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AYRS 98

DECEMBER 1983

WINDMILLS SAILS AND KITES

Sailboarding - Stewkie Semi-Sail Photo: Theodore Schmidt

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The Kielder Daysailer with 'Flying Gaff' rig.

The 15' 6" cruiser by Mally Ghyll Boat Design, Douglas, Isle of Man has a gaff mainsail but the luff of the sail leads forward and is tacked as a dipping lugsail keeping the mast to windward. A headsail can be set if required.

THE AMATEUR YACHT RESEARCH SOCIETY

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

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Editorial Comment - R.Michael Ellison

There is a lot of research being done and some new ideas. There are more old ideas which are now being developed because new materials make progress possible. The comment in publication 41 about the windmill model -"Though the model sailed well into the wind there were high stresses inside the gears, which would not be practical for a full scale boat". On this line of thaught I publish a note about the schooner "America".

From the "America" to "winged keels" is a long way but now we look forward to more exciting new ideas. Members know of our papers on 'vortex generators'. Can it be because our publications are <u>much</u> more expensive in Australia that members there read them with more care ? Graeme Ward has prepared a report on the subject which I look forward to typing for the next number.

To members who write in and point out mistakes and errors I say thank you - this is the way to make progress. Please go easy on the maths, I am a little rusty but usually get there in the end. Other members do not have the time.

I reprint the letter from Howard D. Stephenson. sadly it is reduced in size. It was a joy to receive and I hope it will encourage readers to continue to support the Society.

<u>Bruce and Frank Numbers</u> - Clarification !

Note from K.R.May, Brook House, Middle Street, Salisbury, Wiltshire.

The note on page 28 of number 97 from Multihull International is clearly and correctly presented in that journal but somehow in the transposition has become garbled to a confusing nonsense.

Bruce Number is the square root of sail area divided by, not the displacement as stated, but the <u>cube</u> root of that parameter. Hence in the example quoted B.N.= $\sqrt[2]{300}$ divided by $\sqrt[3]{900} = 1.8$ Similarly for the metric side. The figure of 14.05 which appears from nowhere is the volume of sea water (density 1.02) which weighs 900 lbs and 0.40 is the cubic metre equivelent of 408 Kg of sea-water. The cube roots of these should have been shown as dividing into the root sail area to yeild the stated Frank Numbers.

Clearly it is more scientific to use self-consistent units to get dimensionless ratios, so that they always have the same number regardless of the chosen system of units. It is true that the water density effects the Frank number, but when the cube roots of water volume is used instead of cube root of weight the difference in the final result between sea and fresh water is less than 1% so is negligible.

It is reasonable therefore to take water as being 64 lb/ft^3 and 1020 Kg/m^3.

142, Agincourt Ave.,
Belfast, BT.7.1QD.
8th Oct, '83.

Dear Sirs,

Marooned as I am on a peasant island, you will understand that here there is a dearth of inventive thinking, and boats tend to be 1930 designed monohulls, defying any new ideas, bludgeoning their way through the decades complacently.

When I leave school, I intend to change all of this and I am keenly interested in revolutionizing the concepts of sailing, whose advocates over here are usually afraid of change and terribly traditional quite unlike you happy breed from the land of light and liberty.

I believe you posess a vast fund of research data, so, my hunger and ignorance being in parallel, I require to know how I can participate as soon as possible. Multihull design is my forte, but I have yet to produce, hence my anticipatory request for information,

I am, Sirs,

Yours Sincerely,

Howard D. Stephenson.

Editors Notes - Mainly for those not fluent in algebra !

Exceeding Wind Speed Down Wind

Reaching under sail at 24 knots in 16 knots of wind has been observed at sailing speed events. We note that kites can be flown in a spiral which looks like a figure of '8' thus greatly increasing the power obtained. Very large windmills have blade tip speeds that must put the apparent wind direction very close to the direction of travel but they still provide power to the generators.

Having carefully read and typed the articles by Theo Smitt, Reg Frank and Hugh Barkla I tried the "faster down-wind than the wind powered by the wind" proposal on a number of members and most have trouble in understanding how this is possible.

At school I drew boats in preference to learning latin verbs. One was to powered up wind by a windmill. The lecture I received about perpetual motion and why such things are impossible put me off course until Ken May's windmill driven model powered itself up hill against the wind on our stand at the 1970 London Boat Show. Several yachts have been powered by windmill (for the sake of confusion sometimes called wind turbines which is a better name if you are looking for a grant or a sponsor !). In New Zealand "Te Waka" a 9.4m (30')yacht powered by an 8m(26') three blade windmill driving a 0.9m (3') diameter propeller has been measured at 7 knots in 14.5 knots of wind. Her speed was almost constant on all courses.

Having accepted up-wind as practical many of us are having trouble in understanding the forces that work down wind. The first thing to accept is that this is not perpetual motion. No wind = no go ! The speed can not increase until the whole unit flies apart because as the vechicle or craft starts to move the apparent wind is first reduced and then comes ahead when the speed of the wind is reached. The power comes from the movement of the mass of air across the land or water. I have been told that a windmill vehicle with blades driven against the wind by gearing from the wheels has exceeded wind speed down wind. I also heard that ice yachts can leave point 'A' at the same time as a free balloon and arrive at point 'B', directly down wind, before the balloon by tacking down wind.

In the case of the kites and ice yachts the sail travels further than the free air and, by obtaining more 'lift' than 'drag' from the airfoil is able to "gain ground" in the same manner as when going to windward by tacking. It is a small step to consider the sails on a windmill to be close-hauled to the wind while the vechicle maintains a straight course thus - as Theo Smitt points out - reducing the wind drag and surface drag of the craft which covers less distance. In this mode it is not possible to reach wind speed.

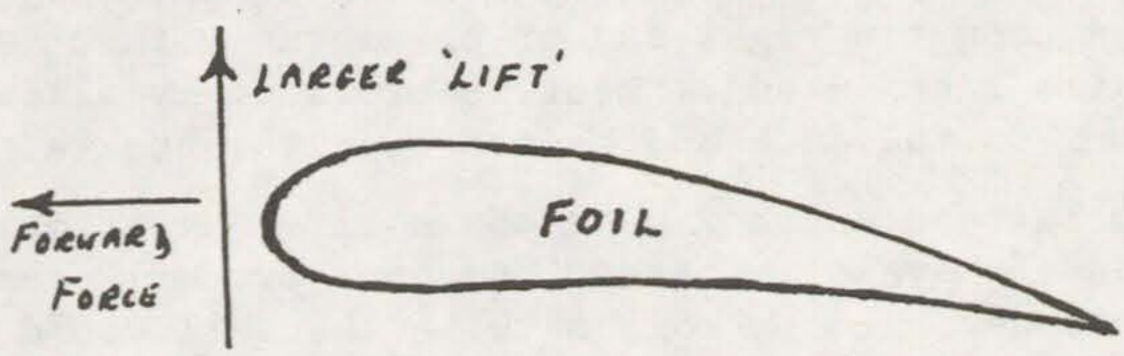
Consider an aerofoil which in the case of a powered glider is able to maintain height with a very small power requirement. If we cut off one wing and put it upwards we can picture a sail with air movement provided by wind rather than engine. By using an aerofoil hull shape we repeat the 'gain' as the hull will follow the line of least resistance and move forwards so long as the force from the aerofoil is forward of the beam.

It may be helpful to consider wings, sails, windmill blades, hydrofoils, yacht hulls and propellers as all using the same fluid flows to obtain a lot of 'lift' for a small amount of 'drag'.

The change of direction of force used through moving parts to obtain power is used by windmill blades, hydrofoils and ships propellers. For many years I wondered why paddle steamers were less efficient than screw driven ships and have never seen the aerofoil shape of the propeller put forward as the reason.

To get to wind speed down wind we must reduce drag and this can be obtained by hydrofoils. John Morwood recently said that a craft displaces its own weight of water when moving. Even 'on the plane' the hull leaves a hole behind which she would fill if she stopped. Clearly this is not true if the hull is lifted out on foils - the drag is greatly reduced - and there is no hole ! Like the powered glider our problem is the extra power needed for take off.

I hope I have not added to the confusion.



Roller Reefing Note from Brian A Naylor, Rossmore, Hillside Rd., Ash, Aldershot, Hants.

I found myself being forced to reconsider the ordinary roller boom reefing whilst looking for a cheaper way of remote reefing with the same simplicity of operation as, say, the Stoway or the Fjurgstrom. The former requires an expensive mast section and internal gear and the latter requires a stayed and rotatable mast.

To achieve the simplicity of operation I felt that halyard adjustment had to be automatic so I joined it to the boom drum-rope which can be actuated via transfer pulleys by a winch placed by the side of the hatch. It is difficult of course to ensure constancy of luff tension and the sail must be cut and roped in a way that reduces the effect of such tension. The halyard is made of rope of the same diameter and type as the drum rope and they are joined at a slider which carries the necessary two joining cleats and a spring giving some compensation for the discrepancy developing the rolling-up sail and the unrolling drum (or vice versa). The action causes the cleat mounting to ascend or descend the mast on a track. In an emergency the halyard could be snatched out of its cam-cleat if the rope is not out of reach, which it could be if a boat somewhat larger than mine (22') were fitted with the gear.

Though the angle between mast and boom is acute as you suggest, (Pub. 97 page 12) I did not find that to be of much importance in a remote gear - the important consideration was the matching of take-up on luff and leach by (1) ensuring that the bulk of the sail attachment at the tack was kept down, and (2) reducing the boom section at that point to cope with that and ensuring that less than the full boom circumference is taken up in the early rolls. Additionally a roller set on top of the gooseneck bolt pushes the luff aft slightly to stop rolling exactly on top of the previous round. The luff rope is led back into the groove by means of a common double-ball fairlead.

This gear works quite well, especially if the starting point is the middle reef so that discrepancies are kept to a minimum. It is necessary to un-jam the sail by coming up into wind and/or letting out the halyard before reefing or 'unreefing', but no topping lift movement is required. Otherwise the whole operation is very simple so that one always uses the right amount of canvas without any reluctance. An extra tension adjustment is provided by allowing the winch to swivel on the deck and be set by a turnbuckle.

I am against battens as they wear the sail and get lost if not stitched in and I have eliminated them, but properly shaped and orientated ones designed to roll up with the sail could be another way of combatting boom droop.

Roller Reefing Gears - Some problems to cure

Note by Michael Ellison.

The majority of sailing yachtsmen have realised the advantages of roller reefing headsails but which type is "best" and what problems to guard against still worry many.

The worst problem members report is the part furled sail with its halyard wound in that can neither be released or stowed. Gears that do this have a halyard to a slider which moves over the forestay spar. If the angle between the stay and the halyard is small and the swivel sticks the halyard winds round the spar and jambs solid. Two reported cures are to send a man aloft or to cut the sail with a bread knofe tied to a boat hook.

The next problem is failure of the reefing line to the cockpit or the cleat to which it is secured. The sudden extra sail area could be dangerous, especially to a multihull. The cure is to have a locking pin which prevents the drum rotating and use it in strong winds or if the yacht is left with the sail furled on the spar. A regular check for chafe and a fixed cleat rather than a quick release cleat should prevent trouble.

Setting a storm jib or light wind headsails worry several members. Usually a light headsail can be set flying on the spinnaker halyard without much trouble from chafe and the storm jib can probably be used in the same way if it is only being used as an emergency replacement for the roller headsail, perhaps hanked to the downhaul part of its own halyard which could lead back through a block on the stem head providing that the stem head fitting will withstand an upward pull. To be used for the storm sail in rough conditions the halyard would need to be wire and the sail set aft of the furled headsail to be able to tack and to avoid chafe both of the sail and the forestay at the masthead. The two parts of the halyard could perhaps be secured to the anchor winch providing again that it can withstand the loads imposed by a flogging sail in gale conditions.

In a gale I found that a small corner of the headsail sheeted in hard was enough on its own to hold my yacht steady and pointing to windward when the helm was secured to bring her into the wind. The cloth weight of my sail is that of a number two genoa which is satisfactory for most cruising conditions but not heavy enough for a storm in open water.

The less expensive reefing gears have a halyard block at the top of the extrusion and a spare line is sent up when the sail is lowered. The use of this block means that the halyard tension puts the 'spar' into compression so that it tends to sag but it leaves the 'normal' halyard free for setting a second sail or for emergency use. Keeping one roll of sail round the spar wraps the halyard against it thus reducing windage and sag to leeward.

Kite News From Theodor Schmidt, 26 Fore St., Evershot, Dorset, England DT2 0JW

This report follows the kite article in publication 97 and describes a few recent developments.

Keith Stewart's firm Stewkie Aerodynamics has improved their Para-sail (an inflated rectangular kite with multiple shroud lines like a parafoil, the ancestor of the modern ram-inflated parachutes). It is now easier to handle and can still be parked upside down on the water and launched from there.

Another modification of the above kite has resulted in a semicircular planform and a thickened profile, resulting in positive buoyancy when filled with baloon gas. This kite, called the "Semisail", can be used in the lightest of winds and can be made to pull up to typically 60 degrees either side from downwind while remaining remarkably stable in a wide range of wind speeds from calm to fresh. It is completely stable in a steady wind and can either be flown from a single line, setting its horizontal angle by attaching a weight in a specified position (this can also be done by radio control) or more usually on two lines, the steering being effected by pulling on the 'wing tips'. Flying in a static position, it needs very little attention. Long lines are not necessary, but if these are used the kite can be steered around the sky dynamically, thus increasing the pull by two or three times.

Filled with air, these kites are not as stable and can't fly in very light winds but in stronger winds the difference is less marked.

This year has seen more kite sailing than ever before with several people using Stewkie kites on sailboards and various small craft including a small Wharram catamaran. Keith Stewart has been happily sailing around on his new "Kite Yacht V" (an enlarged version of last year's proa) and I have been experimenting with all sorts of kites on canoes, culminating ia a recent passage along the coast from Lulworth Cove to Weymouth, pulled most of the way by a tiny parafoil. "Jacob's Ladder" team are thinking about hydrofoils and some preperation is going on in Cornwall for an Atlantic crossing by kite.

A good year for kites. What has 1983 shown so far ?

In very light winds the buoyant "Semisail" is superior to any sail, particularly in swell, as rolling which can spoil the performance of a sail has little effect on a kite.

In moderate winds many types of kites can be used and reaching or running over ten times the driving force of a sail can be produced by a fast-moving kite of the same size.

In strong winds, 'Flexifoils' have been shown to work very well, even in force 10 storms.

Thus kites can be used in most circumstances, but not as universally as sails, particularly in turbulance or in confined spaces. Also, while kites work fine once in the air, getting them there and back is another story and each kite has its own launching and handling problems...

Much more work needs to be done in this field and the BP oil Company have made a start as shown in their patents describing methods of launching and retrieving kites on shops. (GB patents 2098946 to 952).

I would be pleased to hear from anyone with news of any other recent kite sailing activity.

Stewkie Semi-Sail Photo Theodor Schmidt.

Error in 'Kite' Calculation - Publication 97.

Theodor Schmidt writes to say that page 8, line 5 of number 97 should read ....the kite's aerodynamic drag angle, which is arc tg (D/L). For small angles the result of not using the tangent will be similar but the error will increase as the angle.

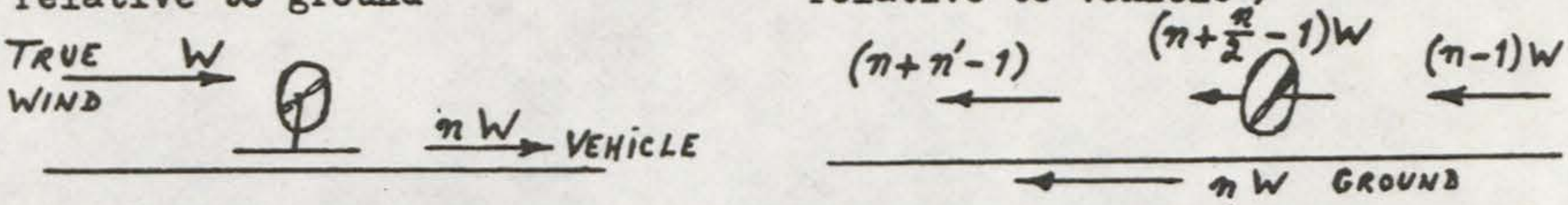
<u>Downwind Faster Than The Wind</u>

From H.M.Barkla, 4 Irvine Cres.
St.Andrews, Fife, KY16 8LG.

The following argument is based on the power of a mill or propeller being equal to the product of the thrust and the velocity of the fluid through the disc. It is shown appendix that, within the limitations of the actuator-disc or streamline theory, this is true and is consistent with the change of velocity of the fluid being equally divided between the upstream and downstream sides of the disc.

