ISSN 0144 - 1396

AYRS 101

AUGUST 1985

WINDMILLS AND HYDROFOILS

The Kielder Daysailer with Tethered Kite Rig. *T.S. Morley*

CONTENTS

2. Tethered kite rig.
4. CHAIRMANS REPORT.
5. News.
6. SABU.
7. A Bruce foiler.
9. The Blot.
11. Sampanette.
12. BANDERSNATCH.
17. Foils & weight.
19. Foil movement in waves.
24. Wind turbine/propeller.
27. Vertical axis mill.

Tethered Kite Rig

The Kielder Daysailor moving nicely at about an S.L.R. of 1.0 under her Tethered Kite rig (cover photo) (Pat Appl.No. 8203621). After several test sails in winds of up to force four and mainly single-handed, I have reached the following conclusions:

1. As expected it is an excellent sail for broad reaching and running; tacking downwind, or wearing being easily effected by simply adjusting its pair of braces.

2. As a bonus, reaching up to four points off the apparent wind (6 points true) is possible but the boat must be worn to change tacks, so windward performance is poor. A higher aspect ratio kite of lower camber and rhombus-shaped (to lower centre of effort) could be designed for close reaching its downwind performance would suffer and the one shown in the photograph is a good compromise.

3. Raising and lowering the sail can be done easily singlehanded with the boat running. The spar, which supports the sail's shoulders, folds as the sail is lowered and may be stowed in the cuddy or semi-folded along the forward gunwales.

4. The area may look small but it is about all she and I can handle when reaching in a force four. It is approximately twice the boat's waterplane area. If the sail was to be used entirely for downwind sailing, its size could be increased by 50%.

THE SQUARE RIG IS BACK

T. S. Morley 8/84.

P L Y M O U T H

is now the home of our

A D M I N I S T R A T O R

THE AMATEUR YACHT RESEARCH SOCIETY

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

The Society (open membership) furthers the theory and practice of nautical science and related subjects. We are registered as an educational charity (no 234081) and a company (No 785326) without share capital, limited by guarantee. (VAT No 200 1168 38).

The Society has members in all countries of the world where sailing is a sport. Information for publication comes from members and people interested in sailing or building yachts. Funds come from members' subscriptions, from the sale of books and from donations. The subscription for the present year is £12.50 or $20.00 U.S.A.. New ideas or details of problems are welcome. We try to pass these on to avoid duplication of research and to put people with similar interests in touch with each other.

Administration and Membership:

Michael Ellison, 10 Boringdon Terrace,
Turnchapel, Plymouth, PL9 9QT, England.

CHAIRMANS REPORT.

On completing 30 years of existence we may well congratulate ourselves. For although our mission in life is most important and of absorbing interest it is by definition not commercial - and survival unfortunately depends on money. I dare say that not many, even of our well-wishers, expected us to last so long. And even they could not have foreseen the devastating blows, general or particular, that have knocked us about. Recession and runaway inflation on the one hand; the American fiasco on the other.

So we may congratulate ourselves on our survival. And we have much to be proud of in the course of these long years. We have justified our existence; wherever we look we see the triumphant applications of ideas diffidently put forward by our modest amateurs. Not least, for instance, certain details in the America's Cup victory; and then there is the huge and growing international programme of speed-sailing that really exhausts the vocabulary of superlatives in scale and speeds - all deriving from our little Portland events of a dozen years or more ago.

Publication is once again practicable, though still vastly expensive even on a much more modest scale than of yore. And today we have run into a much more copious commercial competition against our technical works, which once stood almost alone in the field. But we still go on producing new thoughts and practices, and publishing them.

So we continue to hold our heads high, bloody perhaps but unbowed. But we do however face a very difficult financial position, as the Treasurer's report shows. Spiralling costs - the old cry - and loss of membership, especially in America, have brought us to a degree of imbalance that is unacceptable. Increasing the subscription is of limited efficacy, and we must once more cut down on our costs, modest as they are, while increasing our publications, our sales and our membership all we can.

This is our position. We have a marvellous and quite unique Society, and we are going to have to work pretty hard to preserve it. Your help and suggestions will be welcomed.

REGINALD BENNETT

Portland

Portland Speed Week 1985
This year the event will involve two weeks from 28th September to 13th October. The first week is for board sailors from U.K. to have their speeds measured so that they can get onto the "ladder" of recorded speeds and if good enough qualify to enter the second week. Entries will again be limited and applications should be sent to the R.Y.A. at Victoria Way, Woking, Surrey, England as soon as possible. In past years there have been few problems for people entering boats and experimental craft but there seems to be an increased interest for this year. Jacob's Ladder has been seen trying new kites for an entry in the "open" class. The event is again being sponsored by Johnnie Walker.

Southampton Boat Show
13th to 21st September. The 13th is "preview day" with an entry cost of £6.00, open from 0900 to 1700. For the rest it is open from 1000 to 1900 at a cost of £2.50. We have again booked space in the dinghy arena.

London Boat Show 1986
Next London Show opens from 1st to 12th January and we will have a stand as usual. The dates are early with trade day on 31st December. We like to have at least two members on the stand throughout the show and would welcome help if you can spare any time.

New World Record
The World Sailing Speed Record Committee met in London on 11th July and ratified the speed of 32.35 knots by Michael Pucher on a sailboard with 4.2 sq.m. sail area on 15th April at Port St. Louis du Rhone in Southern France. The record was set during a speed sailing event held from 9th to 16th April mainly for sailboards. The "Mistral" wind was gusting to force 10 across low land and a sand beach. Eight competitors exceeded the previous world record, the runner-up at 32.17 knots. The timed runs were also reocrded on video. Mr Pucher is Austrian. Speed meetings have also been held in Australia in December and at Brest, France from 23rd to 29th March to replace their autumn event.

Michael Ellison

NAUTICAL MILE RECORD. How should it be recorded?

Flying Gaff Rig on Sabu

The new rig has so far suffered from lack of sea time. We retired from the 'Round the Island' (force 5 W'ly) when the end of the boom broke and our passage to Plymouth was mainly to windward. The rig is close winded and steady progress is possible tacking through 80 degrees. With the wide beam the vang holds the peak well removing twist from the sail.
The main problems are the shrouds which lead from the masthead back to the aft edge of the 'wing'. (Cover of pub 95). When the wind is free the leech fouls the shroud and sail shape suffers, chafe will be serious on a long passage. The second problem is that the mast can only be supported at the head due to the gaff slider. This means that it tends to bend in the middle especially in a chop with full sail. When the sail is reefed the gaff thrust to the middle of the mast has to be taken on a line from the throat and this must be treated like a running backstay.
We have now considerably increased the sail area on a mast 6' shorter than the original. She is not slow but no comparison of performance has been possible so far - we have yet to "get our act together".

Michael Ellison

Prestel ! Micronet ! Viewdata !

Are there any members with these facilities or their equivalent ? Isn't it time the A.Y.R.S. got into the electronic age of communication; electronic mail and noticeboards using home computers as Viewdata terminals.
I think it is time that the vast store of information and research that has been accumulated over the years by the A.Y.R.S. should be computerized to make indexing and cross-referencing more comprehensive.
There will be problems of compatibility and useability at first, but I would like to kick off the discussion. It will need someone with much more knowledge than I to get it set up.
Recently Mike Ellison has been punching out copy on a very old typewriter. I think a good daisywheel typewriter/printer with a wordprocessor is needed, preferably about three similar/compatible computers, i.e. one in the U.S.A., two in the U.K. for starters.
As most members are aware, information can be sent from one computer to another using phone lines, and that information can be reformatted by the receiving computer and dumped to the printer - so much less time-consuming than retyping. So, more publications.
I would be interested in members' ideas and comments on how to raise the cash to equip with some Information Technology equipment.

Thanks to Kathy Sharp who retyped most of this ^issue on a daisy wheel.

