harbour in 1954 with a 40 foot long foiler which he was hoping to fly. His boat was vastly over-invented with about 6 foils and the pyramid rig. He never did manage to fly under sail, though he had the boat up under a fast tow. Indeed, perhaps it was the sight of so much of his wealth being wasted that caused me to start the A.Y.R.S. A photograph of his boat was published in the very first A.Y.R.S. publication.

Flying foilers like Mayfly and Icarus have both the weather foil and the inverted T aft pulling downwards. Harold Fawcett overcame this fault by hingeing the foils at their tops so that they always produced lift, whether to weather or lee. By this, the boat is helped off the water by the weather foil, thus avoiding the balancing trick which would be necessary in the flying foilers which I have suggested so far.

I have drawn two tandem foils on each side. This is not strictly necessary and single flap foils on both sides would be perfectly functional.

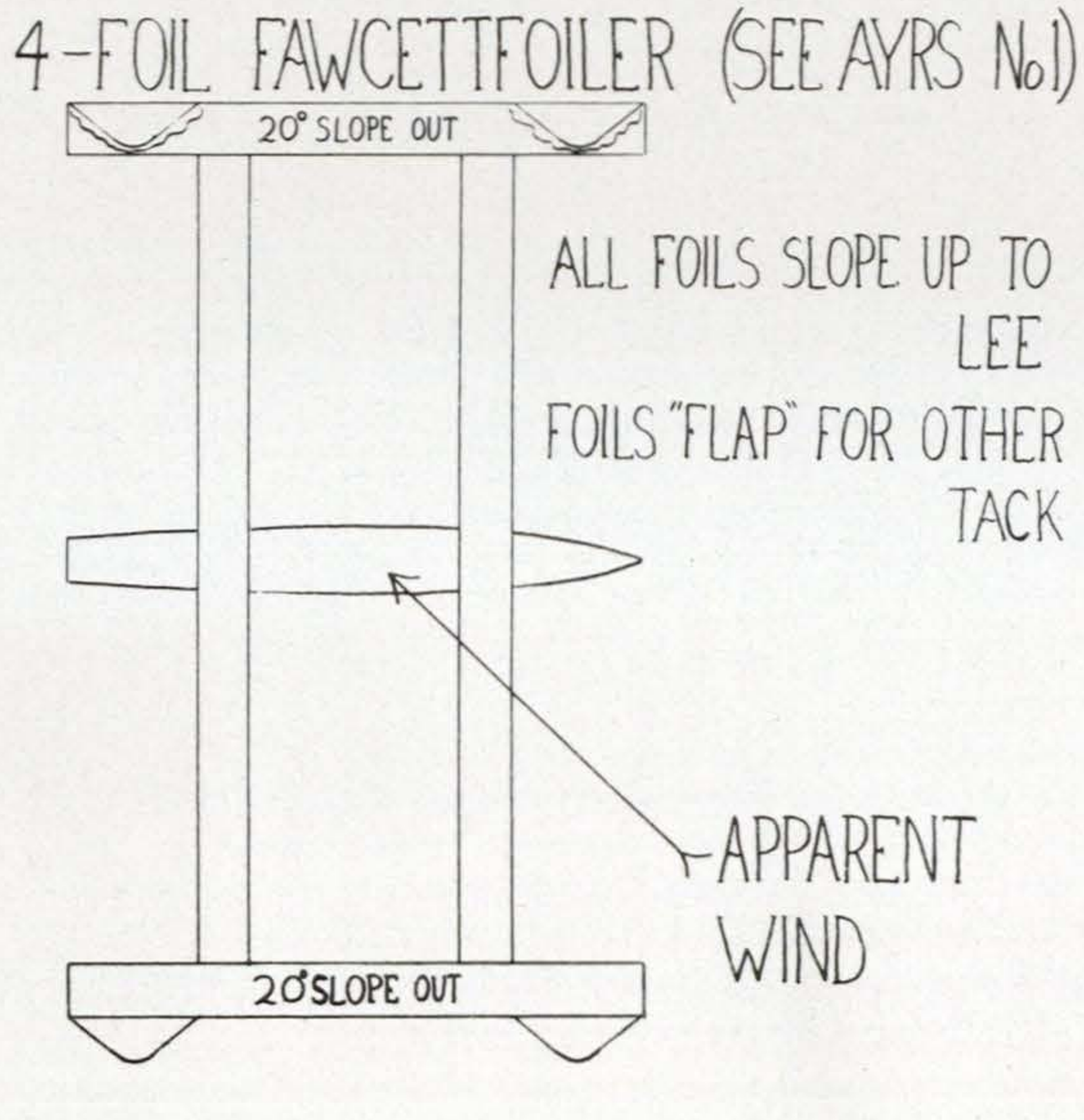


FIGURE 13.

In our review of "Hydrofoil Options," we next come to some inverted T configurations. George Chapman and David Chinery could not get them to work. Christopher Hook had difficulties, to say the least. Mine not only worked (see A.Y.R.S. No. 2), but could actually heel the boat to windward. David Chinery says that they worked fine at speed but the boat was very capsizy during acceleration. Where my boat differed from the others was in its struts, which were ogival sectioned steel strips of 1½ inch cord – the kind they put on hand rails. These struts gave no lateral resistance whereas those of the others did.

My conclusion is that to get inverted T's to work, the struts have to be freely rotating to align with the water flow and thus give no lateral resistance. All designs shown here will have that feature.

Fig. 13 is a fully balanced-out, inverted T foiler. The struts align with the water flow. The foils have a dihedral angle of 30° and thus half their area is used for lateral resistance. This boat will not be heeled by the wind forces but has no stability and would capsize when not sailing. Under way, however, a foil might surface, thus preventing capsize. Also, when a foil nears the water surface, its lift falls off, which is a principle used by the Russian hydrofoils. Sailing stability might therefore be adequate.

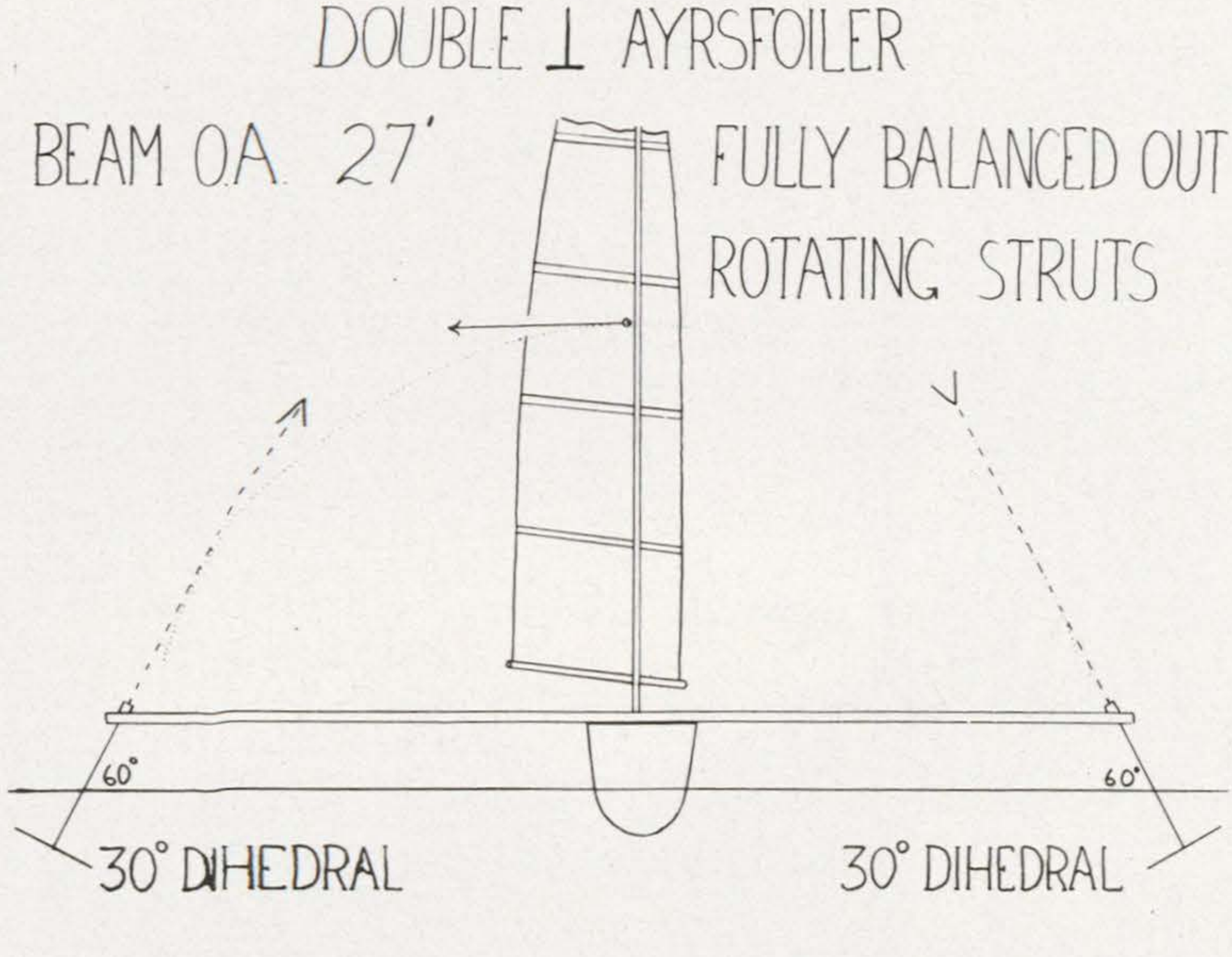


FIGURE 14.

This drawing could have been made with dihedral in the foil, like half of the previous diagram. It might then have been called, "An Inverted T Bruce Foiler." However, I have chosen to have a horizontal foil and a centreboard. The cross arm rocks, thus giving either a positive or negative angle of attack both to the wing and the foil from which I derive the term "Aero-hydro Ballast and Lift." The rocking of the cross arm would be under manual control by a small strut attached to it.

This boat would be far more stable than from having a crew member on a trapeze and the whole boat would be lifted up when the foil was to lee. I cannot myself make up my mind whether she would be faster as an inverted T Bruce foiler or as I have drawn it. In either case, she would be very fast indeed.

Since hydrofoils were first invented by Forlanini in the late 19th Century, there has been continuous argument as to whether surface-piercing or inverted T foils are better or faster, the protagonists always being biassed by their inventions. My readings lead me to believe that the inverted T foil is the faster which seems to be confirmed by Boeing's adoption of them in their "Flying Princess." If this is so, this or the inverted T Bruce foiler is the one to adopt.

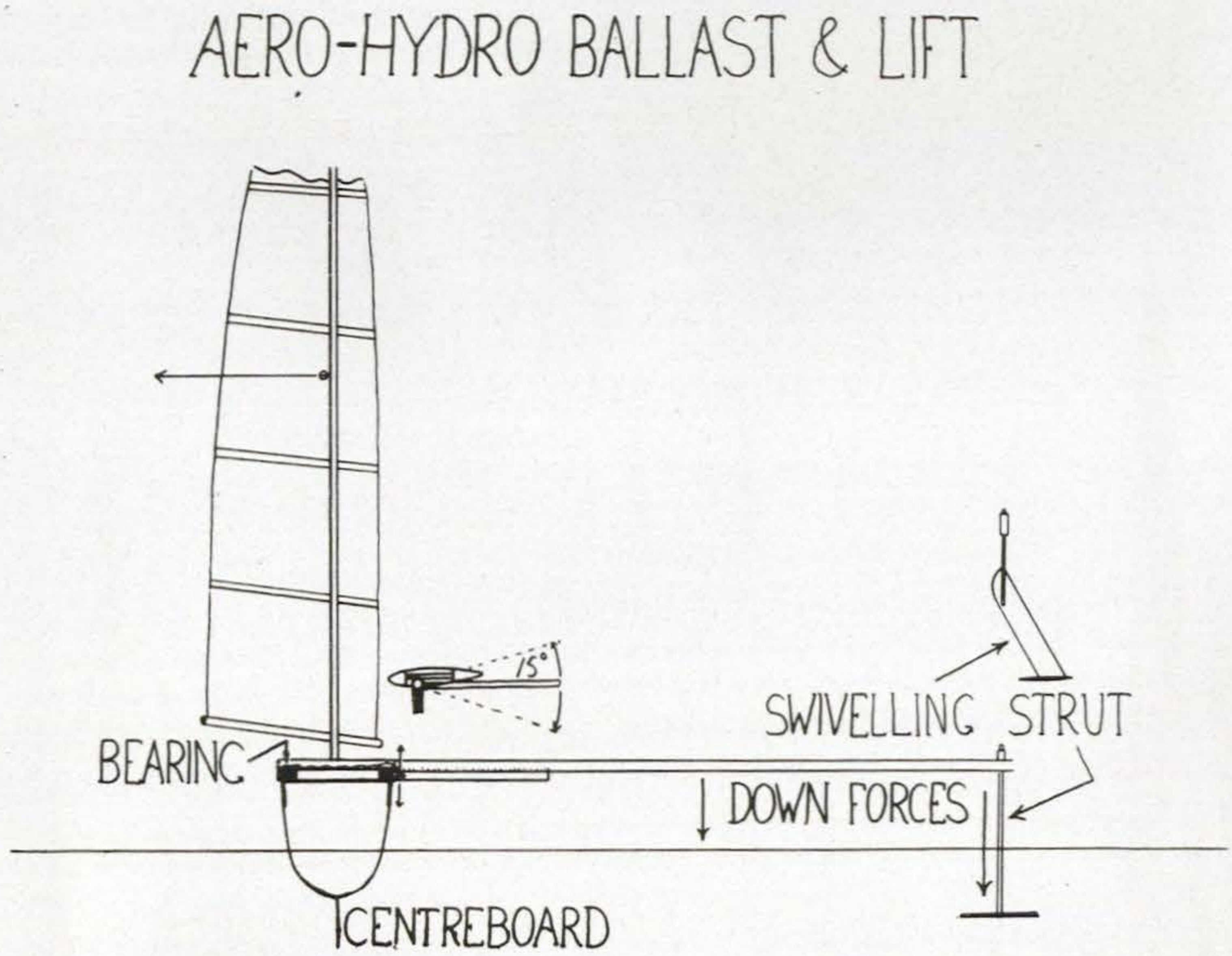


FIGURE 15.

This shows a double, inverted T Bruce foiler with wings and foil incidence control. It is slightly under balanced-out but this is countered by the ability to set the foils to work slightly against each other, thus giving an aerohydrodynamic force to heel the boat both ways. I made some models of this system many years ago and found that it worked well.

This boat suffers from the basic trouble of the inverted T craft of being unstable when not moving if there is no hull stability or outrigged floats. However, it may find a place in sailing foiler mythology.

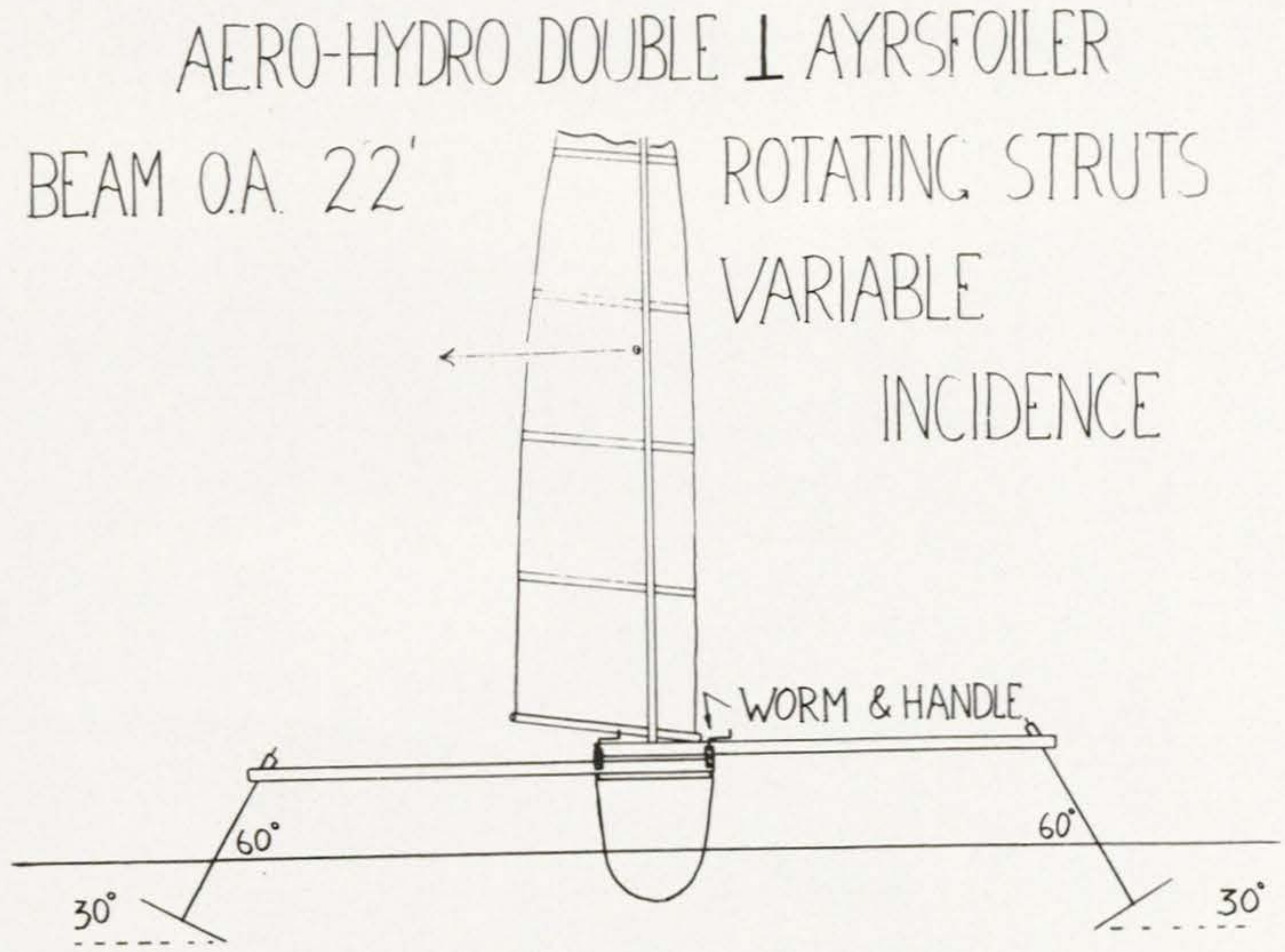


FIGURE 16.

This drawing is really mistitled. Essentially it shows how I would suggest attaching rocking cross arms to hulls. It is, of course, drawn for two cross arms, one above the other, though on the same axle or axles.

It will be seen that I keep to my suggestion of the light alloy ladder. Two sheets of alloy are appropriately shaped and placed between the rungs or at the end, as is necessary. These are pivoted on an axle which is held by another two plates which are attached to the hull.

If a rocking cross beam is necessary for speed sailing, no good alternative to the ladder is seen. It would be hard to devise a system to rock alloy poles across the boat. However, if such is necessary, I have no doubt that our ingenious members would soon come up with an answer.

ROOT SYSTEM FOR DOUBLE ⊥ AYRSFOILER

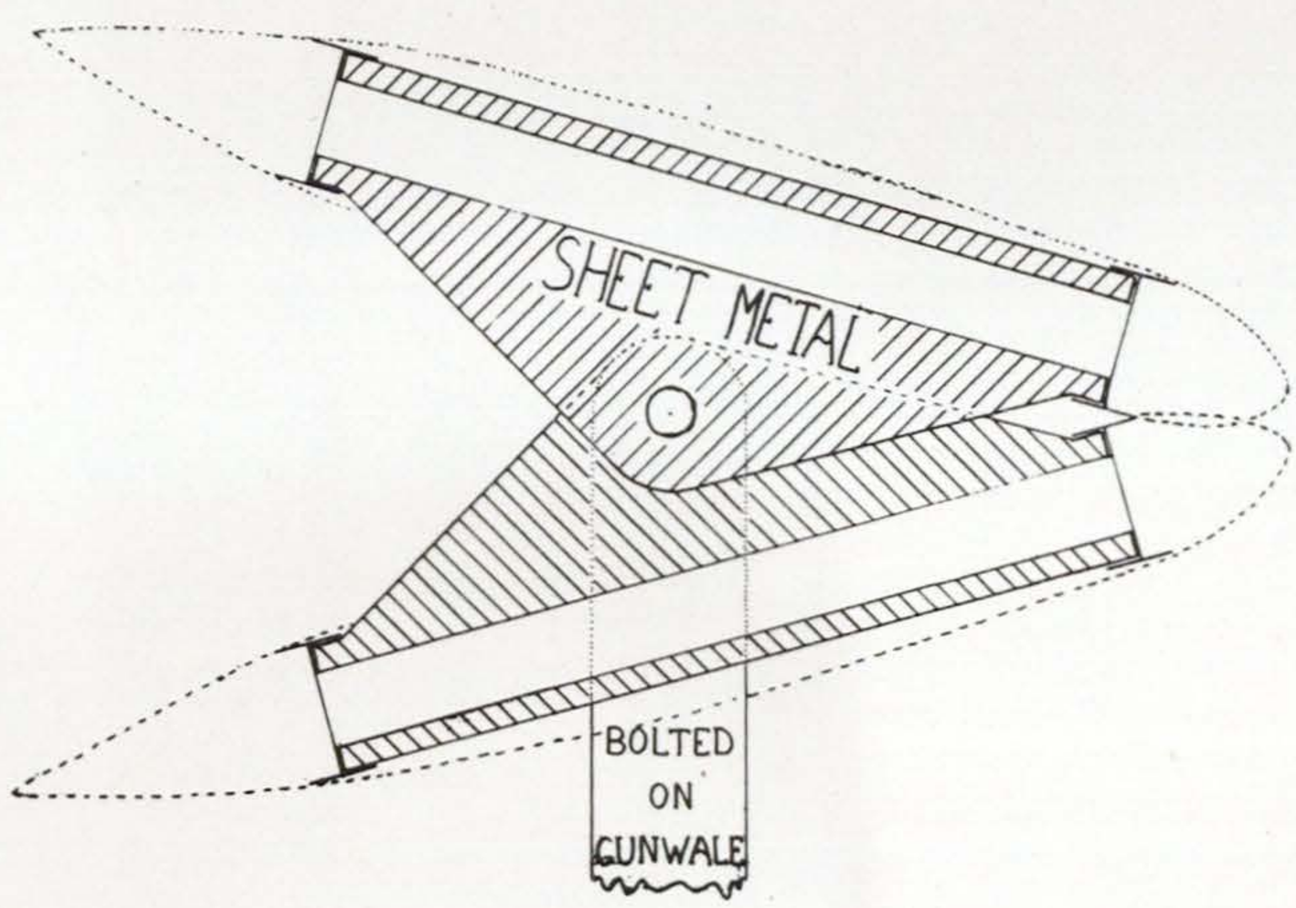


FIGURE 17.

Reg Bratt may or may not recognise this as his idea. However, he proved that a four foot model with inverted T foils aft and a U foil forward could fly. It is the only way in which inverted T's can be used as a flyer.

Inverted T's may not give static stability, but they give enormous stability when flying. What could be called the "Foiling Metacentre" where the lines of action of the two aft foil forces meet is above the centre of effort of the sails. One can think of the boat being suspended from that point, with its centre of gravity far below. Flying stability will be very good indeed.

I have drawn a Fawcett flap foil at the bow at a cant angle of 45^{o}. This might steer the boat and would do so better if its cant angle were 60^{o}. If this failed, steering could be (1) by a V or U foil at the bow; (2) by differential incidence of the aft foils, which I have drawn; (3) by using two sails and adjusting sail trim – or finally, (4) by using a Hook foil (an inverted T foil, with feeler arm) forward. Differential incidence might steer by banking the boat outwards on the turns which would cause the boat's stern to slip to lee.

If inverted T's give the least resistance and one could steer with a forward foil at 60^{o} cant angle, this might be the simplest, best and fastest flyfoil.

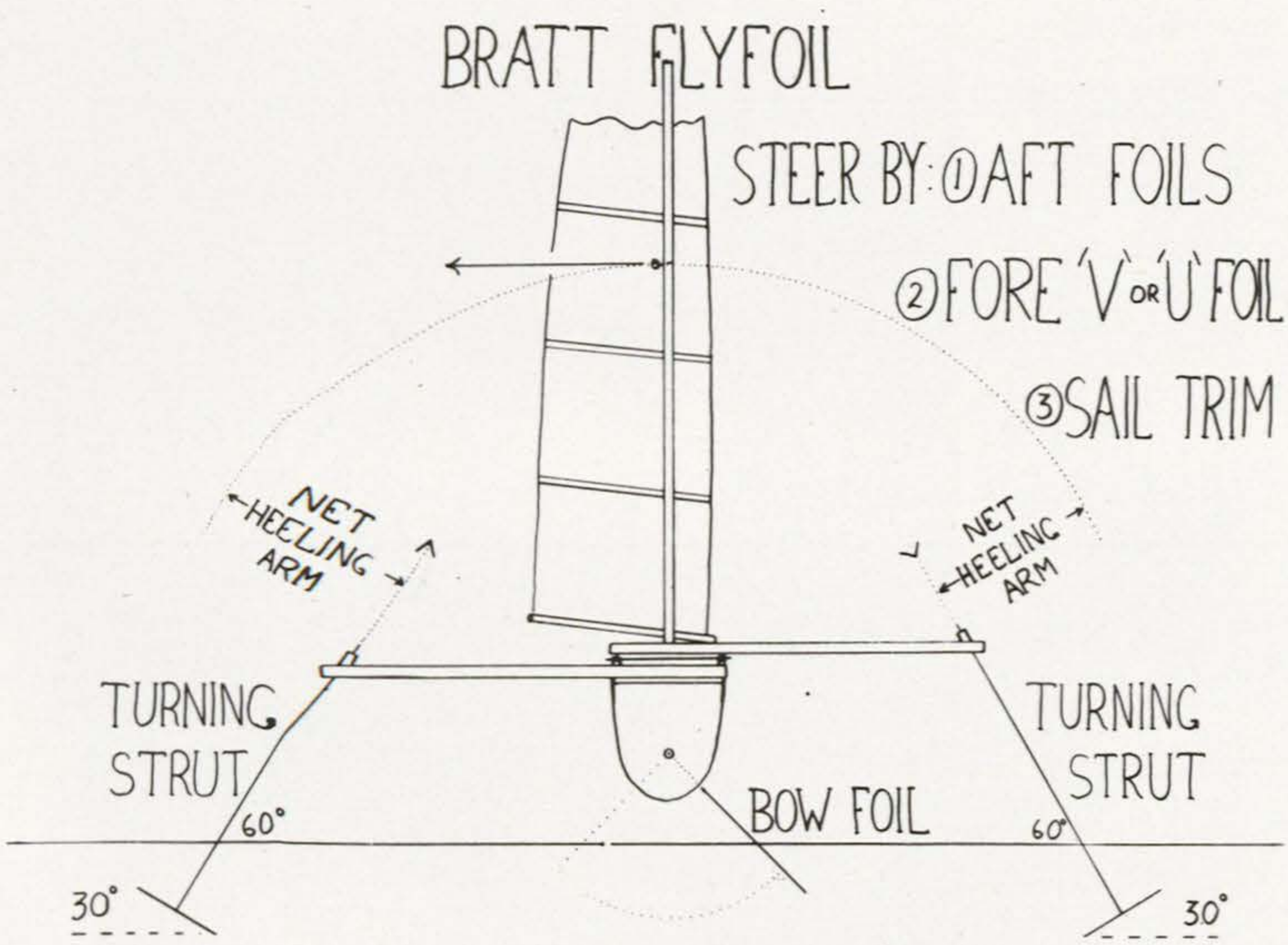


FIGURE 18.