<u>On Land</u> - The vehicle's speed will be taken to be nW, where $n > 1$ and W is the true wind speed, so that the apparent wind relative to the vechicle is (n - 1)W from ahead. If the propeller accelerates the air to (n + n'- 1)W relative to the vechicle, the relative velocity at the disc will be $(n + \frac{n'}{2} - 1)W$.

Air & Vehicle relative to ground — <u>VELOCITIES</u> — Air & Ground relative to vehicle



Resistance to progress on land, composed principally of friction in bearings, in gears and in tyres, is probably more appropiately considered as part of the power loss in transmission between wheels and air propeller, so that, in the steady state, the forward thrust from the propeller can be equated to the backward thrust on the periphery of the wheels. These equal and opposite thrusts will be taken to be T.

As long as n'/2 1, the velocity nW with which the ground drives the wheels exceeds the velocity (n + n'/2 - 1)W of the relative air stream at the propeller disc, so that, the thrusts being equal, the propeller absorbs less power than the wheels generate, and the difference is available to meet the power loss in the transmission.

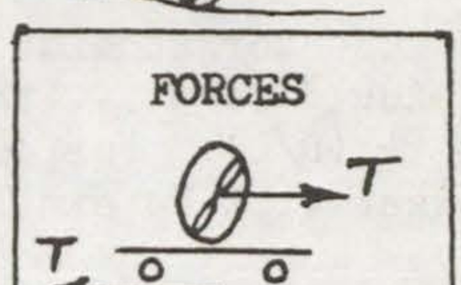
The magnitude of n' may be controlled if the gearing (including variable pitch) is variable. Two simple cases will now be considered, n' having values 1 and 2.

<u>n' = 1</u> — <u>AIR VELOCITIES</u>

Relative to Ground — Relative to Vehicle

behind vehicle — ahead of vehicle

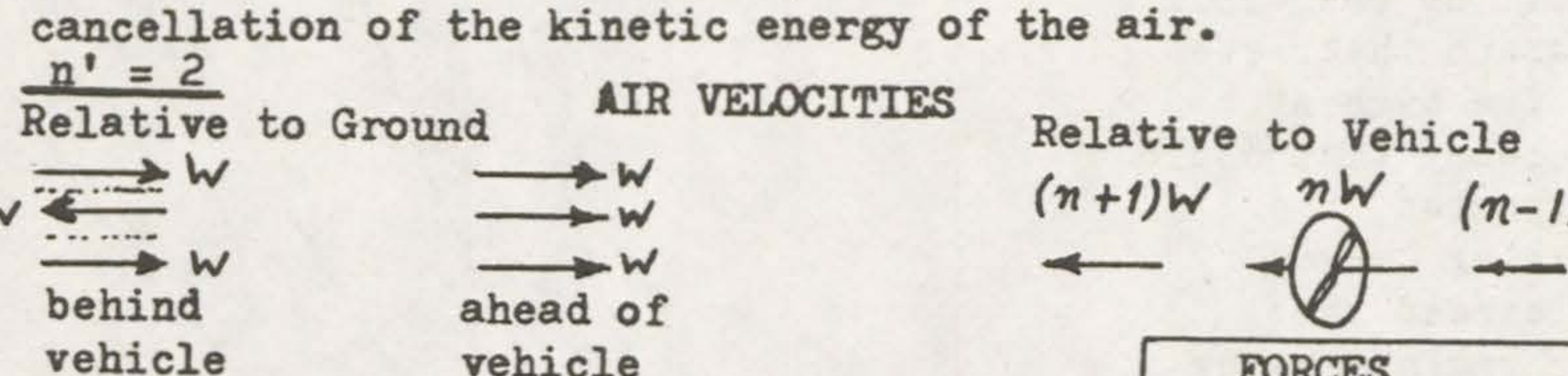
Power absorbed by propeller = $T(n-\frac{1}{2})W$
Power given by wheels = T n W.

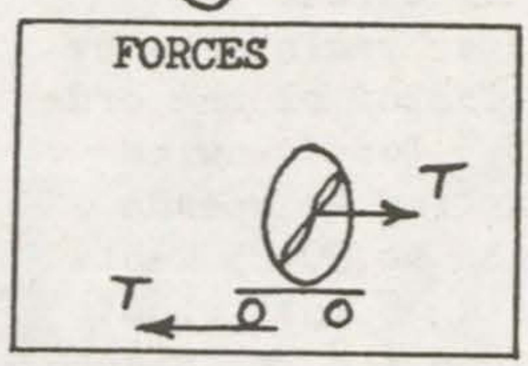


Required efficiency of transmission of power from ground to air $\eta = \frac{T(n-\frac{1}{2})W}{TnW}$ i.e. $\eta = 1 - \frac{1}{2n}$

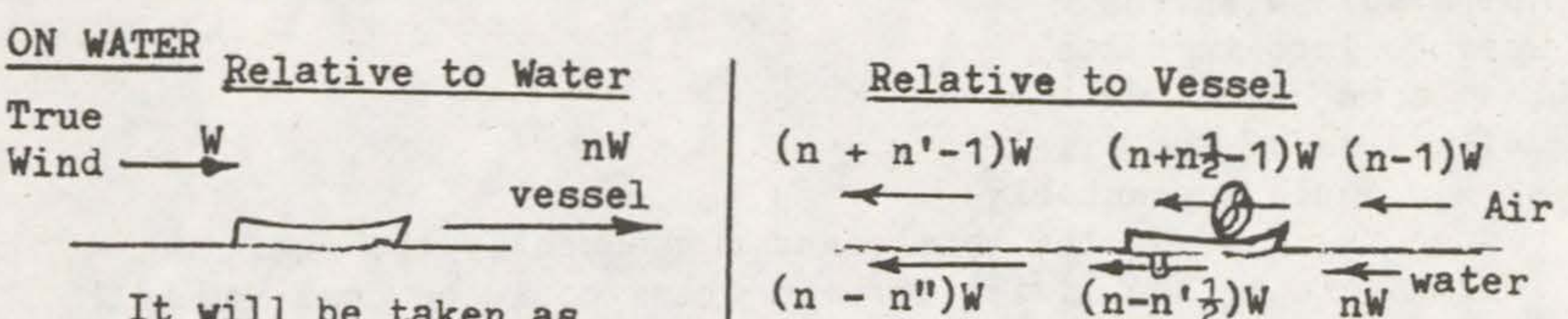
the higher the efficiency, the higher may be the vehicle speed relative to the wind speed; eg. if = 0.75, n = 2, and as long as 0.5, n can exceed 1.

A tube of air in the wake of the propeller being at rest relative to the ground means that the kinetic energy of the true wind has been completely extracted from this portion. In the context of the present problem this is, then, the condition for the maximum utilisation of the energy of the wind, but it is of interest that a different condition is obtained if the power delivered by a propeller of a given area is maximised in terms of n' as variable; for if the propeller were to add a slightly greater velocity to the air, (n' slightly greater than 1), leaving a small negative velocity relative to the ground, the increase of mass-flow would more than compensate for the less perfect cancellation of the kinetic energy of the air.

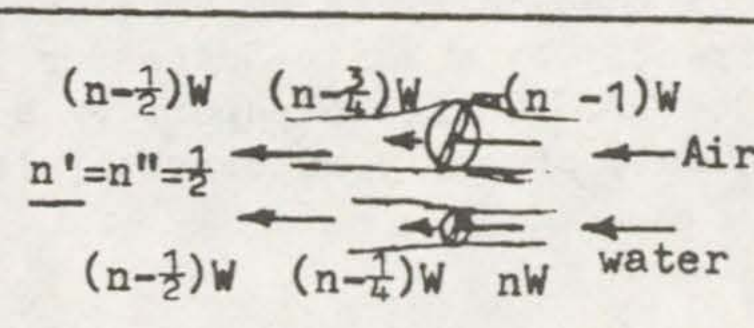




Since the power required by the propeller (= TnW) is equal to the power from the wheels, this can only be an ideal limit, attainable with 100% efficiency. There is, in this case, no upper limit to the value of n. The reversal in direction of a tube of air in the wake of the propeller indicates, within the accepted limits of theory, that the total kinetic energy of the air treated is unchanged, ie no energy has been extracted. Perfect efficiency correspondingly implies zero resistance, no energy being needed for overcoming friction.



It will be taken as axiomatic that full utilisation of the relative velocity between air and water requires equal final velocities for the treated streams of air and water, ie n' + n" = 1.



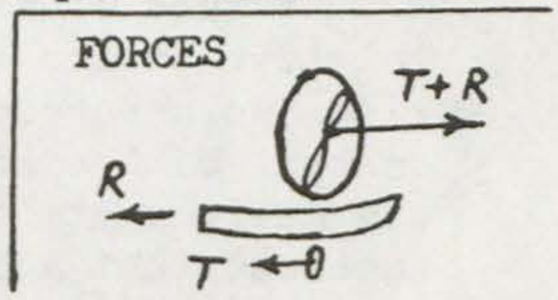
We will consider only the case of

$n' = n'' = \frac{1}{2}$.

Then: power from the watermill = $T\,(n - \frac{1}{4})W$

power needed by propeller= $(T + R)\,(n - \frac{3}{4})W$

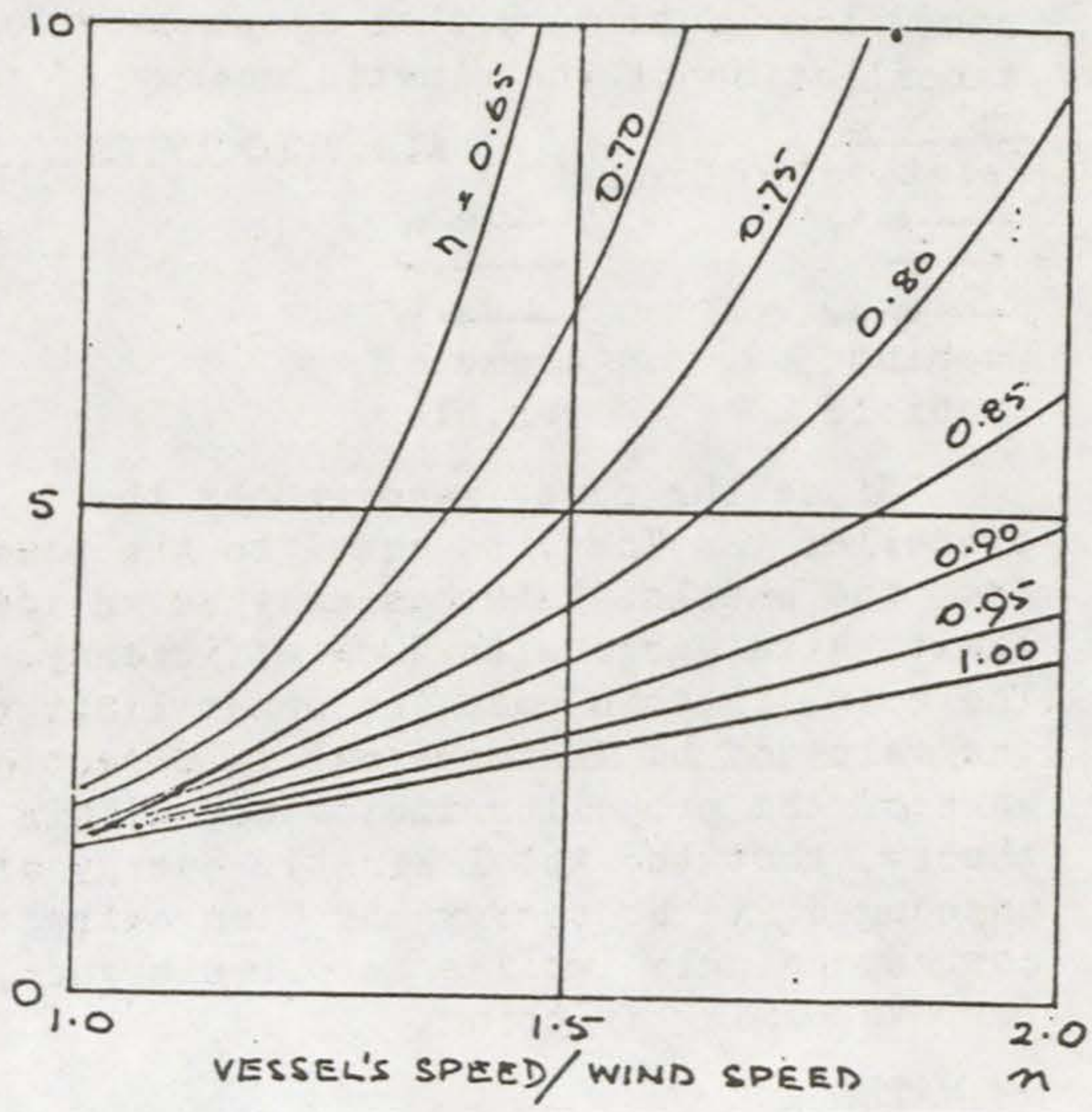
Taking the overall efficiency of transmission of power from water to air to be η. $(T + R)(n - \frac{3}{4})W = \eta\, T(n - \frac{1}{4})W$



$$\frac{\text{propeller thrust}}{\text{resistance}} = \frac{T + R}{R} = \frac{1}{\eta\,\frac{n - \frac{1}{4}}{n - \frac{3}{4}} - 1}$$

PROPELLER THRUST
RESISTANCE

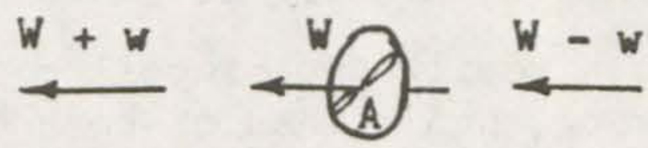
$\frac{T + R}{R}$.



It will be seen from the graph that, even with the highest efficiency that could be expected, the propeller thrust must exceed the water resistance by a factor of the order of 5 for downwind sailing at speeds such as 20-25 knots in a 15 knot wind. Since the resistance of a planing vessel is of the order of one fifth of the weight, the propeller thrust has to be comparable with the weight. This suggests that some downward deflection of the air stream could appreciably reduce the load on the water, and consequently the resistance. Taking this to the limit, forward drive could be combined with 100% load-carrying by a helicoptor rotor, preferably driven directly by a Voith-Schneider Prop/mill ! (The airship of my 1964 IPPS Bulletin paper, -- and lectures at least from 1952, -- would probably be slightly less unpractical.)

APPENDIX THEOREM FROM ACTUATOR-DISC TREATMENT

It is fairly obvious that the power required by a propeller must be equal to the product of the thrust generated by it and some fluid velocity. How this velocity is related to the velocity upstream and that downstream is not so obvious. Elementary actuator-disc theory will be used to show that the mean of the upstream and downstream velocities is what matters, and so, if the acceleration of the fluid is taken, as is the usual practice, to be equally divided between the upstream and downstream sides of the disc, this makes a consistent picture.



Taking the fluid velocity at the disc to be W and assuming the increase to be w equally on the two sides of the disc, then

mass flow $= \rho AW$ ...(1)

then rate of increase of kinetic energy of fluid in streamtube $= \rho AW\left[\frac{1}{2}(W+w)^2 - \frac{1}{2}(W-w)^2\right]$

$= 2\rho AW^2w$

ie power delivered to fluid by propeller $P = 2\rho AW^2w$ ....(2)

now rate of change of momentum of fluid in streamtube $= \rho AW(\,(W+w)-(W-w)\,)$

$= 2\rho AWw$

ie thrust on propeller $T = 2\rho AWw$ ...... (3)

Since, from equations 2 and 3, $P = TW$ power delivered by propeller = thrust on propeller x fluid velocity at disc.

Equation 1 is based on the velocity at the disc being the mean of the upstream and downstream velocities, so that we can say

POWER DELIVERED BY PROPELLER = THRUST ON PROPELLER x MEAN OF VELOCITIES UPSTREAM AND DOWNSTREAM.

From Hugh M.Barkla, Oct 1983.

"The Sea People" is a new magazine mainly for owners of James Wharram designs. Cost is £ 3.00 or U.S.A. $ 5.00 for two issues the first of which has just been printed and includes surface post. Produced by James Wharram Associates the 28 pages contain interesting articles about ocean cruising, new design for 'micro multihull' class racing, a 'dolphin link' project and film making from "Tehini", naturist sailing, chartering and fishing all involving their designs and suitably illustrated. Not connected with "The Sailorman" which is the journal of the Polynesian Catamaran Owners Association over which Jim has no control and from which he recently resigned. The address is :- James Wharram Designs, Greenbank Rd., Devoran, Truro, Cornwall TR3 6PJ.

Windmill Boat Propulsion

by W.R. Frank B.Sc.,
87 Staincross Common, Mapplewell,
Nr. Barnsley, Yorkshire S75 6NA

This article studies a 20ft diameter windmill, with parallel sided blades, and uniform twist angle, suited to amateur construction.