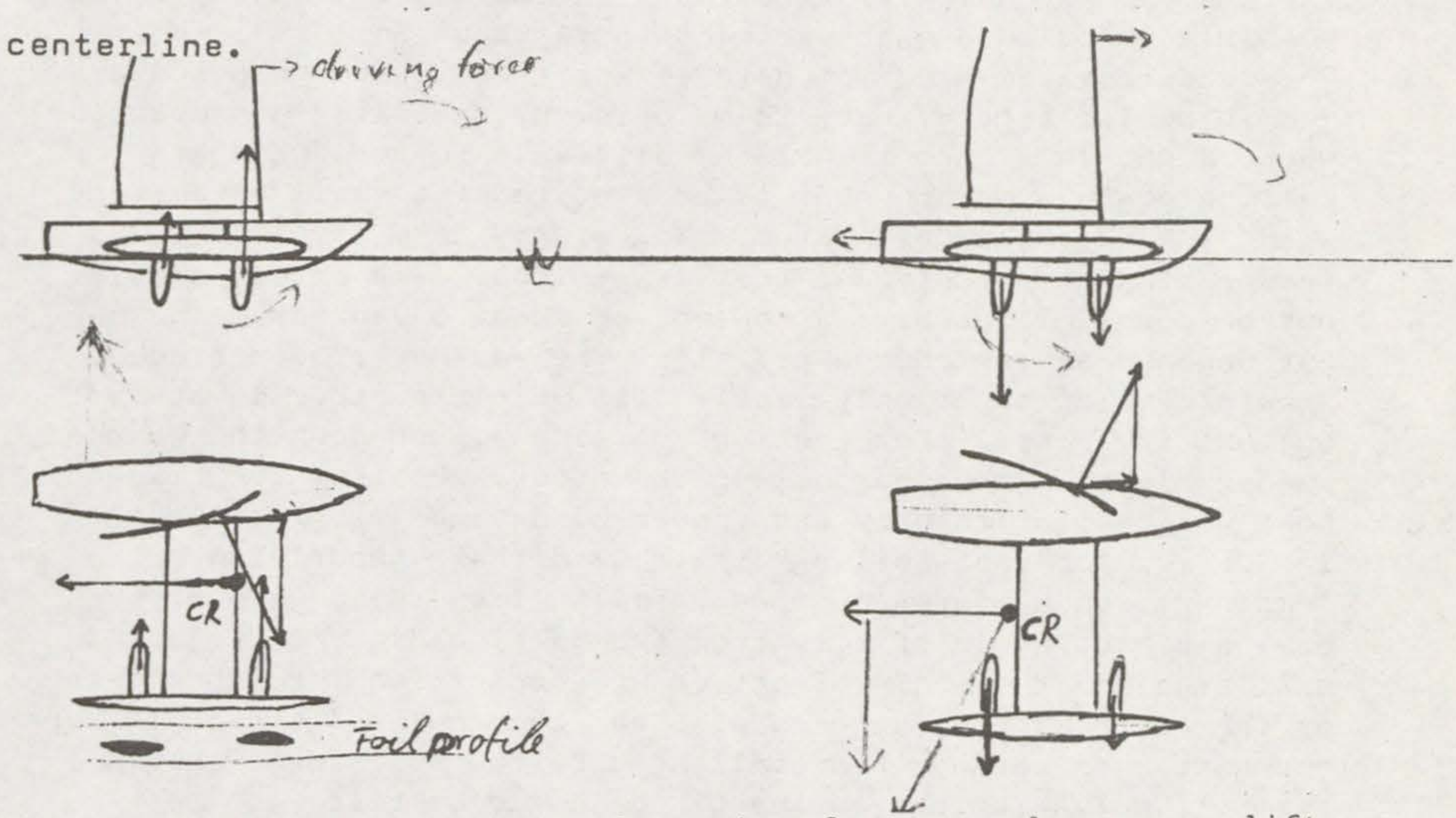
Norman Champ
Apprentice Editor

6501 Budenheim
Südstrasse 25
28th December

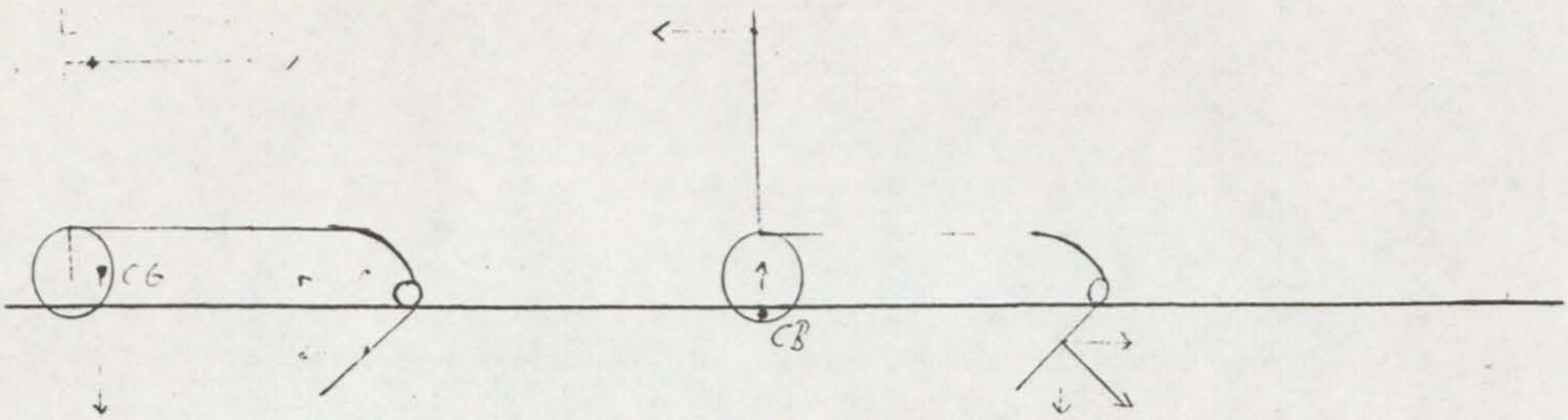
The Administrator AYRS
Michael Ellison

Dear Sir

When I became a member of the AYRS is September 82 you told me that you would bill me a year later. As this has not happened, I must have misunderstood something or you have forgotten me. Now I send you the money for another year.
I have also a question and some ideas. Has there ever been an oceangoing Bruce Foiler ? In publication No 93 on page 29 Noel Fuller mentioned that he considered building a 9m Bruce Foiler.
Now some thoughts on Bruce Foiler design:
Edmond Bruce suggested building a tandem Bruce Foiler because there would be less possibility of both foils coming unstuck when they are to weather. Let's say we use asymmetric foils, which produce zero lift at an angle of attack of minus two degrees. The two foils are mounted on an ama, perhaps similar to Splinter's (sse MI October 81), with their chords parallel to the boat's centreline.



When the foils are to weather, the aft one produces more lift than the forward one. The centre of resistance moves back ahd the stern is pushed down. The reverse happens when the foils are to lee. When carefully designed this foil arrangement should keep the boat level and compensate for the drag of the ama and the foils. Another aspect: I think when the foil is to weather, it does not depend on the centre of gravity but on the centre of buoyancy whether the boat is non-heeling or not. A catamaran of a given beam could achieve non-heeling with a single canted board to windward but not with one to leeward.



Now one can build a Bruce Foiler which is balanced out on the weather tack (foil to weather) and under-balanced out on the lee tack. Take one reef in and the boat will be over-balanced out on the weather tack. The ama will be pressed into the water. The centre of buoyancy moves to weather till an equilibrium, the non-heeling state again, is achieved. In a gust, the boat should sink evenly, and not only the ama, as the foil force increases. If the ama pops out in a wave the boat is over-balanced out and the ama is very quickly pushed back in the water. It should be possible to build a quite safe offshore Bruce Foiler.

The rudder system used on Charente Maritime 11 and proposed by you in publication 87 has, in my opinion, one major disadvantage: when caught in irons, it will be difficult to get the boat sailing again. My proposal is best suited for small catamarans with a kick-up rudder system. You simply take asymmetric rudder blades and only use the leeward one. The chords should not be parallel but have a tow out of about 5 degrees. The tow out depends on the chosen profile. The weather rudder blade should develop no or only little lift when the other is at its optimum L/D ratio. For tacking you simply push down the weather rudder blade, tack, and pull up the other. Most of the time the boat will sail with only one rudder blade and less resistance.

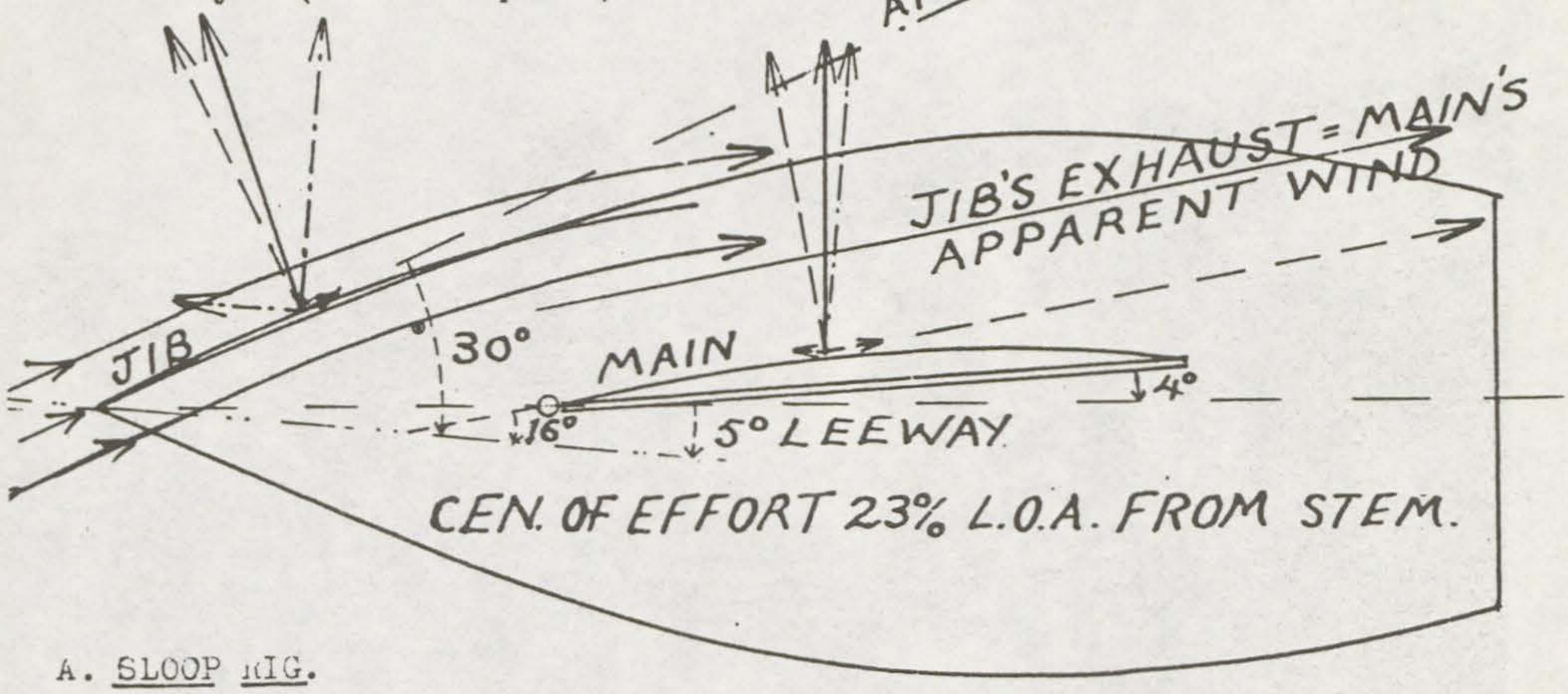
In "Design for Fast Sailing" it is said that "thedriving component, on a windward course, falls of as the square of the cosine of the angle of tilt from the vertical". The projected sail area and the angle of attack are proportional to the cosine of the tilt (or heeling) angle. When the angle of attack is kept constant by sheeting in or falling off, the sail force should fall off only with the cosine of the angle of tilt.

A few months ago I began studying biology. In a lecture a professor mentioned that the whales used to communicate over hundreds of miles using low frequency sounds. Nowadays this frequency of about 12Hz is occupied by the ship's diesel motors. Perhaps it is possible to build an anti-collision alarm using a microphone tuned in to this frequency.

Robert Biegler

The BLOT (alias SLOT) EFFECT.

"The cat (Una) rig is notoriously close-winded and will lie closer to the wind than a sloop rig, in spite of some modern theories to the contrary". (H. I. Chapelle).