Poor Kinnego sits dismally on my front lawn. She is 25 ft. by 4 ft. with two cabins, now fitted with semi-circular tops like a Chinese Sampan. She never did get fitted with the foils for which she was designed though we have had a lot of fun with her. Perhaps I am waiting for foils to be optimised before doing so. Perhaps, on the other hand, I am just too lazy to put them on.

Richard Poland then produced this idea of leeboards cum L foils which looks interesting. Both the leeboard part and foil are of the same area and of steel, thus being equivalent to foils with cant angles of 45°. Differential incidence would give stability to the boat.

The leeboards are held to the top chine by a metal strap in which they can be both pulled up and their incidence varied. They are held to the sides at the top by a steel bar with threaded ends. Nuts hold the tops of the boards together but slightly loosely. Pulling the top of the leeboard aft will increase the incidence of the foil. Pushing the top of the weather board forward will give negative incidence. Two Laser sails fit nicely over the cabin tops. I had planned to try out both the Chinese and Ganges sculling oars on her, too but even there, I must confess to failure.

Perhaps someone would like to take her over and try out this, or some other foil stabilisation?

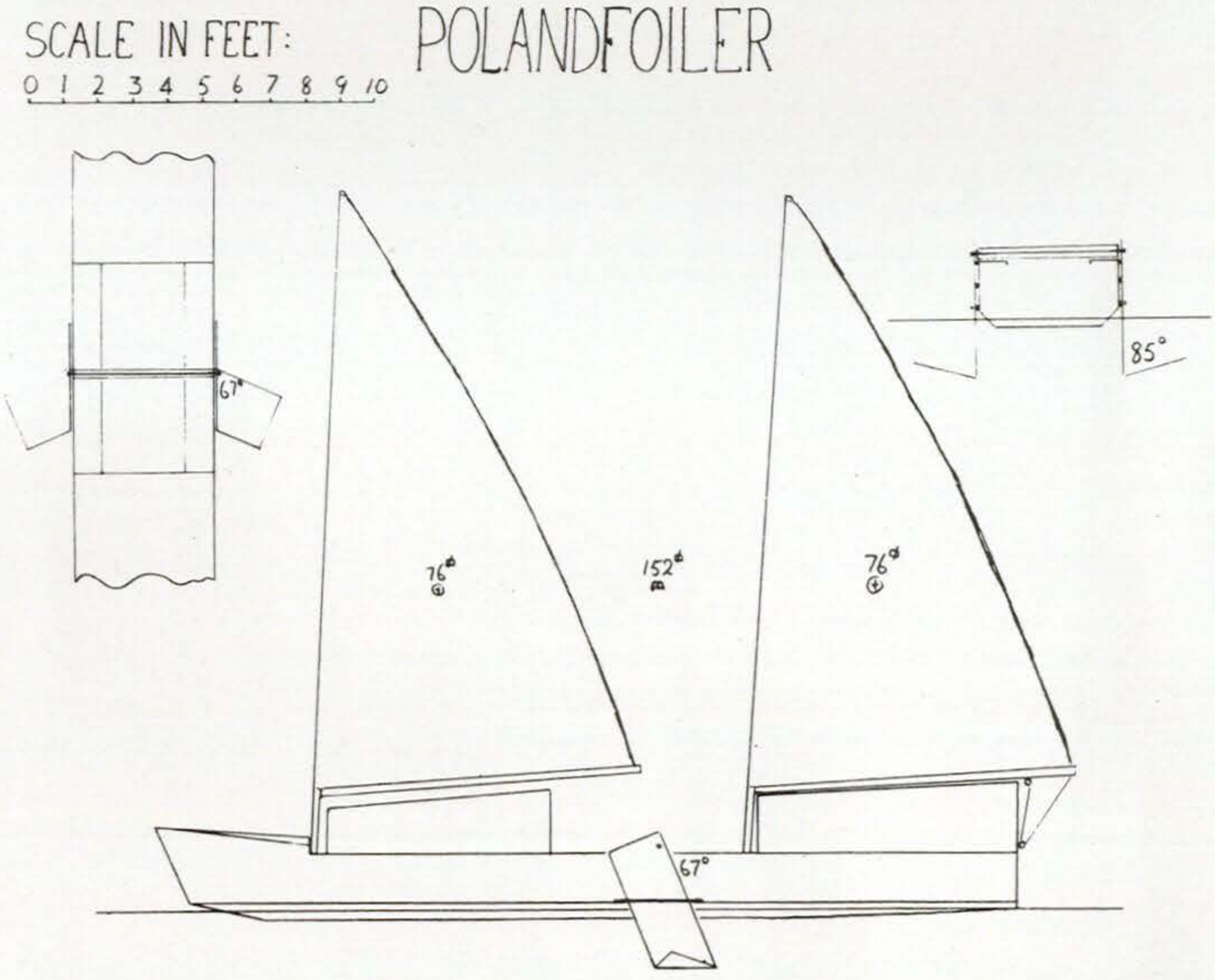


FIGURE 19.

Foil design is the great unknown. Many shapes and sizes work and work quite well to the confusion of many of us. It was primarily to find the optimum that I wanted to get a development class going.

My comments of the basic facts are as follows:–
1. Bruce gives the formula for this as: Sail area/board area = 257 $(V_B/V_A)^2$, for a centreboard. If now, a boat can go at the speed of the true wind on a beam reach, the V_A will be T_T X$\sqrt{2}$. The amount of centreboard then needed will be only 1/128th of the sail area. More board will be needed going to windward. In practice, foils are about 10% of the sail area to allow for accelerations and temporary conditions.

2. Minor variations in cant angle may be better than 45^o but negligibly so. Inverted T foils can have dihedral from 0^o to 45^o.

3. This figure is a guess. More clearance would be needed for deep sea work.

4. & 5. These features are now generally accepted.

6. If we knew the optimum profile, we would be well on the way to an optimum foiler. Profile shapes will now be argued.

FOIL DESIGN

1. WORKING AREA – 3%-4% SAIL AREA/SIN CANT ∠

2. WORKING CANT ANGLE – 45° (40°, BAKER)

3. CROSS BEAM END ABOVE LWL – 10% OF BEAM O.A.

4. SECTION – THIN (T/C = 5%-6% MAX) ? 1 IN 12 ARCH

5. CHORD PLACED EXACTLY FORE & AFT. THIS IS BEST BY BRUCE AND PREVENTS CAPSIZE ON STERNWAY.

6. PROFILE – NOT AGREED. WORKING PROFILE VARIES FROM A.R. = 3:1 (BRUCE CLARKE) TO A.R. = 1:4 (DUSEK). EDMOND BRUCE GIVES A.R. = 1·1. HOLTOM USES RIGHT ▽

FIGURE 20.

It can be argued that foils are not like wings. There is little similarity, for example, between the shape of a ray and that of any bird. Dissimilar fluid forces seem to be at work.

I guess that we should go for maximum waterline length and a Span^2/Area of 1.1. This decrees a near triangular shape. Very low aspect ratios, however, slip through the water with little fuss though often with an abrupt change in waterflow about one third of the length from the leading edge. I call this the "Waterfall." Higher aspect ratios seem to kick up a lot of fuss but seem to work better. This makes one think that our foils might be considered more analagous to planing shapes than wings.

If we do not know something, experiment is called for. I draw two methods of testing, one for the bathtub, the other for a pond. I suggest that one should evaluate more by the strength of the lift and drag forces produced rather than by the shapes of the waves.

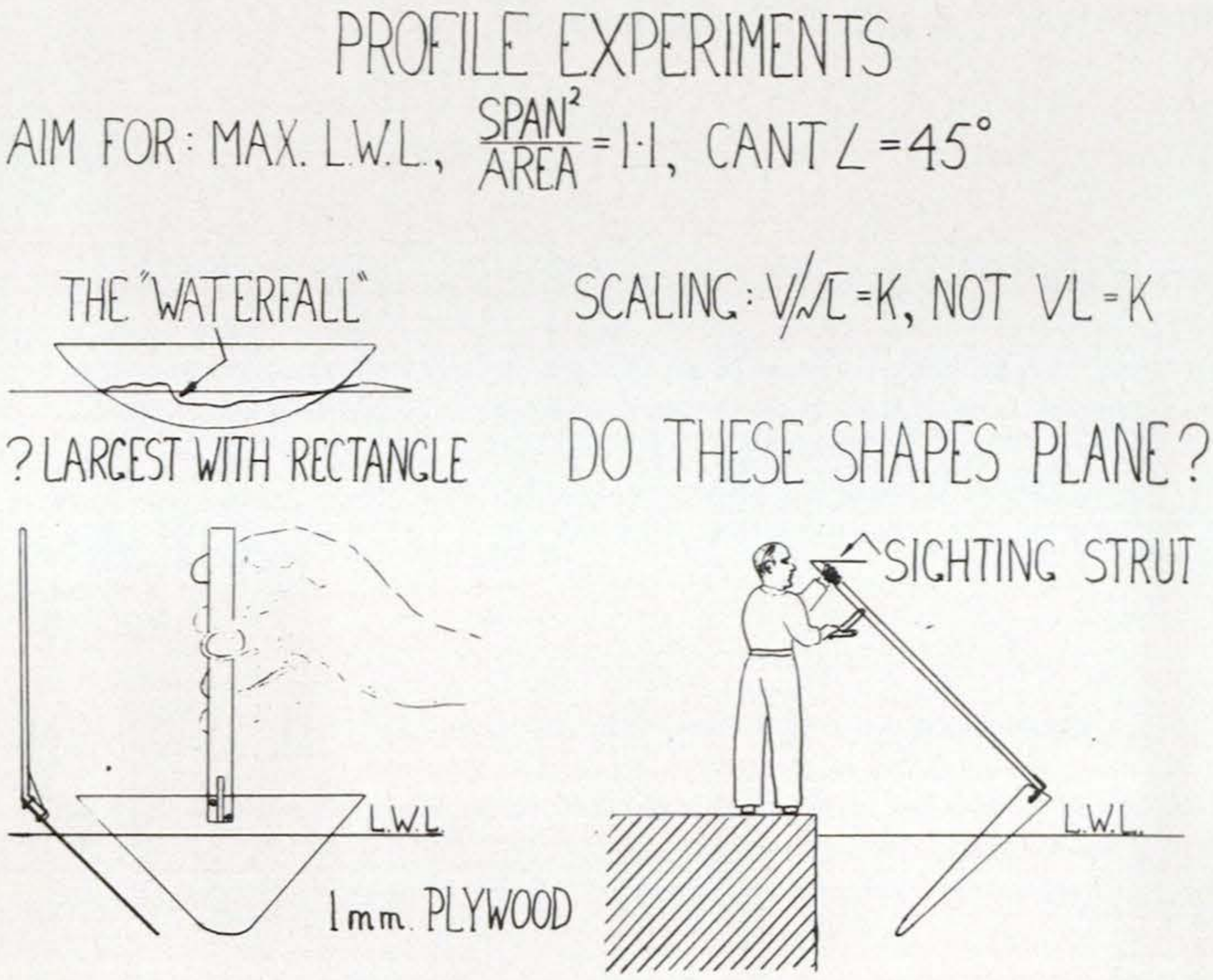


FIGURE 21.

This drawing reviews some keel shapes. The aspect ratio should be 1.1 but the monohulls are very low indeed. The 22 sq. m. yacht uses 0.36 while a 1976 yacht only has 0.71. The 1921 U.S. patent for a double foiler had foils in boxes which could be raised or lowered. I lent the specification to someone and did not get it back, so I may have got the details wrong. The aspect ratio, as drawn is 1.3 but this would have been 1.45 if the pivot point had been at the L.W.L.

Below the heavy line are some shapes, all with aspect ratio of 1.55 which, at a cant angle of 45^{o} would give an effective aspect ratio of the preferred 1.1. The top three could be thought of as wings, while the bottom three could be thought of as planing shapes. The waterline of a planing power boat at speed might look like one of these.

Of all these shapes, that on the extreme left of the bottom line appeals to me most. David Chinery thinks likewise. When working, I suspect that a lot of wash would come from the straight trailing edge but this would not matter if the lift to drag ratio were good.

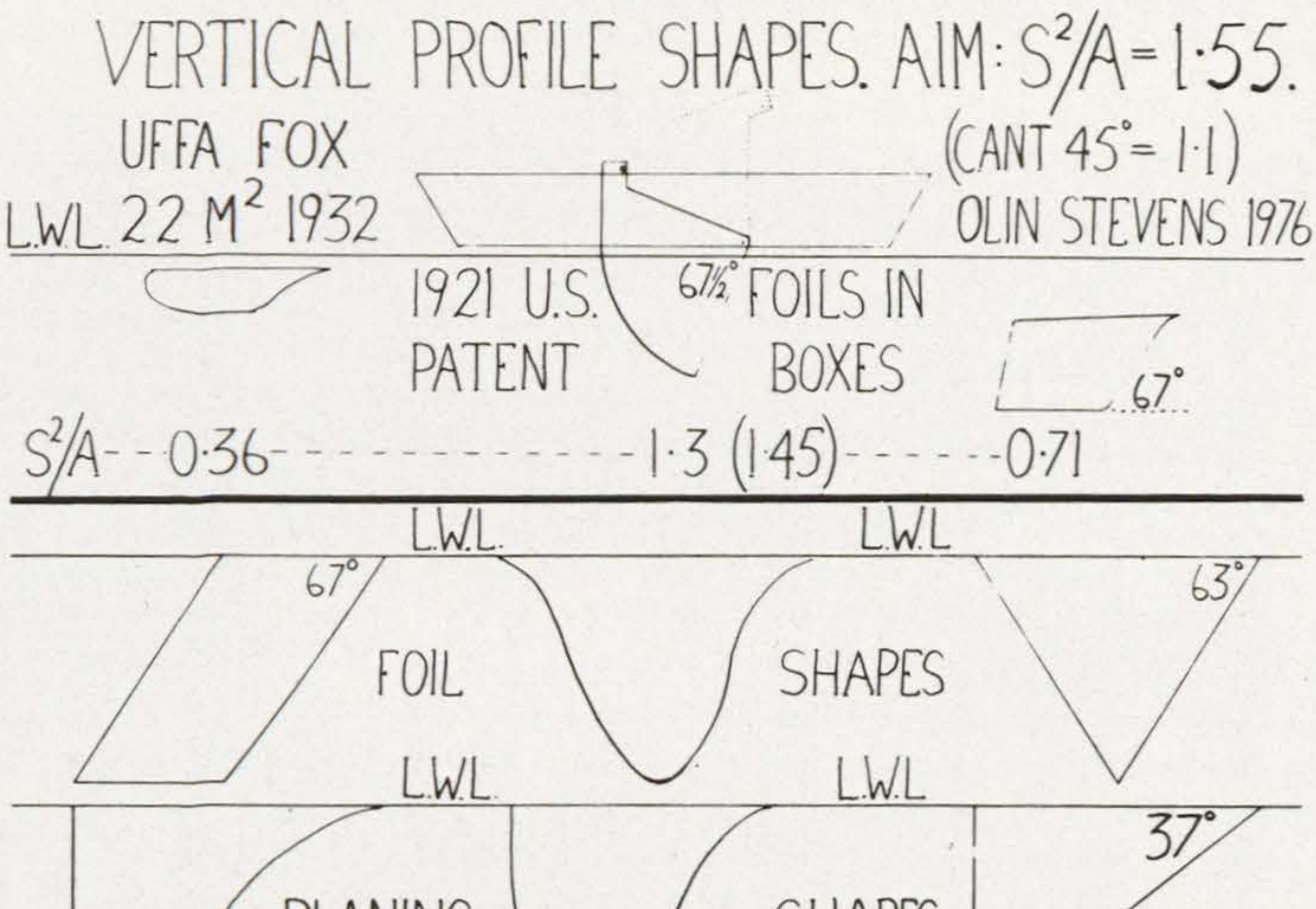
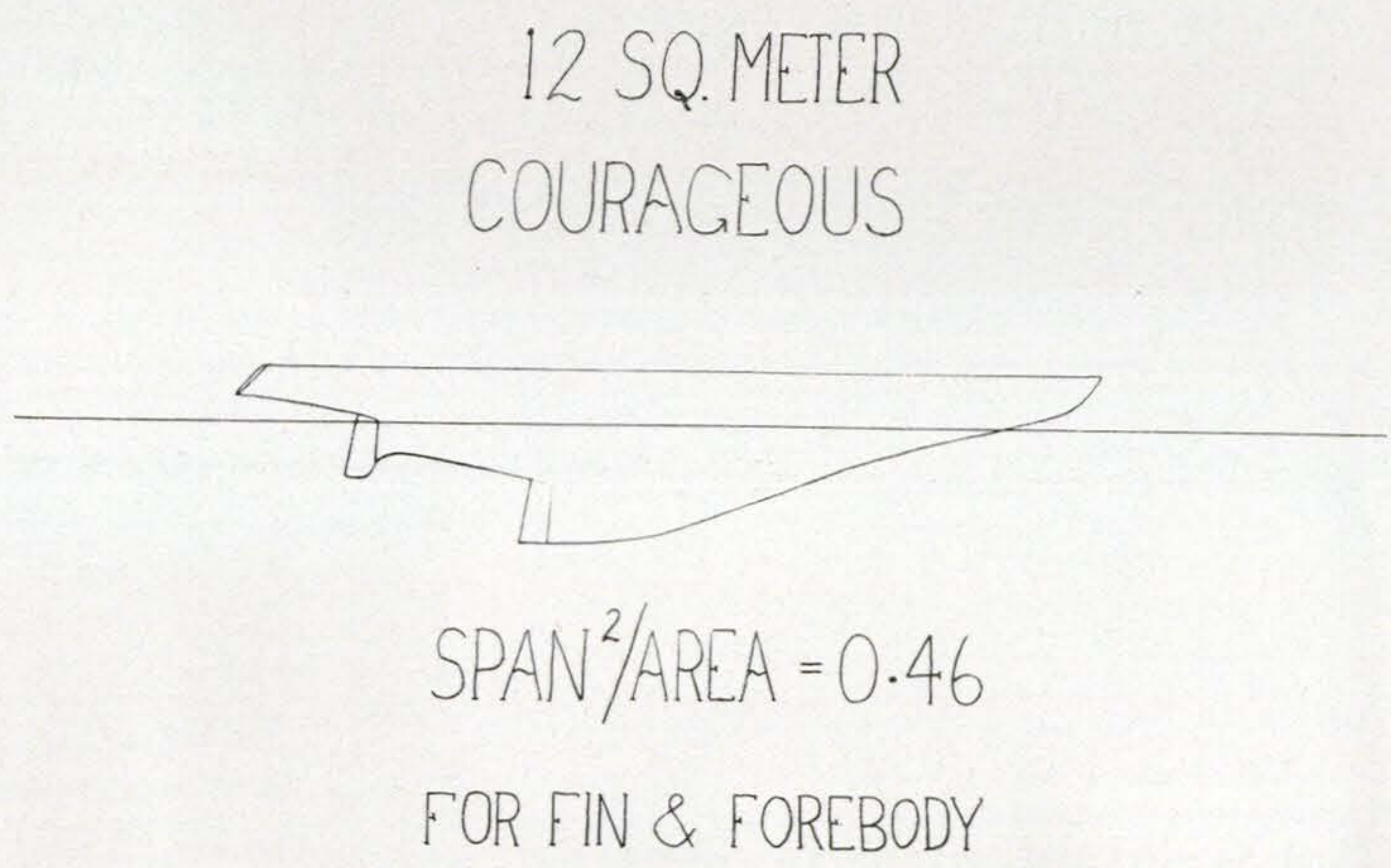


FIGURE 22.

Because this is an Americas Cup year, I did not have far to look to find a keel similar to my preferred foil shape. It is now the accepted shape for the 12 Metre fin keel but of far lower aspect ratio (0.46). I have copied the 12 Metre Courageous as best as I could.

The "Bustle" aft of the fin will almost completely block the fuss produced by such a fin which can be seen in many boats as a wave on the weather quarter, when close-hauled. I am not sure what other function the bustle has except for this purpose, though I have been told that it is a 'rule cheating' phenomenon.

From our point of view, if the shape is good enough for a 12 metre, it should at least be tried as a hydrofoil, even though Edmond Bruce described the Twelves as "Sailing Houseboats."



LOW VERSUS HIGH ASPECT RATIO FOILS

I think that all A.Y.R.S. members give lip service to the principle of an aspect ratio for foils of 1.1, as found by Edmond Bruce. However, when it comes to practice, many people, include Chinery, Horgan, Dusek, Ellison and others seem to prefer very low aspect ratio.

It will be noted that the names given are of people who are mainly interested in largish blue water cruisers. With them, it is the sea motion which counts. David Chinery's Mantis IV with this kind of foils had a pleasant motion and was eminently seaworthy in her design. David's smaller craft with higher aspect ratios, by contrast, seemed always on the point of capsize, especially in light winds, though they were stable enough at speed.

My interpretation of this difference in outlook between the cruising practicality and the theoretical ideal is that low aspect ratio foils have quite a lot of buoyancy in their structure. This gives them a stability by buoyancy very similar to that of a trimaran, though perhaps a little softer. Josef Dusek's Dalibor is considerably under balanced-out even with his pyramid rig and heels somewhat. Even he is worried by sea motion and is going to fit tortion springs to his foils so that the cant angle can flatten a bit when shock loads come on.

Compared to these cruising boats, Gerald Holtom's foiler has an aspect ratio approaching 1.0 and he does not even have any outrigged buoyancy. However, each of his foils has an area of about 16 sq. ft. and are about 3/4 inch thick, giving a buoyancy of about 64 lbs. In practice, the Holtom foiler has excellent static stability coming partially from the foil buoyancy and partially from the flattened hull sections aft.

From all the foregoing, the following principles of design emerge:–

1. We should find the optimum foil shape and always use it.

2. Static stability should be achieved either by flattening the floor of the main hull, as with Dalibor or by using a small amount of outrigged buoyancy at the top of the foils, if a catamaran-like hull shape is used.

FIGURE 23 & FIGURE 24.

This is my last "Hydrofoil Option." It is a "Heeled hull Bruce foiler" on the starboard tack and a "Flying-on-Two Foils" craft on the port tack.

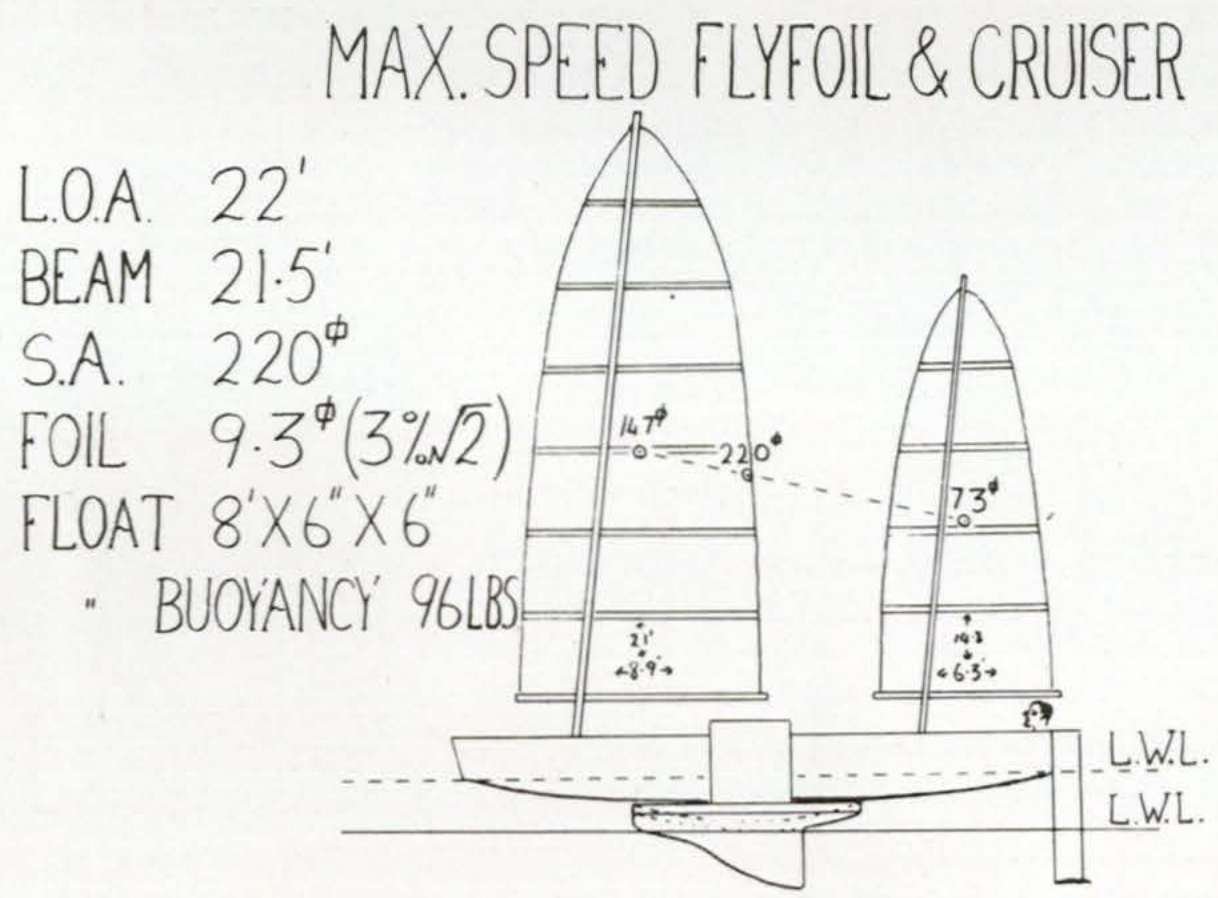
As a Bruce foiler, it has only one foil which consists of the working area only, above which is a tiny float of 96 lbs. buoyancy.