Rectangular blades sacrifice some power, but not much. Uniform twist angle reduces the range of rotational speeds; but there is still adequate speed range left.

Windmill and propeller are coupled through variable speed gearing, and blades of both are adjustable for blade angles. Note that for a windmill, increase in blade angle reduces the angle of attack; the opposite for propellers.

Windmill and propeller seem likely to work well together; because windmill power reduces as it spins faster, whilst the propeller demands more power as it rotates faster; the combination will find an equilibrium.

Comparing windmills with sails. Against the wind, for the same speed made good to windward the boat goes slower than a craft tacking; so hull resistance and windage are less.

Downwind; windmill swept area is likely to be less than sail area, but the windmill is more efficient, and in the numerical example later, going at 30% wind speed downwind, windmill and propeller generate twice the thrust compared with a sail of area equal to the swept area.

At other headings to the wind, auto gyro, with rotor spinning freely, seems likely to provide less power than using the propeller. The windmill sailor will find out windmill pointing direction gives most power. He can set the windmill like a sail nearly edge on to the relative wind, or it can face the relative wind or true wind. A keel is needed.

Mathematics and Explanation

In graphs, I have used symbol 's', representing the ratio, rotational speed in radians per second, divided by free wind speed in ft. per second. So 's' is small when rotational speed is small, but also when wind speed is high. 's' is big when rotational speed is big, also when wind speed is low.

Graphs plot 's' against power, and against axial force, and one graph shows how wind speed, angle of attack, blade axial force, and power vary with 's' for a part of the blade.

On these graphs, if we take a value for 's', then go vertically, we get variations in force and power with changes in blade angles. As the adjustment angle is made bigger, blade angle 'theta' reduces. It sometimes goes negative. Power rises, as blade angles are reduced, to maximums and then decrease. The decreases are complicated. They start at the outer radii, and here the blades start operating as fans, taking power from smaller radii, putting it back into the wind. It seems likely that this region of smaller blade angles will be unstable.

On the left side of graphs, power drops off quickly, and this is because angles of attack rise steeply and blades stall. On the right hand side power reduces, and probably more than graphed because blade surface drag becomes more important.

<u>Blade Length</u>. In the example, I have cut out the inner 40% of the radius, losing only 16% of the power, but allowing uniform twist angle along the blades.

<u>Twist Angles</u>. Suppose that air is moving past a blade at 30 feet per second, and the blade is moving at 100 feet per second. When feathered, no lift, the blade is inclined at an angle, 'delta' in the diagrams, whose tangent is 30/100. At the speeds used, and for the accuracies required, we can use the value of the angle in radians and take this as being 30/100 to simplify calculations.

Since linear speed of rotation is proportional to radius, twist angles will have tangents which are inversely proportional to radius. At the hub, nearly a right angle. That is why it pays not to use the inner 40% of radius.

We want to use uniform twist which will be correct in only two preferred places. We need to find out whether the departure from ideal is going to have excessively bad effects. (it does not)

Now refer to the vector diagrams. We can decide on a value for angle of attack for rotational speed, and for wind speed through the windmill. Then, at one preferred radius, which I made 8.5 feet, estimated the corresponding chord width. This is the width at that radius for all the blades added together. I then made the blades parallel at that width. The blades will now work as expected only at 8.5 feet radius, because, everywhere else, twists and chords are "wrong".

So what happens ? So far, I have not found any way of finding out graphically. We have to rely on some rather complicated algebra, then repeat the calculations scores of times. Easy for a little computer.

Members who have not been blessed, (or cursed), by training in mathematics can skip all the explanations and use the formulae. The graphs apply only to this windmill. If any reader wants his own design evaluating, full size or model, he could write to me and my little computer will provide answers.

What Happens ? Back to the vector diagrams. I am assuming that readers will accept that these are valid. Academic justification is 'the diagrams rotate at windmill speed'.

First assume that wind speed through the blading remains constant, V.(1 -n -p). If rotational speed increases angle 'delta' which was our twist angle, reduces. So the angle of attack, 'alpha' reduces too. So 'Lift' reduces. But blade speed has increased, so lift has increased. Whether the nett result is increase in lift or decrease, the push against the wind has altered; so wind speed through the blading has altered. We don't know what the end equilibrium will be.

('Theta' was the blade angle after rotating , to get lift).

It can be set out as an algebraic equation, terms sorted out, giving a quadratic which can be solved. Repeat many times for different circumstances.

Windmill theory applied to boat windmills.

AYRS 81, 'Power from the Wind' explains. Here we go a bit further and relate power and axial force to speed of rotation and blade angle setting.

Divide the blades into sections at radii 'r', radial span 't'. Take all the chord widths at that radius, and add them to give total chord 'c'.

The windmill rotates at 'omega' radians per second, so the linear speed at radius 'r' is (ω.r.).

The swept area for this section is (2 π.r.t.)

Total blade area is (c.t.) at radius r.

Formulae

Force = change in momentum per second = mass per second times its change in velocity.

If n is the ratio, boat speed/wind speed, and p is the ratio, reduction in wind speed through the windmill/wind speed, then: Relative (apparent) wind speed = Wind speed V x (1 -n), where n is positive downwind, negative against the wind.

Wind speed through the windmill, relative to the windmill = V.(1 -n -p).

Mass per second passing through the windmill
$= \rho .2.\pi .r.t.V.(1 -n -p)$.

This mass loses speed V.p before the windmill, V.p. after the windmill, 2.V.p. in all.

1) Axial Force R = $2.\rho . 2.\pi.r.t. V^2.(1 -n -p).(p)$.

2) Axial Power = R. V. n. n is negative against the wind.

Rotational power, (ordinary windmill power)= R times wind speed through the windmill. = R.V.(1 -n -p).

Efficiency E = blade efficiency x gearing efficiency x water propeller efficiency.
Power given out by the propeller in pushing against resistance and axial reaction, = E. (R.V.) (1 -n -p)
The axial reaction opposes against the wind, helps downwind.

Formulae to use in design and calculations.

Formula 1, previous page, for axial reaction. plus :

3) Nett power = $2.\rho.2.\pi.r.t.V^3.(1-n-p)(p)(E.(1-n-p)+n)$.

The procedure now is to estimate the force F produced by the blades. Then equate with R, for each blade section.

We can draw a graph of equation 3), and find which numerical values for 'p' give maximum power for a specified 'n'. I found that 'p' = 0.3 suited both going to windward at 30% wind speed, and going downwind at 30% windspeed, when efficiency 'E' was 0.5.

We specify an angle of attack, and I used 0.8 radians, coefficient of lift approximately 0.4, likely to operate at minimum drag/lift.

Force R exerted by the wind. Force F, produced by the windmill.

Lump all the blade sections, span 't', at radius 'r'. They rotate at linear speed $\omega.r.$, OA in diagrams. 'Theta'= blade angle. Wind speed past the blades, V.(1 -n -p). BA in diagrams. $\omega.r./V = s.$ Tan Delta = (1 -n -p)/s.r. For high speeds of rotation, delta is small enough to use its value in radians instead of the tangent.

Angle of attack 'alpha' = delta - theta.

4) Angle of attack alpha = ((1 -n -p)/s.r.) - theta

Alpha is measured from zero lift angle, and considered equal to coefficient lift /k, where k = 5. More precise expressions can be used just as easily in a small computer.

5) Lift = $(k.\alpha)(\rho./2)\,c.t.\,\omega^2.r^2.$ When delta is small and cosine delta nearly unity. Axial force F is near enough equal to lift L when delta is small.

6) Axial force $F = (k)(\rho/2)(c.t.)(\omega^2.r^2.)(((1-n-p)/s.r.)-\theta.)$

Putting R = F we get an expression used for deciding on rotational speed, chord and design angle of attack at one particular radius.

7) $(1-n-p).(p). = \dfrac{k.\alpha.c.\,s^2.r.}{8.\pi}$

Combining 7) and 4) leads to a quadratic,

$$p^2 - p\left(1-n+\frac{k.c.s.}{8.\pi.}\right)+\frac{k.c.s.}{8.\pi.}(1-n-s.r.\theta.)=0$$

$$p^2 - p.B. \qquad + A \qquad = 0$$

8) Windmill solution. $p = \frac{1}{2}.(B - \sqrt{(B^2 - 4.A.)})$.

Use values for p in formulae 1) for axial force R, and in 3) for power. Nett thrust, which is propeller thrust minus axual force against the wind, plus downwind, is found by dividing power by boat speed.

Windmill Blade Design for boat propulsion.

Two or three blades, twenty feet diameter extending from four to ten feet radius. Operate at 15 radians per second = 2.4 revs per second, in a free wind speed of 20 feet per second, with boat moving at 6 feet per second against the wind. s = 15/20 = 0.75 n = -6/20 = -0.3

Efficiency assumed to be 0.5 allowing for blade drag, gear friction, propeller drag. Power from the wind was :
$2.\rho.(2.\pi.r.t.)\, V^3.\ (1 - n - p).(p).\ (E.(1 - n - p) + n)$.
A graph showed optimum 'p', for maximum power to be 0.3, not only for 6ft per second against the wind, but also for 6 ft. per second downwind. We now use the expression for the force R needed to slow down the wind.

$R = 2.\rho.(2\pi.r.\ t.)\ V^2.\ (1 - n - p).(p)$ and the expression

Axial force $F = \frac{\rho}{2}.k.\alpha.t.c.\omega^2.r^2$.

$$\frac{R}{F} = 1 = \frac{8.\pi.(1 - n - p)(p)}{k.\alpha.c.\ s^2.\ r}$$

I decided to use a radius of 8.5 feet, calculate the chord width for there, and use two parellel blades this width.

Coefficient of lift 0.4 comes from $\alpha = 0.08$ if k = 5. 0.4 for two reasons. Lift/drag is lowest, and we have some scope to increase the coefficient downwind without stalling. Inserting the numerical values and putting F = R gave total chord 'c' as 3.94 feet.

We could use two blades each about 2 feet chord or three of about 16 inch chord.

Twist

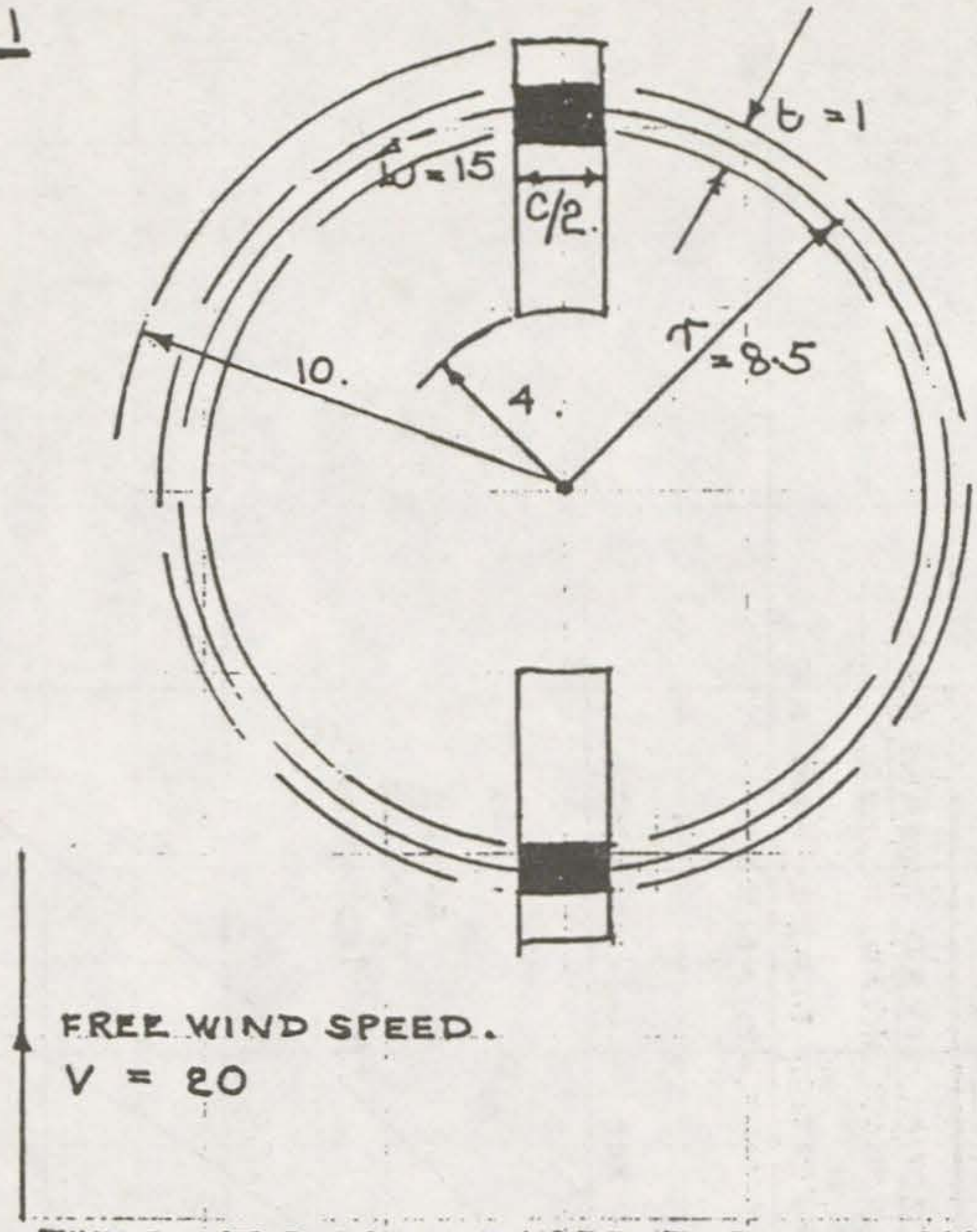
At radius 4 feet, linear rotational speed = 15 x 4 =60 ft per second. Wind speed through the windmill is 20 feet per second. Tangent of the delta angle is 20/60. I used 20/60 radians which is near enough. Tangent at 8.5 feet radius is 20/ (15 x 8.5). Difference is 0.178 radians.

If we use uniform twist with length, the twist angle at any radius is given by :
Twist angle at radius 'r' = 0.333 -((r -4) x 0.0395.)radians.
The blade will be turned through 0.08 radians to operate at angle of attack 0.8 and will then be at angle θ.

At 8.5 ft. radius, the blade will behave as calculated, but nowhere else. Question is; how will it perform at different radii, when using different blade angle adjustments and for different speeds of rotation.

We write, $A = \frac{k.c.s.}{8.\pi}(1 - n - s.r.\theta.)$ and $B = (1 - n + \frac{k.c.s.}{8.\pi})$
when $p = \frac{1}{2}.(B - \sqrt{B^2 - 4.A.})$ Use these values for 'p' in the expressions above for axial force R (which = F) and for the power produced.