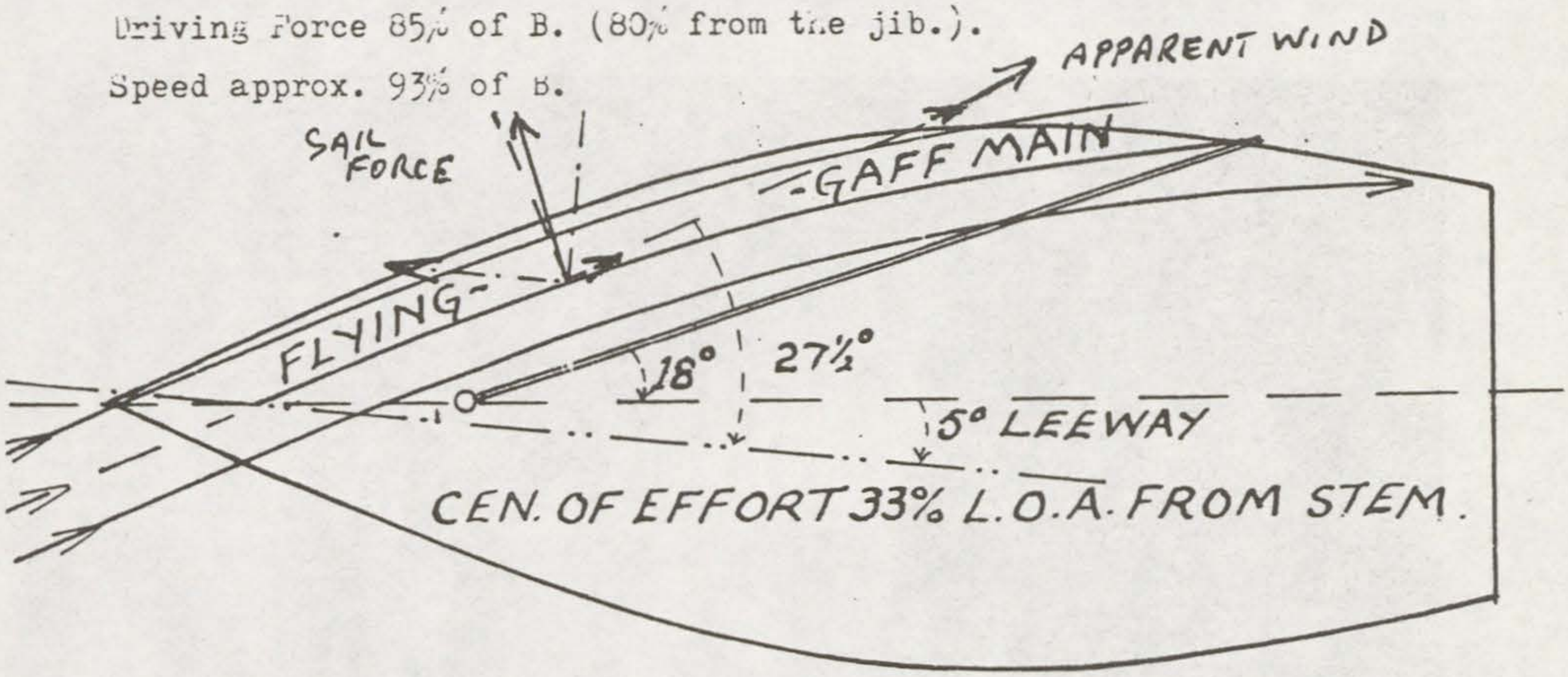
A. SLOOP RIG.

Tack through angle 85°.

Heeling Force 125% of B.

Driving Force 85% of B. (80% from the jib.).

Speed approx. 93% of B.



B. FLYING GAFF UNA RIG.

Tack through angle 80°.

Assume: Sail Force prop. to foot length, Free luff lift:drag = 9:1, Mast-attached lift:drag = 6:1, attack angle = 10°, leeway angle similar but probably 1° less with the Una rig.

T. S. Morley 8/84.

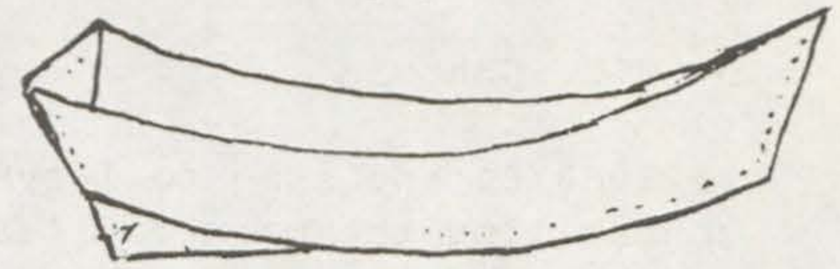
"Sampanette"?

"SAMPANETTE" ?

Greetwell,
Bodinnick-by-Fowey,
Cornwall.

Material

1. One sheet 8' x 4' x 6ml Marine (or External) plywood.
2. 2" Fibre Glass tape.
3. Resin Glue and Catalyst.
4. Broom handle for paddle or oars.
5. Copper wire.



A friend of mine found a small sketch of this boat (Dory ?) amongst a large pile of old yachting magazines, possibly American or Australian. With the sketch was a photograph of the man who had designed and made this craft, and to prove the concept possible he had paddled it across a large bay of rough water.

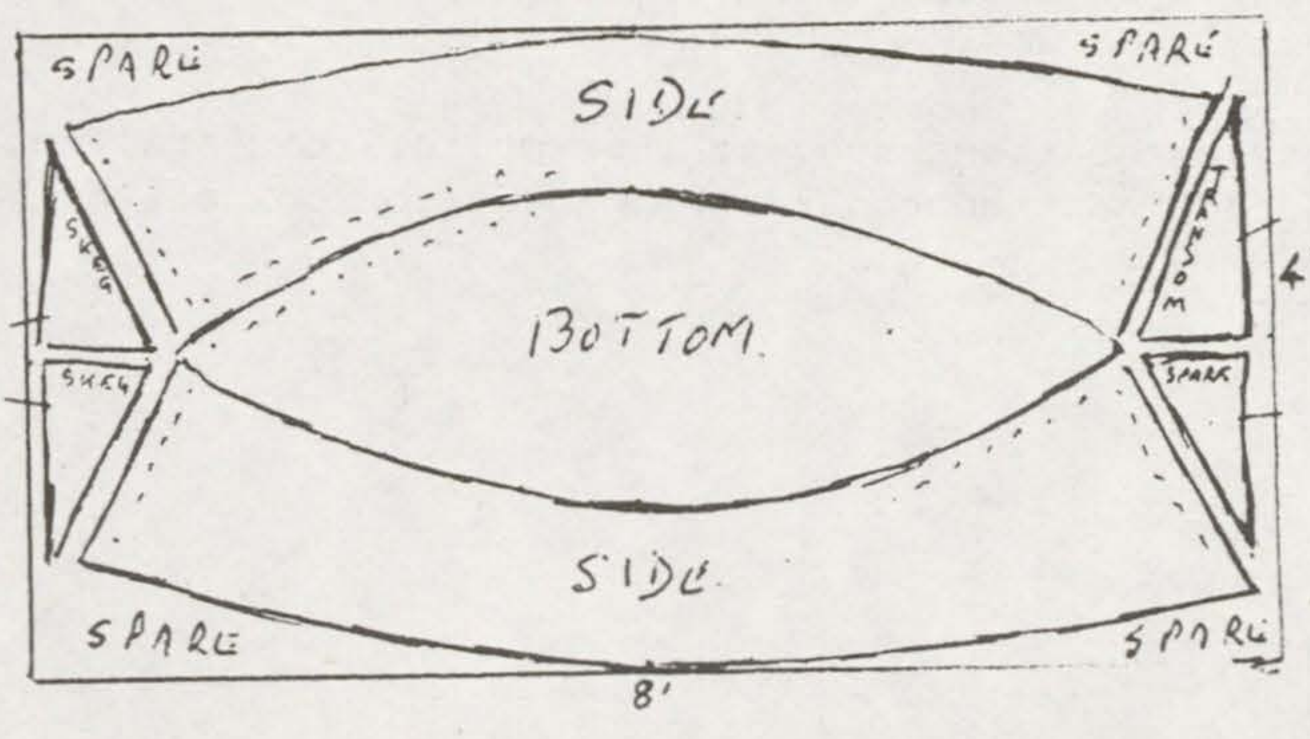
We projected the image of the sketch onto a screen to approx. 1/4 size, then enlarged to full size and copied it onto brown paper patterns. These were then placed on to a sheet of 8' x 4' x 6ml marine plywood, and cut round, using a Black and Decker jig saw.

Holes were drilled at approx. 2" intervals around the edges. The two sides were then sewn onto the bottom, using old electric copper wire, and finally covered with fibre glass tape. This method of construction is, of course, used when building a Mirror Dinghy. The boat was cut out and sewn one day, fibre glassed the next, and painted on the third day.

The result was very satisfactory, so much so that as the craft looked not unlike my large 16' Sampan "FU HSING", I decided to make one for myself, and fit it out in the same colouring and design as the larger craft. The result was a delightful little boat, that has been sailed rowed and paddled in perfect safety by a young 14 year old friend.

I now tow "MINI FU HSING" behind the big sampan, causing considerable comment and clicking of cameras from holiday folk and yachting types.

The greatest difficulty is experienced getting one's grandson out of "MINI FU HSING", causing howls of protest when it is time for him to go home !

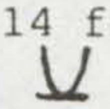


Dennis Banham

BANDERSNATCH REPORT 1984

by G.C. Chapman

In 1983/84 the same foil system was used, with inverted V feelers controlling the main foil assemblies and hence the incidence of the main foils.
Performance was improved over the inverted T feelers used in 1979 which gave a more bumpy ride (and 15.2 knots on the inshore course), but both in 83 & 84 the constraints of the Hamoaze and weather gave much less foil born mileage not enough practice so poorer helmsmanship.

HULLS. For 1984 I built new folded 4mm ply hulls to increase displacement and give easier handling at low speeds. To reduce the draught and retain leeway resistance the keels are 4" wide, 4mm thick over the full 14 foot length, the hull sides being fixed 1" inboard thus,  almost to the bows which were built to accommodate boxes in which the feeler arms slide up and down. At the sterns there are small transoms. These hulls I find give comparable displacement performance to the deeper Vs of "Bluey".

FOILS. Photos show that sustained flight is possible at 12.5 - 13 knots, interestingly foil lift is greater than I calculated. They also show and I knew the sail was not sheeted in as hard as it might have been, indicating a potential for greater speed and stability in that wind strength 15 - 16 knots with practice. The 1983 run (Photos Multihull International No 191. Dex. 83 p304), was faster and steadier but then so was the wind. At present, performance compared with surface piercing foils is disappointing, I have looked for reasons. Although the inverted V feelers work and the anti crash foils just above them periodically come into play, I consider there is still too rapid and excessive a motion of the feelers, and long skis which can span 2 or 3 wave tops would be better. These were suggested long ago by Grunberg (alias Graig) and recommended to me by W.R. Frank.

Rework of the basic equations suggest that my foil dihedral could usefully be reduced, and the canard now begins to look attractive.

SPECULATION DEPARTMENT At Portland in 1984 "OK SHAPE", alias "LOISIRS 3000" at last showed that a reasonably elegant, seaworthy and beachworthy canard can be built. Earlier canards have failed on those counts and as far as I am concerned gave canards a bad name. OK SHAPE is a catamaran with an arm reaching forward to a buoyant ski about 12" wide by 4' long, with the rudder beneath: ICARUS type foils are carried on the main beam.

What attracts me about the canard is the possibility of controlling inverted T foils' incidence in a smoother manner than on FORCE 8 or BANDERSNATCH; though skis may help them. And reducing the feeler lift would help reduce drag, by transferring that lift to more efficient foils.

DESIGN FOR LEAST DRAG If a limiting value of the athwartships, heeling component of sail force is a chosen (related to sail area expected apparent wind speed &c), and the weight of the boat and crew are estimated, then for the lee foil by itself to resist leeway and to support the weight $\text{Tan } D = \frac{F_H}{W}$ where D is the foil dihedral, F_H the sail heeling force and W the total weight (less any weight taken by feelers or rudder foil).

The distance between foils will depend on the height of the CE of the sail, and will be a minimum for a boat with its CG amidships. If the crew chooses to sit to windward (eg on a catamaran) then the distance between foils increases.