The foil aspect ratio is 1.1 in profile (1.55 at 45^{o}) and it greatly resembles the 12 Metre keel in its plan form. A single inverted T foil aft both steers and lifts the stern at speed.

The sail rig is of two semi-elliptical sails to keep the centre of effort down and thus reduce the overall beam. When flying on a beam reach, the crew has to sit right aft to keep the stern down. Close-hauled, he would have to sit further forward.

Figure 24 shows the traverse section. The cross beam rocks for sail balance and aerodynamic ballast, though the anhedral at the end of the wing will provide this without rocking.

The foil plan form with its attendant float is drawn at the top. This should be fairly easy to build and conforms to the shape and size which I have guessed to be optimum.



PERFORMANCE CALCULATIONS

With luck, this boat might be made at a weight of 140 lbs. which, with a 180 lbs. crew would make the total weight 320 lbs. This would give a Bruce number of 2.2 which, experience tells us, is approximately the ratio of maximum V_B/V_T (Boat speed to true wind speed).

To calculate the take-off speed, we first estimate what sail force athwartships is needed. From the geometry, it would appear that take-off will occur when the sail force is 1.32 times the total weight or 422 lbs. If the sail area is 220 sq. ft. and the C_S (Sail coefficient) is 2.0, this will occur at a V_A (apparent wind speed) of 19 knots. Assuming a V_B/V_T of 2.0, take off will occur at a V_B of 17 knots which will occur at a true windspeed (V_T) of 8½ knots.

Better mathematicians than I will probably be able to work out this more accurately than I have. However, the figures seem reasonable and one wants to stay hull-borne up to about 18 knots below which a catamaran hull has apparently a better lift to drag ratio than foils.

In all, this boat would be a remarkable speedster on either tack, but especially when flying. Its only serious competitor from our review, might be the Bratt Flyfoil, about which I cannot say much.

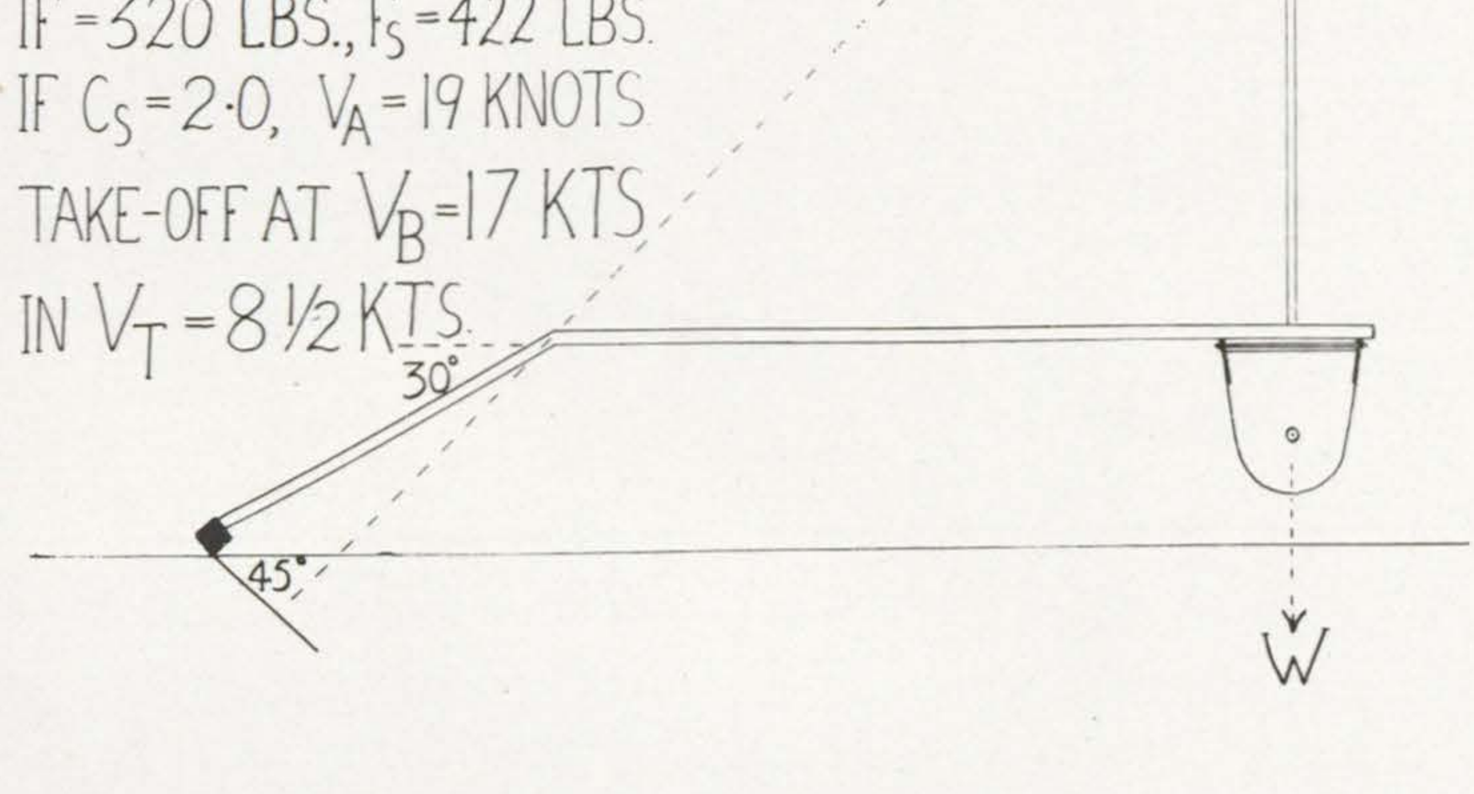


FIGURE 25.

Having seen Gerald Holtom's model foiler right itself from the upside-down position, this drawing shows how the buoyancy of floats can be neutralised to give automatic self-righting in foilers and trimarans. This can be achieved by having a hole in the top of the float and an air-pipe to the bottom, whose outlet will be above water whether right side up or inverted.

The so-called "Rogue Wave" tips the boat upside down. Both air pipes twist so that their ends come above water. The scend of the waves will now put downwards pressure on the lee float and it will sink, its contained air coming out through the pipe. Eventually, the buoyancy of the mast will overcome the buoyancy of the sinking float and the mast will come to the surface on the weather side. The wind will now strike the exposed wing pulling the mast and sail just far enough out of the water for the wind to get below the sail and flip the boat upright again.

When the boat is once more upright, its weather float will now be full of water which can be shifted by a self-bailer.

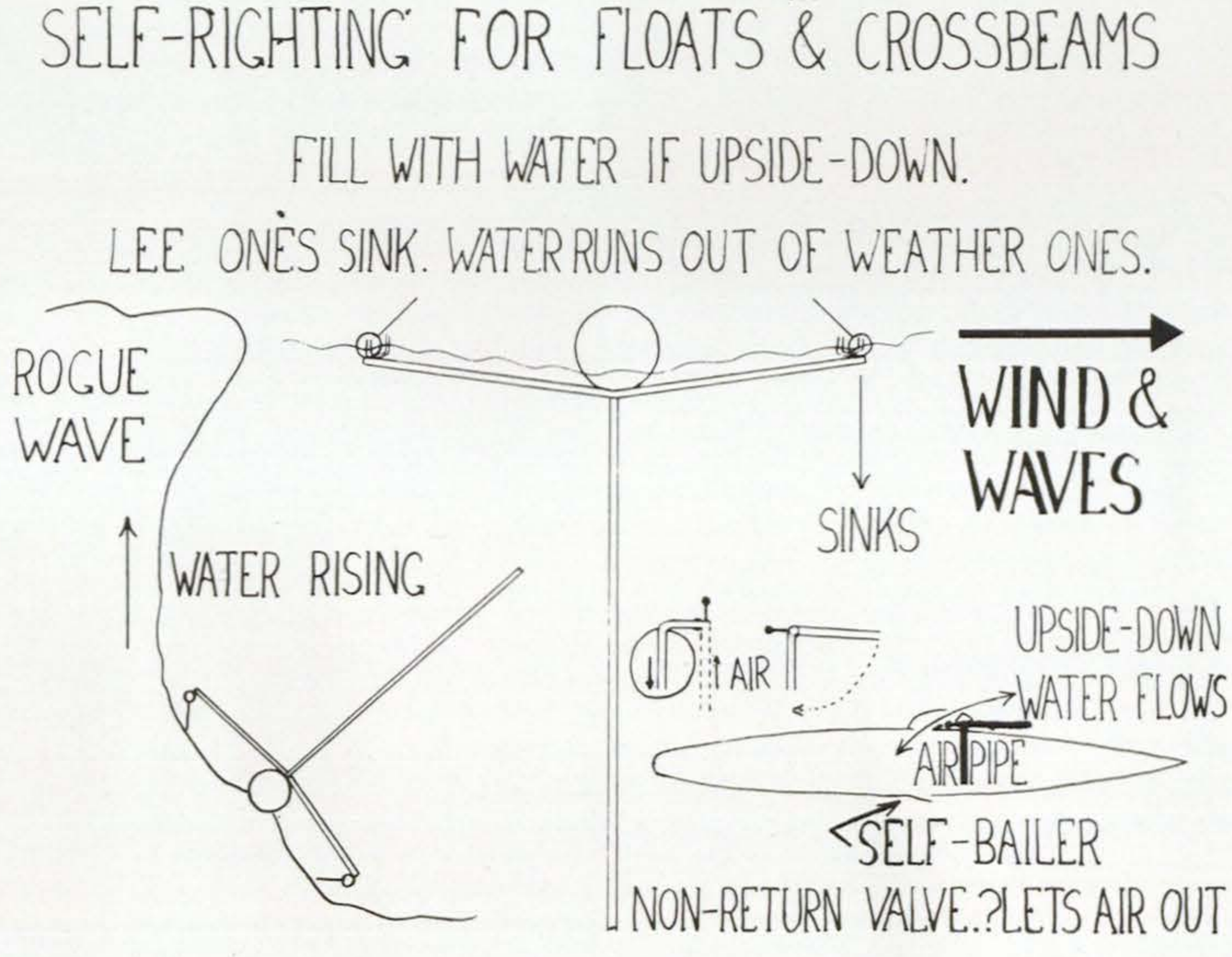


FIGURE 26.

CONCLUSIONS

Here ends my review of "Hydrofoil Options." Doing these drawings has greatly increased my insight into foilers and I hope that they will be of value to others. Doubtless, some people will immediately think of other options and, if so, please let us have them.

I have covered many types of craft and ideas from the simple Bruce foiler to the method of doing an "Esquimo Roll" in a 46 foot yacht. Amongst all these ideas are surely to be found one or two optimum craft for speed sailing or even safe cruising both longshore and across oceans.

The final item consists of the "Laws of Scaling," as given by Edmond Bruce. It would be a wise precaution to make a scale model of any boat one wished to make at full scale. The final sentence seems a bit cumbersome. It could be more clearly put thus:–

"If a person makes a one twelfth scale model of a yacht and it sails at 2 knots in a windspeed of 3 knots, the full scale yacht will sail at 7 knots (i.e. $2\sqrt{12}$) in a 10.5 knot (i.e. $3\sqrt{12}$) wind." Unfortunately, this is only limitedly true for monohulls and is not fully accurate for multihulls. However, it worked precisely for Gerald Holtom's foilers whose top speed he calculated from models would be 17 knots. His foiler achieved that figure fairly consistently at the Weymouth Speed Trials.

THE LAWS OF SCALING

A MODEL OF A SAILING YACHT, SCALED BY A FACTOR OF S_C, WILL HAVE :-

1. LINEAR DIMENSIONS $1/S_C$ AS LARGE.
2. AREAS $1/S_C^2$ AS LARGE.
3. VOLUMES AND WEIGHTS $1/S_C^3$ AS LARGE.

IF THE MODEL SAILS AT V_B KNOTS IN A WINDSPEED OF V_T KNOTS, THE FULL-SIZED YACHT MAY BE EXPECTED TO SAIL AT A SPEED OF :-

$V_B\sqrt{S_C}$ KNOTS IN $V_T\sqrt{S_C}$ KNOTS OF WIND

POSTCRIPT

I started doing these drawings and writing with only the ambition of sorting out my ideas and expressing them. I finish with the feeling that my life-long ambition of knowing what the fastest and most efficient sailing yacht looks like has been accomplished. It is the "Heeled Hull Bruce Foiler" with a semi-elliptical sail.

This has filled me with such enthusiasm, that I have ordered a 445 cm. kayak and ladder. Alas, I may chicken out of flying at speeds over 18 knots, or even flying at all, but the exercise will be well worthwhile. The total cost is not likely to be much in excess of £100.

THE JOHN PLAYER/R.Y.A.
WORLD SPEED SAILING COMPETITION 1977

by

Commander G. C. Chapman, R.N.

The sixth annual speed sailing contest, sponsored by Players and organised by an RYA Committee under the chairmanship of Beecher Moore was again held on Portland Harbour, from 1st to 8th October, 1977.

The full list of these craft, which did timed runs appears later. It is worth tabulating the five **fastest** craft in order of speed:–

Boat	*Owner/ Helmsman*	*Speed (knots)*	*Prizes Trophies and Cash*
1. Crossbow II	Timothy Colman	33.8	Fastest at Weymouth-£500 Likely World Record Holder at end of 1977 £2,000.
2. Mayfly	Ben Wynne	23.0	A. Class - £125.
3. Icarus	Andrew Grogono	22.2	B. Class - £125.
4. Hobie Cat 16	Coast Catamaran Ltd.	19.8	——
5. Windglider	Thijs Academy for Boardsailing/ Dirk Thijs	19.1	10 Sq. M. Class - £125.

The other prize awarded, was the design prize, to Jon MONTGOMERY (entering as SI SI Marine Ltd. of Teddington) for his 4.5 metre o.a. by 2 m. beam inflatable catamaran SI SI, sailing in the 10 sq. m. Class. The hulls contain two 8 inch tubes each, one above the other, so that the hulls are 16 inches deep. The tubular connecting structure, in alloy, carries supports for the two lee-boards, just inboard of each hull, and the single rudder. The basic structure including hulls weighs 85 lb. (air filled) and the rig would weigh about 30 lb. You can save about 2 lb. with helium inflation. This little boat, intended really as a readily transportable "fun-boat" for two, achieved a most creditable 13.5 knots (with a trapeze) and is the neatest inflatable I have seen.

The event was notable for a number of reasons, and most of these contributed to the raising of records – which is the main aim, after all.

At long last the Committee provided an "inshore course." This was arranged to be on the west side of Portland Harbour, where there is normally about 6ft. depth, some 400 metres from the shore-line. Winds within 20° or so of 250° magnetic come over the low-lying Chesil shingle bank after an unencumbered 40 miles of sea, so they are reasonably clean: and the fetch inside the harbour is a third of that on the main, circularly marked, course. Transit beacons ashore, and buoys 400 metres offshore, mark the course. The normal timing and "Nanny" boats are used, so that sailing can be transferred from one course to the other in 10 minutes. This first marking was not entirely satisfactory, and useful lessons were learnt. The local clubs would provide an invaluable facility if they could instal permanent beacons and buoys, and the cost need not be prohibitive.

This course was used on two days, whilst the wind direction and depth of water permitted: and enabled two records to be broken, in A Class and 10 sq. m. Class. MAYFLY did her 23.0 knots on the inshore course, retaining her lead over B Class from previous years.

The Committee also provided a visual tote of the queue of boats booked to run; this enabled competitors to see how many were in front of them and greatly aided peace of mind. It may also have speeded up the proceedings.

The competitors – some 50 or so – produced two major changes. First, the remarkable 19.1 knots by Dirk THIJS on a 6.9 sq. m. sail area surfboard, brand-name WINDGLIDER, which rocked the conventionally mounted members of the 10 sq. m. Class on their heels. And second, the large increase in the number of "Works Entries," and the large proportion of those that are free-sailing surfboards.

In the 10 sq. m. Class Ken MAY (KIKI, sailed by his son Jonathan), Reg BRATT (AUSTER, which had won for the two years before) and myself (BANDERSNATCH, a new boat) considered we constituted the main competition. After warming up on the first two days, the inshore course was initiated on 3rd October, when KIKI did 15.9, AUSTER 15.4 and BANDERSNATCH 14.5, the first two breaking the 1974 record of 15.0 (Reg BRATT's BOREAS). Then the cookie crumbled. KIKI's sail was measured and found to be 3% oversize: back to the sail loft, on Tuesday. And on Tuesday, 4th, the wind blew harder and on the main course WINDGLIDER, surfing down the waves, did 19.1 Admittedly, KIKI and Jonathan MAY recovered sufficiently to do 16.4 on the main course on the Wednesday, but Reg BRATT and myself did no better during the rest of the week.

The free-sailing surfboard (one must not call them all WINDGLIDERS or even WINDSURFERS, just as a HOOVER is not any old vacuum cleaner), gives its sailor the ability to manipulate his sail and his board very rapidly, so that he can derive the best advantage in drive and lift from the sail, and the best performance from his craft. He has a flexibility of response denied to those of us who cling (literally) to stays, shrouds and sheets (hence the term "free-sail"). This is a sport for the very fit and practiced; and demands either a flat calm sea, or good regular waves which permit surfing.

However the so called surfboard should really be called a WAVEBOARD,

since the non-sailing variety uses the leeward slope, and the force of gravity, to obtain a free downhill ride – whether or not there is any wind. Arrival in the surf – i.e. the area of breaking crests – heightens the excitement but spoils the effect. So the free-sailing surfboard should be called a WAVE-SAILER, which generic term I hereby donate to the AYRS, as slipping off the tongue more readily than free-sailing surfboard.
The above discussion raises an interesting point of interpretation of the rules of the event. The rules say that the boat "shall be propelled only by the natural action of the wind on the sails, spars and hull, and water (not ice) on the hull." Nothing about gravity. So a boat using the leeward side of waves contravenes the rules – or does it?

If the WAVESAILERS ask for a course in Weymouth Bay, to exploit the waves there, then I want one in mid-Atlantic, to exploit the swell.

KIKI's performance is, nevertheless, not to be sneezed at. Light weight (175 lb. the whole boat), length of main hull (20 ft.), and an effective sail (high boom rig) all contributed, and logically raised the speed. AUSTER, which weighs 325 lb., is too heavy for her wing-mast, high-boom rig and hydrofoils to make up the difference. BANDERSNATCH, 173 lb. with a very similar rig to KIKI, and the foils from last year's BLUEY, flys very nicely: but at around 14 knots instability starts to set in. Lack of experience prevents me from being sure whether this is due to a design fault: ventilation: structural inadequacy: or just sheer pilot incompetence. I think all those apply! Remember, it took MAYFLY three years to work up from 16 to 19 knots, and a further three to reach 22. Despite new foils, with 6 inch vertical elements to aid yaw stability, MAYFLY still suffers some porpoising and yaw instability and her new record (23.0) must have been aided both by a bigger sail this year, and by the use of the inshore course. I have heard that ICARUS and ICARUS II both suffer similar instability when speeds rise proportionately.

So I am tempted to conclude that we are close to the practical limits of speed for the MAYFLY type of 'aeroplane' surface-piercing hydrofoil configuration: and I suggest that higher speed on hydrofoils will require the use of foil systems which are not prone to ventilation – this indicates the use of fully submerged lifting elements whose supporting struts confer better yaw stability.

Doug Pattison's FORCE 8, which has just those features, should have demonstrated that this is practicable. However, she seemed to be difficult to control, and generally did only short bursts flying straight and level. I suggest her present defects are:–

* The use of a rigid wingsail which cannot smooth out the wind strength variations in the way a soft sail can;
* Too small side floats – so the main cross-beam was frequently buried for a quarter of its length;

* Vertical struts and horizontal foils forward: this gives undue stresses, and hence weight. It is better to incline the struts outwards at around 45^{o} and use the leeway acting on the foils to generate lift and resist heeling.

Mike Simond's RAMPAGE also uses three inverted-T foils on a standard UNICORN. One of these, under the port hull, has its incidence controlled by the helmsman in order to set the boat's height. He has gradually developed this arrangement over several years, and achieved 16.2 this year. This just equals the best recorded standard UNICORN speed of 16.2 knots in 1974, by FINGERS. However, the inverted-T's are at last creeping up and looks like justifying Christopher Hook's long felt expectations, once the control problems are mastered.

So I do not believe we "conventionals" should despair. Ken MAY should build in carbon, Kevlar and epoxy to reduce weight still further: and Reg BRATT and myself should look for better foil systems (and also use carbon, etc.).

The other noticeable change was the increase in "Works Entries." The rules of the event allow only one boat of each "class" or design. In general, boats of a production class which entered were put in by their makers, with their professional crews, and whilst they would be (and were) undoubtedly delighted to break a record, one suspects their main aim was to achieve an authenticated speed for use in their advertisements. Of the "Works Entries" of boats with stayed masts (as opposed to free-sailers) six were catamarans, one a FOILER (another registered name) and one a replica of last year's MAYFLY —a pre-production prototype confusingly named MAYFLY ONE, and sailing in the 10 sq. m. Class. It was accompanied by two sister production prototypes, increasing the congestion on Castle Cove Beach. At least all three were red, to distinguish them from the blue genuine original.

The wavesailers nearly swamped the event. Eleven of the 36 craft which did runs were free-sailers: of these, one a 3-sail board: two were two-sail boards: one (Mike TODD's) a two-sail hydrofoil proa: and the remaining six, one man boards. The Committee were (presumably) satisfied that all these latter really were different from one another. In the vicinity of the Nanny Boat, forming a queue to run, they lay awash occupying an area which made it difficult for conventional boats to approach near enough to book runs. This problem was overcome to some extent, but an excess of competitors would be most unsatisfactory. It may be that some form of elimination will be needed.

A change is the withdrawal of support from Players. Beecher Moore said that if that happens, the RYA will endeavour to continue the event on a self-supporting basis, with an increased entry fee. It is good to know that the event is likely to continue, but a pity if the entry fee has to rise excessively.

So far, this has been an event where the majority of **real** competitors have been amateurs, or private venturers, who enter as a SPORT and for FUN. If it becomes a showcase and testing ground for the battalions of commercialised boat-building, squeezing out the amateur, it could kill itself. At present, the only constructive suggestion I can make is that genuinely private entrants (with non-production craft) should be charged a fraction of the entry fee charged to firms, or those sailing production boats. Whatever the YRS stands for, the 'A' is for 'AMATEUR'!

To return to the boats. To save space, the following brief notes amplify the table and the above remarks.

CROSSBOW II Slightly modified from last year. Suffered an 8 inch hole and a split hull – not due to striking anything – on the inboard side of the lee (port) hull, during the 33.4 knot run. This was repaired temporarily, but lack of wind prevented any more useful runs.

ICARUS II First time out was on the first day: rose rapidly on to foils at around 10–12 knots (wind 20) and sailed 200 yards. Then collapsed in a shower of spray with the lee foil somewhat folded. Repairs and trials followed. I believe she needs steel, not alloy, foils – of better design and manufacture.

ICARUS For first few days, put the starboard main foil inboard of the hull– so that both main foils sloped down to windward, i.e. to starboard: thus rendered a starboard-tack only boat. This idea then dropped. As stated she is now back to her 1972 performance, but single-handed.

FOILER Gerald Holtom's commercial realisation of SQUID. Not strictly a FOILER R since the foils are buoyant (instead of density one) and they were rigged too high.

JABS A scale model (half-size?) of a proposed Round-Britain-Race boat for Hywel Price for next year. Inspired by SLITHY TOVE and STRONGBOW – but if anything overdid the lead. Barring depleted uranium the full range of elements was in use – see SI SI.

EXOPLANE 2 and 3 Didier Costes persuaded a compatriot to come and sail No. 3 in the 10 sq. m. Class. Despite last year's Design Prize encouragement, his engineering and his control of the kite-type sail have not improved noticeably.

PRINDLE 16 (and HOBIE 16). One notes that asymmetrical hulled cats do well. Bravo the Gilbert and Ellis Islanders!

SWEENEY Tries the only configuration of foils of a proa that TIGER DID NOT TRY. Probably overweight for its purpose: but a brave and beautifully made experiment which deserves – and I think will get – careful trial sailing.

AMPHI-CAT I am not convinced that this boat strictly meets the rules of the contest, since on each occasion the kites were launched from ashore. However, it was shown that the boat could sail at least at 90^{o} to the wind, and possibly a little upwind. Despite the extra wind speed at a height of perhaps 80 ft. the speed was not impressive. There is the further administrative snag that one may only fly kites within 5 km. of a UK airfield with permission, so Keith Stewart was allowed a 20 minute slot at half-an-hour's notice, from time to time. He also brought an amphibious vehicle, but I did not see this in use.

NON-STARTERS Some of these deserve a mention.

TOPSAIL II Alan ECKFORD's 28 ft. canard hydrofoil with a polythene sheet covered wingsail. After first outing was converted from a canard to "aeroplane" since it went better backwards. Has potential but needs much more development.

AEOLUS Duncan TODD's canard hydrofoil with a quadruple-wing "Planesail" type rig. Proved controllable as a displacement boat, but the foils were inadequately fastened. Has potential, etc.