FIG 1



WIND SPEED THROUGH THE WINDMILL AT RADIUS r

$= V(1-n-p).$

MASS/SEC $= \rho . 2\pi r t . V(1-n-p)$

CHANGE IN SPEED

Vp BEFORE THE WINDMILL

Vp AFTER " "

TOTAL $2Vp$

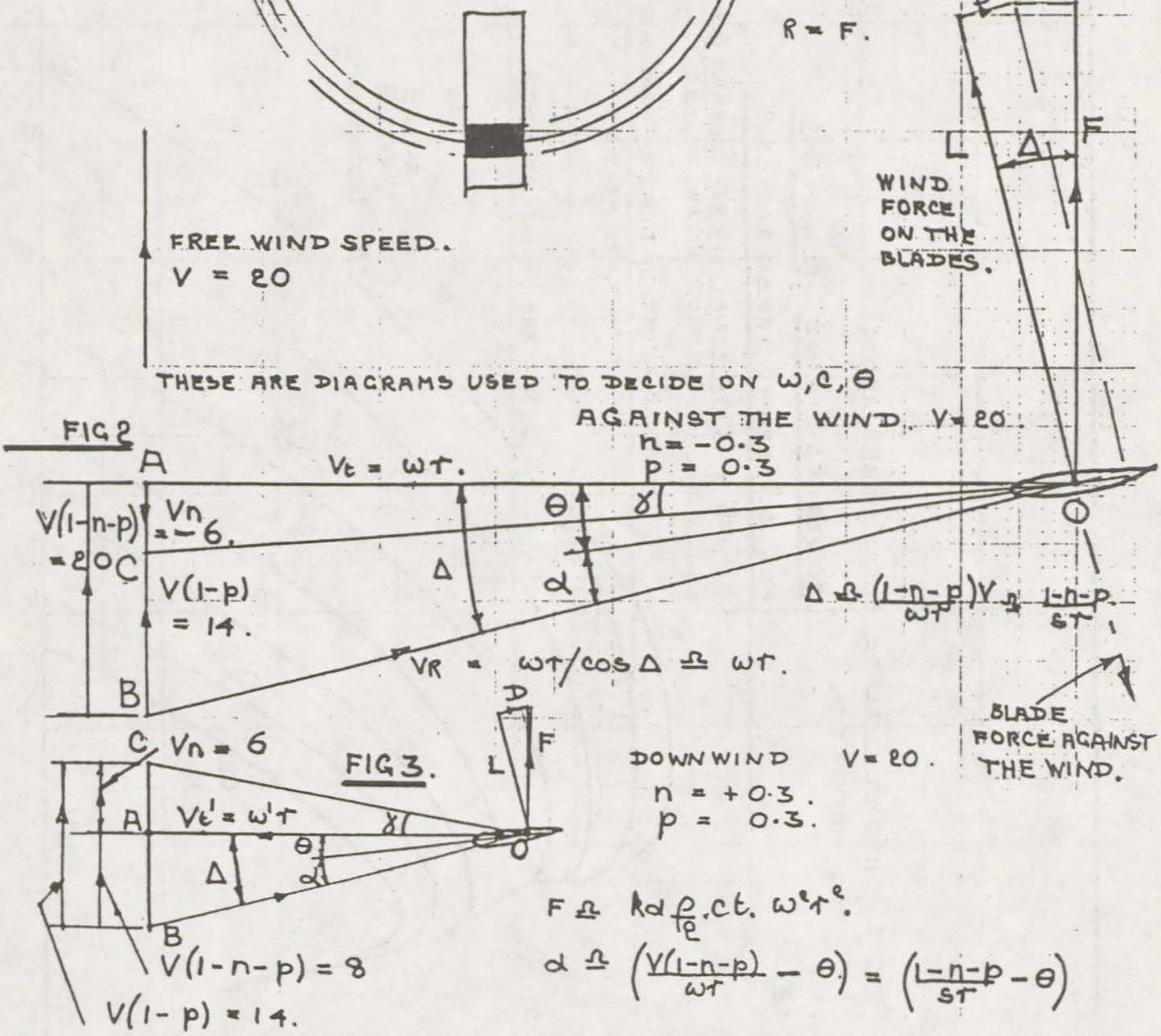
CHANGE IN MOMENTUM/SEC = AXIAL FORCE R

$= 2\rho . 2\pi r t . V^2 (1-n-p)(p).$

$R = F.$

THESE ARE DIAGRAMS USED TO DECIDE ON ω, C, θ

FIG 2



Δ IS BLADE ANGLE SETTING FOR NO LIFT

ROTATE THE BLADE THROUGH α, WHICH REDUCES THE BLADE ANGLE. θ IS THE ALTERED BLADE ANGLE. Δ ALTERS AS 'p' AND ω ALTER.

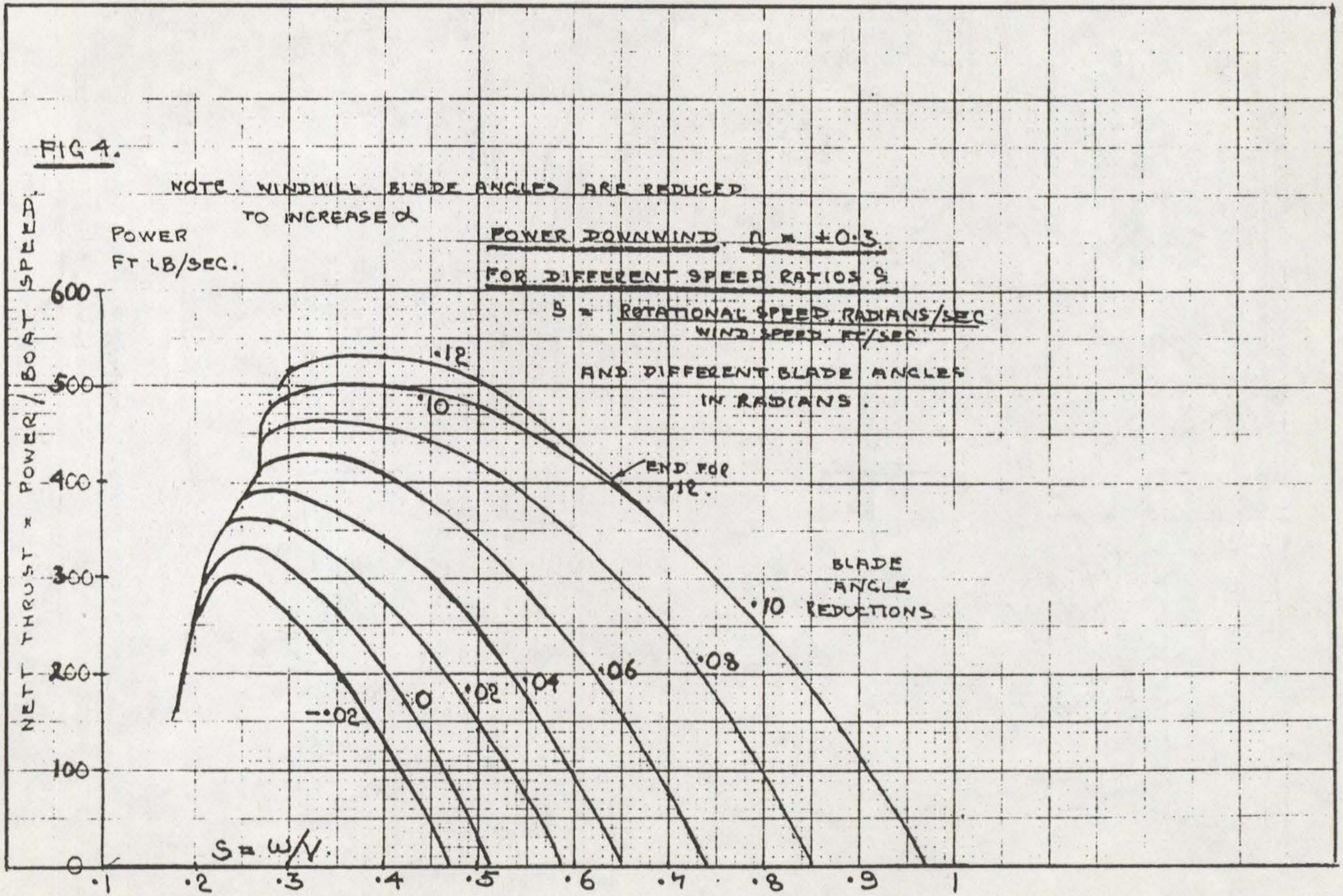
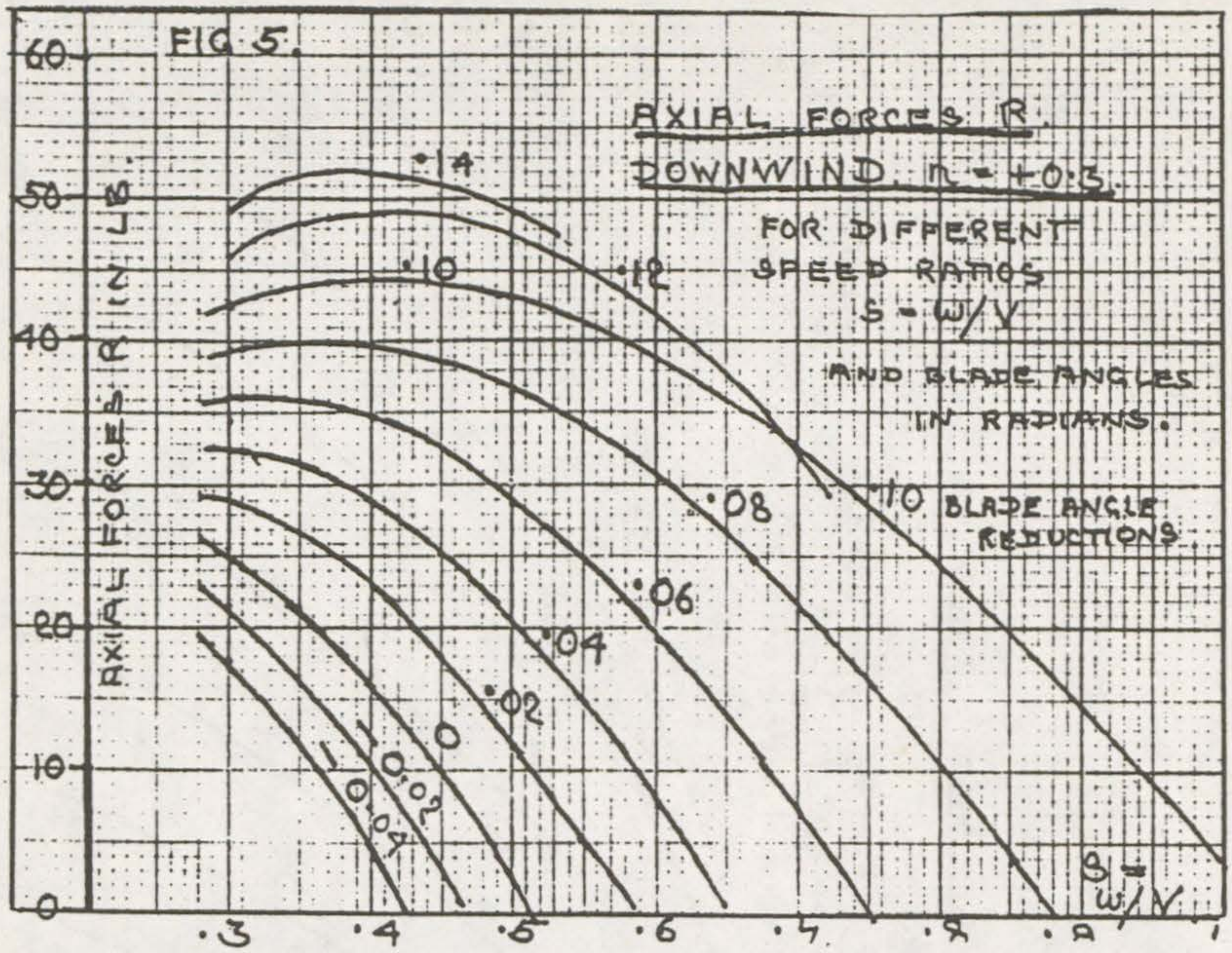
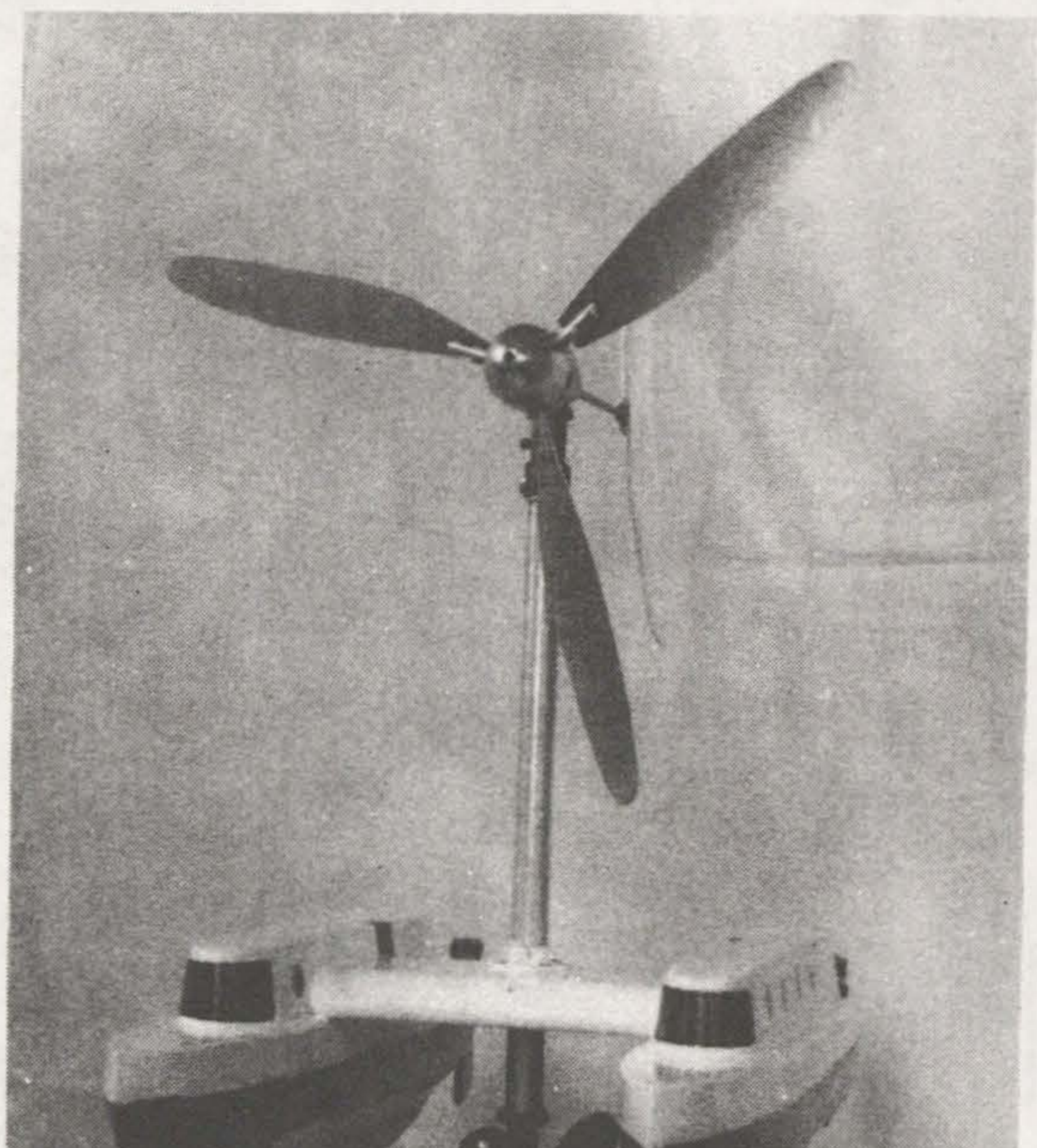


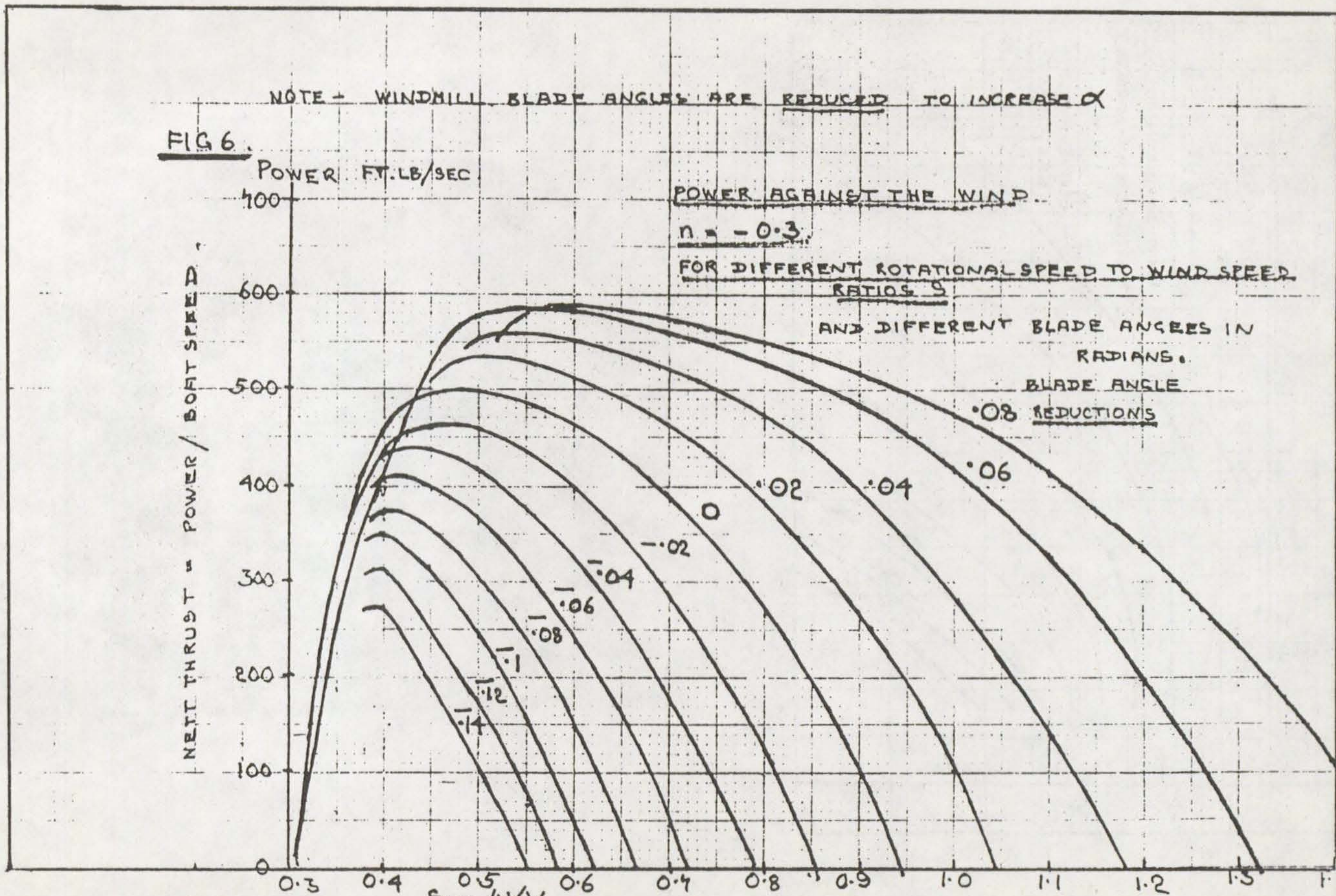
FIG 4.
NOTE. WINDMILL BLADE ANGLES ARE REDUCED TO INCREASE α
POWER FT LB/SEC.
NETT THRUST × POWER / BOAT SPEED
POWER DOWNWIND. n = +0.3.
FOR DIFFERENT SPEED RATIOS S
S = ROTATIONAL SPEED, RADIANS/SEC / WIND SPEED, FT/SEC.
AND DIFFERENT BLADE ANGLES IN RADIANS.
END FOR ·12.
BLADE ANGLE REDUCTIONS
·12
·10
·08
·06
·04
·02
0
−·02
S = ω/V.
600
500
400
300
200
100
0
·1
·2
·3
·4
·5
·6
·7
·8
·9
1





Publication 41, Page 39 shows this windmill .