Whatever the beam, at the chosen F_H only the lee foil is loaded: at lesser values of F_H some of the weight is taken on the weather foil, at greater values the weather foil force reverses and the foil holds the weather side down.

Up to the chosen F_H the total of the forces developed by the two foils is constant and is Weight/Cos D, and is a minimum in relation to other configurations, with different dihedrals. Therefore for the same foils and relative to other configurations induced drag will be a minimum.

Above the chosen F_H drag will increase because the total of foil forces necessarily increases, due to the reversal of the weather foil force which in terms of lift now acts against the lee foil.

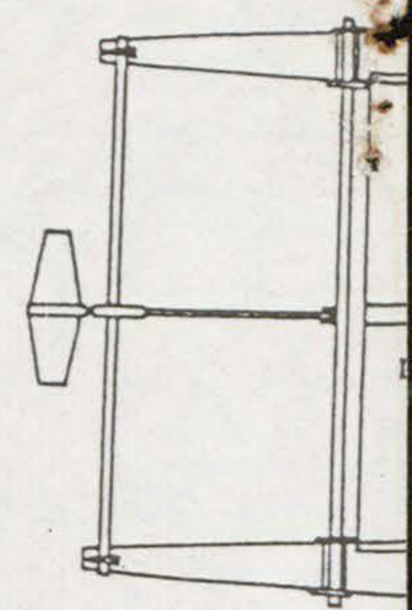
The foils should be of symmetrical section to cater for the weather foil reversal, unless you discount that possibility; and their incidence must be continuously adjusted to hold the boat up and upright.

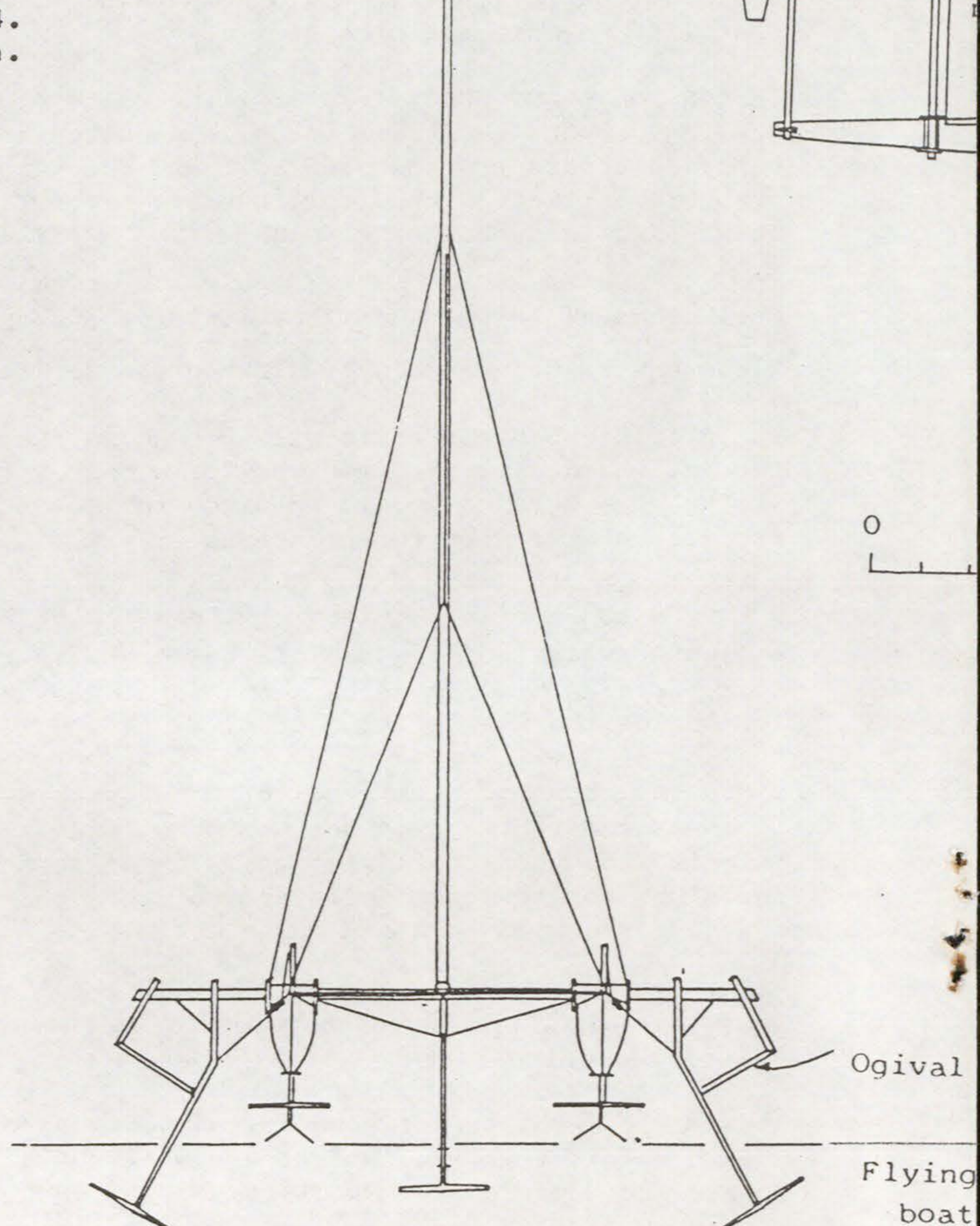
BANDERSNATCH 1984 configuration

10sq metre Flying Foiler

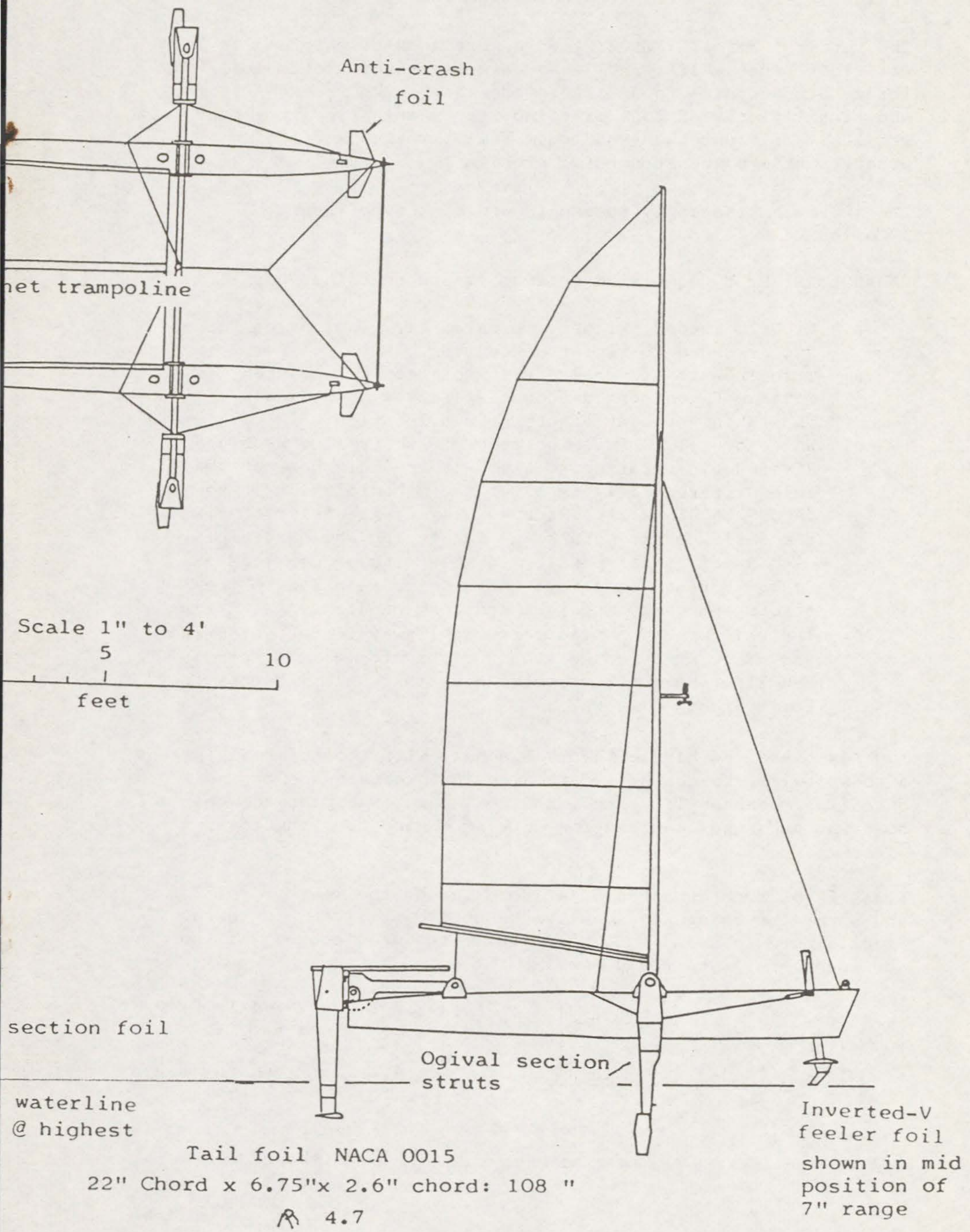
L O A	16 feet	
B O A	14 feet	
Boat weight	Displ.	Foiling
	160lb	197lb
Crew weight	160lb	160lb
Total weight	320lb	357lb
Bruce No.(I)	1.52	1.46

Drawn 10.1.84.
G.C.Chapman.





Main foils 22" span x 6" & 2.5"
chord: 94□" NACA 0012, AR 5.15


Anti-crash
foil
het trampoline
Scale 1" to 4'
5
10
feet
section foil
Ogival section
struts
waterline
@ highest
Inverted-V
feeler foil
shown in mid
position of
7" range
Tail foil NACA 0015
22" Chord x 6.75"x 2.6" chord: 108 "
AR 4.7

If the foils move relative to the struts, no leeway need be carried. If the foil + strut assemblies are rotated to vary foil incidence, strut incidence can be minimised by careful design, raking the struts forward from the foils.

The vertical T foil (FORCE 8) is a very special case and is less efficient because lift and leeway are separated, total foil forces are Weight + F_H and therefore <u>rise</u> as F_H rises. Additionally, the surface piercing struts which resist leeway are less efficient than submerged foils: wetted surface is greater, as are the structural problems.

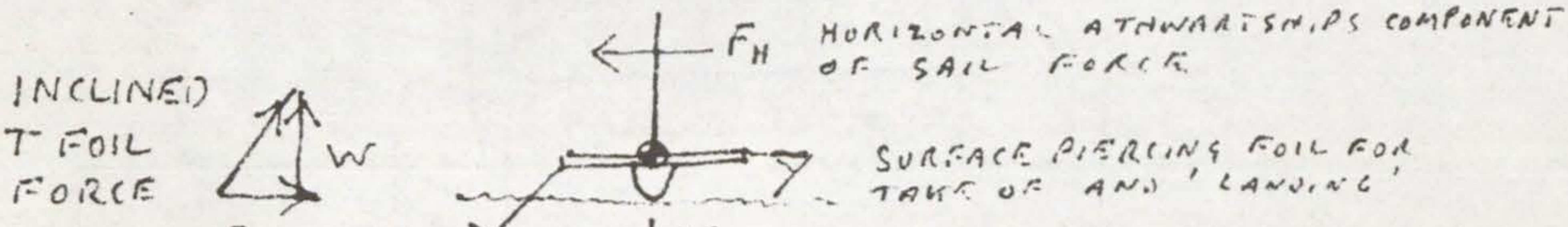
The above remarks apply to canard and Hook-type inverted T foilers.