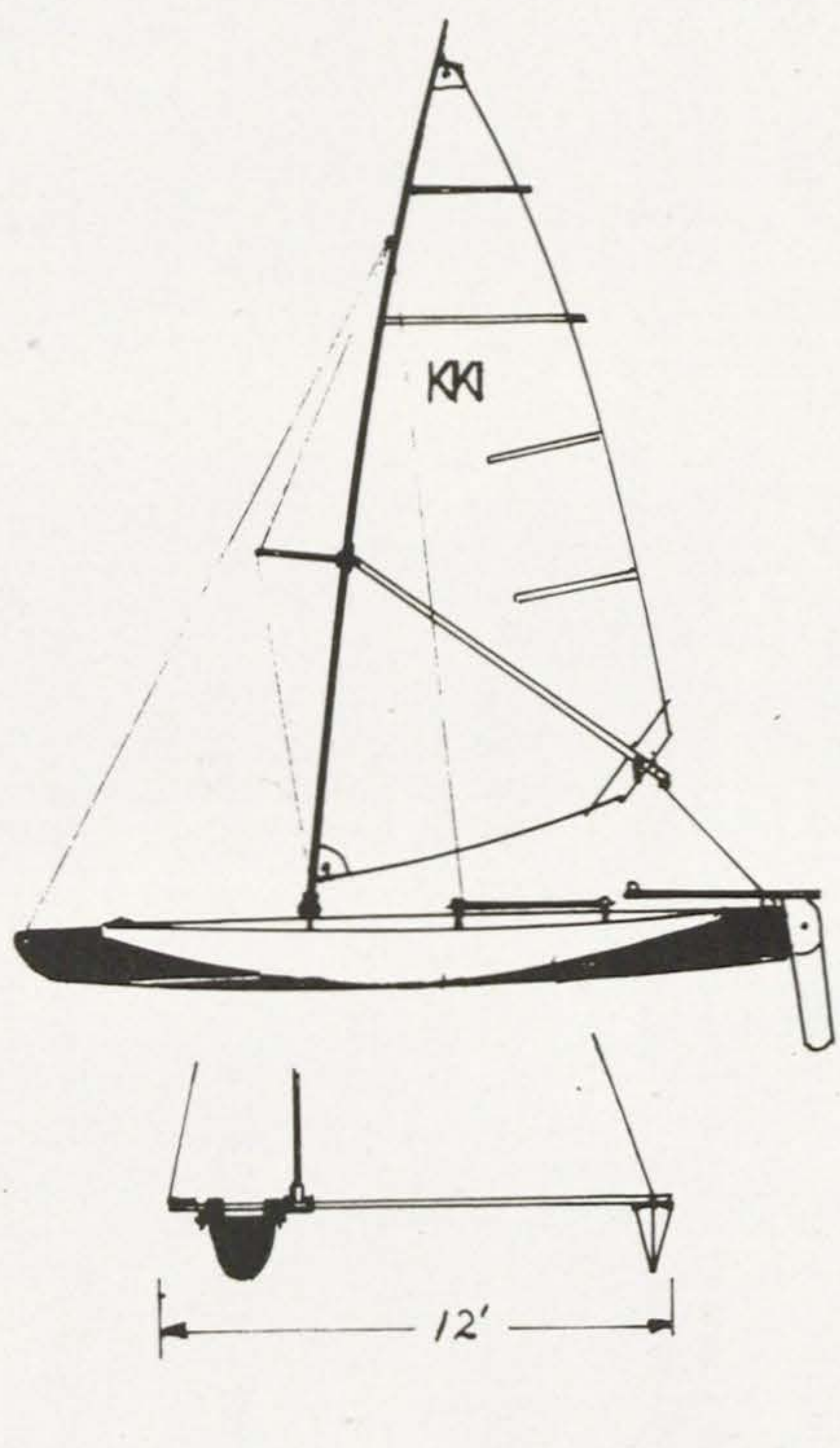
TEN CATE SPECIAL Gary SEAMAN's canard hydrofoil. He built GUIDED MISSILE some years back: and is the leading light in TEN CATE B.V. who market WINDSURFERS in Europe. (See SUPERSURFER). TEN CATE SPECIAL is based on Don NIGG's EXOCETUS, is 34 ft. long, 25 ft. wide and used a 10 sq. m. sail. On its first (ever) outing it was controllable, and got out and back. It had a tendency to put its forward (steering) foil assembly to "dive" and come to a halt: though most of the time it tried to rise. However, the foils were all mounted high relative to a single, central, hull (GRP covered foam under the main longitudinal beam, so the hull never flew. On the second outing, disaster struck and she capsized – with only the foil and cross-beam buoyancy to keep her upright when stopped, I was not surprised.

Notwithstanding Don NIGG's apparent satisfaction with EXOCETUS, I still cannot accept that the so called "canard" arrangement has any merit. After all, a duck (or swan) is simply a bird with a long neck which sticks out in front when it flies. This gives it improved visibility, possibly lower drag, and possibly reduces the cranial vibration to help inertial navigation: but the duck's head is not in any way aerodynamic – or is it? All the canard hydrofoils I've seen, look horribly uncomfortable to sail – and so far they have not been measured at any good speeds.

Finally:–
IDLER (I and/or II) It is now a well established tradition that Peter BROMLEY completes assembling his latest 3-hulled hydrofoil inclined-sail craft on the last day: a calm descends: he goes afloat: it collapses. This year the tradition was maintained.

KIKI – 10 Sq. M. FLYING PROA

Speed: 16.4 Kt. over 500 m. at Portland. Weight: 180 lb.
Main Hull: 19½ ft. x 1 1/3 ft. beam x 1½ ft. depth (max.) (Tornado Cat with top sliced off).
Outrigger: 15½ ft. x 1 ft. x 1½ ft. in 4 mm. ply with 3 bulkheads under beam attachments, all curves are circular arcs.
Mast: 22 ft. in thinnest needlespar section, tapered top. Mast bends and shape controlled by tension in rigging wires thro' two jumper struts mutually at right angles, and by thrust of diagonal spar.
Spar: tensions leech and foot equally, giving twist-free set with no need for downhaul on clew.
No centreboard.Drawing shows set-up for port "hard" tack. Quickly convertible to starboard "hard" tack or to trimaran, by sliding over the cross-beams, Fore and aft positions of mast, cross beams and outrigger, adjustable for trim, outrigger can be canted. Mast rake finally adjusted so that tiller is "hands off" at speed.



KIKI. 10 Sq. Metre Flying Proa

PLAYERS / RYA WORLD SPEED SAILING COMPETITION

WEYMOUTH – 1st to 8th OCTOBER, 1977

ENTRANTS WHO MADE TIMED RUNS – BY CLASSES

Boats Name	*Owner/ Helmsman*	*Best Speed*	*Approx. Wind*	*Date October*	*Description*
Open Class					
Crossbow II	Timothy Colman	(33.8)	24	4	Asymmetrical Catamaran, hulls 60 ft., port leads by 20ft. Two 625 sq. ft. una-rig sails. Total 5 in crew.
Icarus II	"Icarus II Syndicate"/ James Grogono	13.7	17	6	26ft. Catamaran, 27 ft. beam, two full Tornado rigs (235 sq. ft. each). Aluminium hydrofoils, aeroplane configuration. 3–4 in crew.
B Class – Up to 235 sq. ft., 21.84 sq. m.					
Icarus	Andrew Grogono	(22.2)	20	4	Standard Tornado with aeroplane configuration, aluminium hydrofoils.
Hobie Cat 16	Coast Catamaran Ltd.	19.8	20	5	Standard Hobie 16.
Foiler	Robin Webb	17.3	19	3	6.50 m. LOA, 6.4 m. BOA, Holtom designed production Foiler (R). Sail Area: 15.24 sq. m. (Standard Shearwater rig).
Buzby	Chris Moore	16.7	17	5	Standard Shearwater Catamaran.
Aesticat 530	Aestic Products	16.7	17	5	Standard 16 ft. Catamaran–GRP–Asymmetrical hulls.
Nacra 5.2	E. Schuitema	16.7	17	5	Standard production Catamaran–made in USA.

Boats Name	Owner/ Helmsman	Best Speed	Approx. Wind	Date October	Description
Cheri Bi Bi II	P. Tiercelin	16.4	18	3	20 ft. Catamaran, single sail on each hull (inclined slightly inwards). Tiny inclined plates on each hull were removed after 3 or 4 days.
Windglider Tripple	THIJS Academy for Boardsailing	14.5	16	3	Three sail/person, free sailing surfboard. Each sail about 5 or 6 sq. m.
Golden Jubilee	Fibreglass Norfolk Punts Association	(13.0) 11.8	15	5	Fibreglass copy of 1950's plywood Norfolk Punt—a double-ended 2-3 man monohull.
Jabs	P. D. Gardiner/Hywel Price	(8.2) 7.4	12	7	23 ft. plywood hard-chine monohull. Deep CB—8ft. x 17½ ins. steel with 250 lbs. lead bulb. Tornado Rig.
Exoplane 2	Didier Costes	2.1*	10	8	Aluminium 20 ft. proa, kite-sail (attached directly to boat), hydrofoils on main hull, small float to lee.

A Class – Up to 150 sq. ft., 13.94 sq. m.

Boats Name	Owner/ Helmsman	Best Speed	Approx. Wind	Date October	Description
Mayfly	Ben Wynne	(23.0)	18	3	Philip Mansfords original Mayfly, with a new, near 150 sq. ft. rig. New metal foils be Newcastle University.
Prindle 16	Robert Heilbron	17.6*	20	5	16ft. production Catamaran (USA), asymmetrical hulls.
Rampage	Mark Simonds	16.6	18	3	Standard Unicorn (150 sq. ft. Sail), with inverted-T hydrofoils and manual incidence control.

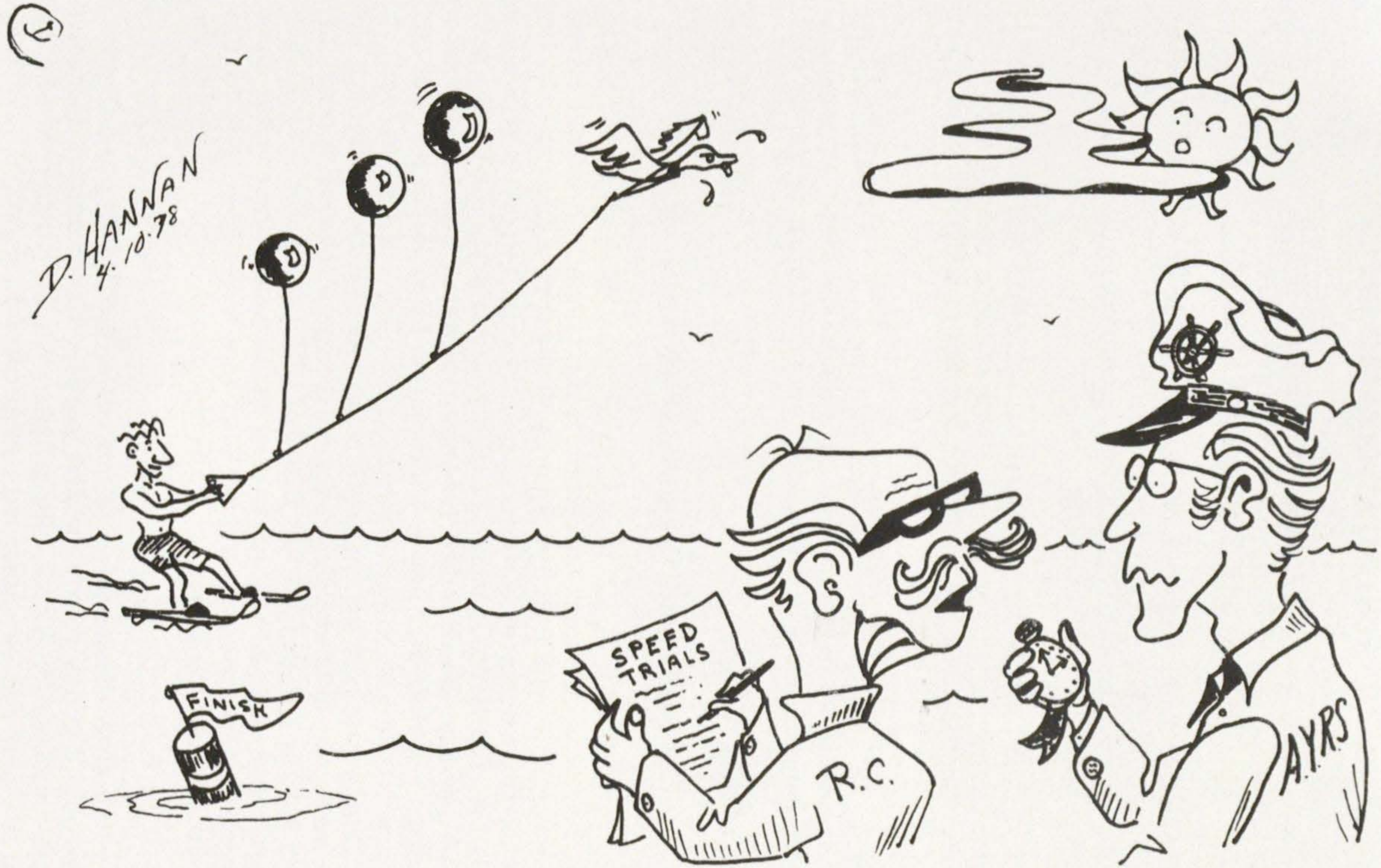
Boat Name	*Owner/ Helmsman*	*Best Speed*	*Approx. Wind*	*Date October*	*Description*
Grebe	Brian Neve	15.6	15	7	Slightly modified Hobie 14.
Force 8	Doug. Pattison	8.1	15	7	18ft. Trimaran, small floats, inverted-T hydrofoils with automatic incidence control and manual over-ride. Rigid, plastic sheet covered wingsail.
Sweeney	Mike Todd	5.7	10	7	Two person/sail free-sailing hydrofoil proa. 18ft. main hull with two aluminium "Mayfly" type foils to lee, a small pod with small inverted-T foil. This was only the second time out. Boat weighs about 230 lbs. Crew 350 lbs. all up 580 lbs. Sails each about 5 sq. m.

10 sq. m. Class

Boat Name	*Owner/ Helmsman*	*Best Speed*	*Approx. Wind*	*Date October*	*Description*
Windglider	THIJS Academy for Boardsailing/Dirk Thijs	(19.1) 18.6	24	4	Standard Windglider Sailing Surfboard, with 6.9 sq. m. sail. (Two variants sailed by Dirk Thijs, Windglider Ranger did 17.0 on 6th Oct., Windglider Spider did 15.2 on 5th Oct.).
Kiki	Ken May/Jonathan May	16.4	20	5	Port tack Proa. Tornado main hull, reduced depth. 10 ft. outrigger, high-boom sail.
Auster	Reg Bratt	15.4	17	3	16 ft. Catamaran, small inclined hydrofoils forward inverted-T rudders. High-wishbone-boom, wing mast.

Boat Name	*Owner/ Helmsman*	*Best Speed*	*Approx. Wind*	*Date October*	*Description*
Bandersnatch	George Chapman	14.5	16	3	14 ft. hydrofoil catamaran, "Mayfly" type foils, high boom sail, bendy mast.
"Mayfly One"	Sea Foil Limited	14.1	18	6	Pre-production prototype of a close copy of the original Mansford Mayfly. Production version will have 12½ sq. m. sail and cost £1750.
K–Kitty	Clive Colenso	13.7	15	3	Two person/sail tandem free sailing surfboard, prototype of a production model by "Hangsailer", i.e. an improved "Tandem."
Si Si	Si Si Marine Ltd./ Jon Montgomery	13.5	18	5	4.5 m. Inflatable hull catamaran, beam 2m. Used a Holt S 100 section mast and 9.78 sq. m. of sail area. Possible prototype for production.
Hobie Cat 14	Coast Catamaran Ltd.	12.8	18	5	Standard Hobie 14.
Supersurfer	Ten Cate Sports BV/ Gary Seaman	12.8	18	5	Prototype of an improved Windsurfer free sailing surfboard.
Tarka–S	M. Stephens	12.6	18	5	10 ft. production catamaran.
Mistral		11.4	18	5	German brand-name free sailing surfboard. 5.6 sq. m. sail by North.
Speedy		10.4	18	5	Swiss btandname free sailing surfboard by Manfred Meyer. 5.2 sq. m. sail by Vogel and Meiser.
Artimede	Artimede S.P.A.	10.2	15	7	15 ft. catamaran, very light, framed trampoline raised like Hobie's. Three sails arranged rather like a 'Pyramid' rig.
Stowaways	Ken and Gordon Way	9.6	12	3	Two person/sail free sailing surfboard by Hangsailer, known as the Tandem.

Boats Name	*Owner/ Helmsman*	*Best Speed*	*Approx. Wind*	*Date October*	*Description*
Hangsailer	Ken/Gordon Way	8.8	18	6	Clive Colenso's brand-name, free-sailing surfboard. 6 sq. m. sail.
Exoplane 3	Didier Costes	7.7	12	5	Smaller version of Exoplane 2.
Amphi-Cat	Keith Stewart	6.7	15	2	9 ft. catamaran, canoe hulls, platform with seat for pilot, foot-bar for control of rudder. Powered by 6 or 7 kites, flown in echelon, launched from the beach.



By Jove, ... I think that we had <u>better</u> redefine the phrase "wind driven craft"; by next year!

ROYAL YACHTING ASSOCIATION REPORT

'B' CLASS RECORD

WORLD SAILING SPEED RECORDS

During the 1977 World Sailing Speed Record Event in Portland Harbour, Weymouth, the 'B' Class Record was broken by ICARUS, with a speed of 22.2 knots, on 4th October. This record was subsequently ratified by the World Sailing Speed Record Committee.

Meanwhile, in the United States of America, a speed trial was held for [NF] [2] who attained a speed of 22.5 knots on the 29th October, faster than ICARUS, but not by the stipulated 2% which is necessary in order to claim a new record.

The present 'B' Class Record is therefore held by ICARUS, but the Committee would like to draw public attention to the faster run of [NF] [2] and to wish her every success in her attempts at record breaking during 1978.

John Reed, Racing Manager. *25th April, 1978*

HIGH SPEED SAILING SYMPOSIUM

The 1978 World Sailing Speed Record Symposium on High Speed Sailing started at 10 a.m. on Saturday, 8th April, at the London Corinthian Sailing Club, Hammersmith, with a lecture from Dr. Wellicome, a lecturer from the Ship Science Department of Southampton University. He gave a very interesting talk on "The Hydrodynamics of High Speed Sailing," illustrated with graphs and diagrams. He described the inter-reaction of foils on each other the hull shape and the water flow – showing that by variation of shape and angle a forward foil can, in fact, obstruct rather than assist a stern foil. He explained how a vortex is set up, and that its effects carry on through the water for very great distances, depending on the speed the craft is travelling. His theory for the use of foils was that it is better to set the foil to windward which gives more lifting power, than to leeward, whereby the force of the wind, as it increased towards the mast top, would only serve to 'dig' the foil further into the water, thus hindering rather than increasing the speed.

Following on from this fascinating talk, and coffee, was Dr. Reginald Bennett, who spoke on 'J' Class yachts in their heyday. He recounted anecdotes of his times on board 'Shamrock'–the strike by the fishermen crew who did not want to crew for the Americas Cup because they would miss their winter's fishing; of the time he saw a masthead man lose his hold of the shroud and crash from side to side against the mast; and, on a pleasanter note, of a particular occasion when 'Shamrock' caught a breeze off a headland and gained enough power to slowly pass all the other boats in the race who were becalmed beneath the shadow of the same headland! Dr. Bennett described the size of the yachts–masts about 175 feet high, and the decks so broad that two 12 Metre yachts would fit side by side! The sails were, of course, enormous, and the sheets as thick as a man's wrist! Dr. Bennett requested that if anyone had any knowledge of 'Endeavour II' he would be most interested to know of its present whereabouts.

After Dr. Bennett's most original talk, Mr. John Hogg spoke on "Wind Flow and Performance Measurement," which he illustrated with slides, of his experiments in this field, and described the difficulties of getting a true picture of the wind direction around the sails. He had set up a mini experiment centre on the free hull of a catamaran, which was ideal for his purposes. He talked about the sail angle and wind direction in relation to speed, and showed some of his delightful selection of gadgets for use in high speed sailing. His idea was that the sailor has a great deal to do with his eyes, and should try to set his boat up to make use of his ears as well–for instance, he had produced a gadget which 'beeped' if one went off course! He also had various measuring instruments of his own design for registering air and water flow. These gadgets were clearly very interesting to the Symposium who were reluctant to desert them even for lunch!

After lunch, Mr. Gerald Holtom, the originator of 'Foiler,' showed a short film of 'Foiler' in her early days, and then some slides of how she was first made. These included a shot through her hull from a hole in the bow – which had, in fact, been made during the fibreglass spraying to carry the fumes away. This, and other slides of the practicalities of building 'Foiler,' complemented the lectures on the theory of high speed sailing.

Mr. Mike Ellison of the Amateur Yacht Research Society, then introduced a film of the 1972 World Sailing Speed Record Event, showing an early 'Crossbow' and various other craft whose descendants are still entering the event.

By now the Symposium was fast approaching its 'time-up' and Mr. Beecher Moore asked Philip Hansford, the designer of 'Mayfly' to answer any questions the audience might have about 'Mayfly.' The main questions were about the foils on 'Mayfly' and their design. Mr. Hansford explained that while they were adjustable when the craft was stationary, they could not be moved whilst sailing. It is interesting to note that 'Mayfly' took the 'A' Class record in 1977 with a speed of 23.0 knots.

Mr. Beecher Moore closed the Symposium, thanking everyone for attending, and a Vote of Thanks was given to Beecher Moore by Dr. Bennett.

R.Y.A. HIGH SPEED SAILING SYMPOSIUM

8th April, 1978

These Notes by John Morwood and Michael Ellison

Dr. Wellicome from Southampton University spoke on "Hydrodynamics of High Speed Sailing."

Dr. R. Bennett (our Chairman) spoke on 'J' Class Yachts, recounting some of his experiences on "Shamrock" (now called "Quadrifolia") and others. The top speeds of the 'J' Class was 13 knots.

John Hogg spoke on "Windflow and Performance Measurement." John is well known to long standing members for his frequent contributions to our publications and talks to our London meetings. He recently retired and we look forward to hearing more of his fascinating contributions to yachting.

After an excellent lunch, Gerald Holtom spoke on the development of his "Foiler" from his first self-righting model to the present 21 foot model in production by Foiler Ltd. His 52 foot hull is at Hythe, Kent, awaiting funds for completion.

The meeting ended with some observations by Philip Hansford on the development of "Mayfly" which was shown in action on our A.Y.R.S. 16 mm. film of the 1973 John Player Speed event at Weymouth. All the speakers gave excellent clear expositions of their subjects and our interest never flagged throughout. The R.Y.A. is to be congratulated on organising such a successful event.

The main interest to designers of future yachts for the highest speed sailing lay in Dr. Wellicome's talk based on research and tank tests into hulls at the 30 to 40 knot speed range. Using a series of slides, showing wave drag, skin friction drag and resistance curves, the following are among the points made:–

1. The maximum speed of a sailing craft is related to the roll restoring moment and also may ultimately be related to the pitch restoring moment of the hull.
2. Skin friction drag increases nearly by the square of the speed.
3. Wave-making drag for narrow hulls increases steeply up to a speed of about $2\sqrt{L}$ and then falls considerably which explains the apparent 'planing' of catamarans. Up to the hump in this curve, two hulls are as good as one.
4. Because skin friction and wave-making drags have to be added, the total resistance curve rises continuously though with a slight hump at about $2\sqrt{L}$.

5. For a displacement hull of the "Crossbow" type, the optimum length varies with the speed wanted. For 27 knots, 58 feet was the optimum for his test hulls, while at 40 knots, the best length was 40 feet. Variations in fore and aft trim which would be caused by the pitching moment of the sails greatly increased resistance.
6. A hard chine, stepped planing hull was next tested, riding on one area just forward of the step and another area just ahead of the transom. These two areas were thus used to maintain trim, the load moving more onto the forward area to counteract the bow downwards pitching moment. A computer was used to predict the interference between the two surfaces and a graph showed the various load distributions.
7. Hydrofoil craft were next compared with aircraft. The best aircraft tail plane has a slight negative lift so that the main wings carry more than the total weight. The derivation of wing-tip eddies was shown. Air flowing outwards towards the tip below the wing and inwards above it join to try to equalise the pressures above and below the wing. Where the two flows meet at the wing tip, a vortex is formed which can persist up to three miles astern, causing vapour trails. A foil tip will similarly produce vortices.
8. Facts about foils:–
   a) A stern foil will have its resistance doubled if it runs in the wash of a forward foil.
   b) The surface loss is double that of the immersed part of the foil except at very low speeds.
   c) A foil near the surface produces a wave which reduces lift by 50% at 5 knots improving as speed or immersion increases.
   d) The lift to drag ratio of a near-surface foil is 7 whereas it would be 14 in air or deeply immersed.
   e) Ventilation and cavitation are to be avoided at all costs and are not helpful below 80 knots.
   f) Recent work at Southampton has shown that the foil force is not acting at 90^{o} to the foil surface.
9. Finally, a graph was shown of the three types of craft, namely, the 'Displacement' boat ("Crossbow"), the hard chine stepped planing hull and the foil-borne craft. This showed the drag from rest to about 35 knots with the appropriate sail force.

At low speeds, the displacement hull has very much the least resistance. The hull with foils has the next least, while the stepped planing hull's drag is only just less than the available sail force. This concerns us in so far as the acceleration will be greatest for displacement hull and very poor for the stepped planing hull. The greater acceleration will allow a shorter approach run to a measured course.

At the top end of the scale, the three curves approach each other in a small triangle at about 30 knots. The stepped hydroplane is never as good as the other two but there are indications in the projections of the curves that the flying hydrofoil boat could be the best at very high speeds of, say, 40 knots.

In conclusion, Dr. Wellicome indicated that a single surface-piercing foil of the Bruce type to leeward shows promise of being the fastest because of the extra righting lever obtainable and the reduction in displacement as the hull tends to lift over the foil.

These tests were made for relatively heavy craft (13 tons) but the answer to a question from Michael Ellison was that the results should be scaleable for smaller and lighter craft.

A.Y.R.S. members will remember that Edmond Bruce found his single foil to be faster when it was to windward in spite of the increased displacement. He thought it was due to increased foil efficiency. Gerard Horgan confirmed this finding with his Bruce foiler. However, nearly everyone who has sailed with a single foil has either had a capsize or near capsize when the foil was to windward and it suddenly popped out of the water. It may well be possible to hinge the mast and outrigger beams in a fore and aft line so that the rig can capsize without capsizing the boat.

Letter from David Chinery, Wildecroft, Buckland, Betchworth, Surrey.

Dear John,

SUBMERGED BUOYANCY

As you showed such interest in our experiment, I thought you would like to have some details.

I am only going to give you the facts!! I would be interested to get your observations.

The Model.
See drawing. 30 ins. overall, 18 ins. beam. Fully balanced out. Single sail made from light transparent plastic, which wraps around the mast and is then stuck with sticky tape.