Model shown on A.Y.R.S. Boat Show Stand 1962.
Model by W.Zalewski.


NOTE - WINDMILL BLADE ANGLES ARE REDUCED TO INCREASE α
FIG 6.
POWER FT.LB/SEC
POWER AGAINST THE WIND.
n = -0·3.
FOR DIFFERENT ROTATIONAL SPEED TO WIND SPEED RATIOS S
AND DIFFERENT BLADE ANGLES IN RADIANS.
BLADE ANGLE
·08 REDUCTIONS
·06
·04
·02
0
-·02
-·04
-·06
-·08
-·1
-·12
-·14
NETT THRUST = POWER / BOAT SPEED.
0
100
200
300
400
500
600
700
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
1·1
1·2
1·3
1·4
S = ω/V.

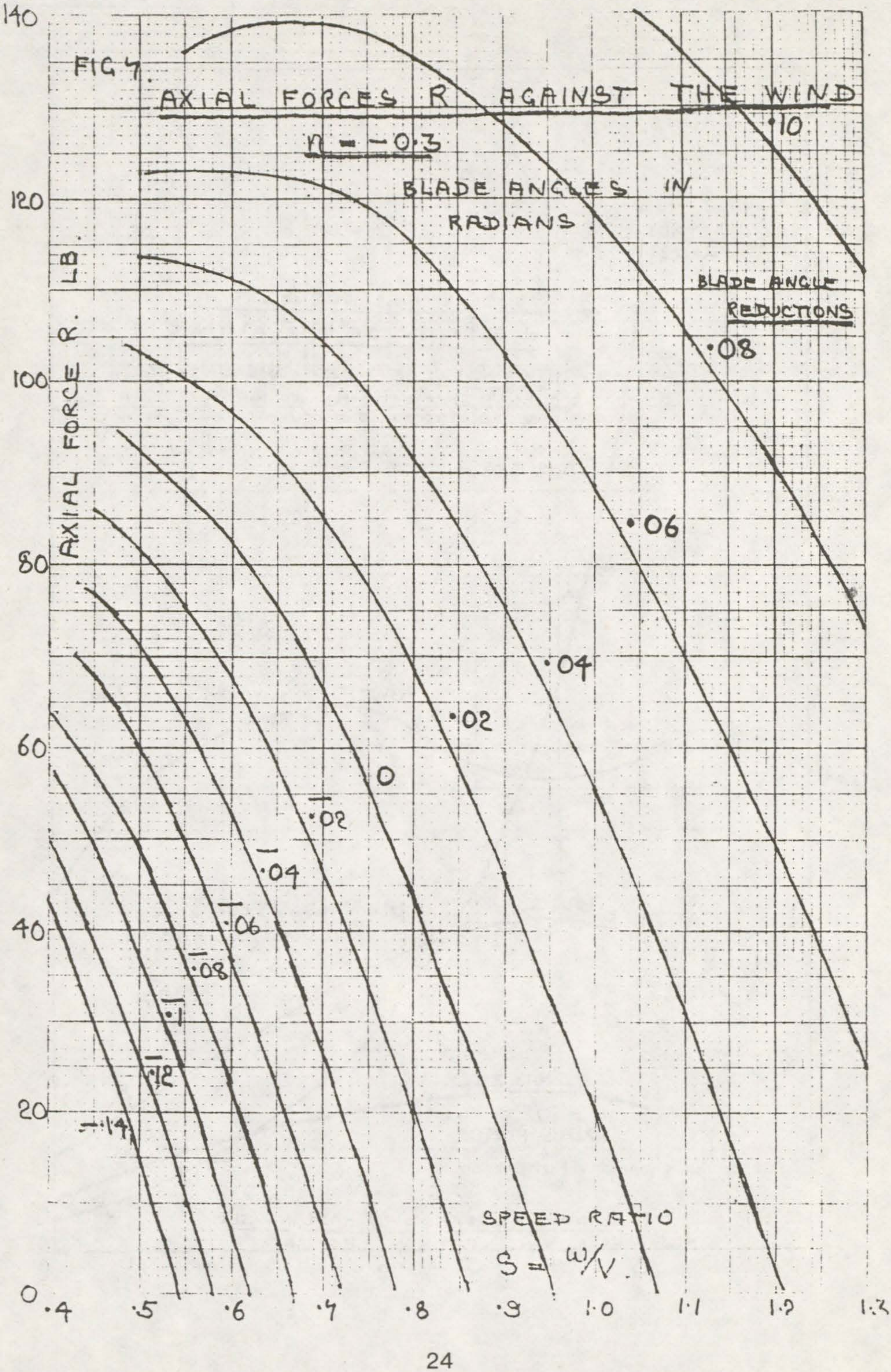
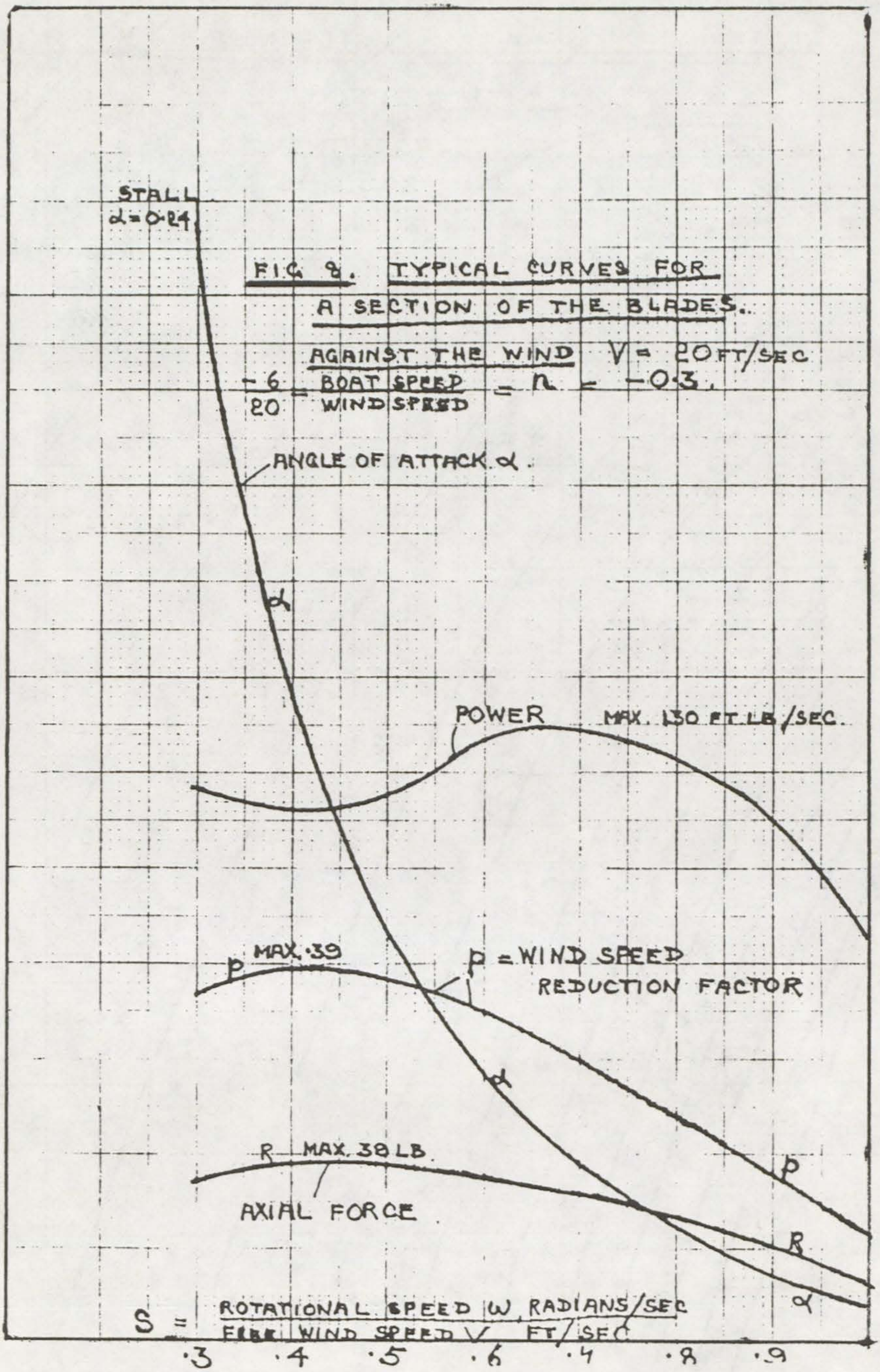


FIG 4.
AXIAL FORCES R AGAINST THE WIND
n = −0·3
BLADE ANGLES IN RADIANS.
BLADE ANGLE REDUCTIONS
AXIAL FORCE R. LB.
SPEED RATIO
S = ω/V.
·10
·08
·06
·04
·02
0
−·02
−·04
−·06
−·08
−·1
−·12
−·14
140
120
100
80
60
40
20
0
·4
·5
·6
·7
·8
·9
1·0
1·1
1·2
1·3


STALL
α = 0·24
FIG. 8. TYPICAL CURVES FOR
A SECTION OF THE BLADES.
AGAINST THE WIND V = 20 FT/SEC
-6/20 = BOAT SPEED / WIND SPEED = n = -0·3.
ANGLE OF ATTACK α.
α
POWER MAX. 130 FT.LB./SEC.
p MAX. ·39
p = WIND SPEED REDUCTION FACTOR
α
R MAX. 38 LB.
AXIAL FORCE
p
R
α
S = ROTATIONAL SPEED ω, RADIANS/SEC / FREE WIND SPEED V FT/SEC
·3 ·4 ·5 ·6 ·7 ·8 ·9

Whale-Tail Propulsion. Further comment.

From Egil Reksten, Grønsundvn 128, 1360 Nesbru, Norway. (4 July)

I do not wish to try your (Owen Lewis/AYRS) unit on my boat. It would have to be greatly modified as my boat is a flush-decked cruising cat with very high freeboard.

Your letters, and a close study of the photo of the 'whale tail' has convinced me that this is practically identical to a several years old Norwegian invention, patented in several countries by a company called "Wave Control Co."

This company has made many tests of foil propelled boat and ship models in wave test tanks, and some tests on smaller boats under actual conditions. Most of these tests have been with "passive" foils, i.e. foils operated by wave action only, but tests with power driven foils have also been conducted, and a small, hand driven catamaran has also been tested.

Last year I tried two of these foils on my boat, but unfortunately the connection between the "legs" and the foils was not strong enough, and broke before any conclusions regarding efficiency could be drawn.

All tank model tests have been positive and clearly show that a craft can be propelled at considerable speeds in all directions to the waves, by wave action alone. So far, however, simple and practical ways to attach and control foils in full scale have not been found (to my knowledge). I have heard that tests will be done with a fishing vessel this year, and this may result in practical solutions.

Properly placed foils will not only be able to propel a boat or add to the propulsive force of sail or engine; they can also greatly reduce rolling and pitching and thus make a boat or ship more comfortable, and increase efficiency of sails.

In spite of my unsuccesful attempt last year, I have not given up completely, and if I get enough time and energy, I may try again. If I should meet with success, I shall let you know.

Note - The unit was mounted on the 'wing' of "Sabu" for the 1982 'Round Britain' race. Being well forward there was no noticeable help from pitching movement. Due to her foils there is very little roll. The unit certainly works and is available for anyone to try if they wish. In its present form we think a skilled person with a large sweep could maintain the same speed with less effort by skulling but if the pedals were changed to a lever the whale tail might be better. Like any other unknown factor it caused some concern to other competitors and that has to be useful !

International Yacht Racing Union. Note on Multihull Committee
London 14 November 1983 by R.M.E.

London Meeting The Offshore Multihull Safety Rules were very carefully considered. I hope that no-one will be satisfied with the rule which resulted from the meeting but the draft was altered to take account of various conditions in different sailing waters and I hope they will be acceptable until improvements already proposed are considered in detail and brought back to be ratified.

Snap Hooks. The representitive from Germany proposed that the heaving line which is carried in the cockpit ready for use should have a snap hook on one end. It could then be instantly hooked to the lifebuoy or thrown to a person in the water to hook to their harness or pass it round and back to the standing part instead of tying a bowline. The hook has many possible uses. I shall fit one for 1984 and hope it is added to the rules as a mandatory item.

Sunshine and Warmth. The rules were drafted by Lock Crowther in Australia. In the climate of the holiday advertisements clothes and a warm bunk are not necessary so there are only to be bunks for half the crew and there is no minimum headroom. If you don't need to dress you don't need room to climb into your trousers ! I asked for this rule to be brought back but it was regarded as a matter for I.O.M.R. rather than the safety rules. I will try again as ease of movement can prevent exhaustion. It also happens that we use the safety rules but not the rating rule for U.K. racing. Out of four passages along the South coast of Australia I had three with strong winds and bad visibility, once with snow. Tasmania also proved rough and windy, even fog. Do not believe all advertisements.

New Rules. The I.Y.R.U. meetings are held in November. I hope that lots of comments about the new rules will be sent in so that they can be discussed and agreed before the meeting and used in 1985. These must be sent in plenty of time, for example Bob Shiels representing U.S.A. had Dick Newick and other designers work through the draft before the meeting. There is no chance for consultation if a new proposal, no matter how excellent, is put forward only two weeks before the meeting. Sharpen your pencil now !

Micro Multihulls. Richard Woods was elected by M.O.C.R.A. as Chairman of a committee of designers and interested people to establish class rules for yachts suitable for coastal cruising and inshore racing.(The yachts to be suitable for trailing on British roads by a normal family car.) There were several races for these yachts in 1983 and rules for 1984 covering construction and use are available for £ 2.00. The maximum length is 7.65 meters (25'), no weight limit but there are to be three bunks and galley and toilet facilities, also suitable safety equipment. No sail to be more than 20% 'solid'. Details from Richard Woods, Foss Quay, Millbrook, Torpoint, Plymouth PL10 1EN or from A.Y.R.S.

Cutter or Sloop the best rig ? Wrong again ?

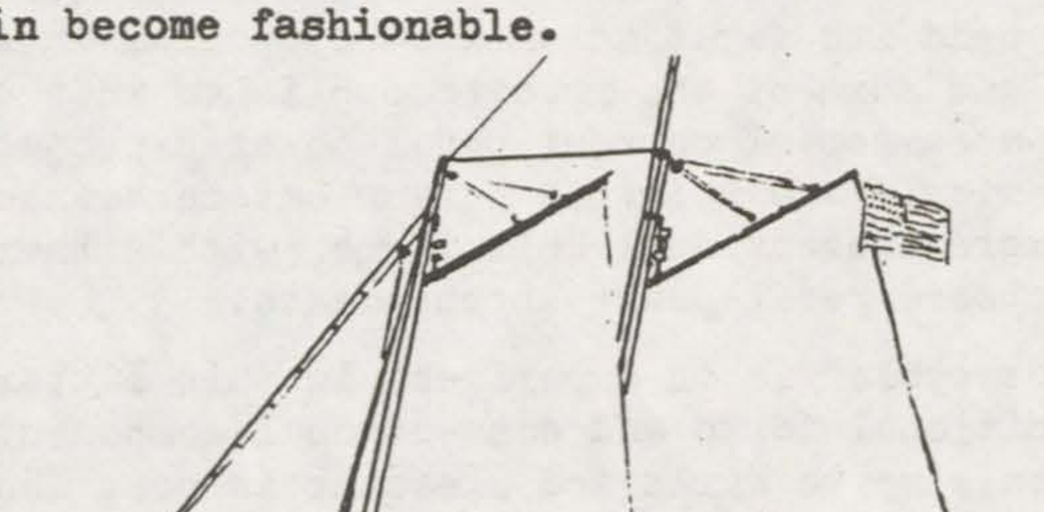
Publication 97, top of page 4, "It has reasonably been demonstrated that the bermudian sloop and cutter rigs offer the best windward performance of the arrangements in general use and that the schooner, ketch and yawl are not competitive when racing."