<u>CANARD DESIGN</u> My suggested optimum canard therefore has:-

a. Lightly loaded ski well forward, carrying no lee forces, and arranged to resist nose-dives.
b. T foils with dihedral set in relation to expected maximum F_H and the distance apart set accordingly, and taking account of the crew's location.
c. While overall T foil incidence is controlled by boat attitude in relation to the ski, the helmsman must be able differentially to alter the dihedrals (as in eg JACOBS LADDER 111). Structurally it is easier to fix the foils to the struts and rotate the whole assembly, with a very small penalty in strut incidence, load and drag. Purists will move their foils relative to the struts and carry a weight and cost penalty.
d. The ski forward should carry no leeway force. Steering should be by a fenced rudder right aft, giving normal handling characteristics with weather helm, whether the foils are up or down.

You may therefore have either a monohull with the helmsman in a cockpit (for speed) or a catamaran for greater ease of operation, beachability etc., and dual role as a displacement boat for other sailing and for getting to and from the foiling waters.

Even if you adopt the above, at some speeds the weather foil and strut are doing no useful work but are still causing drag. To eliminate that and to exploit fully the drag economy of the inclined T foil you would need:-



And of course if you can also have an inclined sail...........

G.C. CHAPMAN

87 Staincross Common,
Barnsley, S75 6NA
9th February, 1985

Dear Michael,

AYRS 100 is excellent. Interesting from start to finish.

One point. Reg Frank, B.Sc. We have lots of B.Sc. holders nowadays. Originally, I suggested to John Morwood that it would be very useful to enquire from members as to their specialties, and to start it off, explained mine. The'B.Sc.' remains in the records. Please remove. Stands out like a sore thumb.

Now this is still a good idea. For example, say someone wants to use titanium alloy foils or other parts, eg masts, or carbon fibre, or wants information on engines, or on sails, or on a thousand other matters. There will be one or more members who can help.

Probably a better way would be to have a column in every publication. 'Can any member give advice concerning making carbon fibre spars ?' etc. Does anyone know of a high power to weight engine suitable for use in a hydrofoil ? Electronics wizard to help design radio control. All sorts of requirements. After reading George Chapman's letters 'Member wants to locate source of supply of p.t.f.e. bearing pads.' My own most useful service might be when people want gunmetal castings or aluminium castings. Amongst our members there is a wealth of experience and special know how, and with a bit of organisation that can be tapped.

Joseph Dusek's model. Note the grooves made by floats and hull. Now add together all the water displaced from those grooves, and its weight is equal to the model weight. John Morwood was right. You were mistaken. The really tricky question is what happens with submerged foils. I would bet, that if the water surface could be observed, that there would be depressions and that the volume of the depressions has weight equal to the hydrofoil weight. When you see John, ask him what he thinks about that. Pity Avogadro didn't do hydrofoil model experiments in his bath. Apart from all that, aren't they beautiful pictures ?

'Only road rollers need weight.' Not so. Hydrofoils need weight. When the hydrofoil has no weight, in theory, then some foils have to pull downwards to provide balances against wind moments, and those downward pulls generate as much drag as the weight which they have replaced.
Of course, if the umpires at Portland would set out a measured distance directly downwind, and organise runs during 50 knot winds, then a hot air balloon, or a helium inflated balloon, floating downwind at wind speed, with a fishing line and tiny foil immersed to comply with the rules, would break all world speed records. A crew is weight, and can provide balance, so in that sense there is no requirement for anything else to have weight.

Light weight road rollers, with buoyant rolls, and sails, might sail very fast downwind. People sail in bath tubs. Why not in road rollers ?

If you would like any more daft ideas, just ask. But just imagine; all this effort at Portland. And a road roller rolls onto the course and beats the lot.

Survival suits. I once did an experiment. Layer after layer of woollen clothing. Stayed floating during early March until our dinghy was rescued after overturning. Then carried on until 2pm, soaking wet through with cold March wind, and I felt warm. Another test in wet suit in very cold weather. I floated around for twenty minutes, and felt warm. But I had 'oilskins', nowadays plastic, smock and trousers, and some woollen clothes over the wet suit. Felt warm. Another experiment. Woollen Norwegian track suit sort of underclothes. Stood on deck in the Humber, at night, cold breeze, slight rain. Stood for 15 minutes. Warm. Next day, this suit under my normal clothing, felt cold and shivered excessively. Removed the track suit. Got warm. Lesson, lots of layers of woollen clothing and a wind proof and shower proof outer cover. Another query. Why are boats built so that crews have to remain in the open ? Why cannot boats be controlled from inside the cabin ?

Enclosed cheque for £25, to pay subscription, balance a donation.

If you could keep up the interest, these publications are very attractive. AYRS 100 would sell at Boat Shows. Much more interesting than the dreary repetitions in yachting journals. Professional writers could take any one of these AYRS 100 articles, and expand it into an article for popular consumption. AYRS is a jewel, a collector's piece. Congratulations again to all concerned.

REG FRANK

Grenville Griffiths has been poring over Philip Hansford's book "Theory of Wing Sections", by Abbott & Van Doenhoff. Grenville has opted for simple Ogival sections for his foils and hopes carbon fibre construction will be strong enough.

THE NAUTICAL QUARTERLY carries an 18 page discussion on The A.Y.R.S. written by Mike Badham. Super reading.

James Grogono may be getting together with Mike Ellison to discuss a second edition of 'Sailing Hydrofoils'.

HAVE YOU NOTICED?
Our Administrator has moved.
To PLYMOUTH.

ESTIMATING HYDROFOIL MOVEMENT OVER WAVES

W.R. Frank,
87 Staincross Common,
Barnsley. S75 6NA
tel: 382272

In the open sea, a sailing hydrofoil is moving at nearly 90 degrees to wind and parallel with waves, which reach forward and rear foils at nearly the same times. There is no pitching moment at exactly 90 deg., although heave is accompanied by secondary pitch. Foils feel the wave frequency. When waves approach from other directions, the same estimating procedures may be used, but it is more complicated.
The mathematics applies exactly, when foil lifts are proportional to angles of attack and to depths of immersion. When otherwise, plot lifts against angles and depths, and use the tangents to replace terms like R/ ,, and R/D.
Complex behaviour may be split up, each separate behaviour estimated, and then the results combined. We may illustrate by an imaginary experiment:

Imagine a model hydrofoil tested in a tank. Its movements are due to waves, but it also resists movements. So do one test over flat water, another over waves.
Over flat water, the model is caused to heave by a mechanism which applies a force at centre of gravity G. Heave Y.sinωt, requires force F.sin (ωt +γ-β).
Now repeat over waves A.sin.ωt; but with G hinged to a slider on a horizontal rail parallel with the waves. The model can pitch, but not heave. Measure the hinge force Fw.sin.(ωt + γ).
For amplitudes only; Y requires force F. Yx Fw/F would require force Fw. A requires force Fw. So A will cause heave of amplitude Y x Fw/F.
To bring in the phase angles, use the rules below. A causes heave of phase angle (ωt + γ-β).

We could do a pitching experiment at 90 deg. to waves, length between foils equal to half a wavelength, so that G does not experience wave generated heaving force; although there will be secondary heave due to pitching.

In the mathematics, for different headings, the wave heaving action is separated from the wave pitching action. All this seems complicated; but in the mathematics, all we have to do is put the sum of moments zero to get heave; put the sum of forces zero to get pitch. For pitch, first estimate pitch if foils were not to vary depths of immersion. The maths. provides ratios which are used to multiply the 'geometrically calculated' heave and pitch. We need formulae for wave frequencies, lengths and speeds.

Using rotating vectors

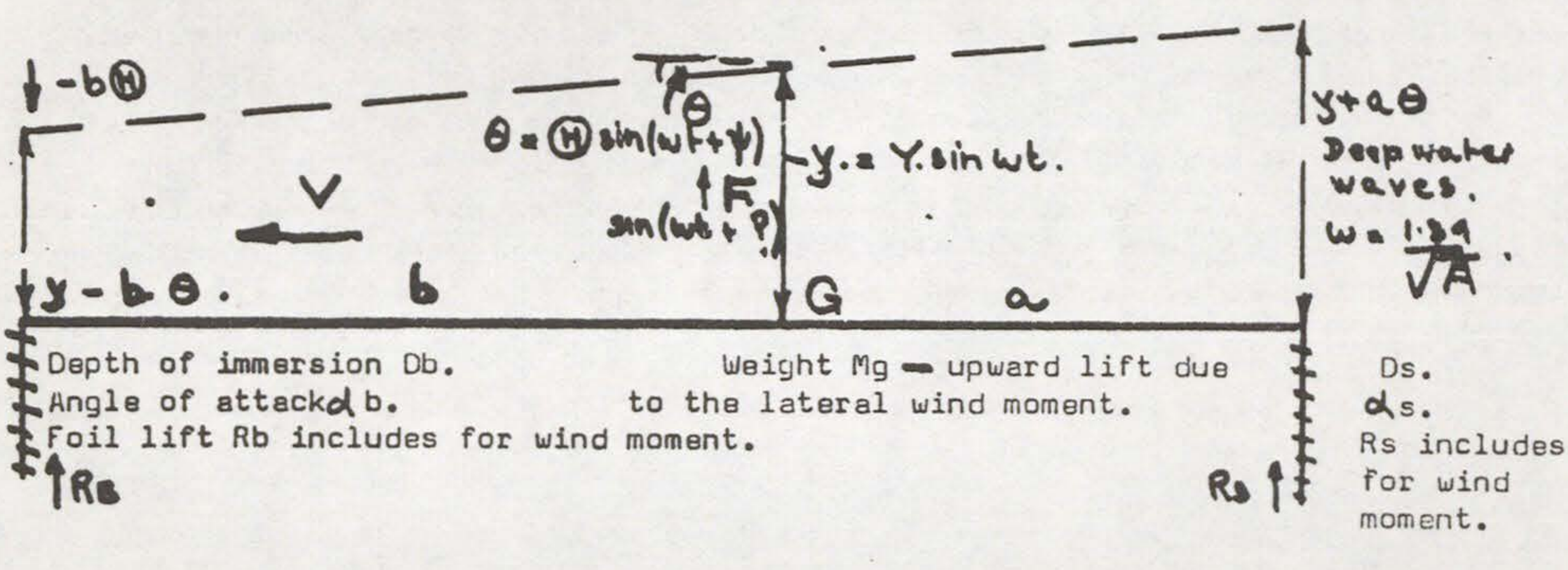
Forces, moments, displacements, velocities, etc., are all cycling at thes frequency felt by foils, f. On heading parallel to waves, foil frequency f = wave frequency ω. Each may be represented by a rotating 'crank'. One vector is taken as datum, and the positions of other vectors measured from this datum. A diagram is a 'snapshot', which freezes the rotation. I have used anti-clockwise as positive, and horizontal pointing to the right to represent time t = 0.
We are not concerned with instantaneous values; only with amplitudes and their phase angles.
There is one complication. In the algebra, there are sine and cosine terms. We could replace cos.(ωt + ψ) by sin.(ωt + 90 + ψ). The cosine zero datum is the vertical through 0. Cos.ωt = sin.(ωt + 90.).

