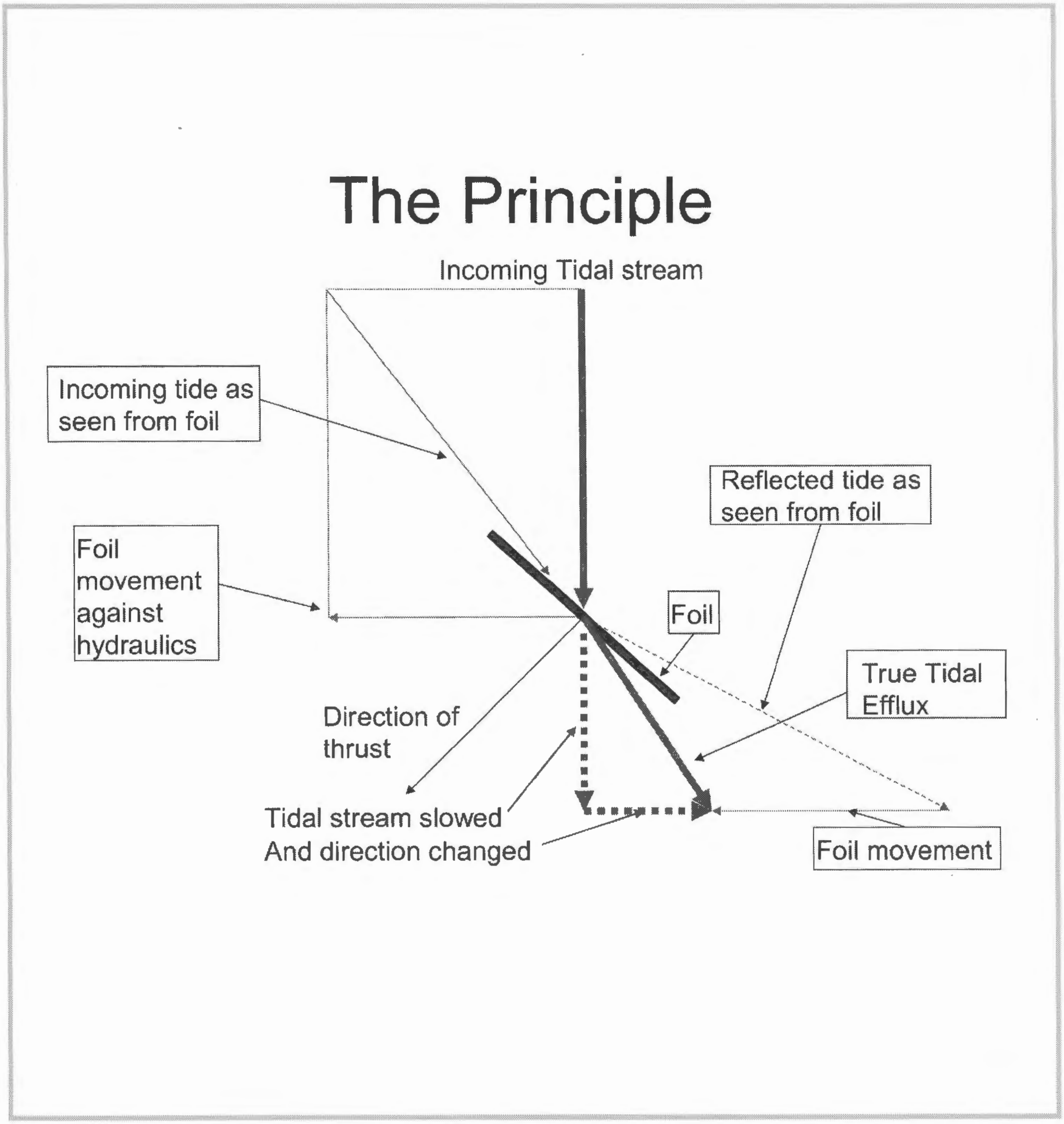
Catalyst

Journal of the Amateur Yacht Research Society

Number 29 October/December 2007



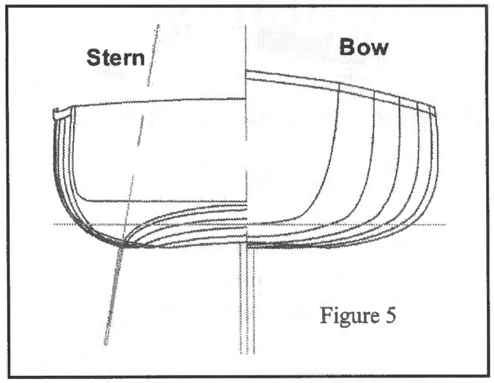
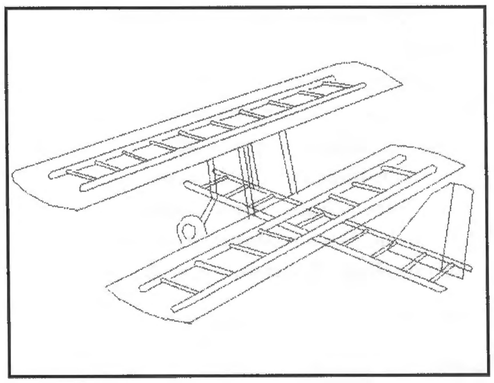
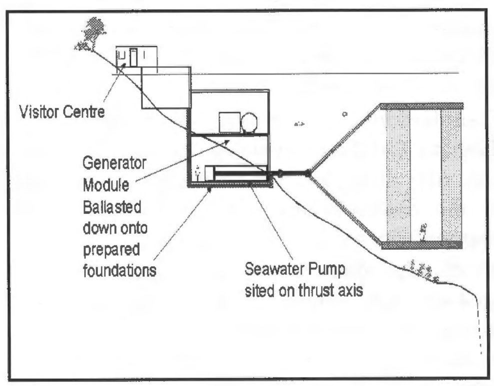
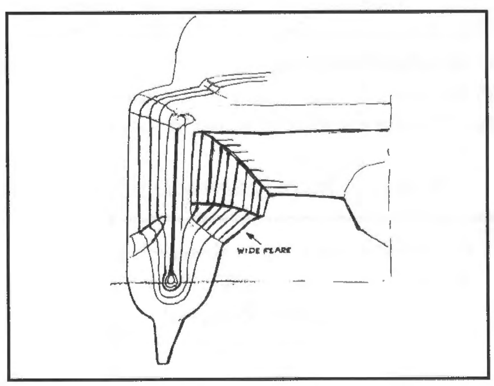


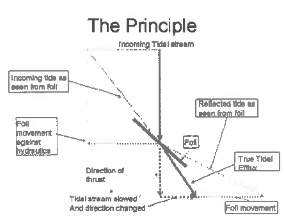
Figure 5







Cover shows the force diagram of* Electrotide, *[see Page 14]



Catalyst

Journal of the
Amateur Yacht Research Society

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Catalyst

Just when you thought Catalyst had been in hibernation, it arrives twice within a few weeks!

I have cascaded the October and December issues together, as I now have more material, and to catch up.

In this issue I hope you will find articles of interest:—

- community electrical generation with Electrotide;
- an attempt to make a hull on aerodynamic principles
- a study of multihulls into a bespoke design

we bring several projects up to date:

- a kite-boat project,
- Quatrefoil,
- a Biplane Hagedoorn craft, and
- 'Newt' a fully amphibious yacht

Simon reviews some books, and our Chairman adds his, now regular, Chairman's Notes. The Calendar hints at events to come.

Perhaps I should here thank the authors of the work in this issue. *Thank you*, on behalf of our readers.

There are coincidentally several common threads in this issue. One is as noted by Roger Glencross, Walter Schofield, by implication the work of John Hogg, and noting the letter from Tim Glover; that there is a place here for AYRS – as a truly objective party – to contribute in setting out a definitive method of measuring and portraying sailing performance.

The second and third is reflected between Roger Glencross and Emmanual Roche in the use of biplane aerodynamics, and the need for an understandable low-speed aerodynamic 'mathematics'.