The hull is made from 1½ ins. dia. plastic tube. The bow and stern sections made from soft wood, shaped as plan. You will notice the hull is in sections, marked A, B, C, D. These sections are different lengths and are joined together – a tight push fit over an inner sleeve, also made of plastic. You will appreciate that by transposing the sections, the positioning of the main (wing) section can be altered. (In fact, we always took extra sections of plastic to the water, and sometimes the model 'grew to 4.')

From section 'B' through a slit in the plastic, protrudes the "Sharks fin," 1/8 ins. plywood shaped with a very sharp leading and trailing edge.

The Pod, sits on top of the fin, and serves to support the mast and beams. Notice the plan shape of the 'pod' to conform to the sail shape.

Method to Submerge Hull.
Inside the hull, are a series of plastic containers, each with a screw lid. These are filled with water until the hull submerges–just. In fact, the hull is held in position **under** the surface by the **two foils**. It is not difficult to achieve balance in the static state.

It is obvious that the pitch of the model revolves round the foil which, incidently, is also the centre of effort of the sail and foil.

(It is very curious to see on the pond just the foils and sail – and no hull).

The Sharks fin is 7½ ins. long at the waterline.

Sailing the Model.
The experiment failed because:–
1. Controlling stability in pitch was very, very difficult.
2. When we had, the model was painfully slow.

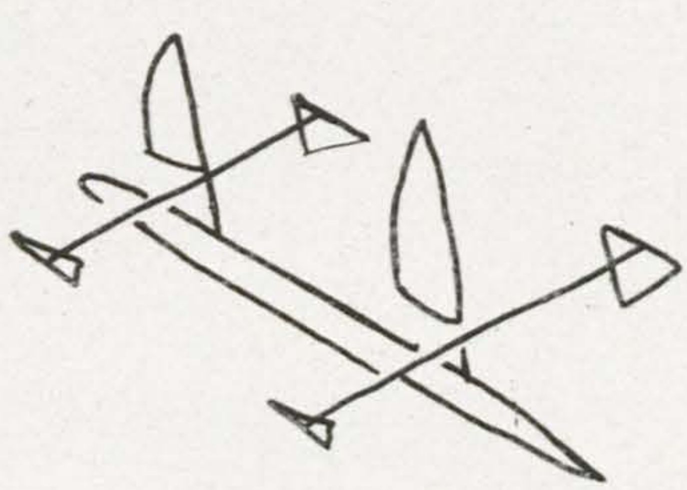
The problem as I see it is:– We balance the model in its static state and then gently push it off. Once the wind takes over, because the centre of effort is some 8 ins. above the pivot point (foils at water level), it immediately pushes the bow down. To offset this, we made a stabilising foil at the bow, which had an angle of attack which varied from 0^{o} to 15^{o}.

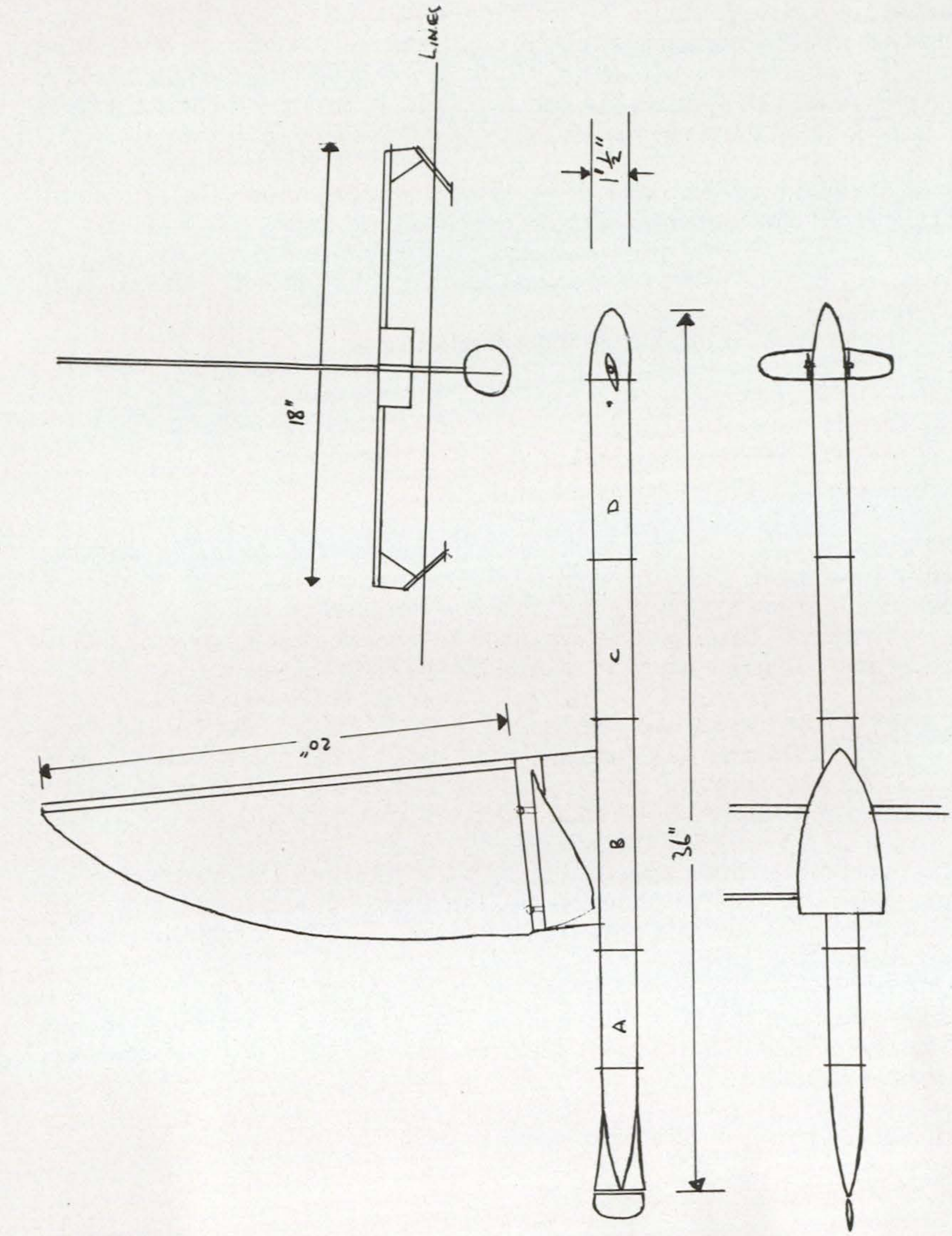
It was possible by trial and error to get both the balance and the stabilising foil right. No matter how hard the wind blew – the model COULD NOT CAPSIZE. The centre of buoyancy is too high above the centre of gravity. This does not apply to a normal foiler, which CAN capsize!! (and does).

The experiment finally failed because we emptied all the water from the hull, which then floated normally, and the model became an ordinary foiler, albeit it sailed at an angle of heel of about 40^{o}. Then the model shot accross the pond – so we gave up.

I have given you the facts. I have often thought about the problem because it fascinates me. If the concept could be made to work, it would be a very safe boat at full size.

I thought of having 4 foils, thus:– Over to you!





LINES
18"
1½"
20"
36"
A
B
C
D

Reply to David Chinery from John Morwood, Woodacres, Hythe, Kent.

Dear David,

Many thanks for sending me such details of your submerged buoyancy model. It certainly was very ingenious.

My first difficulty was seeing how you controlled the model in pitch at all. I then assumed that the fore foil was more or less horizontal and when the main foils rose up, the submarine took a slight nose-down attitude. By contrast, I think I would have had the sail, and pod further forward (in front of the C of B, and a simple horizontal fin aft, as well as the rudder skeg. Then, in motion, the hull would run straight, with a slight tendency to dive. This would be equally unstable in pitch.

IN ALL, HOWEVER, I think one has to have three points of surface touching for stability. The two foils are two. What about a 'Hunt' planing hull forward? Or a V foil? However, I think your 4 foil system looks best.

OTHER COMMENTS. The submerged buoyancy should be of a 12 : 1 length to beam ratio for least wetted surface. I don't know how far below the surface it should be, either 1½ beams or 2 beams. You appeared to use about one beam and would have noted the surface waves.

I guess that, with all the water you used, the scale weight of the model was pretty high.

MY CONCLUSION IS: That your 4 foil configuration is the best way of tackling the problem.

"COULD NOT CAPSIZE." Here you say "The centre of buoyancy is too high above the centre of gravity." I would have thought that the centre of buoyancy would have been in the submarine.

A submarine buoyancy hull would be very expensive to build. I cannot see much benefit in it as compared with a semi-circular sectioned catamaran hull as neither ORDINARILY make surface waves. I guess that your craft was simply fully balanced out which can be done equally well with a double foiler with both foils submerged.

If we get our AYRSFOILER Class going, double foils submerged at rest and fully balanced out will be tried and their relative speed assessed. They seem to be very stable and safe.

Yours sincerely, John Morwood.

Note:
Unlike a surface craft, horizontal foils aft do not bring the bow back to the surface when it is depressed. They cause the hull to run straight and dive further.

DESIGNING FOR VERY LIGHT AIR

by

Dick Andrews,
25 Audubon Drive, Ossining, New York. 10562.

Eighty percent of American boatmen are out-and-out powerboaters, and many of the remaining minority operate "auxiliaries" on which it is the sails, not the motors, that are the secondary power. The simple reason for this state of affairs is that much of the time in many areas, winds are light to very light. So let us design a sailboat for very light air. Definition:– if cigarette smoke drifts, the boat should go. All other factors but this will be ignored in the design.

Right away we have to get rid of all the "go fasts" of sailing that work when there is weight in the wind, but that clearly raise the resistance threshold. We must get rid of drag. So:–no flat bottoms. No sharp chines. No foils. No multihulls. None of that. No keels. In brief:–no foot dragging of any sort!

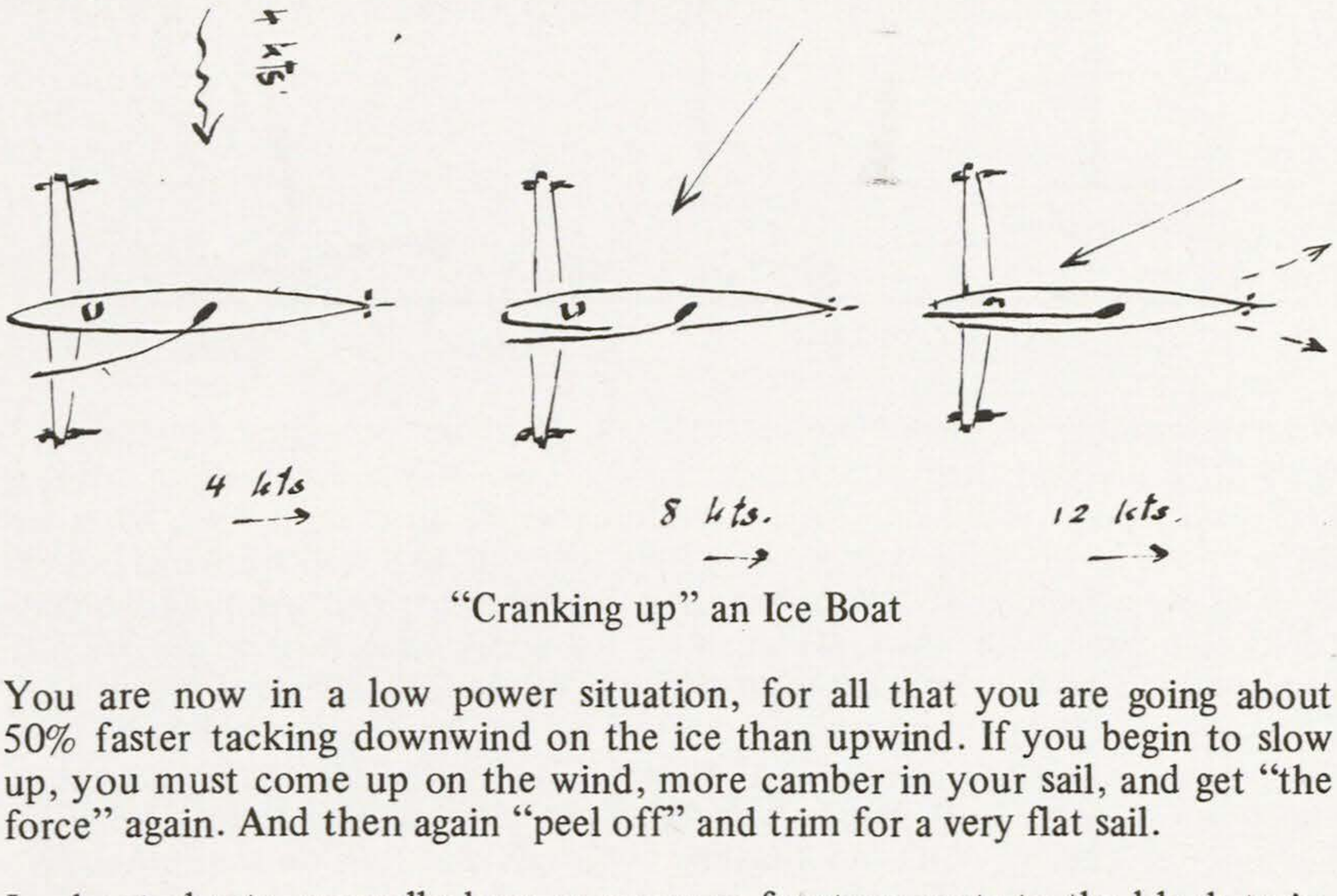
The optimum shape for very low initial resistance is the fat sleek tub.

Putting that aside to dry, let us look at the rig. Well–if the wind is blowing at, say, three knots . . . then there is no point in sailing slower than that. So:–no spinnakers. No bloopers. No big soft-bellied sails. No sail that asks to have the wind get behind and shove. If we are going to sail at wind speed or faster, we have to have a windward rig–by definition. A nice tall luff will give us a low induced drag factor. We need enough chord to the sail to give some "torque" or "kick." Let's have a look at a rig, designed for sailing over wind speed.

An "ice boat" is a craft that sails "on its own wind." A bit of local air movement and the skipper's legs get it going, and then it gradually becomes a sort of "perpendicular glider." It gets drive through its own motion. But it is not up in the air gradually falling, and so the ice boat cannot "glide" in still air. But it approaches that, for at its best efficiency, all that the local breeze is doing is to give the mass of air particles THAT THE SAIL IS MOVING THROUGH . . . an angle of attack or "skew" to the sail.

This is a process, and so the ice boat uses variable camber. A rough analogy is the gear box of a car. It starts off in "low"; the sail trimmed to the local wind. As speed builds, the sail is trimmed in but the plank mast is still rotated. That is the next gear. Now the process is to bring the air flow in tighter and closer to centreline of the craft so that the angle of attack can become finer and finer. Here we are shifting into higher gears where power is less, but drag is much less. Some ice boat sails are cut with no roach to the luff whatsoever and with such rigs, it is the rotation of the mast that provides camber—plus trim—and it is the unrotating of the mast—and bending of the mast—that ultimately gives a very flat low-drag sail with a free leech. One way or another, one must have the "gear box."

Another aspect of ice sailing that is important here, is that of tacking down wind. First of all, it is often impossible to get downwind on the ice by just paying sheet and letting the breeze blow you there, a la spinnaker. On the ice you get high speeds because you don't make gravity waves, but this does not mean that resistance is absent. It has to be blowing even on good ice to let you get away with a run with boom out. Normally, you must tack down wind and – you cannot start off by tacking downwind. You have to come up on the wind and build power, shift to speed, and the "peel off" as the ice boaters say. (The swoop of a bird as it is flying against a wind and then swoops off is an analogy).



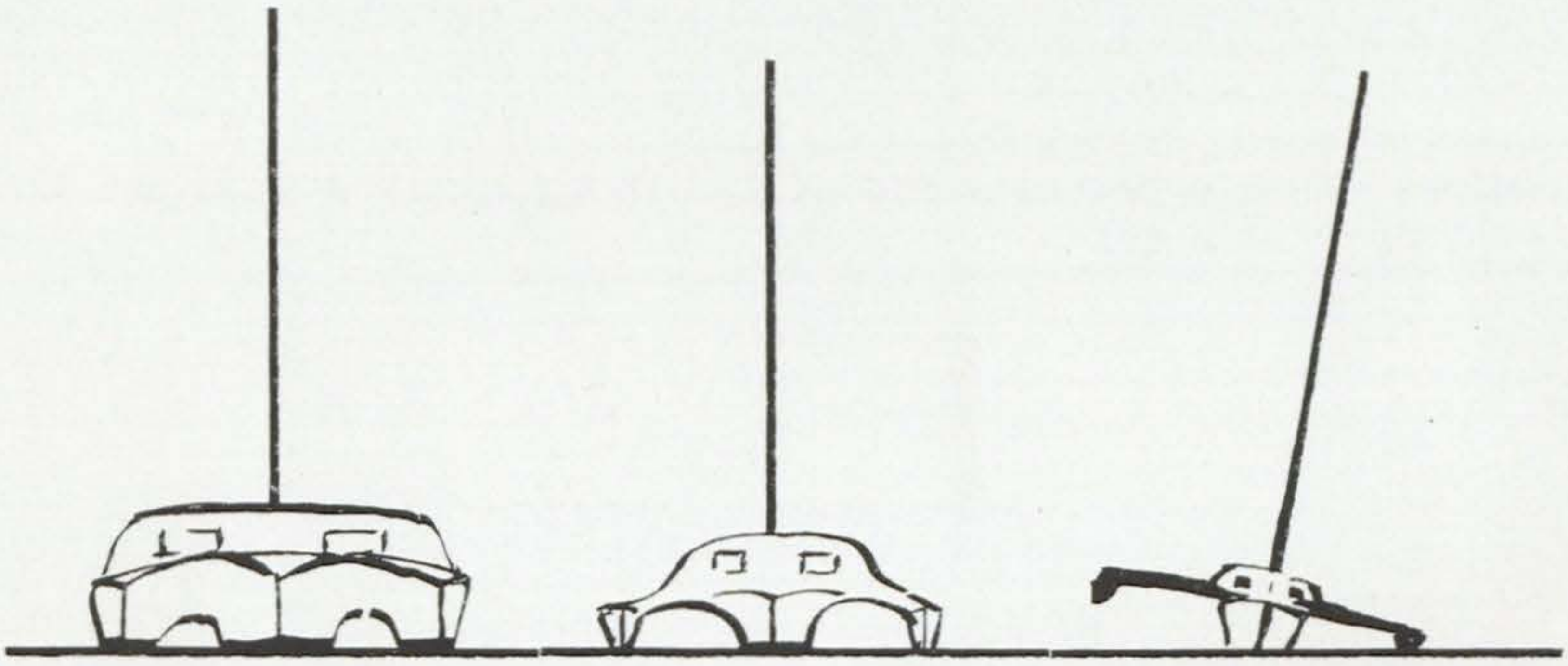
"Cranking up" an Ice Boat

You are now in a low power situation, for all that you are going about 50% faster tacking downwind on the ice than upwind. If you begin to slow up, you must come up on the wind, more camber in your sail, and get "the force" again. And then again "peel off" and trim for a very flat sail.

Ice boat sheets generally have as many as fourteen parts to the block train.

To return to the water, with the right rig and some notion of what to do with it, do we want a fat sleek tub? The problem will be that it will make waves too quickly. We will want the tub in section – either a rounded bottom in section, or double chines with radiused seams (in any chined boat, the more open the angle of the chine, the better. For this reason, double chine is best, or any other chine arrangement that makes for easy angles such as flared sides and vee bottom; flared sides and arc bottom (Star boat); or very flared sides and narrow flat bottom, etc. This writer towed models in pairs on a yoke and found that the easier the chine angle the less low-speed (or low-power) resistance. Box section was poison. 45° side flare on narrow flat bottom (Eskimo "umiak") was the best single chine section).

However we will want to pull the shape out long to delay wave making because–and this is critical–our potential top speed in very low power situations will be that the point of the "hump" when we begin to make waves. If we can make a craft of 20 : 1 beam/length ratio as light as the proverbial feather, we will get more than if we use 10 : 1, but the latter will be a fair compromise if – as usual – we are carrying some freight. Fuller bodied hulls will ghost well, but they simply will be limited as to top speed in the situation. But this is a tricky area, as it is easy to fall off the fine line and be dragging our feet in the water.



Tripple Dipper Clipper Kiss-kisser Vinta

We have another problem. The nice tall sail, desirable for sailing to windward with little induced drag in low power situations–wants equipoise . . . But a keel won't do (weight and drag). Two hulls won't do (drag). Well, what we do is to use a light long balance pole (like the man who walks the high wire). To this, we attach some sort of low-drag float at either end, And–this is very tricky–we don't want the craft to sit on the water level. Not at all! We just don't want it to fall over. We want the lee float to just kiss the water at rest. The other float should be well up clear. What? A leaning or heeling boat at rest? Yes, a leaning or heeling boat at rest. This boat will only be upright at one point in staying of jibing. Why this? One reason is that to have both floats even kissing won't do (having both immersed is poison!) Another is that when a craft heels, its sails tend to stay "asleep." Full length battens also help this but won't do it alone.

A point to re-emphasize here, is that we are involved in a game of low-power sailing. So we have to unload the Drag out of the Lift/Drag ratio.

In our favour here, is the wonderful fact that water – so grudging of high speed in sail – will let us slip along under low power with the right form.

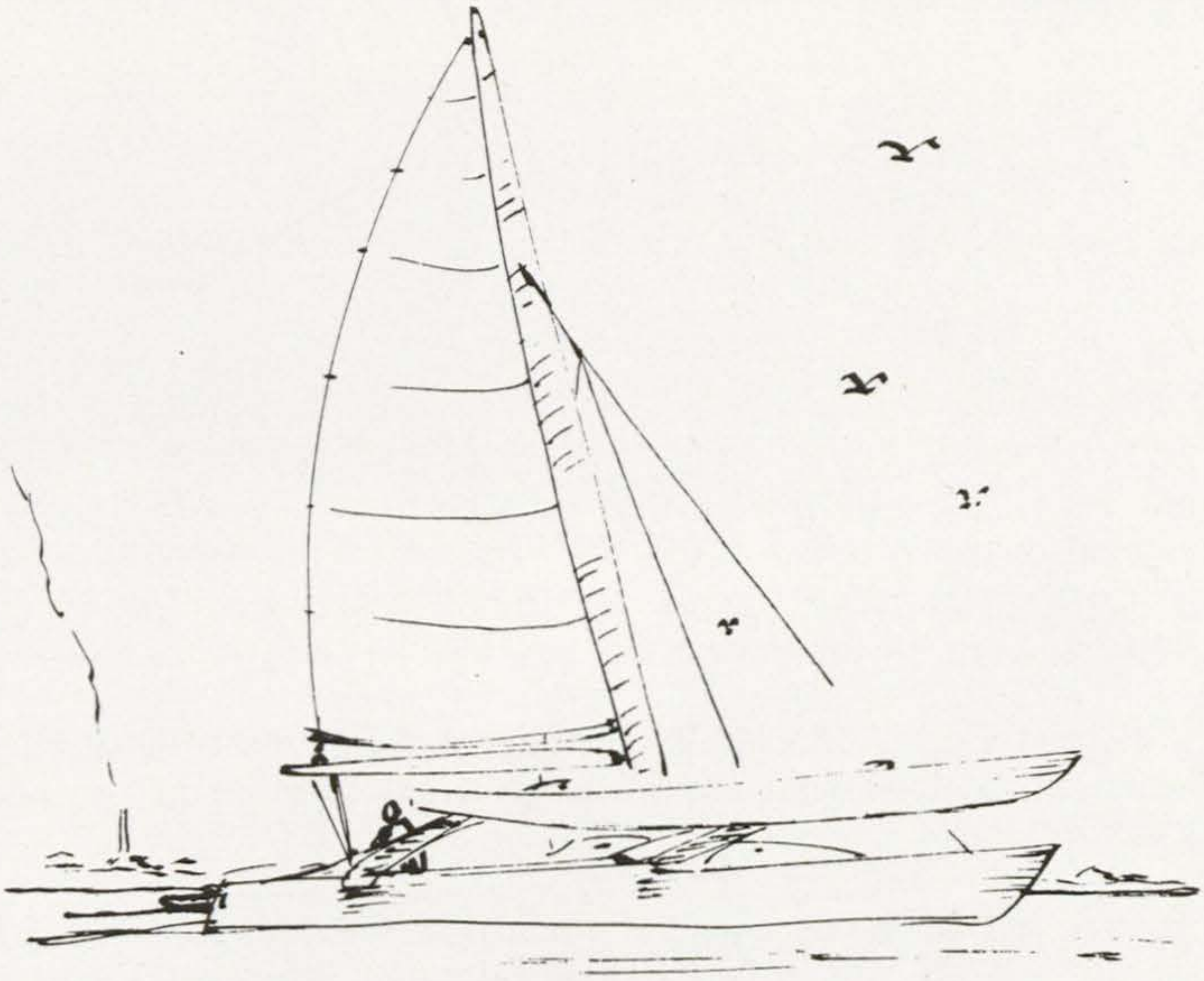
What we have described is a boat that has a single narrow hull of easy lines, rounded in sections, with a moderate and tall rig of efficient form for windward sailing and of controllable camber (the "gear box"), and this is stabilized by a light double outrigger system so that the boat is heeled at all times.

This is very simply the "vinta" boat of the Phillipines and similar craft on adjacent waters. It is the type from which the "trimaran" sprang, but many of our "tri-marans" are on towards being three-hulled catamarans and they don't operate in this ball park. If you look at a vinta boat with a head for heavy air only, it will make no sense to you, so you will, of course, 'improve' it and so spoil it for what it does so well.

But a few designers do make vintas. Kelsall's TORIA was an elegant example at the first Round Britain race, which she won handily. She was a sight tacking out of Plymouth at the start, with her weather float even in the light air flying over the heads of spectators in a launch alongside! She sat heeled at all times and did a 280 mile day. Kelsall's comment that she was usually going faster than she seemed to be, is quite typical of this type of boat. (Well, we didn't promise you a "macho" thrill).

Meade Gougeon, a champion ice boat skipper, made a smaller "vinta" some years ago and with his familiarity with ice boating technique, did wonders with her. He ran right over a select fleet of the best cats, scows and dinghies in a light air race. He told me recently that his best guess is that she did about 2.5 times wind speed at optimum, adding that this drops as the force of the wind is more.

We may ask:–what are these boats good for when the wind isn't very light? Well. . . . . . then they are just ordinary very fast sailboats!