Vector rules. To add, draw to scale, and measure from 0. Draw a parallelogram and measure its diagonal. To subtract vector B from vector A, reverse B by rotating 180 degrees; draw a parallelogram and measure the diagonal.

To multiply. A sin(ωt + a) x B.sin.(ωt + b) = AxBxsin.(ωt + a + b).

To divide. A sin (ωt + a) divided by B sin (ωt + b) =(A./B.) sin (ωt + a - b).

Negative vectors. These can be made positive by rotating 180 deg., and adding 180 to the phase angle.
Changing phases. Fig.5. Vectors at phase ψ and (90 + ψ), have to be altered. Draw the resultant and then resolve it into the new directions.
Mass and inertia. In the experiment, mass is involved in the flat water test, since G oscillates; but mass is not involved in the heave wave experiment, when G is not oscillating. Moment of inertia comes into both experiments. In the calculations, mass is put zero in the wave generated force formulae.
On heading parallel with waves, foil frequency f rad/sec = wave freq.ω.
Vertical displacements of G = y =Y.sinωt. Vel= dy/dt =ω.Y.cosωt.
accn$-\omega^2$Ysinωt.
Angular displacements = Ⓗ sin(ωt + ψ). Angl vel.ω . Ⓗ.cos(ωt + ψ).
Accn $-\omega^2$. Ⓗ.
Mass accl force, $-$ M.ω^2.Y.sinωt.
Inertia acceln moment = $-$I. Ⓗ .sin(ωt + ψ). ω^2



Calculations for heave. G is given linear oscillation Y $\sin\omega t$.
Secondary pitching is $\textcircled{H}$. $\sin(\omega t + \psi)$. Anticlockwise made positive.
Force $\bar{F}$ is applied externally. Moment is zero. The estimates, when the force is generated by waves, replace oscillation of G by wave vertical oscillation. G is then prevented from heaving, but can pitch. The only difference in calculations is that in wave force calculations, the mass acceleration force is omitted.

How the external force F varies.

When a foil force increases, external force $\bar{F}$ decreases and vice versa. Note that when the hydrofoil tilts positively, anti-clockwise, that both foils lose lift.

DAMPING FORCES.

When water moves vertically past a foil, upwards, it increases the foil angle of attack. If the water velocity is u, the foil velocity is V, then angle of attack is increased by (u/V), and foil lift increased by $R.x(u/V) / \alpha$.

When the foil moves, the water being stationary, then the force opposes. That requires increase in the externally applied force.

THE SUM OF THE EXTERNALLY APPLIED FORCES, THROUGH G, is:- $F\sin(\omega t + ?) =$

A, B:

$Y.\sin\omega t.(Rb/Db + Rs/Ds) - \omega^2.M. +$ damping $Y.\cos\omega t(\omega/V)(Rb/\alpha b + Rs/\alpha s))$.

C:

$+ \textcircled{H}.\sin(\omega t + \psi).(-b.Rb/Db + a.Rs./Ds. + Rb./\alpha b. + Rs./\alpha s.)$

D:

$+ \textcircled{H}.\cos(\omega t + \psi).x(\omega/V) \times (-b.Rb./\alpha b. + a.Rs./\alpha s.)$

THE SUM OF THE MOMENTS OF THESE FORCES IS ZERO IN HEAVE. 0=

E, F:

$Y.\sin\ t.(-b.Rb/Db. + a.Rs./Ds.) + Y.\cos\omega t.(\omega/V).(-b.Rb/\alpha b. + a.Rs/\alpha s.)$

G:

$+\textcircled{H}.\sin(\omega t + \psi).((b^2. Rb/Db. + a^2 .Rs./Ds. - b.Rb./\alpha b. + a.Rs/\alpha s) - .I.)$

H:

$+ \textcircled{H}.\cos(\omega t + \psi). (\omega/V).(b^2.Rb/\alpha b. + a^2.Ra./\alpha s.)$

When a foil is not surface piercing or feeler controlled, omit the /D term.

Use the moment equation to find the ratio, $\textcircled{H}$/Y., and the value of angle ψ, then use these in the force equation to replace $\textcircled{H}$ by Y. Solve by drawing vector diagrams. In pitch calculations, put the sum of the forces zero.

These formulae are for instantaneous values of y, whereas vector diagrams are pictures of vector 'crank' positions. When 'sine(ωt)' is used, it means a 'crank', horizontal and pointing to the right. When 'cos (ωt)', that means a 'crank' pointing vertically upwards. These 'sine' and 'cos' positions are the zero angle datums, and phase angles are measured from them anticlockwise plus.
'Cranks' are manipulated using ordinary trigonometry.

EXAMPLE. Hydrofoil 20ft between foils. a=12ft. b=8ft. V=20ft/sec. Wave frequency 2 rad/sec.= freq. felt by foils on heading parallel to waves. The bow foil has angle of attack 0.15 rad; the stern foil, 0.10 rad. Bow foil is surface piercing, and lift is proportional to depth of immersion. The bow foil is immersed 1ft., the stern foil is totally immersed, and Rs/Ds terms are put zero. Mass is 20 slugs. The weight of 644lb is partly carried by the outrigger. The forward component of wind force transfers some weight from stern to bows. Bow static reaction Rb = 300lb. Stern Rs = 200lb. Moment of inertia in pitch, I, is 1000 slug ft^2.

(ω /V) in damping terms is 1/10. Mass acceleration force is -20.2 .Y. = -80.Y.lb. Max

Inertia acceleration moment is - 1000.2^2 . . = - 4000 $\textcircled{H}$. lb.ft. Max

COEFFICIENTS.

A=300. B=4000. C=400. D= -8000. E= -3600. F= -8000. G=35,200. H= 416,000.

Instantaneous values for applied force F.sin(ωt + ?). Figs 5 and 6

((300 - 80).Y.sinωt. + (4000/10).Y.cos.ωt.)
+ (400.$\textcircled{H}$.sin.(ωt + ψ) - (8000/10).$\textcircled{H}$.cos.(ωt+ψ)). --------3.

Instantaneous values for an applied moment. In heave, this moment is put zero.

(-3600.Y.sinωt.- (8000/10).Y.cos.ωt.)) Fig 3
+((35,000 - 4000).$\textcircled{H}$. sin.(ωt + ψ)) + (416,000/10).$\textcircled{H}$. cos (ωt +ψ).)
Fig 4

The 'cranks' in diagrams are maximum values of the oscillating quantities. In figure 3, the combined moments due to OT and TR are represented by OR. In fig 4, the combined moments due to OP and PQ are represented by OQ. Fig 4 is reduced in scale 1/14.1 , and OP put in line with OR. The sum is zero. This ratio, 1/14.1 and phase angle = -40.6°,are then used in the force balance diagrams to replace $\textcircled{H}$ by Y, and to give ψ a numerical value. The vectors at phase angle ψ, have to be 'phase shifted' to zero phase; done by drawing in fig. 5.

Then add these resolved vectors to the original Y vectors in fig.6.

Figure 6 resultant is the maximum value of the applied force, at phase angle 58.8 deg. from the applied heave oscillation Y.sinωt. Left hand diagram.

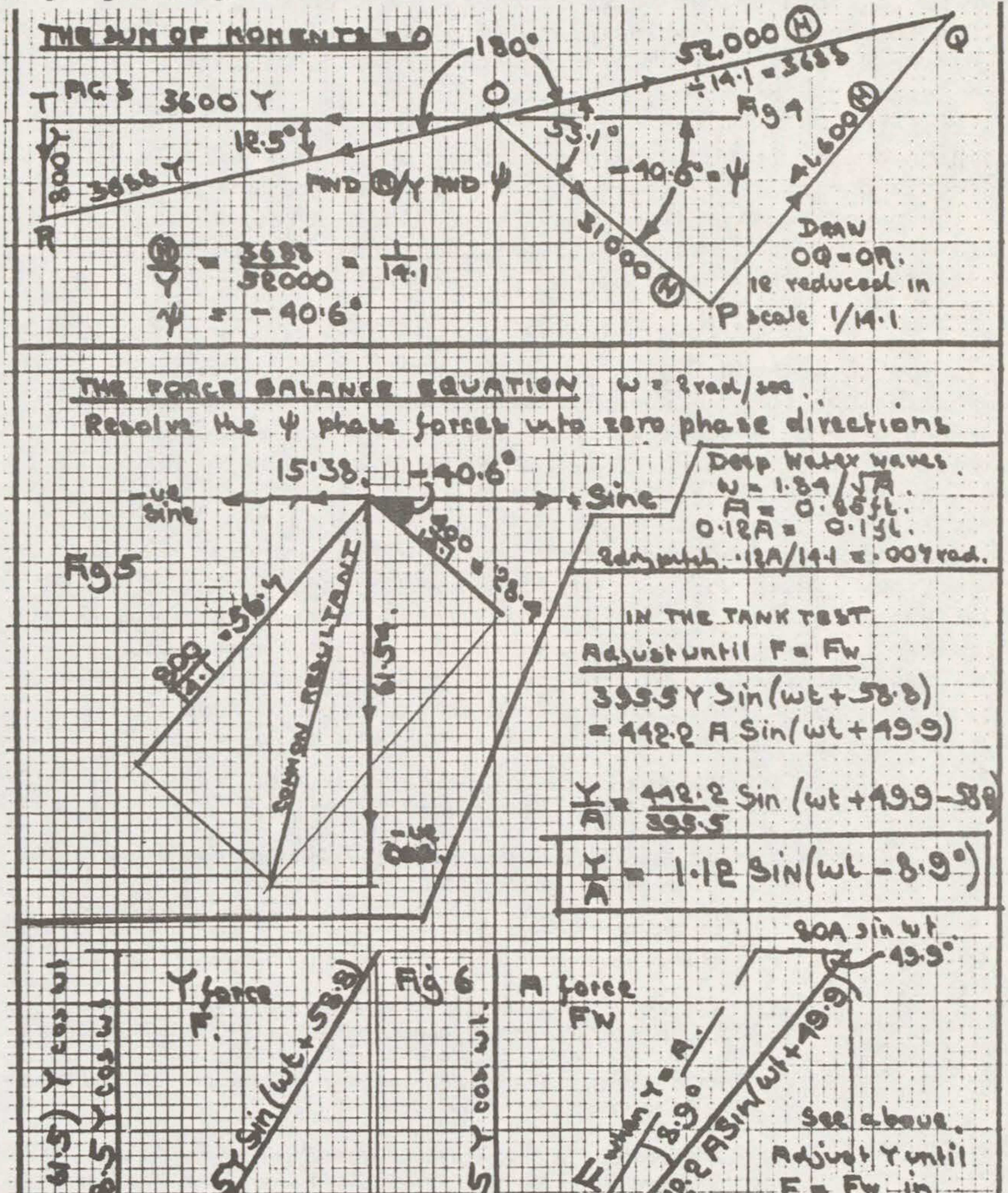
Wave generated forces.