A visiting member has drawn my attention to the schooner "America" of which I have numerous illustrations. She and other yachts of her time (1850) are clearly shown to have overlapping foresails, or in the case of a ketch - overlapping mainsail. We now set the genoa or overlapping headsail to fair the air flow past the mast, they used a loose footed gaff sail on the forward mast to get a generous overlap of the mainsail.

It seems to me quite probable that rule makers of a later day put a ban or a very heavy penalty on these sails in the same way as the present rules ban full battens on monohulls. Perhaps some notable was beheaded by a flogging clew ? A local boom maker on the rule committee ? Or was it just a hard-up enthusiast who won a series of races in spite of being forced by a small crew to use self tacking sails and so established a new fashion ?

Please add to the original statement..."unless each forward sail overlaps the next astearn."

Now will someone please rush off to their wind tunnel, or better to their radio controlled models and let us know if this is correct. If it is we can get on with reducing the height of masts and heeling moment by returning to multi-mast rigs which were found to be satisfactory on shallow draft wide beam craft and which have again become fashionable.



PAINTING BY FITZ HUGH LANE OF "AMERICA" IN 1851 SHOWS A BOOM FROM FOREMAST SHROUD TO FORESAIL CLEW WHEN RUNNING. MAIN AND HEADSAIL LACED TO BOOM. (ENGLISH YACHTS HAD LOOSE FOOT SAILS).

Pedal Power Boating

From Philip Thiel
4720 7th Ave. NE, Seattle,
Washington 98105, U.S.A.

"The winds and the waves are always on the side of the ablest navigators" wrote Edward Gibbon; neatly summarizing the art of navigation in terms of Francis Bacon's "Mastery of Nature through obedience". To these 17th and 18th century aphorisms we might add yet another, appropriate to our own age of environmental concern :"Next to sail power, human power is most ecologically benign".

Paddles and oars of course have been used to move us on the face of the waters since the beginning of time, and have much to recommend them for simplicity and economy. But just as in the case of the use of the wheel in land transportation, with a similar moderate increase in complexity and cost, the conversion of muscle power into motive thrust may be more effectively and comfortably accomplished with the use of pedal power and the screw propeller. The advantages result from the fact that in this case the user operates the boat while comfortably seated, facing forward, with hands free except for an occasional touch to the tiller-lines, and applies the greater power of the leg muscles to the more uniformly acting thrust of the very efficient submerged screw propeller.

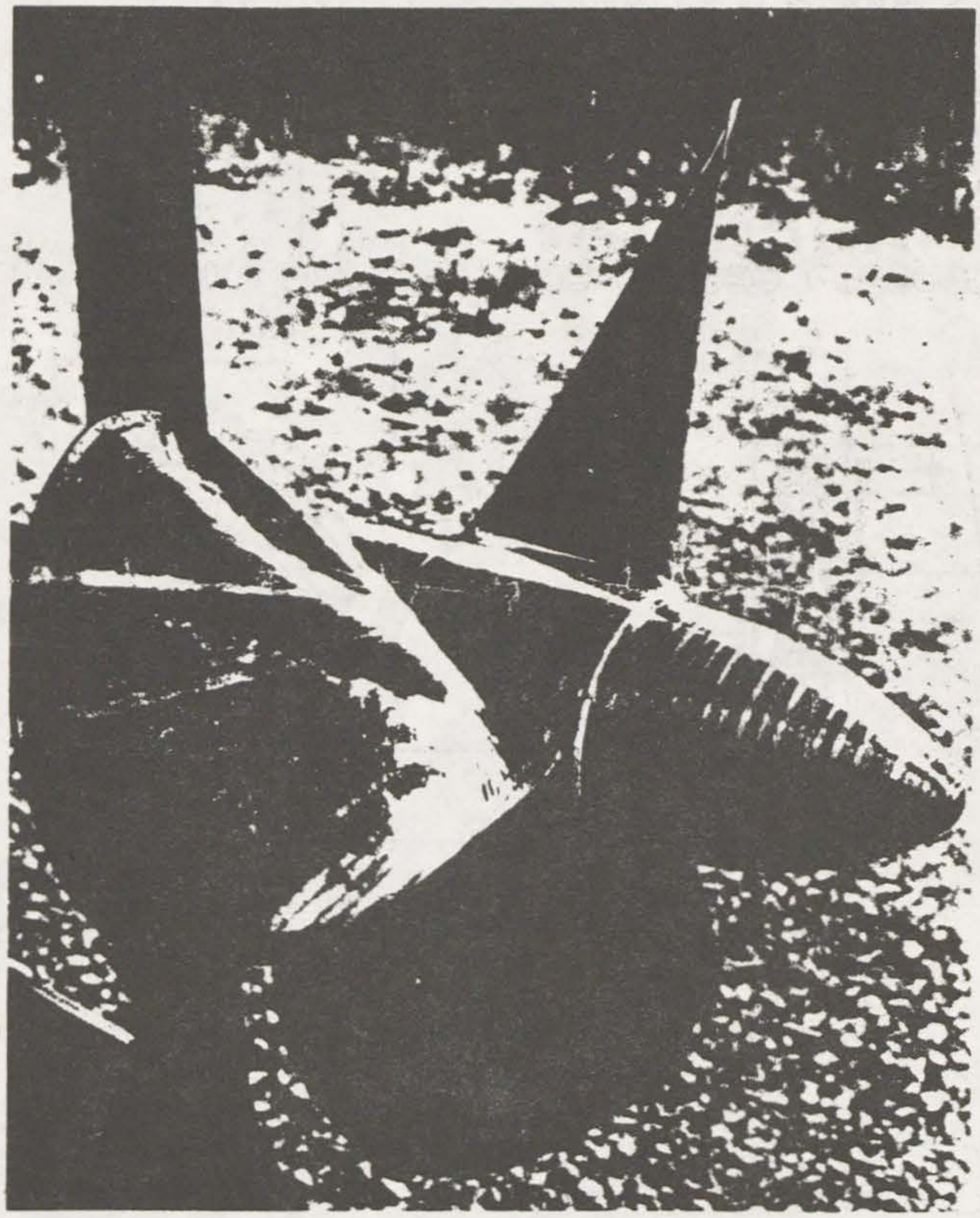
Last year (1982) the International Human Powered Vehicle Association held its first scientific symposium in Anaheim, California, and some of the reports published in the proceedings referred to a number of current pedal-powered projects. These ranged from single and multiple person catamarans and hydrofoil designs to more conventional hull forms, with either portable or permanent inboard pedal-power arrangements.

The "Dorycycle" is an experiment in this latter catagory, and usestraditional forms and conventional components in a configuration easy to build and pleasant to use. The Banks dory hull is simple to construct, and has a respected record in deep-sea workboat service.[1] The power transmission may be by conventional low-cost V-belt and die-cast pulleys, and the propeller is readily made of laminations of marine plywood epoxied together and hand-finished to form.

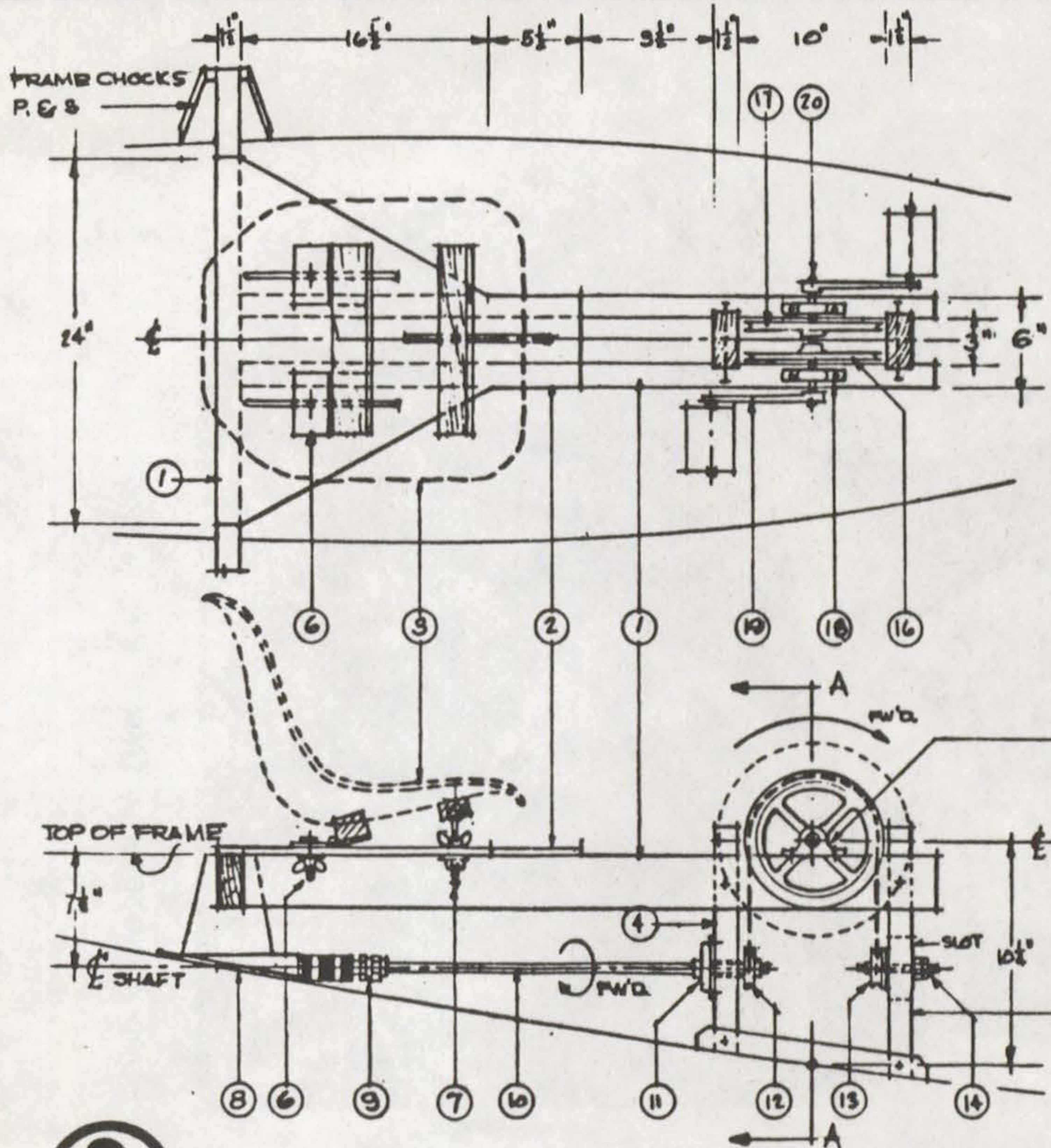
The design challenge is in the use of the low continious-power levels available to an "ordinary untrained bicyclist" : estimated at about 0.12 HP at 50 pedal rpm.[2] Under these conditions the "Dorycycle" makes a sustained 3.8 miles per hour with a 16" diameter by 24" pitch propeller, turning at 180 rpm; with a displacement of about 500 pounds (weight of boat alone is 300 lbs) on a waterline length of 13 feet.

With the skeg and outboard rudder shown the boat runs quietly, has good directional stability, and is very responsive in maneuvering. Material costs are under $ 1,000, and construction presents no difficulties for a reasonably skilled amateur.

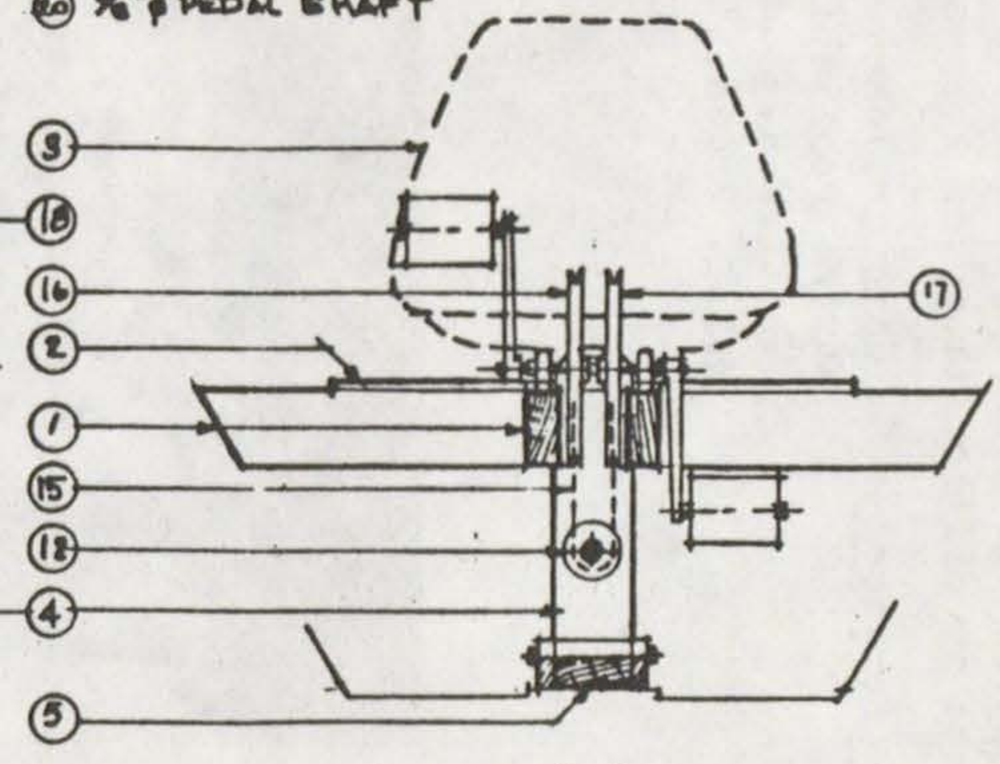
References ; 1. Gardner, John The Dory Book International Marine Publishing Co.
2. Whitt, F.R. and D.G. Wilson Bicycling Science M.I.T. Press, 1974. Cambridge, Mass.



Plywood Propeller by Thiel.