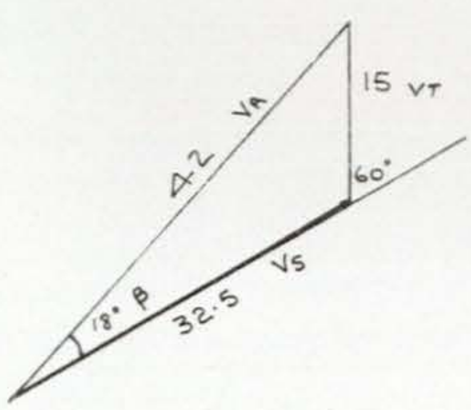
"Modern" Vinta Boat

Letter to Dr. John Morwood from John Hogg, Parklands Cottage, Curdridge, Hampshire. 5th May, 1978.

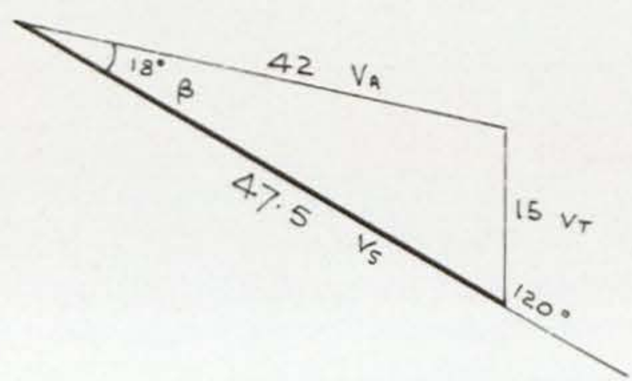
Dear John,

Thank you for your letter of 26th April, referring to the interesting points raised by Dick Andrews. These touch on an aspect which is important to Ice yachts as well as the Fast Sailing "wet" types, particularly in their trials at Portland. This relates to the dynamics of the Wind/Yacht relationship which becomes increasingly important as speeds rise. Dick refers to Ice yachts' problems in "Spotty" winds, and similar problems arise at Portland where the "Run up" to the start is comparatively limited, while after the start, the yacht's acceleration and response to even the normal rise and fall of the True wind speed (V_T) can make or mar the run. It is, I think, in the dynamic field conditions (as distinct from the steady draughts in the wind tunnel) that the low aspect ratio rigs, being less critical to such changes and less affected by mast interference can show a marked advantage sometimes over the higher A.R. rig. But other interesting features arise under these conditions which I refer to below. Meanwhile it may be of use to look at the steady state vector triangles for these conditions which could be as follows. (The figures taken are illustrative only):—

Course	V_T	β	γ	V_A	V_s	Knots
1. Up wind tack	15	18	60	42	32.5	
2. Down wind tack	15	18	120	42	47.5	(i.e. 46% faster)



N° 1



N° 2

Example No. 1 is on an upwind tack on a course of say 60^{0} and No. 2 is on a downwind course of say = 120^{0}. The same true wind speed is taken in each case. β remains the same and we see that V_A does also, but Vs goes from 32.5 kn to 47.5 on the downwind leg.

This illustrates Dick Andrews' experience of an increase in speed of some 50% when on a downwind leg with the wind "coming at the same angle across the foredeck."

With β, VA and VT being constant there is no obvious reason for the large increase in Vs **if VT was in fact a steady draught.** However VT as we know has several variables – gradient; minute to minute velocity in speed and direction; temperature which affects viscosity and Re Numbers.

Taking just one of these – the Velocity, the short time changes or gust ratio might be typically 40% (More in spotty winds).

It will be similar in the directional instability, and to a lesser extent with the other variables. It is during the acceleration that these factors will be particularly important and in this respect, it is interesting to see how β changes over a given range of increasing Vs, in the upwind tack and in the downwind tack:–

Taking a yacht accelerating in a VT of 15 kn, Vs goes from say 10 to 30 kn.

Tacking Course	V_T	γ	V_s	V_A	β
Upwind	15	60°	10	21.8	36.6°
Upwind	15	60°	30	39.7	19.1°
					17.5°
Downwind	15	120°	10	13.2	79.1°
Downwind	15	120°	30	26.0	30.0°
					49.1°

β is much less critical in the second case and can accomodate variations with less effect on the resultant. On the other hand the fact that in the Downwind course β has to be nursed out of that 13.2 VA , it can happen as Dick Andrews says, that the manoeuvre is mistimed and β stays a little too high with a result that the yacht 'gets in a groove' and does not generate that margin of resultant force to produce the required acceleration.

This brings me to a point I referred to at the recent R.Y.A. Symposium – that we are over optimistic if we expect sails and hulls to be correct for boat speeds from 5 to 50 knots and apparent winds of similar ranges and that more emphasis should be given to improved methods of applying variable geometry, at least to the sails if not to both hulls and sails. The methods must be rapid, easy and accurate, to assist craft in accelerating quickly from a start and in reacting rapidly to subsequent velocity variations. Variable geometry includes camber, angles of incidence, wind volumes (in the slot for example), as well as areas.

Yours, John Hogg.

A NON-DIMENSIONAL COEFFICIENT FOR COMPARING WETTED SURFACE AREAS OF SAILING YACHTS

by

Claude F. Doering
18322 Delaware St., Huntington Beach, California 92648, (714) 842-5945.

Various coefficients, ratios, curves, and calculations are utilized by Yacht Designers in establishing and assessing the probable characteristics and performance of their creations. Comparative values of a non-dimensional nature may well be considered the most valuable, as they allow direct comparison of yachts which are widely different in size. A suitable non-dimensional coefficient for assessing the efficient use, or reduction of, wetted surface area has not, however, to the best of my knowledge, been devised.

Resistance due to surface area exposed to the water has been cited as responsible for 30% to 50% of the total resistance in the lower speed/length ratios where sailing yachts commonly operate. Efficient use of a given wetted surface area to enclose maximum volume and provide adequate lateral plane, while maintaining good sailing lines and stability is, therefore, essential in obtaining optimum performance. But how does one know when the optimum shape has been achieved? Casual observation of the lines, in my opinion, can not suffice, and I prefer a mathematical solution.

As with many other yacht characteristics, I am advocating the use of a comparison of the wetted surface area to a standard geometric figure. The non-dimensional coefficient I will refer to as Hemispherical Coefficient, or C_H. The C_H is simply a comparison of a craft's total wetted surface area to the surface area of a hemisphere with a volume equal to the craft's displacement.

$$C_H = \frac{WS}{\pi\left(\frac{6V}{\pi}\right)^{2/3}}$$

where: C_H = Hemispherical Coefficient
WS = Total Wetted Surface Area, in sq. ft.
V = Displacement, or Volume, in cu. ft.

Obviously, the more nearly the hull lines approach those of a hemisphere, the lower will be the C_H value. I am not suggesting that a craft's lines should approach, or resemble, those of a hemisphere; only that the hemisphere is a convenient geometric shape for use in obtaining comparative values. I do, however, believe that when comparing craft which are characteristically identical, or very similar, in all other respects, the one with the lowest C_H value will be the best performer, as she has made the most efficient use of her wetted surface area. This should be particularly true in light air, where the yachts are operating at extremely low speed/length ratios, and resistance due to wetted surface area may approach nearly half of the total resistance.

The accompanying table lists several yachts of my design, and their characteristics, as examples in the use of C_H values in conjunction with other characteristics in analizing performance. Hull profiles and midship sections are shown in the corresponding figures.

The 19.5 ft. Sloop, fig. 1, is a V-bottom day sailer, developed for plywood planking. She has a relatively high Displacement/Length ratio for a day sailer, and low figures for both SA/WS and SA/Displacement. Note also that the C_H value is rather high in comparison with most of the other monohull craft shown. The V-bottom sections and fin keel, with no fairings whatsoever, have resulted in more wetted surface area than is really necessary to enclose her volume, or displacement.

The 20 ft. Sloop, fig. 2, was designed as a mini-cruising vessel and has a rather high Displacement/Length ratio. She is also capable of carrying somewhat more sail area than currently designed. SA/WS is slightly low and SA/Displacement is slightly above average. Although this craft has a full length keel, the rounded sections and generous radii at the keel have allowed a proportionally larger volume to be enclosed by the wetted surface area, producing a C_H value which is lower than that of the 19.5 ft. Sloop.

The 25 ft. Sloop, fig. 3, is a medium displacement fin keeler, with the fin faired into the hull with rather small radii. The figures for SA/WS and SA/Displacement are both above average, indicating good performance. Note, however, that the C_H value is only slightly lower than the full length keel 20 ft. Sloop. This is due to the sharp transition from hull to keel, where additional surface area is required to enclose a proportionally smaller volume.

The 25 ft. C-Class Catamaran, fig. 4, and the 31 ft. Trimaran, fig. 7, are both extremely light displacement racing craft. Although both have high C_H values, these craft operate at higher speed/length ratios where resistance due to wetted surface area is lower. Also, their narrow hulls produce less form resistance than the monohull craft, and their extremely high SA/WS and SA/Displacement figures indicate the driving power available for high speed sailing. Attempts at fairing underwater appendages to lower the C_H values on this type of craft will be of no particular advantage.

Fig. 5 shows a medium displacement 27 ft. Sloop. SA/Displacement is above average, and SA/WS is high, indicating good performance. The forefoot is slightly concave in profile, and the keel is completely cut away in the after sections, with a large spade rudder. The sections are quite rounded and faired into the keel with large radii, producing the lowest C_H value of any craft shown. In my opinion, this craft could very well be a better "drifter" for her size than is the 25 ft. Sloop with its more "modern" fin keel configuration. A skeg mounted rudder may, however, prove more effective.

The 38 ft. Sloop, fig. 8, is quite similar in form to the 27 ft. Sloop, except the sections are narrower and deeper, the forefoot is slightly more concave in profile, and the keel is carried somewhat farther aft. Although the craft is of relatively heavy displacement, she seems to exhibit good characteristics and should perform well, although, again, a skeg mounted rudder may be an improvement.

The 31 ft. Cutter, fig. 6, appears to have the profile of what some may consider the "world cruiser" type. She has V-bottom sections, developed for plywood planking, and a full length keel with a sharp transition from hull to keel. Although she has a high SA/Displacement figure, it will take a good bit of wind to get her moving, as indicated by the SA/WS figure. Obviously, with the nearly straight lines and sharp transitions in her sections, and a full length keel, the relative volume enclosed by her wetted surface area is low, resulting in a high C_H value. More efficient use of her wetted surface could be made by using a different planking method and rounding and fairing things a bit, and would greatly improve her light air performance.

The 44 ft. Yawl, fig. 9, has a forefoot similar in profile to the 27 ft. Sloop and 38 ft. Sloop, except that the lines have been carried farther aft, and the after portion of the keel has not been cut away. She therefore exhibits a higher C_H value.

Through casual observation, it is obvious that the 31 ft. Cutter has a high wetted surface area, and also that the 19.5 ft. Sloop has proportionally more wetted surface area than the 25 ft. Sloop. However, it is not quite so obvious that the 25 ft. Sloop makes only slightly more efficient use of her wetted surface area than do the 20 ft. Sloop and the 44 ft. Yawl, both of which have considerably more lateral plane area for their sizes than does the 25 ft. Sloop. It is also not very obvious, without using C_H values, that the 27 ft. Sloop and 38 ft. Sloop actually make considerably more efficient use of their wetted surface areas than does the 25 ft. Sloop.

The purpose of this report is to advocate the use of an additional non-dimensional coefficient to assist the Designer in achieving the desired performance, and not to suggest that one hull form is superior and should be used exclusively. Each form shown, as well as many other variations, have their merits and are established through a series of compromises. However, this brief analysis has lead me to some conclusions which I believe will assist me in producing designs for more efficient sailing yachts, and I hope it will be of value to others.

Design	$\frac{LWL}{BWL}$	$\frac{\Delta_T}{(.01\ DWL)^3}$	C_P	C_{WP}	C_{LP}	$\frac{SA}{\nabla^{2/3}}$	$\frac{SA}{WS}$	C_H
19.5 ft. Sloop, fig. 1.	2.93	200	.530	.662	.366	17.07	1.90	1.862
20 ft. Sloop, fig. 2.	2.34	381	.530	.650	.726	16.48	2.08	1.641
25 ft. Sloop, fig. 3.	3.30	202	.548	.665	.363	18.06	2.33	1.603
25 ft. Catamaran, fig. 4.	18.36	27	.554	.585	.144	57.09	4.50	2.623
27 ft. Sloop, fig. 5.	2.94	324	.520	.653	.536	17.44	2.78	1.295
31ft. Cutter, fig. 6.	2.87	351	.550	.687	.800	18.82	1.89	2.064
31ft. Trimaran, fig. 7.	11.38	37	.538	.672	.315	56.62	5.57	2.758
38ft. Sloop, fig. 8.	3.13	382	.486	.698	.559	17.37	2.74	1.312
44 ft. Yawl, fig. 9.	3.22	279	.528	.673	.646	19.39	2.41	1.666

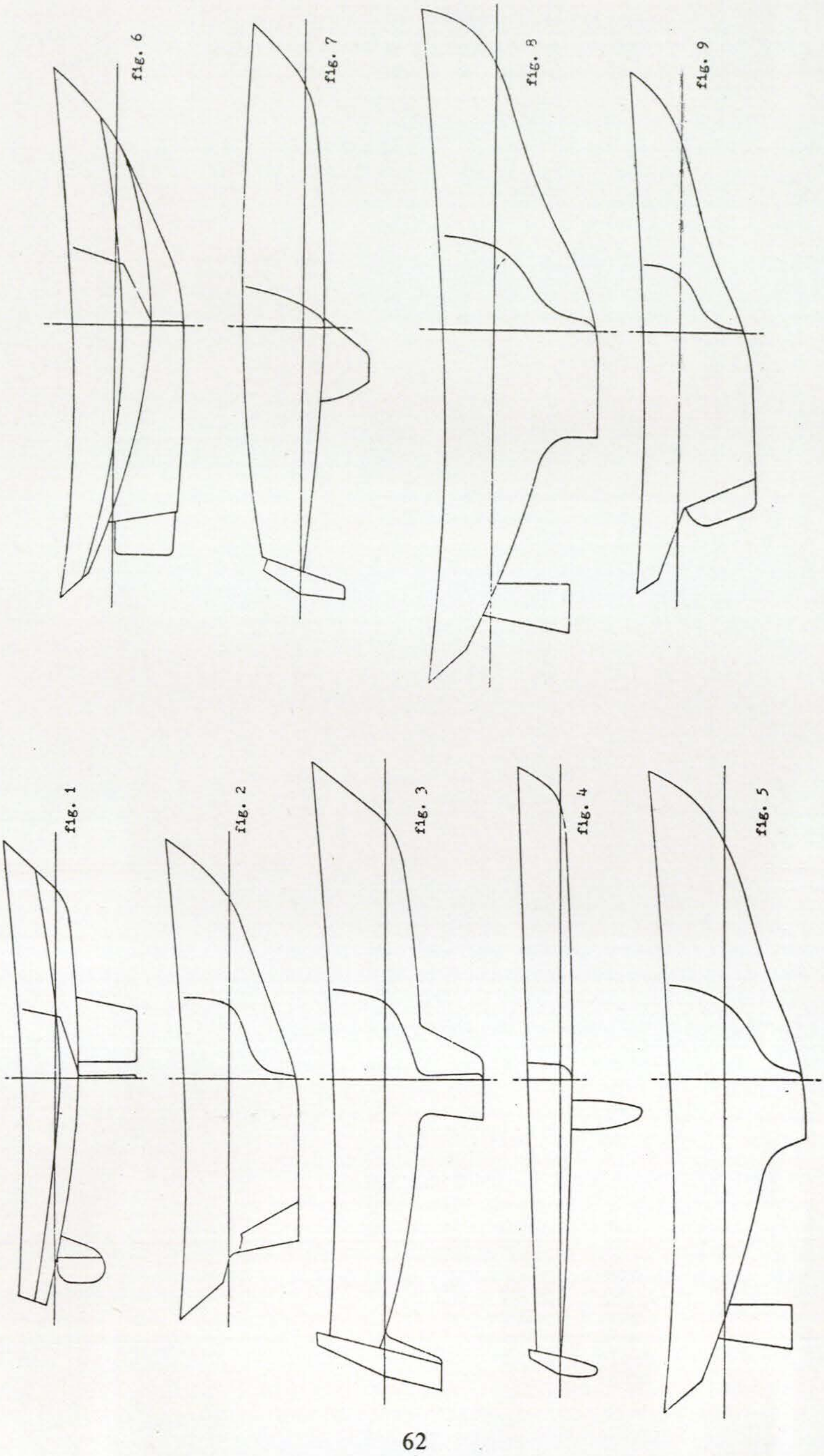


fig. 1
fig. 2
fig. 3
fig. 4
fig. 5
fig. 6
fig. 7
fig. 8
fig. 9

Letter to Claude F. Doering from John Morwood, Woodacres, Hythe, Kent, 22nd May, 1978.

Dear Claude,

You raise some interesting points in your analysis of your designs.

Considering wetted surface, one must start off by thinking of the hemisphere. Next, one must think of elongating the hemisphere so that the keel line becomes a semi-ellipse and various length to beam ratios could be considered. However, none of these shapes is any good for a sailboat because the aft end will drag a lot of water due to the acute rise in the buttock lines aft.

Considering this line of thought more practically, one then finds that one must think of half a spindle shape with an arc of a circle keel line. This gives quite a sweet canoe stern. All under-water sections will be semi-circles.

Fortunately, one of our members, the Late Edmond Bruce has published a series of tank tests using such spindle shapes of various length to beam ratios and this is available in the AYRS book "Design for Fast Sailing" – see leaflet. In this book, Edmond shows that the critical factor is the angle of rise of the buttock lines which should not be more than 14^{o} and less, if possible, because that is the angle at which aft turbulence becomes massive.

The rise of the aft buttock lines can be reduced by flattening and widening the stern sections and using a transom–hence the dinghy shape. It can also be reduced by widening the hull from a semi-circle to a semi-ellipse – a 4 : 1 semi-ellipse has only 10% more wetted perimeter than a semi-circle.

You will now see that the hull for minimum wetted surface has now almost designed itself.

I have only one more thing to add and that is that my researches shown in AYRS 89 give an L.D.R. of 11.0. This produces a DRL of an optimum of some figure which you can easily calculate but which I have forgotten. I devised the LDR to conform to Edmond Bruce's studies of spindle-shaped hulls. It would mean a length to beam ratio of one of his spindle hulls of 11.0.

FIN KEELS.
One must now add a fin keel. According to Skene, one should subtract the sectional displacement of the fin from that of the hull sections, thus giving a "Coke-bottle hull," like that of supersonic aeroplanes. This idea seems to be the common practice of the best designers.

THE FOREFOOT.
Finally, the forefoot has to be dropped not only to throw off the bow wave a bit further forward but also to give less pounding. The forward V should approximate to a 90^{o} angle.

If you can design a hull as near as possible to all these criteria, the hull will be a near optimum. Unfortunately, the stability is likely to be poor and the sail-carrying power low. However, in these days when sailing is usually ruined by the engine weight and propellor drag, that would not matter.

You often have strong winds in California and such a design as I outline would be the most easily driven under sail or motor.

If you care to design a boat as nearly to the above parameters as possible, we will be very happy to publish it in the AYRS.

Alas, relating wetted surface to a hemisphere means nothing to me in terms of possible performance. The SA/WS ratio, on the other hand, is a precise and meaningful indication of speed in light winds.

I am sorry not to be more enthusiastic about your concept. We don't really need any more yachting formulae – even my LDR is a formula of which I am not proud. However, I wished to correlate my research to that of Edmond Bruce and give it in terms which would be valuable for our multihull designers who seem to be our more active members.

Sincerely, John Morwood.

CAPSIZE PROBLEMS

from

Dick Andrews

25 Audubon Drive, Ossining, N.Y. 10562 – April 1978

Capsize Problem:— Mention is made of this subject in "Hull Research '76." I see no problem at all. Any craft can be capsized. On one famous occasion, the New York City fire department managed to capsize the huge liner "Normandie" right at her pier. The five-mast bark "France" capsized in the South Atlantic, etc. So we don't have the right name for this problem.

It is a righting problem. The solution is very obvious. One must figure an axis, transverse or longitudinal, around which the craft will be rotated 180 degrees to right side up. Buoyancy on one side of this axis will be reduced. A force will then be applied to turn the thing back.

The multihull establishment is so dogmatic on the subject of weight, that it cannot think beyond some sort of water bag on an arm, or some sort of buoyant appendage stuck down. I have no objections in theory, but something tells me that either rig has a problem.

The water trick only works in air. The air trick only works in water.

Either one stops working the instant it arrives at the interface of air and water. This shortens the useful work in tuning the craft back up.

This is bad enough in a flat calm; it is impossible when the interface is in the usual leaping turmoil.

Mineral weight on a lever works throughout the needed arc. The longer the lever the less the weight required.

I intend to persue this in further trials. The double outrigger "Serendip" righted smartly with relatively little force.

The test with "Serendip" showed that the polar curve of righting forces is not just a pretty picture. The weight on an arm stuck out at an angle was effective very promptly, when the same weight on the same arm produced not a quiver as stuck straight up like a normal keel.

But to say "lead" to some of these lads produces exactly the same shock as certain other four letter words would have done at a Victorian tea party!

THOUGHTS ON TRIMARAN AND FOILER CROSS BEAMS

by

John Morwood

The cross beams of trimarans and foilers have to sustain two loads of about equal value, namely, the upthrust from the lee float or foil and pull upwards from the stays attached to the mast. Because both forces act upwards on the hull and the thrust of the mast acts downwards, the cross beams and mast mounting should all be integrally designed and appropriately strengthened where necessary.

Victor Tchetchet, the father of the modern trimaran and indeed the inventor of the word itself, used sprung planks for cross beams. This system is cheap and works well as I found when I tried it myself. Each of my twelve foot cross beams was made from two 6 inch by 1 inch planks attached at the outer ends and sprung by six inches in the centre. It seemed to be adequately strong and no appreciable movement was noticed in any sailing I did. Victor sailed his trimarans much harder than I ever did and none ever broke to my knowledge.

The sprung plank cross beams have the advantage of being strongest at the centre where the breaking strains will be greatest. The mast can be mounted on the fore beam. The stays can be taken either from a bridle between the ends of the cross beams or from the end of the aft one. If from the aft beam, the float or foil will develop a slightly increased angle of incidence on the lee side in strong winds.

My cross beams with small floats, water skis and foils weighed about 80 lbs. This would not be tolerable nowadays. Sprung light alloy extrusions of pear sections could be used instead and would be much lighter. Wind resistance might be more than desirable but might well be less than is feared.

Arthur Piver and subsequently the Californian designers used timber baulks for cross beams and, by decking between them, produced a strong enough structure for Atlantic and Pacific crossings. Weight and windage seems to have made this kind of structure less used at present. It would appear that people hanker for the use of light alloy cross beams.

We next entered the stage of light alloy tube stayed down to the hull but this had a short innings. The stays were often in the water and could cover the boat in fine spray. John de Kat tried this in the 1968 OSTAR and his boat broke up either from the parting of the stays or the general weakness of construction.

Next came the style of cross beams, either built up of wood as with Hedley Nicol and Lock Crowther or welded light alloy with Derek Kelsall.

The final and present system is seen in the splayed hull ends of Dick Newick's foam and glass cross beams, though his 'Val' trimarans appear to be a regression, even using stays.

OPTIMUM SOLUTIONS

A cantilevered structure has to be stronger at its base than at its top. An unstayed mast, for example, will break a few feet above the deck. By this argument, trees should have splayed bases but few have. One supposes that they are overstrong. For example, a pine tree can be blown over and rip up its roots. The exception is the Cypress which is a tree of the swamps and its splayed base is probably to spread the root system over a large area. In general, the Cypress and the Eiffel Tower in Paris are my models for cantilevered structures.

For maximum strength, therefore, our cross beams should be of T section alloy. The vertical web gives the maximum strength in the vertical plane while the top of the T takes the compression loading. The dimensions of the T would scale parabolically from next to nothing at the beam end to a much larger T at the hull. Round holes could be cut in the web to lighten the structure.

A shape such as the above would have a lot of wind resistance and would have to be streamlined for windward performance. A variation on the theme could, however, be made using a streamlined alloy pole for the top compression loads and alloy strip for the tension loads at the bottom. This strip would be curved into a near parabola. Between the two, alloy strip could be welded to both at 45^{o} to 60^{o} angles like the jibs of cranes. Alternative pieces of this would be in tension and compression. If all the alloy strip were aligned fore and aft on the flat, windage would be minimum.

CHEAP SOLUTIONS

The cheapest of all solutions is the stayed alloy strut or pole, which is why it is used. From my knowledge and experience of this system, I am not enthusiastic about it.

Sprung planks of wood or alloy should next be considered. They are simple, cheap and do not put enormous tensions on the hull. It is not necessary to have two planks of equal length. The lower one need be only half to three quarters the length of the upper one.

Alloy ladders make very good cross beams and have good strength both in flexion and tortion. Both Edmond Bruce and I have used them with success. Those with "I" sectioned side pieces are best. For extra strength, ladders can either be put side by side or, more stronghly piled on top of each other. By using shorter ladders as the extras near the hull, a good approximation to the parabolic shape can be created. Such ladders or ladder systems would need to be streamlined but this would be easy to accomplish with foam and cloth wrapping.

THE SPECIAL NEED OF FOILERS

Foilers can be defined as displacement hulls stabilised by canted (or possibly inverted T) foils. In very light winds, canted foils should be vertical whereas is extreme conditions, the boat should be 'fully balanced out' with the righting foil exactly countering the capsizing moment of the sails whether at full size or reefed.

This necessity makes it imperative, in my opinion, for the cant angles of foils to be variable within limits. From Edmond Bruce's tests, the cant angles should be between vertical and 45^{o}. The Baker foils were at 40^{o}. My model tests showed that 30^{o} was too flat.

Variable cant angle can be achieved by hingeing the foil at the top and hingeing the strut to the foil at about the centre of area. The strut is allowed to slide up and down in a slot or between the rungs of the ladder. Its cant angle can then be automatically controlled by shock cord or a spring trying to keep it vertical. In drifting conditions, the foil will be vertical but, as the wind gets stronger, cant angle will increase as the strut is thrust up by pressure on the foil, stretching the shock cord. When the foil reaches the 'balanced out' position, the strut will meet a stop.

This system will take most of the load off the end of the cross beam and put it on the strut attachment position. Great strength in the cross beam need only stretch out the strut attachment beyond which only minimum strength will be required.