Tank test. G held against heaving, but the hydrofoil is free to pitch. The applied heave oscillation amplitude Y, is replaced by the vertical water oscillation A.sinωt. The only difference is that there is no mass acceleration force. So, if we add 80 to the horizontal vector, we get force Fw due to a wave amplitude Y. We want Fw due to wave amplitude A, so multiply by A/Y. But Y is unknown. We do know that the wave generated force Fw has to equal applied force F.

Refer to fig 6. To increase the amplitude of force F up to Fw, the original heave Y has to be multiplied by Fw/F, and its phase altered by 8.9 deg.

So wave amplitude A causes heave of A.Fw/F.sin (ωt - 8.9 deg).

These phase angle concepts are confusing. But the procedures and arithmetic are simple. For other frequencies, copy this example. For other hydrofoil speeds, coefficients are re-calculated. For other headings, some information about waves is required. Otherwise, put the sum of the forces zero to get pitching.



St Andrews,
Fife
Scotland
April 1985

Dear Mr Ellison,

You may like to have the enclosed paper on the Vertical-Axis Turbine/Propeller for Ship Propulsion, if you do not already have Wind Engineering; the windmill builders are now linked with a group considering ship propulsion, so you may have seen it.

You may be able to put me right over my notion that I am the first to expound the principle of the vertical-axis machine as a device for both stream-bending and stream-accelerating or decelerating. Have you come across any evidence of this being anticipated ? I am too old to start a campaign to have such a machine built; it would be a satisfaction to have priority recognised - if I have it. Although I have sent xerox copies of the paper to several people who should, I thought, be interested, I have had no response. Now that I have the proper reprints I shall be sending out a few more.

To change the subject completely, there is another thing that I wanted to ask you. When my triscaph "Trion" was built in Cowes in 1955 for the speed-trials, we had the floats tested in Saunders-Roe's seaplane tank, and there is a nice set of experimental figures which has never been published. There is such a shortage of genuine measurements on anything comparable that I feel they should appear. The man who paid for the testing is long dead, and Crago, who did the testing, sees no objection. Would you like it for an AYRS issue ? The triscaph configuration could be useful for a rescue craft, for example: with the floats trimmed bow-down in the displacement mode, a low-power outboard would give cruising speed of 4 or 5 knots, while the system for changing trim to planing attitude would automatically immerse a big outboard for the 30-knot stuff.

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Hugh Barkla

Michael Ellison
10 Boringdon Terrace
Turnchapel,
Plymouth, PL9 9QT

Dear Mr Barkla,

Very many thanks for your letter of 9th and the enclosed paper on Vertical-Axis Turbine/Propeller.

Two members are active on their own in this field. Joseph Dusek, who lives in Sydney recently took out a patent on a vertical axis windmill. His idea is to use the wind 'lift' on the upwind sweep of the blade to give power via hydraulic or an air pump. He has done a lot of research on his own and builds models and a full size hydrofoil craft "Dalibor" on which he has tried various rigs. Not similar to your idea but I am sure he would be very pleased to read your paper

The second member, Douglas Hannan, is an ideas man in New York who makes a living from after dinner talking and drawing cartoons. He has sent many ideas for saviarious rotors (reversible) and other inclined rigs. He tries these on models but I have never seen any maths to indicate performance or possible power outputs and so I assume that these have never been measured.

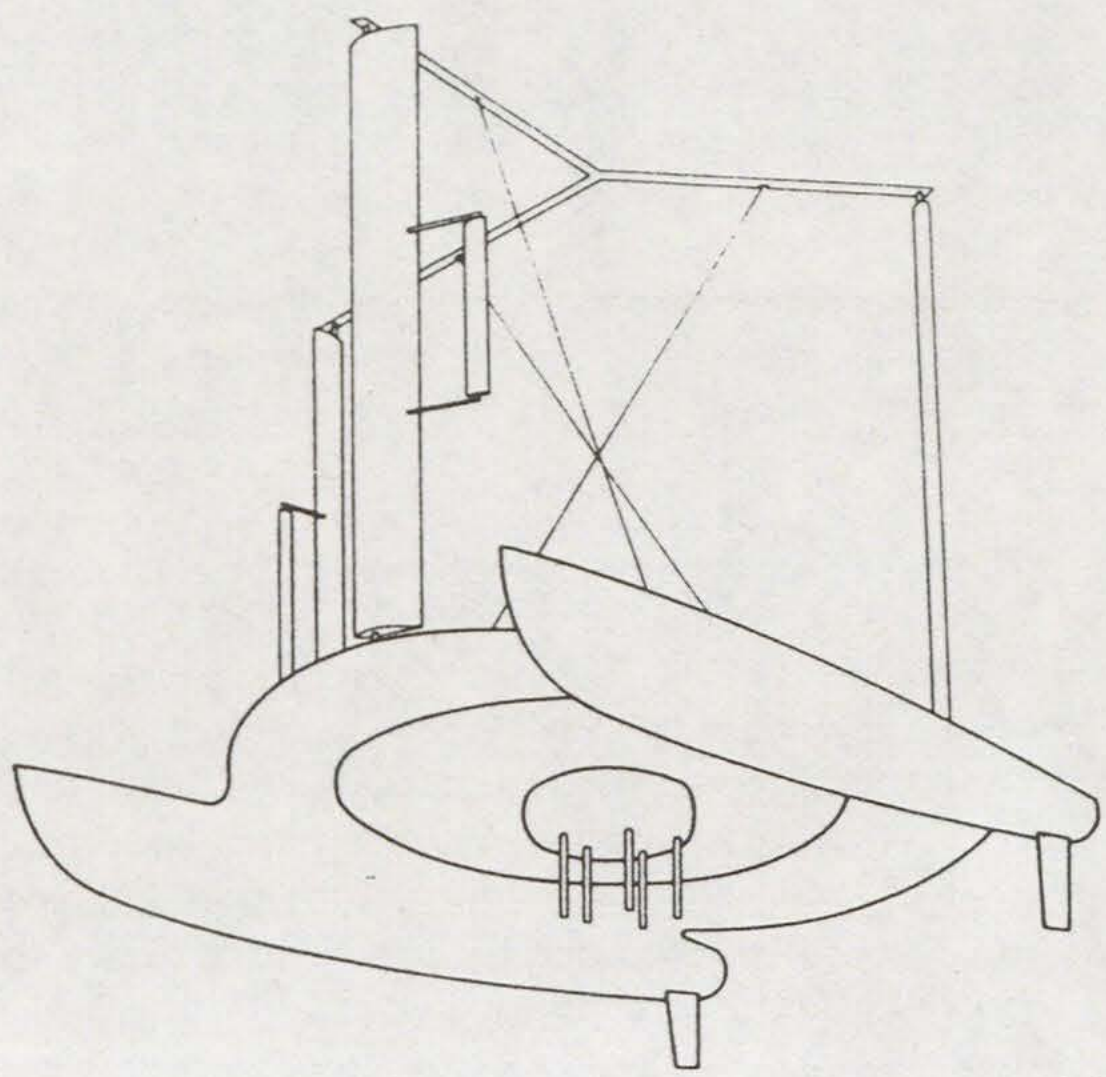
Of course there are many other members like George Chapman, Reg Frank and Harry Morse who will study the sums. I am sure these people understand all that we publish. A few years ago I made a big effort to understand the patent papers by Anton Fletner for his rotors. He had I gather ordered the construction of a vertical axis windmill powered craft when he went on holiday. On his return he stopped work and changed to his rotors. The later ones using power fans and slots were never tried at sea.

I would be very pleased indeed to have the "Trion" test figures for publication. I feel that one of the biggest things we could do to help design progress would be to publish such information, not only for special craft but for "ordinary" fast racing craft as well. As we are not trying to sell anything honest figures could be published - even just towing a range of craft at various speeds could be helpful.

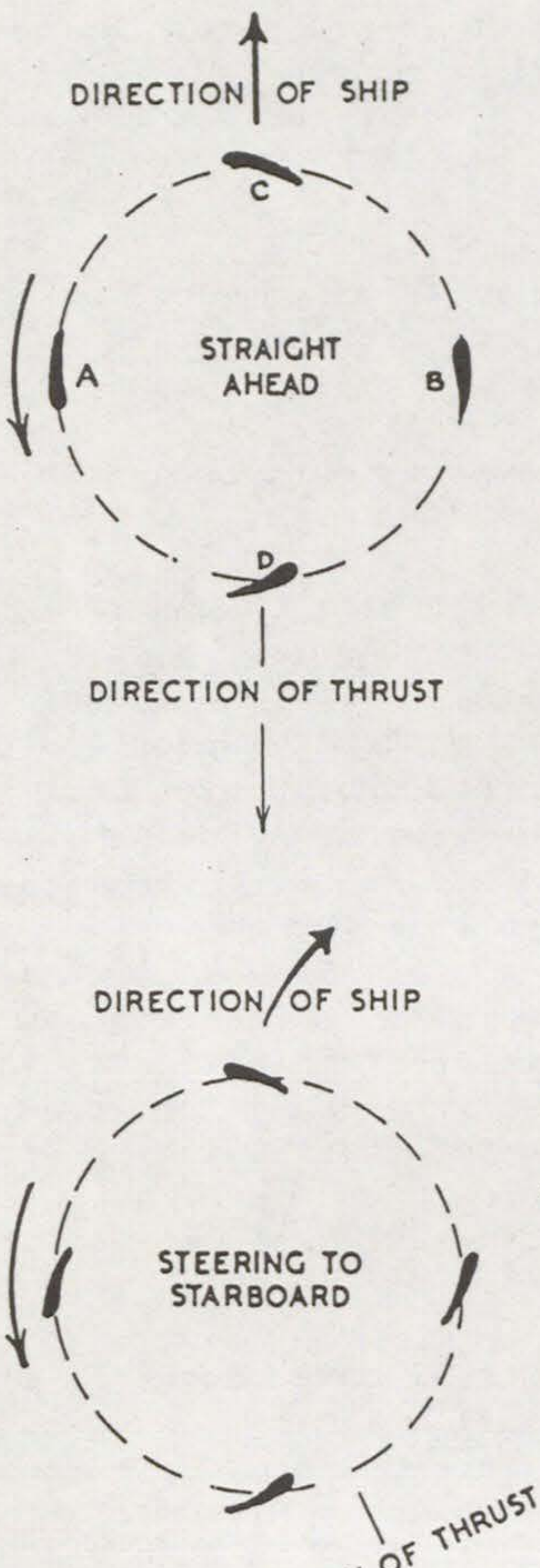
At the end of June I shall move to Plymouth, I have bought an old terraced house near the harbour plus a small building to use as an office. Hopefully this will help us get back into growth and action again. B.B.C. Television spent two days in Plymouth recently making a programme about A.Y.R.S. to show in June or July (one of "Making Waves" series). A U.S.A. magazine "Nautical Quarterly" are publishing a feature article about us in May with a foreword by H.R.H. Prince Philip and I hope this will bring in some more overseas members.