1. FRAME 1½" × 3½"
2. PLYWOOD DECK ½" WITH SLOTS FOR SEAT ADJUST.
3. MOLDED FIBREGLAS SEAT WITH FITTED HARDWOOD BLOCKS BOLTED UNDER
4. VERTICAL SUPPORTS 1½" × 3½" NOTCHED ¾" × 3½" FOR (1)
5. BLOCKING 1½" × 3½" GLUED TO HULL
6. 4" HINGES P & S WITH BOLT & WING NUT
7. ½" EYEBOLT ON ℄ WITH WING NUT
8. BRONZE SHAFT LOG WITH FLEX. HOSE TO (9)
9. BRONZE STUFFING BOX
10. BRONZE PROPELLER SHAFT ¾"
11. FLANGED THRUST & STEADY BEARING - SET SCREWED TO FLATS ON SHAFT
12. 2½" ⌀ DRIVEN PULLEY KEYED TO SHAFT
13. 2½" ⌀ IDLER / TAKE-UP PULLEY WITH BUSHING
14. ⅝" ⌀ TAKE-UP SHAFT WITH WELDED PLATE 8" SQ.
15. V-BELT 70" LONG
16. 9" ⌀ IDLER PULLEY WITH BUSHING
17. 9" ⌀ DRIVER PULLEY KEYED TO ⅝" ⌀ PEDAL SHAFT
18. ⅝" ⌀ BALL BEARING PILLOW BLOCKS
19. STOCK BICYCLE PEDALS KEYED TO ⅝" ⌀ SHAFT
20. ⅝" ⌀ PEDAL SHAFT

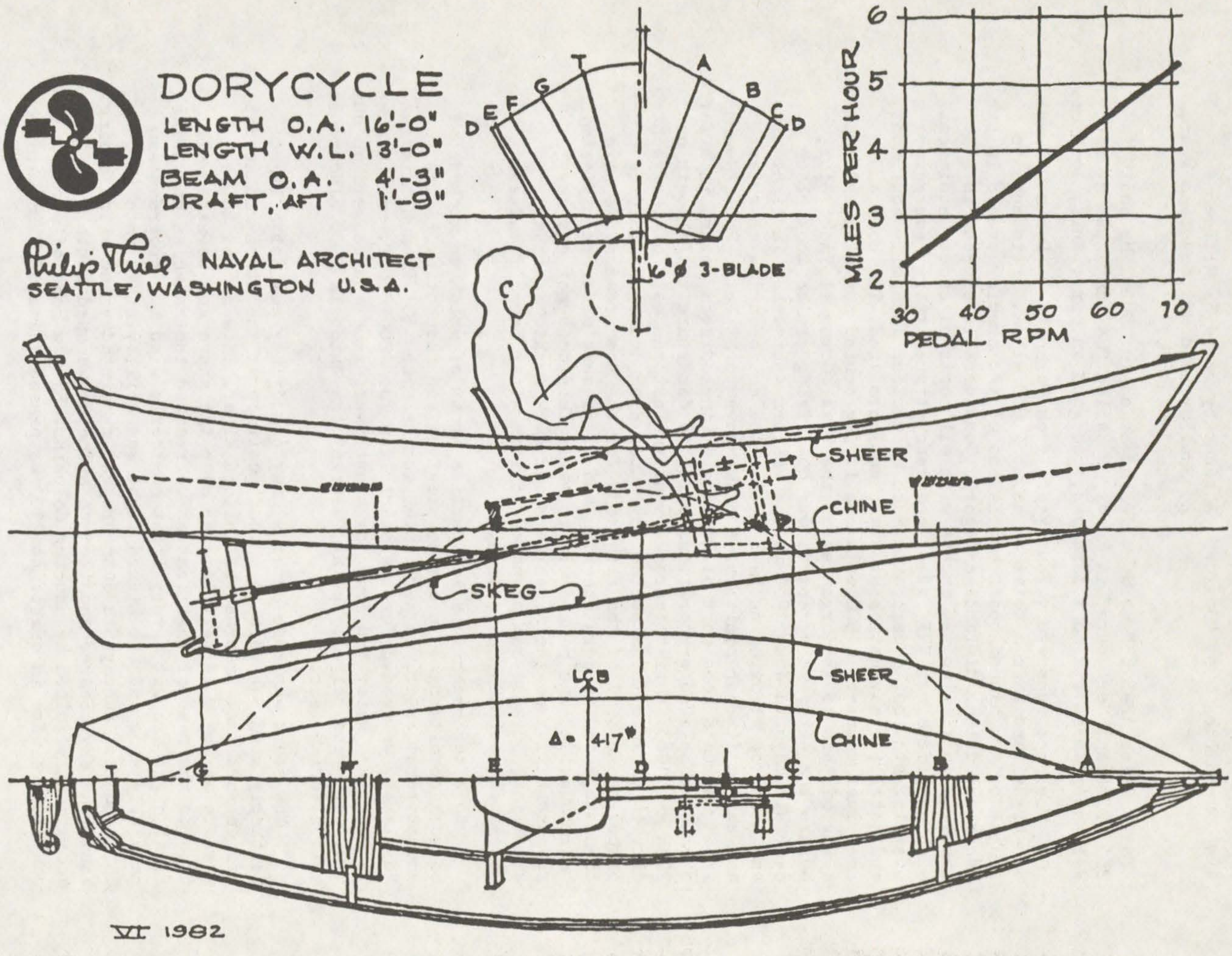


SECTION A-A

DORYCYCLE (MARK 1) SEAT & PEDAL LAYOUT

PHILIP THIEL NAVAL ARCHITECT SEATTLE, WASHINGTON U.S.A.

12/10/82


DORYCYCLE
LENGTH O.A. 16'-0"
LENGTH W.L. 13'-0"
BEAM O.A. 4'-3"
DRAFT, AFT 1'-9"
Philip Thiel NAVAL ARCHITECT
SEATTLE, WASHINGTON U.S.A.
16"ø 3-BLADE
MILES PER HOUR
2
3
4
5
6
30
40
50
60
70
PEDAL RPM
SHEER
CHINE
SKEG
LCB
Δ = 417#
SHEER
CHINE
A
B
C
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Azores and Back 1983 "Gavida" Account by David S. Millner

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"Fancy doing AZAB 83" my G.P. friend asked in 1981. "My boat" (a 28' trimaran) "or yours" (a Moody 30 called "Gavida") was my reply. Well he planned his so I said yes, too good an opportunity to miss.

The race runs every four years from Falmouth to Ponta Delgada, Sao Miguel and back a total of about 2,500 miles. It is open to single or two handed boats and is one of the premier events in the shorthanded long distance category. Considerable expense is involved in fitting the yachts with all sorts of safety equipment such as liferafts, VHF radio, emergency transmitters, emergency steering etc. but modern aids such as weather facsimile equipment and satellite navigation aids are not permitted. The boat and crew must complete a 500 mile qualifying cruise non-stop and submit a log of this to the organisers, the Royal Cornwall Yacht Club, before the entry is accepted. Our qualifying cruise took place over six days in June 1982 in the Western Approaches in light airs and some fog allowing us to practice the art of using a sextant and sun to fix our position. A shake down to St Peter Port, Guernsey from Gavida's home port of Dartmouth (including a return in a force 8 gale) completed preparations prior to departure to Falmouth on 27th May 1983. Whilst there we went against the wall of the yacht club to clean off the bottom to reduce drag and fix a folding propeller instead of the fixed one for the same reason. We were then subjected to scrutineering and after some minor rectification work "Gavida" was passed fit to sail. This does not put any responsibility on the organisers and each yacht, as in any situation, puts to sea prepared to look after herself and must not expect outside assistance.

So after receptions and parties (most of which we missed due to work commitments), pre race briefing and inspecting fellow competitors' craft, in particular for me a new 30' French trimaran "Rizla +", we headed for the start line for 1200 B.S.T. on 4th June. On board was water and food for about four weeks and we were on our own, our principal ally being "George" the Autohelm 2000 électronic self steering gear.

The start was made under a grey cloudy sky against a light Southerly wind. We were in a good position at the start and headed off on port tack towards the Helford River. This proved to be a mistake as the wind fell lighter near the shore and we were well towards the rear of the fleet as we reached the Manacles buoy. The first night brought a very light Northerly wind but progress was painfully slow and the Lizard light was still visible into the early hours. Sunday 5th June brought my birthday and a freshening wind. The sky cleared and the sun shone as we sped South, occasionally joined by dancing dolphins. By now none of our competitors were in sight. At 2100 we passed ahead of "Windward Joy" another boat in our class, two handed up to 30' loa, but we were on different courses. This is a race of wind and current strategy on a grand scale. The course taken will always be dependant on current and wind direction and strength but must also allow for expected conditions along the track. These cannot be predicted with any accuracy in advance but statistical information for the month in question is shown in the North Atlantic Routing Chart. Each boat held her chosen course and we soon lost sight of each other over the horizon. Soon afterwards, just before dark, we were joined by a tired bedraggled pigeon who would not take food or water but was glad to rest.

Any boat needs a watch system to ensure that all the crew rest and are fit to tackle whatever the elements or fate throws at them. The formal part of our system started after dinner when I would take a short watch until 2300 hours. I then slept until 0300 and was on watch to 0700. We breakfasted together with a bowl of cereal then I was usually back to bed by 0730. The day-time was less formal and we tended to fit in with each other without really trying. Variation from the system arose from one or other of us being particularly tired or wide awake or from circumstances arising. Our third night was such a night and having stayed on watch until midnight I was called on deck at 0230 as we were in a tangle which needed both of us to sort out to avoid the risk of tearing sails and losing too much ground.

The third day was cold and rough and I lacked energy following the bad night. At sea in these conditions one tends to go below to lie down in a sleeping bag to keep warm when off watch, which invariably leads to sleep. This day I was even sick, to my disgust. Our pigeon was little happier getting what shelter he could in the wet pitching and heeling cockpit which he soon started to mess up. He did however take some bread and water but enjoying most of all the potato skin water! We meantime were making good progress in the right direction along the rumb line under working jib and reefed main.

The fourth day was little changed, grey on deck and "Gavida" rolling well to large beam seas. More rain fell and some of this forced its way onto the best seaberth through a crack in the timber around the main hatch. The midday meal was typically a bacon and egg sandwich while the ingredients for this remained fresh. The pigeon also ate well. It was the sort of grey day where we discussed our reasons for being out there, miles from anywhere in the cold, wet and rough conditions. We both decided that we were there to say we had done it but we looked forward to pleasant, warmer sailing further South and the satisfaction of completing our first proper ocean crossing.

At 1645 we saw the first ship for over 24 hours, a Spanish merchant ship heading on a reciprocal course and passing close to us. We looked at our visitor who had already made a number of attempts to fly off and find his bearings for home without success. We therefore caught him and threw him towards the ship in the hope that he might find home and he headed for the greater comfort of a large vessel much to our relief as he was anything but a clean companion. Subsequent research showed that the bird was a racing pigeon whose home was in Coleraine, County Derry and it had been released 350 miles from home in Okehampton, Devon on 4th June. Sadly no further news has been received of its fate to date.

The wind was falling light and by the fifth day heading us, requiring us to go onto another tack to maintain a best course and the temperature increased. The sky also cleared permitting our first attempt at taking sun sights during the passage. By afternoon my shirt was off but the but the mathematics required for working out our sights was a little rusty. Soon the sun gained heat and we were able to enjoy ideal ocean cruising weather and I started to think of my ideal ocean cruising boat; we can all daydream. This pleasant state continued over the sixth day and little changed until a Royal Navy aircraft flew close to inspect us. We were briefed in Falmouth that a major NATO exercise was taking place and they knew of our race. The excitement of this first encounter was soon turned to anger and fright as a helicopter came in close then turned to give us all his downdraught causing us to heel right over and nearly tearing the large light wind sails which we had set. The NATO cabaret continued as the main fleet of two carriers, supporting warships, helicopters and jets filled the sky with noise and action. As a grand finale we were on deck after dark putting up a spinnaker when a powerful spot light appeared just above us from another helicopter, temporarily blinding us.

The seventh day was more peaceful with not enough wind and in the early morning "Whisperer", another boat in our class built as a pure racing boat, overtook us in light airs under spinnaker. "Gavida" is a heavy, production family cruising boat and was not designed to win races. We were however stirred into trying to keep up with "Whisperer" and set sails wherever we could to catch every breath of wind.

The good weather gave ample opportunity to take and plot multiple sun sights and we obtained a very accurate fix 480 miles from the island of Sao Miguel and still on the rumb line. The outward leg has, one hopes, generally favourable winds and currents so the rumb line was our chosen track.

We were hoping to complete the outward leg in about twelve days to leave us a few days to see the island but our real ambition was to arrive in about ten or eleven days when our ladies were arriving by air with fellow competitors' friends and relatives. We were constantly doing mental arithmatic as to how many days at the current speed we would need and in the light winds our hopes seemed unlikely to be achieved.

On the eighth day David, my skipper, saw our first whale of the trip. We saw four in total and together with other reported sightings it was pleasing to feel there were still some out there. Dolphin sightings were numerous, usually in schools of six or more but on one occasion fifty or sixty were seen. At night the dolphins left trails of light like torpedoes as they shot through the water in the blackness which was a feature of the outward leg with little or no moon. The spinnaker went up at 2200 just before dark at the start of what was to be a memorable 24 hours. We had little sleep as the wind was strong and I was called from my off-watch slumbers twice to attend to the sail on the foredeck in the small hours. By o645 it was just not safe to keep the spinnaker up any longer as we had no spare should it rip. A replacement even on such a small boat could cost about £ 500. The sail was nearly lost under the boat as we fought to get it down in the strong wind and we found the spinnaker pole had bent when it hit the forestay under pressure. I nearly burned a finger in the process on the halyard.

This was the start of a bad day which we called "Sunday, Bloody Sunday". For the first time we both went below to sleep at the same time. George, our self steering gear had strained all night to hold our course and after we had tried to raise the spinnaker again later that morning George gave up the ghost, leaving us pointing in the wrong direction with the spinnaker wrapped around the rigging. The trouble was dead batteries which left us in our tired state with no self steering, no navigation, cabin or compass lights, and no water from the taps as the batteries power pumps to bring water up when required. In addition we had already found our two radio direction finding sets to be malfunctioning and out of action. So onto steering by hand and our three gallons of water in spare containers. A little later a violent rolling caused a casting on the end of the boom to break under pressure. By afternoon of this the nineth day the wind was again frustratingly light although the bright points of the day were the sun and the number of miles travelled during the previous night under spinnaker.

Our watchkeeping system became a simple and formal three hours steering, three hours off, which included cooking and navigation and normal chores like the daily washing up.

The tenth day started with the sails slatting with the swell but by midday the wind and waves astern were much stronger and larger making it very difficult to hold the required course and it was made worse by the risk of gybing with the wind nearly astern. At 1430 we were only 100 miles from Sao Miguel and a NATO convoy was seen on the horizon.

The wind held and our hopes of a good time grew. We went into the night expecting to see a light at the Eastern end of the island before dawn. Nothing at sea goes exactly as planned and between midnight and 0300 the wind picked up to storm force. Two prolonged gusts of a few minutes saw "Gavida" screaming away from our destination, the noise below sounding as if the boat would break up at any moment as we pounded from wave to wave. We had to reef down and the off watch man was needed on deck. Our trailing Walker log chose this dark stormy night to wrap itself around the rudder. Sheet lightening filled the sky and lit a very angry scene.

The reefed main and the distance travelled off course allowed us to sail a good course back for the island and the light was spotted just before dawn. Our first landfall - just where expected - very pleasing indeed.

In his tiredness David sailed in further towards the cliffs than was desirable and we became becalmed while out at sea a competitor appeared and sailed right past us. We used our six foot dinghy oars (as permitted in the race rules) to move away from the island in the swell and soon followed the sighted boat, now identified as "Assassin", a Contessa 38, in setting a spinnaker. Another six hours took us slowly along the South coast of the mist covered island during which time a turtle was sighted. We crossed the finishing line at Ponta Delgada with a flourish under spinnaker where we were astonished and delighted to find only fourteen boats ahead of us and only one, "Whisperer" in our class. To our satisfaction the plane with our ladies on board was not due for another five hours.

The wind continued to get lighter and boats some way behind us were later becalmed in sight of the island for up to two days.

The first night ashore was rather like a night at sea. I was awoken after midnight to find that David had slipped on the slimey slipway and was lying concussed in the nearby hospital. By the time I arrived he was coming around slowly but could not remember the race or the excitement of the finish a few hours earlier, nor the Azores. His head was X-rayed and as no local doctors could be found, I rowed across the harbour to fetch a doctor who was in the race fleet. He gladly came ashore despite the late hour and checked that all was well and cast a professional eye over the X-rays. These proved to be satisfactory but we persuaded David to remain in the hospital overnight. I thaught I would be sailing back single-handed. Although David's condition improved over the week some symptons showed up on the return leg and he has suffered ever since with severe headaches and vertigo.

The hospitality of the islanders was notable and the race for them was the event of the year. The island itself was formed by a volcanic eruption and large craters contain vivid lakes. It is very lush and green and the hedgerows are full of dazzling azaleas, hydrangeas and wild roses. The beaches are made up of fine black sand and become searingly hot, not surprisingly they are well used by the locals. The volcanic activity on the island can still be seen in hot bubbling sulphur pools one of which has been made into a warm, brown-watered swimming pool. Although we were apprehensive at first, once in the water it was really delightful and refreshing although a little unusual.