Letter from Ken May to John Morwood.

Dear John,
I like your article on cross beams "Sprung planks" certainly make a stiff system. Sprung tubes would do likewise but are perhaps more difficult to attach.

Weight for weight, the light alloy tube must be just about the stiffest thing you can get. 'Trifle' has, I think, big tapered ones which make a marvellous system. I like the 'Val' system, too, which must have little wind drag and be stiff, with a horizontal bow-string. They are just like some I sketched some years back!

Trees probably don't have splayed bases because their natural habitat is the forest where they have mutual protection from the wind. They want to get up to the light as quickly as possible and weight is no consideration. The Swamp Cypress has a wide base so that it can extract oxygen from above the bog, in which there is very poor holding anyway.

The Eiffel tower shape is certainly what is needed but its profile is hyperbolic, not parabolic, I think. Consider a circular tube of uniform thickness. The stiffness is proportional to the fourth power of the diameter. Then, for a tapered cantilever beam of length L, the diameter at distance x from the hull for uniform resistance to deflection is proportional to $1/\ (x/L)^{1/4}$, which gives a hyperbolic type of profile. But the junction with the hull would be of impractical width, so wall thickness would have to be increased instead, near the hull. However, nothing is perfectly rigid and reasonable.

Flexing no doubt is a good thing to absorb shocks. Another important factor is what material has the greatest fatigue resistance.

Ken May

Extract of Letter from Derek Holden to Michael Ellison
Kasteelstraat, 68, 1900, Overijse, Belgium – February '75).

Dear Mr. Ellison,
I have been developing a design, using 1 inch to one foot sailing models, for a single Bruce foil stabilised cruiser of about 30 foot overall. In order to promote some safety offshore, I have developed the reserve buoyancy on the foil into a partly submerged float. That is, it would, by design, at rest, displace say 1,000 pounds and fully submerged, 2,000 pounds and be, naturally of minimum drag form. Having a length of float of about 22-24 feet, I really end up with an asymmetic catamaran with a foil on the smaller hull.

This makes two points:–

1) I believe that virtually no one gives sufficient concern to the structural requirement of the foil support arm or wing. thoughts of pantagraphing light members just isn't on. I believe that on the basis that the foil may be considered to be held fairly rigidly by water (side loads) the beams should each be capable of withstanding a load provided by the main hull A.U.N. times (x) 2 (as its dynamic load).

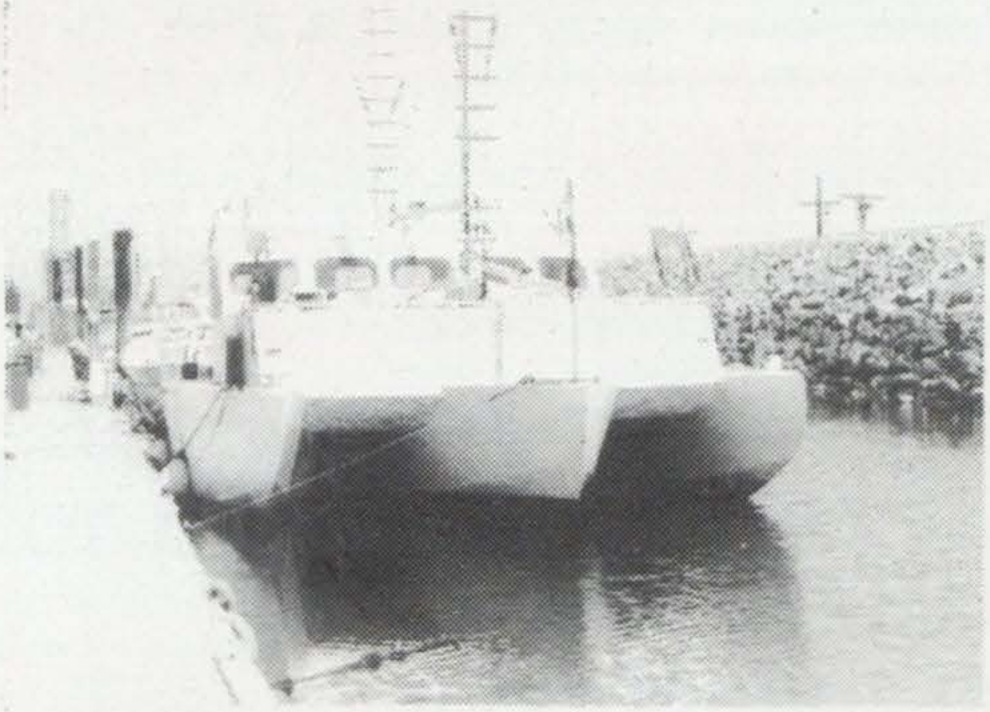
2) In the February 1975 "Yachting Monthly" on page 280, a design requirement discussion for the forthcoming Whitbread Multihull Race, Mike McMullen (top of column 3) says, quote–"If a multihull is loaded well below her marks there is a tendency for her outriggers to dig in . . .". McMullen is a sailor with a considerable offshore experience, so where does this leave my partly (and sometimes wholly) submerged outrigger as well as some of the more recent trimarans like FT who also consider immersion of the outrigger.

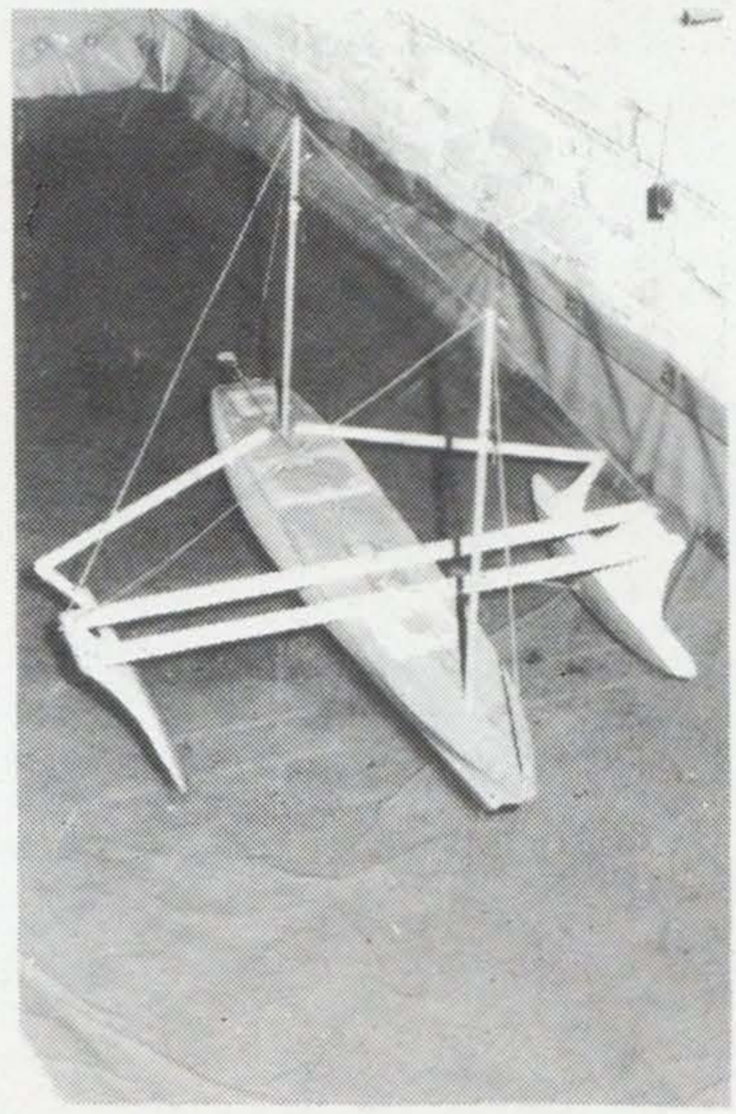
My models do, incidentaly sail better with the foil to windward and tend to dig in when it is to leeward, although the float has been comparatively small – it shouldn't should it, maybe insufficient foil lift?

P.S. – I think the best way to balance trim from tack to tack with the wide beam of a fully balanced out foil would be to use a mizzen on one tack only.

Derek Holden

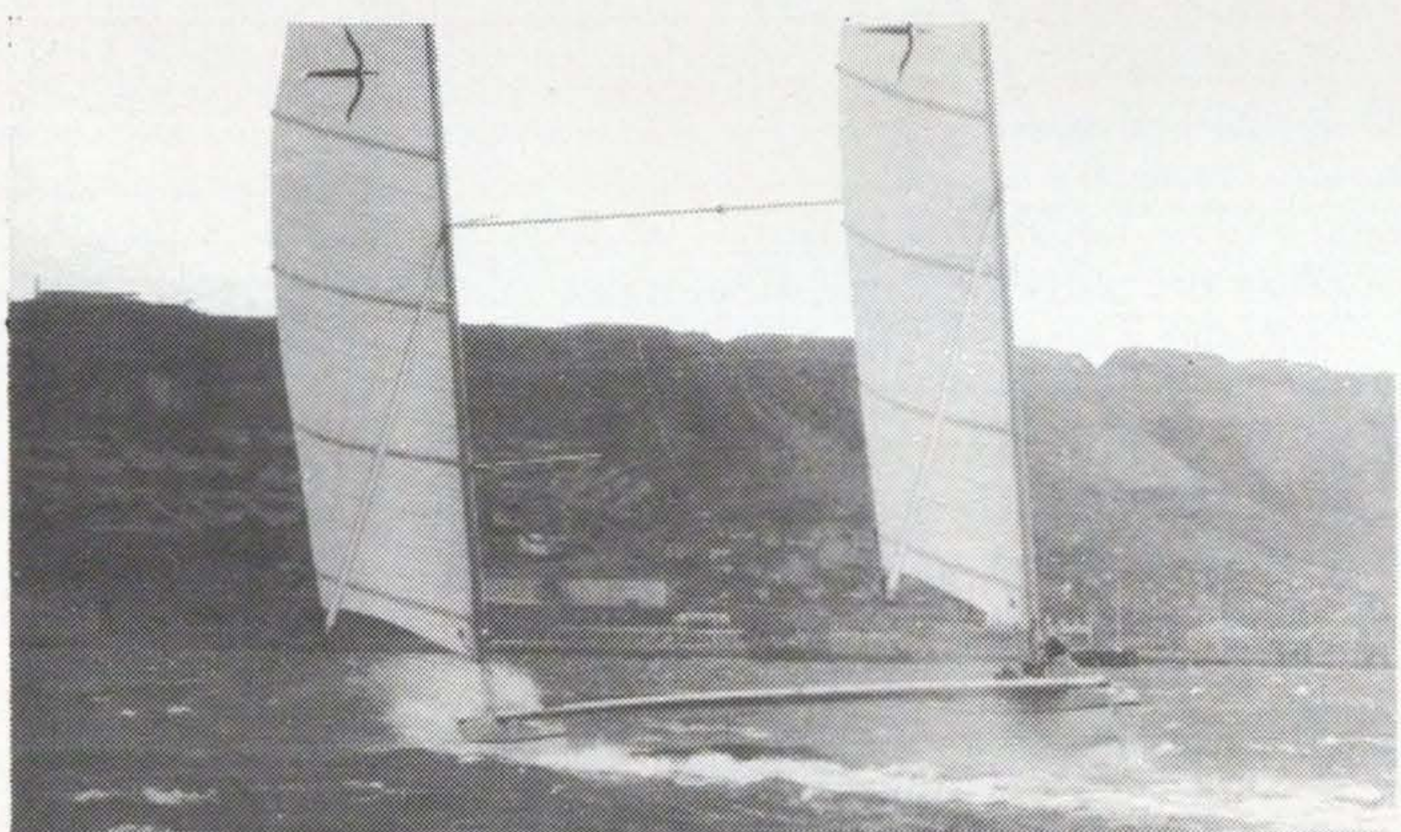
VARIOUS BEAM ARRANGEMENTS





A model by Joseph Dusek

"Mantis 3"



"Crossbow II" exceeding 30 knots

Letter from George Chapman to Reg Bratt.

Dear Reg,
At the speed sailing Symposium yesterday, you asked whether anyone had also seen streams of bubbles emanating from the tips of foils, the plume expanding as it approached the surface and making a distinct noise on surfacing. I said I thought this was cavitation, and a chorus of voices said one does not get cavitation until 40 knots.

I still think they are wrong. Years ago, in the old HMS AJAX, one could stand on the quarterdeck as the ship got under way, and see the helices of cavitation from the propellor blade tips streaming away from the screws. As I recollect, at about 20 r.p.m. this could happen, and for a 15 ft. diam. prop. that means a top speed around 9 to 10 knots. Similarly, in destroyers, I have seen a similar plume of bubbles emanating from beneath the ship as it turns, at speeds of around 15 and more knots. This came either from a sonar "dome" or from the Chernikeef Log – both normally streamlined in the fore and aft direction, but subject to a sideways component as the ship turns. There is no doubt that this is not ventilation: both the tips of the props and the projections from the bottom of the ship, are well submerged.

More recently, on BLUEY, I have noticed on occasion, that after a foil has ventilated, down to a fence, and the surface-connected ventilation has disappeared, a plume of bubbles has stayed with the foil, emanating from the fence, usually the leading end, and snaking about behind – perhaps a foot or so long*. As far as I can remember, this goes away when the part affected goes deeper. There is a need for much more observation!

I suspect the "40 knot" cry arises from the belief, given by James Grogono in his book, that foils will be liable to cavitation at speeds around 30 to 50 knots. This statement – which I do not doubt – has come to be mis-interpreted to mean that cavitation **cannot** start below 40 knots. It does, and you and I have seen it.

Best wishes – see you in October. Yours, George Chapman

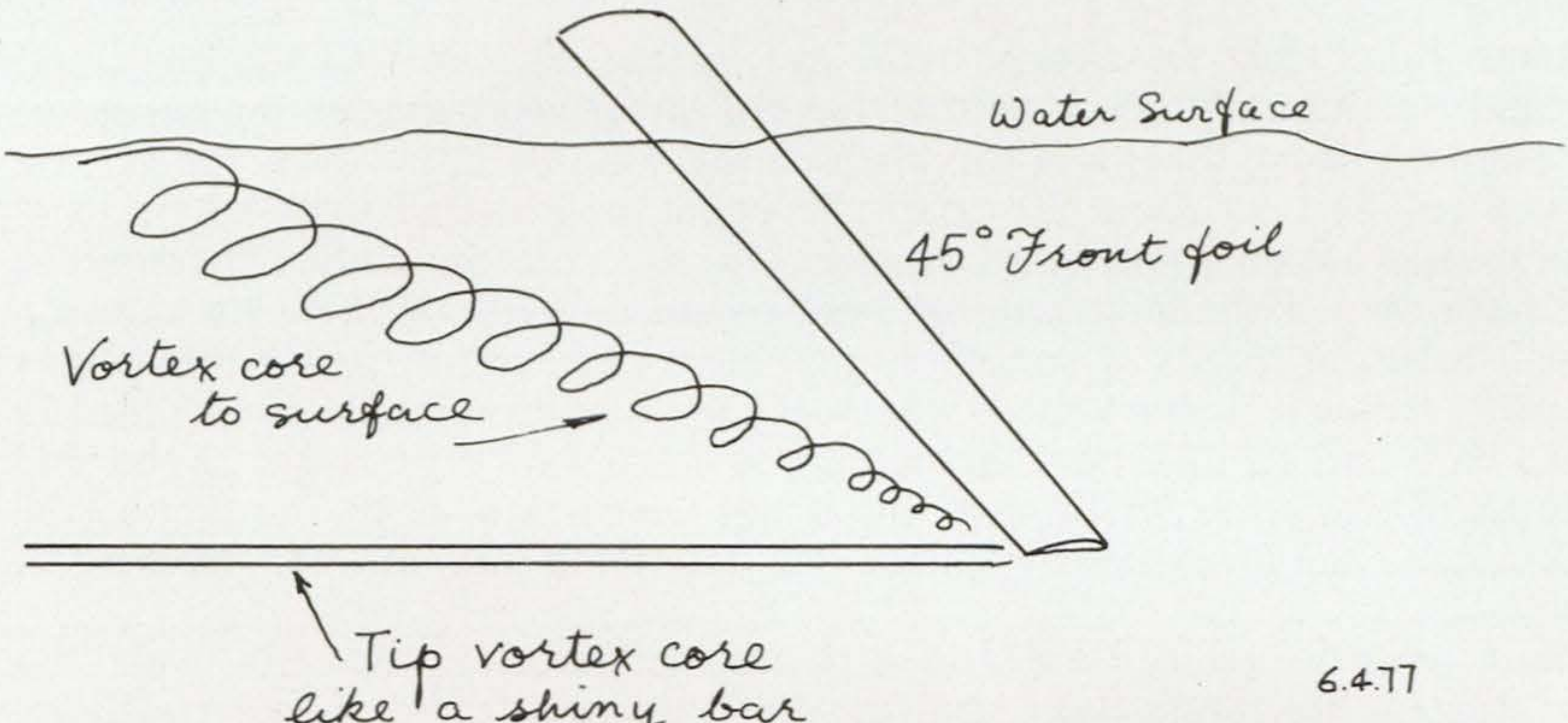
* and not necessarily "surfacing."

Letter from Reg Bratt to Cdr. George Chapman

Dear George,
It was very good of you to write. I had better make myself clearer. My front foils, 24 ins. long, 4 ins. top tapering to 2½ ins. are at 45^{o} dihedral, no significant sweep forward or back, near zero incidence.

I did not mention bubbles. I dare say they are there somewhere behind the boat, but unseen by me. Two separate phenomena can be observed on the front foils.

The tip vortex core appears sometimes looking like a straight bright aluminium bar attached to the tip of the foil. This is the same thing as the well known propellor tip vortex which we have both observed. This usually has no contact with the surface so could only contain water vapour (or gas at low pressure out of solution in the water). It represents induced drag and I suppose is to be associated with excessive loading. If a cavitating, or near cavitating propellor tip leaves (or approaches?) the surface, it would presumably suck in air which would be left behind as a string of bubbles.



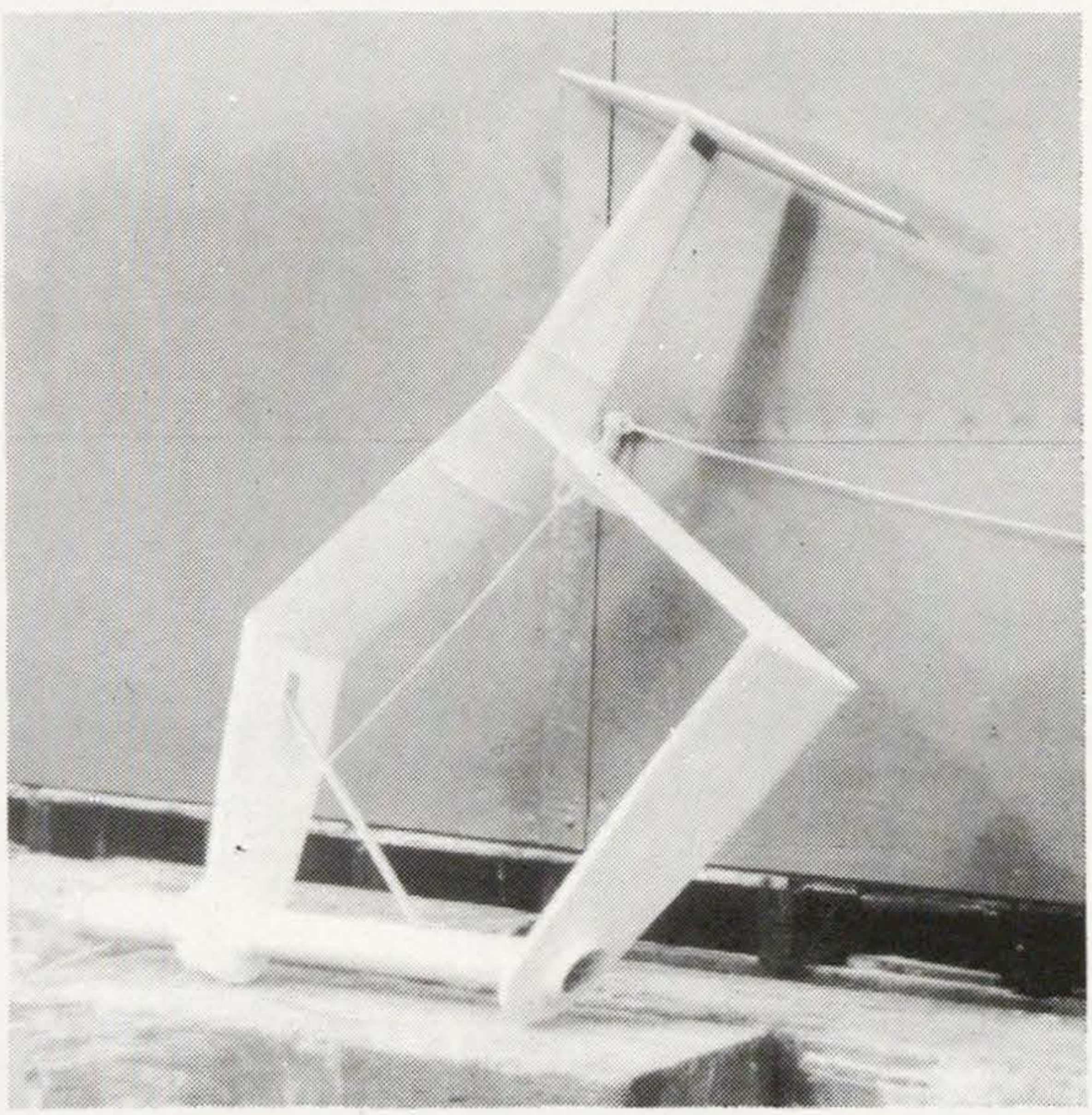
The other vortex is different to anything I have heard of though I suspect and guess that it might be a stall vortex occurring at a varying distance from the foil instead of in its text book position on the upper surface. It starts at the lower tip of a front foil and runs in an oblique cone to the water surface. Although seen on three different boats (two at least of which were at too coarse incidence), I am hesitant to be insistant on the accuracy of my description. Observation is awkward because of ones position, other pre-occupations, and the uneven water surface. The angle of incidence of the surface piercing front foils varies greatly with waves and if stalling, is to be avoided entering a wave, the maximum angle of indidence must be limited to accord, and leave a safety margin. Though I now use very small angles, I have certainly not always done so. I think I can say the vortex is associated with entering a wave. It is noisy, like the bath water, and is associated with sudden loss of lift. Perhaps one could call it detached ventilation. If it is a stall vortex the stall would account for the loss of lift rather than the ventilation way behind the foil.

My front foil difficulties derive in part from the fact that I have persisted in keeping them very small and I suppose one cannot reasonably expect the same good characteristics from surface piercing front foils as from deep running rear ones. My rear foils are 3 ins. chord, 24 ins. span twice, N.A.C.A. section made with precision; but the tapered front ones are crude, and not nearly accurate enough. I can see how to do it now, but when, is another matter.

I have no great experience of fences, but can make some comments. If a fence is not precisely aligned with the direction of flow, it will, in addition to acting to ventilation in manner of a garden fence to you or me, act as a low aspect ratio foil. If it has positive incidence and develops lift, it will raise pressure below, thus blocking flow from above. At the same time, its upper surface will have low pressure and it will add to a tendency to ventilate to its level. It would be capable of sucking continuously and leaving a train of bubbles. A badly angled fence could leave a plume of cavitation without ventilating and there would be no bubbles, (other, possibly, than the cores of small violent eddies).

I must desist.

Best wishes, Yours aye,Reg.



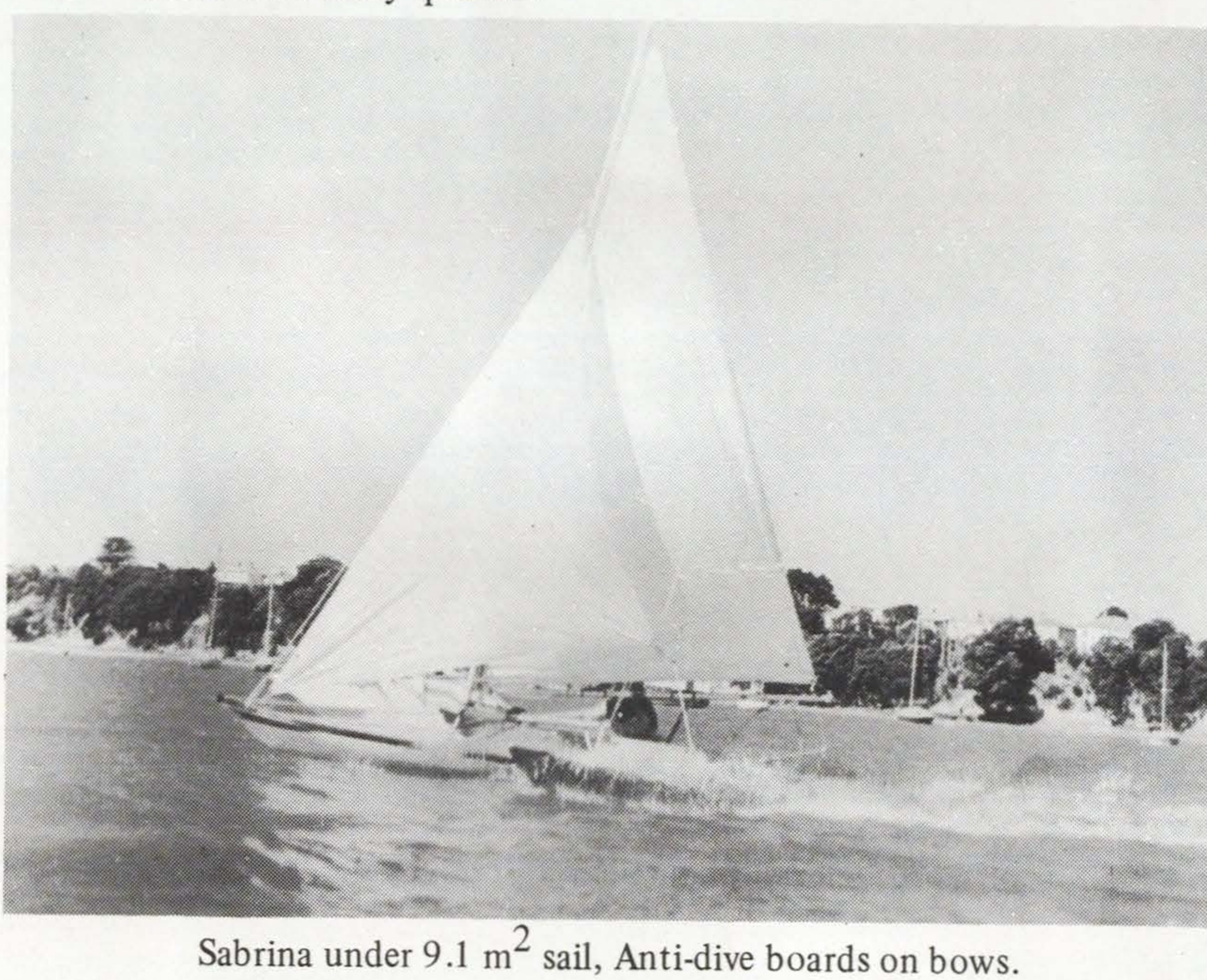
A Lifting Foil, designed and built by Cdr. George Chapman. At high speed only, the inverted "T" section remains immersed.