It is strange that around the whole world so very few people are building and trying out new ideas. Those that do try get very little encouragement ! I also notice that recently "people" have almost stopped buying our back numbers. Anything published more than two years ago is regarded as being of historic rather than future research. The time will come when we will have to use video film to distribute our information, I fear that this will be quite soon.

MICHAEL ELLISON



Sketch of proposed 100-ton biscaph. The incidence of each air-blade is controlled by its own tail



THE VERTICAL-AXIS TURBINE/PROPELLER

← VOITH SCHNEIDER PROPELLER ACTION

<u>HAVE YOU NOTICED?</u>

Our Administrator has moved. To <u>PLYMOUTH.</u>

VERTICAL AXIS WINDMILL

The present invention relates to the above device in the form of vertical axis windmill to produce power from the wind. The device consists of windmill mounted on vertical shaft, helicopter fashion, and unlike similar windmills that produce power by using drag of reclining blades off the wind, the device stated above uses aerodynamic force of advancing blades into the wind which flip upwards.

In order that the invention may be better understood and put into practice preferred forms therefore are hereinafter described, by way of example with reference to the accompanying diagrammatic drawings in which Fig. 1 is a view which describes invention. The device consists of windmill mounted on hollow vertical shaft (1) helicopter fashion. The windmill operates on principle that exposed area of reclining blades is pushed off the wind while

advancing blade into the wind rotates 85 degrees and projects small front section of the edge of the blade into the wind. Blades of the windmill (2) are attached through bearings (4) to short beams which are hinged to the hub and shaft. This system enables blades to not only rotate along their horizontal axis 85 degrees, but also to flip upwards producing additional aerodynamic force which is extracted by means of pneumatic pumps (5) or any other mechanical, electrical or hydraulic systems. The power from systems is transmitted through hollow shaft (1). On movable plate (6) under the rotor, rolling small wheels (7) connected by short arms to axles of blades. By moving plate up or down output of windmill is regulated or shut down in high winds, or when not in use. Upper curved dish (8) supports trailing wheels in flip-up mode.

J.T. Dusek

L A T E E X T R A

VERTICAL AXIS AEROGENERATOR (VAAG).

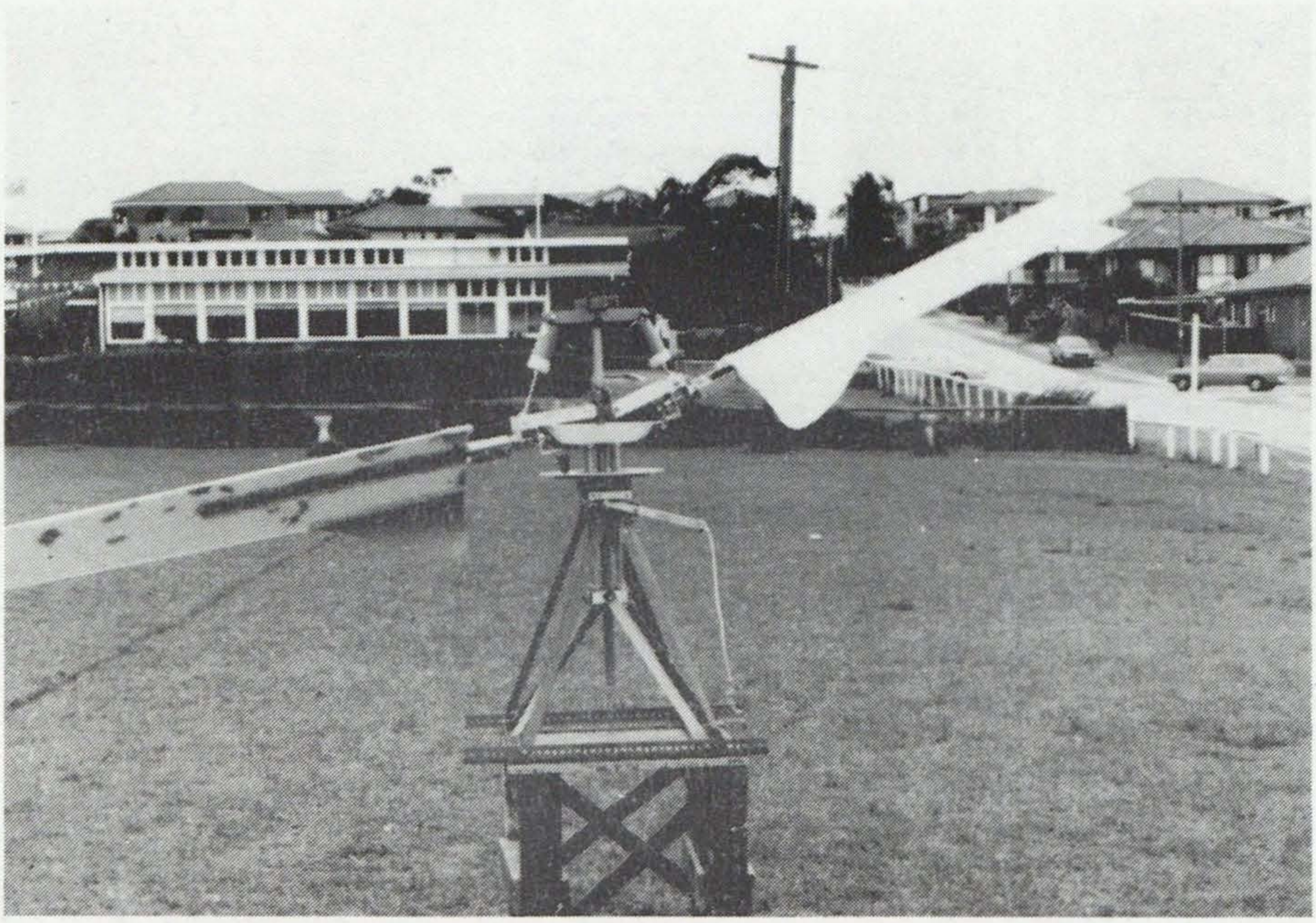
PETER A.RICHARDSON

RoTaboaT MayFly.

A VAAG/Screw driven craft. Using data from a tunnel tested Musgrove VAAG a fibre composite has been constructed. A trimaran hull 5m LOA X 3m Beam has been tailored to the turbine. Pedal power from a bicycle crank-set with fixed sprocket provides initial rotation of the turbine. SEE SOUTHAMPTON SHOW 1985.

NINE BOLD PLACE, LIVERPOOL, L1 9DN.

Compiled and edited by Norman Champ.



Vertical Axis Windmill. *J.T. Dusek.*

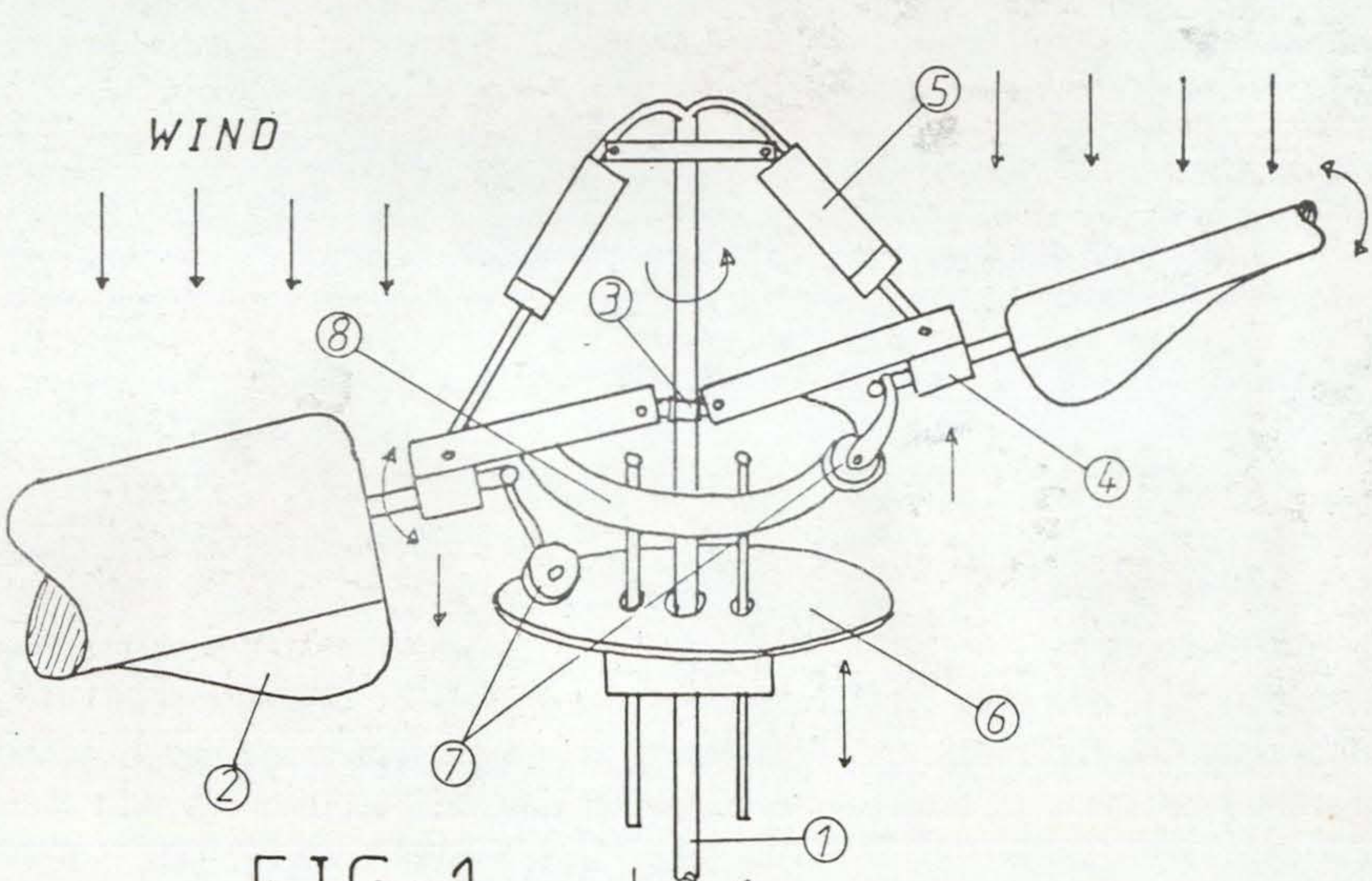


FIG-1