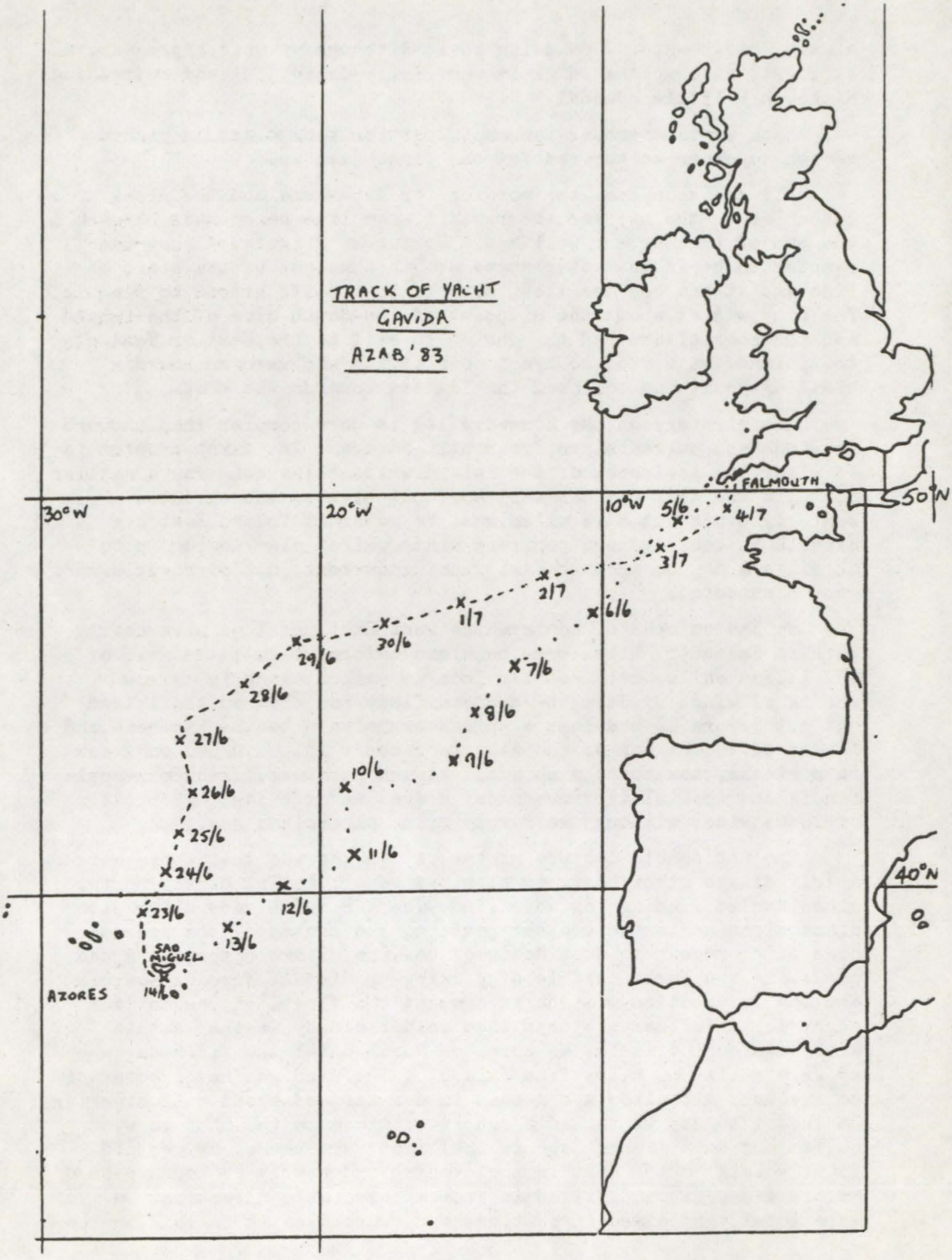
Back in the harbour impromptu parties took place on yachts rafted together as the rest of the fleet came in.

All too soon came the morning for departure and the fleet assembled in the bay for the restart, the line being made between the end of the harbour wall and a Portugese frigate. A buoy was reputed to be in the water somewhere to the East of the start line and at the gun the fleet set off in a stiff breeze to find it. The buoy was at about the midpoint of the South side of the island and the competitors had the choice to sail to the East or West of the island. We waved goodbye to our ladies who were on board a visiting yacht and followed the leaders towards the West.

The strategy on the homeward leg is more complex than outward as winds and currents are frequently adverse. The first problem is to clear the influence of the island where calms can trap a sailing boat. To the West one can sail North to pick up the expected Westerly winds but more miles must be covered. To the East one expects to tack against contrary winds whilst also losing up to 12 miles a day on a South-East running current, but stronger winds can be expected.

We had no news of boats which went East until we were nearly back in Falmouth but we were becalmed before we left the grip of the island while boats not far from us sailed along in narrow shafts of wind. By dark the Western fleet had cleared the island but not before we had lost a spinnaker halyard to the masthead and I went up to the top of the mast to recover it. We dined on fresh thin steaks, tomatoes, mushrooms, tinned potatoes, fresh pineapple (an island speciality grown under glass) and the last of a bottle of local wine, although we rarely drink alcohol at sea.

The noticeable feature of the return leg was that there were nearly always other boats in sight as we all sailed slowly North, close hauled wishing for more wind. The VHF radio came alive with discussions as to the weather pattern, the centre of the Azores high being somewhere just North of us. One or two competitors had receiving equipment capable of picking-up distant forcast sources and the information was shared amongst the fleet. It was hot and sunny for a further two days then colder cloudy weather set in withoccasional drizzle. We crept on North until the fifth day when we were still 900 miles from Falmouth. The wind was never constant so frequent attention was needed to our compass based self steering. On the fifth day we tacked a couple of times to the East on wind shifts but soon tacked back in the light variable winds. We did finally tack to the East in the evening and nearly 24 hours passed before a decent wind filled in from a favourable direction. We were totally becalmed three times and dropped sails to roll on the


TRACK OF YACHT
GAVIDA
AZAB '83
FALMOUTH
50°N
40°N
30°W
20°W
10°W
5/6
4/7
3/7
2/7
1/7
30/6
29/6
28/6
27/6
26/6
25/6
24/6
23/6
6/6
7/6
8/6
9/6
10/6
11/6
12/6
13/6
SAO MIGUEL
14/6
AZORES

glassy swell, otherwise the sails flogging from side to side were destroying themselves and our nerves. During one of these periods I went for a swim, it was about time I had a good wash, strange to think though that there were miles of ocean under me. We recorded 16 miles in as many hours before progress returned. I spotted a whale on the seventh day, his back above the water as wide as the yacht, his head and tail hidden, he was only feet from us swimming in the opposite direction. The eighth day marked the end of the Azores bread, mold having been cut away from the outside. It was another cold day and we sailed through a fleet of French trawlers. BBC radio was back in range and we heard that the South Coast had been basking in the hot sun thanks to the ridge of high pressure from the Azores to the English Channel which had caused us such adverse conditions. The prime frustration related to the limited holiday or time off available to most competitors which took the edge off the pleasures of an ocean passage. Indeed after such a slow start some boats did retire to motor home although this is not feasible if one is too far from land because of limited fuel which can be carried. The race was however still open and we did not know whether we were ahead or astern of the Eastern fleet. We were spread over a huge expanse of ocean. In the light conditions I read a Nevil Shute paperback although I am usually happy to watch the ocean when cooking, sleeping, navigating or sailing duties did not fill the hours of the day.

The sun reappeared on the eigth day and celestial navigation again filled the time. We had been with the same boats for days and were getting to know voices of some of our rivals quite well. Progress continued and by the eleventh day we felt we were getting close to home. The sailing was good, the sun shone and we reported our position to Lloyds of London for onward transmission to the Race Committee at Falmouth via a Geest banana boat bound for the West Indies. We had about 100 miles to go when by a freak radio transmission we heard that one competitor was still sitting out a North-Easterly gale off the Iberian Peninsular, 350 miles from home.

The last 24 hours found light close hauled conditions which George could not cope with so we steered by hand taking what seemed an age to get past the Lizard then bashing against an unpleasant head sea into Falmouth Bay to finish almost becalmed in the early morning after a passage of 12 days,15 hours. With a sense of relief we motored to a mooring and went to sleep. We discovered we were 19th into Falmouth and 4th in our class but overall maintained our 2nd in class position which was very satisfying indeed.

In the morning we cleared customs, went ashore for a much needed shower, met fellow competitors over lunch then motored back to Dartmouth. We returned to our normal everyday lives, much richer for the marvellous experience.

Report on Equipment by David Millner "Gavida" 1983.

1) I found my new Henri Lloyd Ocean Racer jacket with its built in harness very useful.

2) The Autohelm 2000 was very good unless an optimum windward course was required. In certain conditions the power used seemed much heavier than claimed by the makers. It was useless of course once our batteries had lost their charge.

3) The dodgers were removed for the race but the spray hood over the companionway proved a great comfort, as well as aiding downwind speed.

4) The Stevens-Lefeld ready meals were a great boon especially in heavy weather although we preferred to alternate them with other food for greatest variety.

5) "Floating caravan" equipment such as electric water pumps are not to be recommended for an ocean passage. Our only other means of drawing water from the tanks would have been to take off the sealed lids.

6) It is interesting to note that a family cruiser with standard rig can achieve similar time on passage to faster boats with larger rigs. For example a Contessa 38 "Assassin" only passed us after 1200 miles at sea on the outward leg.

"Dalibor" Progress. Note from Josef T.Dusek, P.O.Box 404, Potts Point, N.S.W. 2011, Australia.

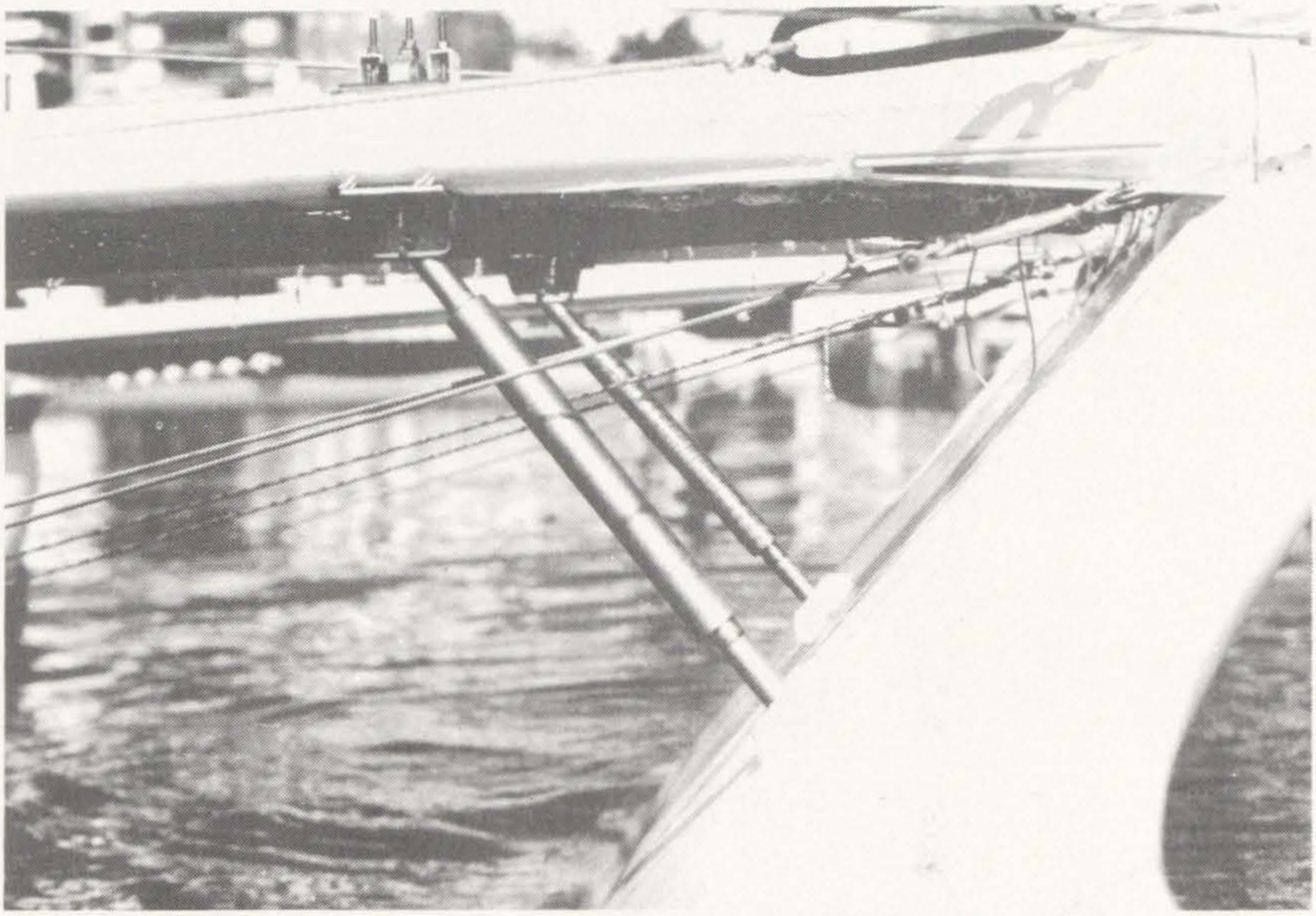
I came back to Sydney to escape the European winter and 'recharge the batteries'. Next year (1984) I hope to concentrate on speed trials in Brest and Portland. I should be in Grado (Italy) early in May. I am still looking for a sponsor and if somebody from U.K. would like to put stickers on "Dalibor", I will be very glad.

To get "Dalibor" to Brest and Portland will involve some cruising along Italian and French coasts and through French canals, and if anyone is interested in sharing fun and expenses I can offer forward accommodation and cabin for two.

After being unloaded from the ship (from Sydney)a friend and I sailed North around the Jugoslavian coast against light or heavy winds (nothing between, so we mostly motored) and eventually ended up in Grado, Italy.

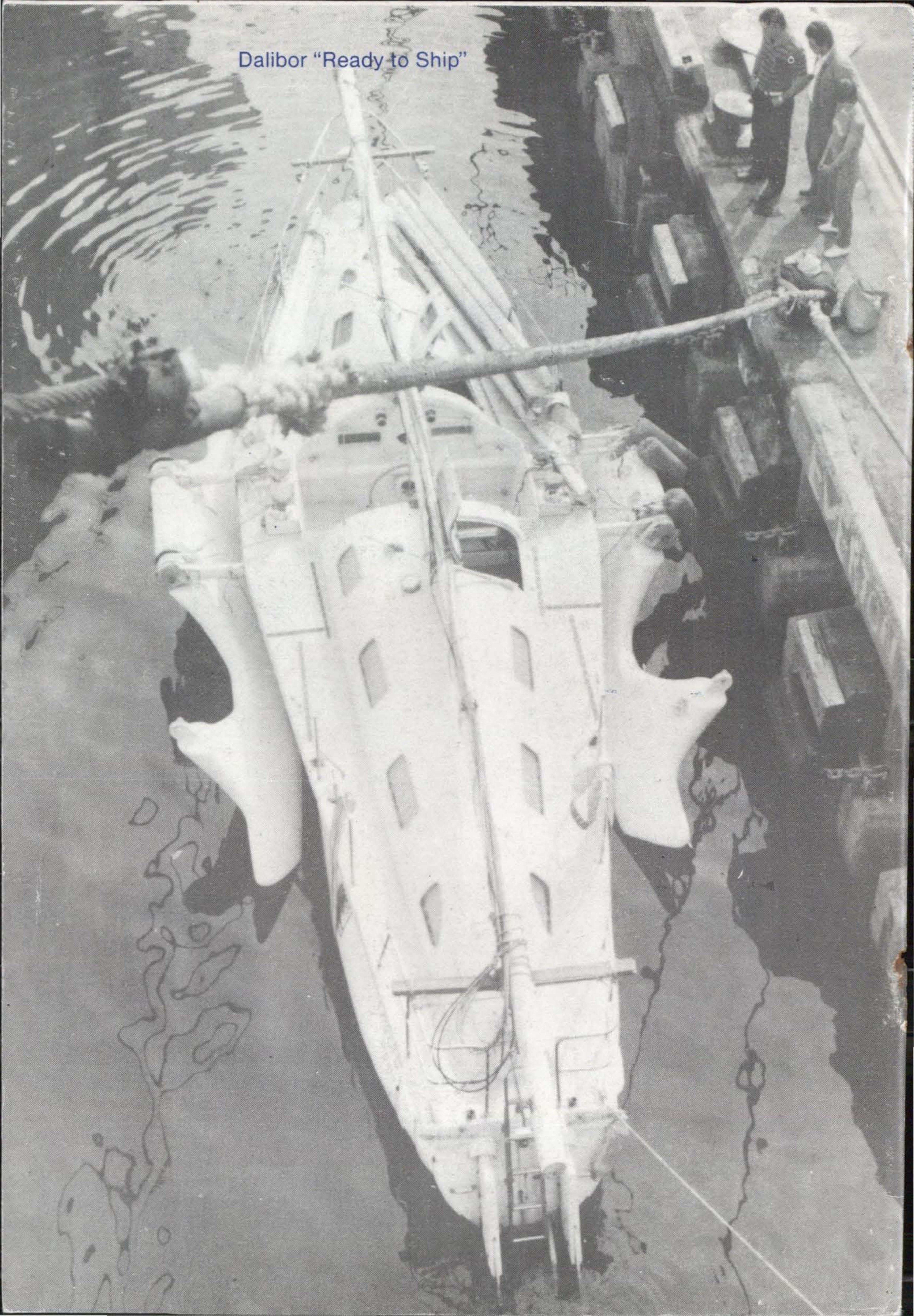
Contacts regarding short day charter which I made last year turned sour, and if I had not had to chase new ones, I might have enjoyed cruising more, because the Yugoslavian coast is excellent from this point of view.

Regarding the cruise. We had a few Boras with the famous and nasty Mediterranean chop, and my fat "Dalibor" did not like it



much of the shock absorbers (struts) on the foils had to work hard during these few instances. Progress was slow due to over-loading (heaps of spares, tools and other junk).

After being stuck in Venice for four days by a bad Northerly, I realised that I could not make the speed trials this year and had to leave "Dalibor" to winter in a private club in Grado. I was very lucky to meet someone who is looking after "Dalibor" on the dry. He is also experimenting with a modified Nicol tri with a hydraulically operated float pantographic system.



Dalibor "Ready to Ship"