Letter from Noel Fuller, 7 John Davis Road, Auckland 4, New Zealand, July, 1977.

For the last year I have been playing with a 4.3 metre L.W.L. dual canted board foiler named Sabrina after a very little girl I know. Initially the object was to convert a Kayak into a sailing canoe which would be useful offshore or over mudflats, would survive a wide range of conditions and could be carried on the roof of my small car. In this Sabrina is very much a success. She can fit easily onto the cartop by one man hoist over the boot. She can sail in 20 cm. of water, make to windward in strong winds, stay upright even without way on, carry camping gear and a second person if need be.

The foils with their built in buoyancy cut easily through waves and suffer little in the way of torque or shock loads except when dropping into a hole at speed. Pantographing cross arms are a great convenience and are not difficult to engineer. She tacks easily by backing the headsail and balances well for self-steering. The 3/4 rigged mast, though stayed to the after cross arms is also free standing allowing me to fold one cross arm for restricted waters or for coming alongside.

To demonstrate her sea kindliness, Sabrina has one four stage 170 mile coastal voyage to her credit that included calms and winds gusting to well over 40 knots from every quarter.



Sabrina under 9.1 m^2 sail, Anti-dive boards on bows.

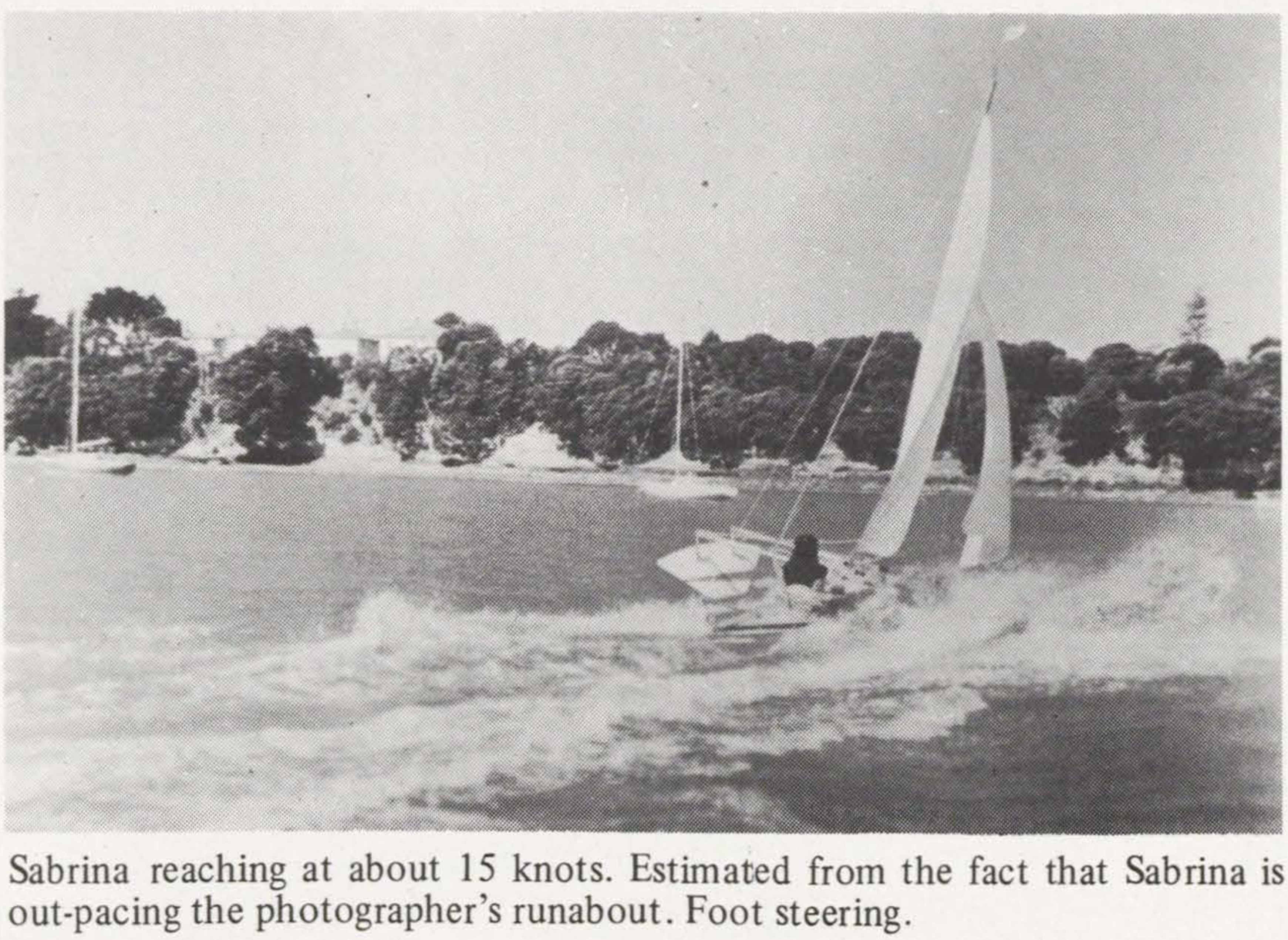
With a GRP hull, Sabrina weighs 100 kgm. With each foil of area $0.7m^2$ she is balanced out for $7m^2$ of sail but carries the following:

Main:	$5.1\ m^2$	(one reef)
Jib	$1.9\ m^2$	
Genoa	$4.0\ m^2$	
Spinnaker	$10.0\ m^2$	

The last two sails are sheeted to the end of the boom. All sails can be changed and handled from the cockpit which makes for a lot of fun with ropes. The pantographing arms are readily adjusted while under way. Steering is done from the cockpit via foot pedals or from outboard seats using a whipstaff tiller. The cockpit has raised topsides which run to the forward cross beam just before the mast where they divide waves coming over the bow. The cockpit is partially decked in and a quick release cover fits tight around the helmsman. A venturi below handles the water that still finds its way in. I have not so far had to stack out.

Beam seas have completely engulphed the hull. The refusal of the foiler to notice them raises an important design issue. In beam seas the weather foil grips so firmly in the approaching wave that there is little chance of the boat giving way when struck by the tumbling wave crest. In a low profile boat with clean decks the wave may sweep harmlessly over.

Several AYRS members, having experienced larger offshore foilers may be in a position to report on behaviour in beam seas in heavy weather.



Sabrina reaching at about 15 knots. Estimated from the fact that Sabrina is out-pacing the photographer's runabout. Foot steering.

Standard dress on Sabrina is a wet suit complete with helmet, socks and double glazed motor cycle goggles. The wet suit was purchased the day after I suffered from exposure while trying to help scores of other yachts frighten a big warship away. Winter sailing has convinced me of the need for gloves as well. At 15 – 16 knots (photograph 2) goggles are necessary and at higher speed the spray criss-crossing from every point makes vision impossible from the cockpit even with goggles but this has only happened twice very briefly.

In terms of my original goals Sabrina has proved satisfying. However, Sabrina did not get this way all at once and in the process, I too changed in outlook. Sabrina began as an enquiry into Bruce foils and has come to be regarded as a test bed for researching a much larger vessel.

In developing Sabrina, I lacked at first AYRS data and began with retractable foils of aspect ratio 3.65. They proved too small and were also very sensitive to sail balance and angle of attack. I proceeded to larger foils of aspect ratio 0.74 hinged as before on the undersides of asymmetric polystyrene floats. Balance and alignment became less critical. Windward ability was fairly good at 60^{o} cant angle but stability was best at 45^{o}. A bendy rig proved essential. The floats were a nuisance in waves. It was easy to calculate that their buoyancy could be completely included in an enlarged foil with no effective increase in wetted surface. The resultant foil, visible in the photographs was symmetric in section and its rather low aspect ratio of 0.50 was adopted with mudflats in mind. It is set at 50^{o} to the horizontal so that 5^{o} heel lifts the weather foil clear for best speed. The new foils brought a dramatic increase in speed. Most of the foil was normally out of the water and windward ability deteriorated a little. Heel never exceeded 5^{o} except when strong gusts arrived or when bearing away in strong wind from a reach when tangential force cancelled foil action.

Recently I put a wishbone boom on the mainsail. As I hoped the drive of the mainsail was much improved. Alas heel increased and so therefore did leeway. It was brought home to me that a very low aspect ratio foil is fine for mudflats but not to be considered for a high performance vessel such as the larger craft I plan. I now think of my current foil plan form as a mudflat ratio. I should be interested to know how others have actually performed. The AYRS periodical lacks hard information here. I know an aspect ratio of one is recommended with a truncated triangular planform. The calcs. about the lift to windward obtained with a canted foil must be modified with respect to crossflow over the foil and edge losses. The lee foil delivers more push than lift. The weather foil is rather more efficient to weather than the lee foil and makes much less fuss. Nevertheless, out of harbour, I would not be without the security the lee foil provides. Nor can a fine bowed craft afford the bow burying of the weather foil without the compensating lift of the lee foil.

With two foils the problem of excessive wetted surface in light winds is considerable. Methods must be devised that permit control of the degree of immersion of the foils. The simple solution that two people are planning here for their boats, is foil shaped floats with daggor boards or swinging boards, continuing the canted foil to a sufficient depth. A variation is control of the cant angle using a vee shaped daggor board box and foam wedges; an approach which could find interesting application in racing catamarans. A canted foil negates somewhat the foil action of the lee hull of a Cat or Tri. I suppose this should be compensated for in extra foil size.

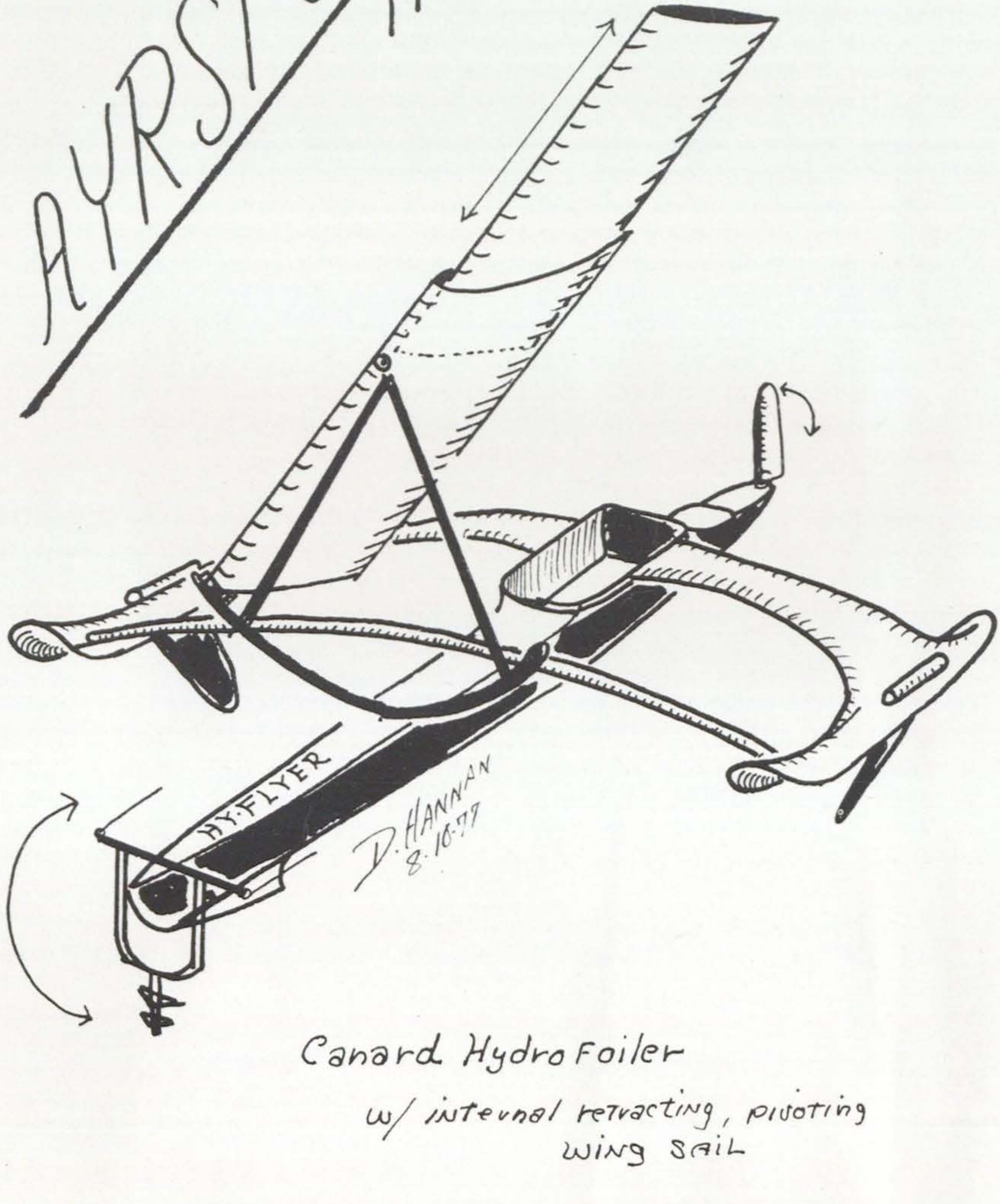
An approach more suited to the self-righting craft I have in mind involves the use of Hydraulics to waggle the cross arms and foils up and down. Coupled with control of cant angle this should enable matching of righting moment with minimum wetted surface for any condition of sailing. There are other advantages of this type of foil control. A way is offered of combining canted foils with flying foils. It is required to lower the foils below the hull while decreasing the cant angle below 45^{o} and introducing an appropriate angle of attack. Pitch control foils can be lowered bow and stern. Using Bruce foils this way may be inefficient when contrasted with the high aspect ratio ladder foils of the flying foiler but the overall efficiency of the craft may be greater than if it remained a displacement hull or become wholly a flying foiler. That is it can go faster on a reach because of the flying foils and can sail faster than a flying foiler to windward or in light winds or difficult seas by retracting the lifting foils. I would value some discussion of this approach. The challenge is to optimise the relationship and engineer it so that the changeover can occur smoothly and quickly without prohibitive penalties in weight, cost or vulnerability to breakdown.

An advantage of hydraulic control is the ease with which shock absorbers can be included. A spin-off for the cruising foiler might be found in converting the shock absorbing devices into a power source – for example a heat pump capable of extracting heat energy from the sea and from the refrigerator.

The bugbear of a weather canted foil is the heeling moment about a central hull. When there is a lee foil it may help in strong weather to bring the center of effort of the weather foil below the hull level. A model I made recently had no immersed hull at all. The two canted foils maintained perfect lateral stability. Increase in wind strength simply caused both foils to sink evenly and then rise as the craft gathered speed.

My current concern with Sabrina is to use her to investigate the matter of canted foil shape and efficiency. The plan is to make a single foil at a time and sail it against the previous best foil on the other arm.

AYRSFOIL: 1983



Canard HydroFoiler
w/ internal retracting, pivoting wing sail

COMMENTS ON FOILER DESIGN

by

Noel Fuller
7 John Davis Road, Auckland 4, New Zealand.

CROSSBEAMS

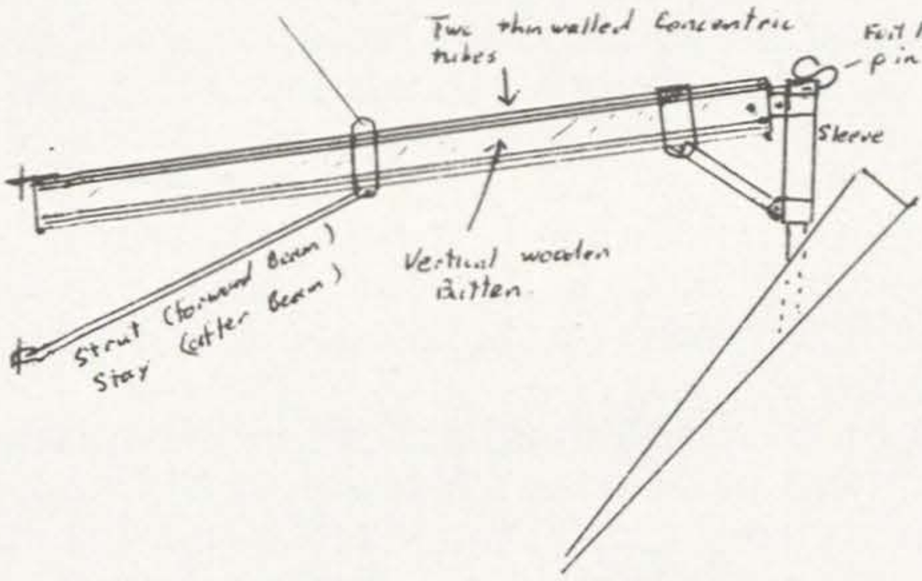
OSCILLATION

Oscillations in crossbeams produce wrong angles of attack in foils as do waves. The foils in turn reinforce the oscillating system resulting in drag or destruction. Sabrina taught me about this during her first **short** sail. The oscillations to be avoided are set up through flexure and through torque.

FLEXING.

A small amount of flexure can be desirable. Undamped reflex cannot be allowed. On Sabrina, flexure is dealt with by making the crossbeams into heavy damped shock absorbers shown in figure I below. The system has the advantage for a few weeks of permitting telescoping of the beams for tuning purposes. The mast, hull and beams are linked in such a fashion as to form complete trusses.

Fig. 1.



TORQUE.

Stresses due to torque concentrate at discontinuities, chiefly leading and trailing edges in the case of single wing type beams. The only type of single crossbeam that can properly bear torque forces is a large diameter cylindrical section tube. This approach has very limited application. The right place for torsion is in the hull as a torsion box consciously formed, with a desirable section, relating mast, hull and crossbeams. For fast sailing, minimum stress, and minimum weight, torsion must be removed from the crossbeams.

TWO - SPAR SYSTEM.

Any foil-float suspension system whose thickness to chord ratio is very much less than one should be treated as two separate crossbeams situated at the extremities of the system. Torsion is then removed by **independently** staying these two beams back to the torsion box. In Sabrina's case the ends of the beams are unstayed so oscillation of the foil can still occur.

POSITION AND SPACING

The positioning and minimum spacing of the crossbeams depends on the shape of the foils and floats. That is:

> Beams must be so placed and spaced that the line of foil force, vertically projected onto a fore and aft plane, passes between the beams at all times.

FOILS

FOIL SHAPE.

To determine the line of foil force the lift/drag ratio of the foil should be known and the position of the Centre of Foil Force (C.F.F.). Most of us can only guess. Are there rules that can tie down the guesses? Perhaps there is no alternative to the tedious process of building up the guess system from costly experience.

CENTRE OF FOIL FORCE.

A most important difference between an immersed foil and a surface piercing foil is that the C.F.F. of a surface piercing foil moves. Add a float and the movement can be extreme.

In Sabrina's case the CFF of her mudflat foils moves forward with immersion. When coupled with the movement aft of the sail centre of effort, in a gust, large weather helm can be produced that can stall the rudder. This phenomenon must be bad news for fast craft and worse news for proas.

FOIL DESIGN.

Should the shape of the foil be determined by choosing a locus for the CFF and drawing a foil around it? Where many factors operate together selecting one to design from is a treacherous process indeed! I can think of some disasters that can be designed this way. Nevertheless the locus of the CFF **should** be considered when designing a foil and **must** be considered when placing the crossbeams. Obviously the best lift/drag ratio is what we are trying to find but the point I make is that the relation of foil shape to foil suspension has a significant role in the production or reduction of drag.

The line of foil force on Sabrina's mudflat foils usually passes a little aft of the forward crossbeam and never passes forward of it. Hence most of the lift force is carried by the forward crossbeam which is suitably stiffened. By this means torsion produced oscillations of the foil are largely eliminated even though the beams are not stayed their full length.

An experimental foil just completed is so shaped that the locus of CFF is vertical and below the forward cross beam. Pitching of the foil about the cross beams will be solely due to drag if my assumptions are correct. The chief assumption is that the CFF lies at 25% of the chord. Sabrina's mudflat foils are formed in section from ogivil curves. I've observed that the CFF lies at about 25% of the average immersed chord or even a little further forward.

12 METRE KEEL SHAPE

From these observations it seems to me that the 12 metre keel shape used as a surface piercing foil may tend to oscillate because of the large fore and aft movement of CFF. This will also produce large shifts in craft balance that will necessitate a large rudder-and speed on the sheet. It is probably of some importance that an exactly balanced out craft will experience least displacement of CFF. I do not therefore conclude that the 12 metre keel shape should not be used and it does have other features to recommend it.

THE 'AYRSFOIL' CLASS

John Morwood our founder and the editor of this number proposed a development class using a standard hull on which members could try different hulls and rigs.

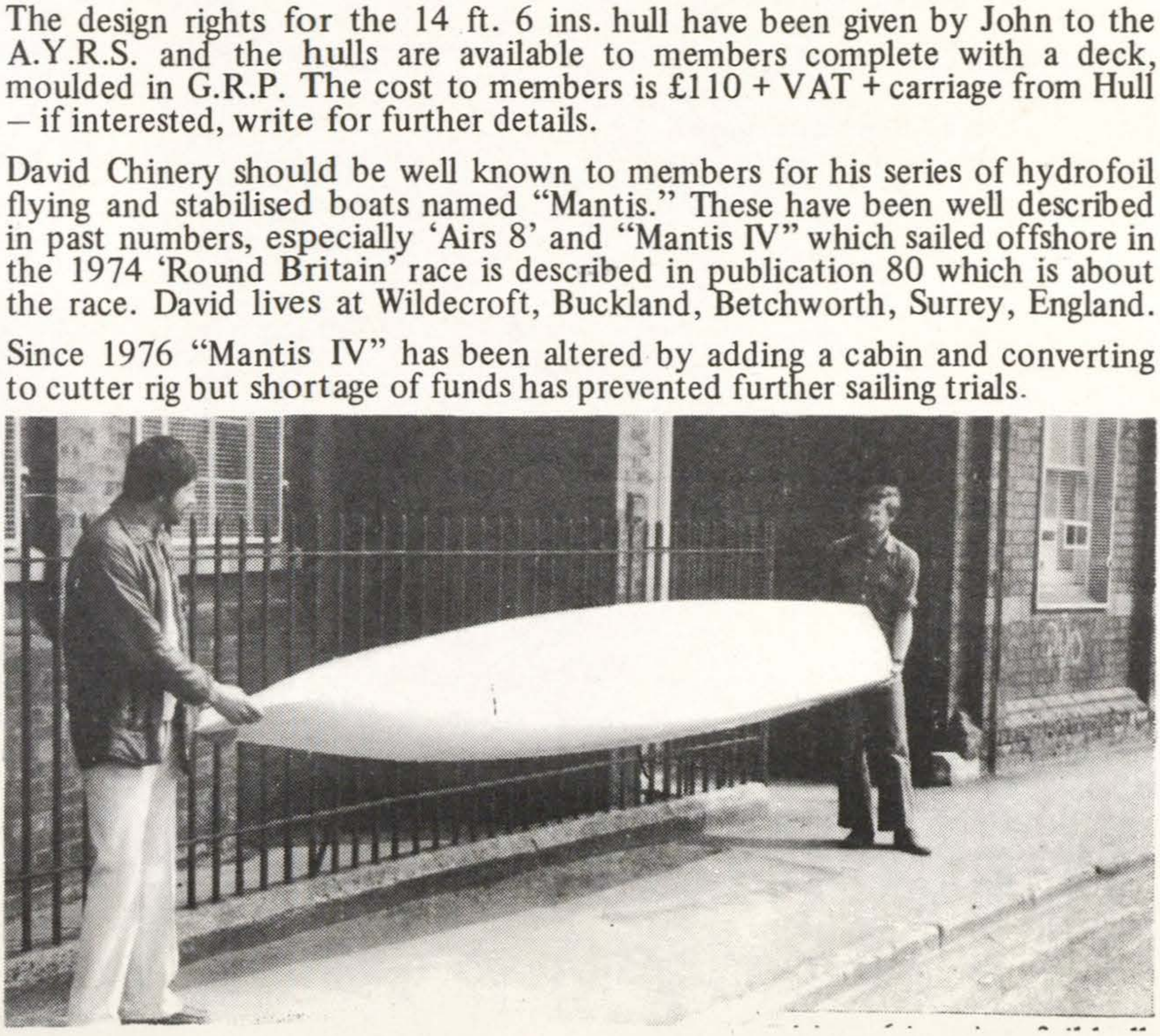
The idea was put to a meeting of members and it was felt unnecessary to restrict members in any way and if a hull is not necessary why insist on having one. It was agreed to have some races to encourage the development of light fast craft to compare foil craft with catamarans and other fast boats.

John Morwood produced a design of a 14 ft. 6 ins. hull suitable for experiments with foils and in January 1978 at the London Boat Show, he agreed with David Chinery and John Stanton on slightly modified lines which we later published. Having a flat run aft and a small chine at stern the hull has a higher top speed than the canoe which could be used as an alternative.

The design rights for the 14 ft. 6 ins. hull have been given by John to the A.Y.R.S. and the hulls are available to members complete with a deck, moulded in G.R.P. The cost to members is £110 + VAT + carriage from Hull – if interested, write for further details.

David Chinery should be well known to members for his series of hydrofoil flying and stabilised boats named "Mantis." These have been well described in past numbers, especially 'Airs 8' and "Mantis IV" which sailed offshore in the 1974 'Round Britain' race is described in publication 80 which is about the race. David lives at Wildecroft, Buckland, Betchworth, Surrey, England.

Since 1976 "Mantis IV" has been altered by adding a cabin and converting to cutter rig but shortage of funds has prevented further sailing trials.



By courtesy of Foiler Ltd., 31 Castle Road, Hythe, Kent.

AYRS 90

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