I wish you all a most productive 2008, and hope to hear from many of you with your ideas and projects. *Good luck.* My New Year resolution is to get out the April *Catalyst* before May.

Percy Westwood, Catalyst Editor

from T Glover

What Have you Done for AYRS?

I have been a member of AYRS for some years and the same old questions are asked at nearly every meeting I have attended:—

1. How can we get more members? (Young or old.) We prefer younger ones because the average age of our members at meetings seems to be rising inexorably. In thirty years time there will not be any left. So I am now making a positive personal drive to recruit more members.

I have AYRS burgees, which I fly on my yacht, my Hobie 14 catamaran and my amphibious land yacht. The wheels of the land yacht are 52 inches *[1.3 m]* diameter and next summer they will have the AYRS web site displayed on them. So what I am suggesting is that when any member is testing, towing on the road or otherwise displaying in public this design, please have AYRS information shown at the same time. You do not even have to speak if you find it difficult to talk to strangers. I am very lucky, I don't.

Take some copies of *Catalyst* with you. When I am out and about I take *Westerly Owners Association* stuff with me and try and 'sell' membership. I think they got over 100 new members at the last boat show. I will now spend my 'walk about' time with AYRS instead. So think how you can make AYRS membership increase. My goal for the year is to sign up just one new member. (If possible younger than I am, at 72.) If we all try and succeed we double the membership in one year! *We* are the best advertisement for AYRS. Spread the word.

2. I have been asked positively to contribute to Catalyst. Besides my big project *Newt*, an amphibious land yacht, I was asked to write an article on Patents and Patenting ideas. This is now underway. While engaged in this I asked how much time can I spend on AYRS as an ordinary member? 1-2% of my time? About thirty minutes a week. That does not seem a big commitment. So then I became embarrassed. I was asked to join the committee. I declined because I was 'too busy'. (Really)! So that is when I felt *really* guilty. How much time have you spent helping AYRS in the last year? The future is up to all of us. Please consider the following list:

1. Get out and sell membership. (At the Yacht Club). When you see someone with a new yacht design, sign them up.

2. Think what knowledge you have that others may not. Aluminium welding, glues and wing-sail making, where to get stuff, where to get things done. Write it down and send it to the *Catalyst. [We could list useful resources in Catalyst, Ed]*

3. Have you ever dreamt up a project? (Come on, we all have.) Write your dreams down and send it in. There may be other members like myself who would love to help make it happen. Hold the other end while you do the rest. Launching, taking pictures of the test runs (you can't sail it and be on the shore to take the pictures at the same time).

4. Have you ever stopped and thought how many hours the committee members spend on your behalf and how much effort goes into each copy of the *Catalyst* magazine *[. . . blush, Ed]*. I hope like me you are seriously embarrassed. Let's do something:— write, sell, do, and help. It's our society; no one else's. Lets get off our backsides and do something now.

T. Glover ASIS FRPS

from The British Inventor's Society

British Female Inventor and Innovator of the Year 2008

Women across the nation have the chance to be recognised as the British Female Inventor and Innovator of the Year 2008 with the latest competition by the Global Women Inventors & Innovators Network (GWIIN) taking place in the vibrant city of Cardiff, Wales for the first time.

The awards event organised to celebrate and promote the creative, inventive and innovative products and inventions by women, includes categories such as awards for environmentally friendly products or services, awards for technology and communication, another for innovative businesses, awards for Higher Education & Learning Institutions such as universities and colleges.

Innovations from previous winners of the awards:— a security product to protect the public from cyber criminals, Pre.vu, a music sampling device built into a standard CD jewel case, Grobox, Forensic Anti-Contamination Plates for crime scenes, Anywayup Cup to prevent toddlers spilling drinks and the small-scale Solid State Gyroscope which detects angular spin in moving objects.

For further information about the award categories and entry forms visit www.gwiin.com

Ideas in Favour of the Aerodynamic Hull

Chris Antcliff

So much of sailing above and below the water line relies on the application of aerodynamic principles. So you might expect the hull itself to take a symmetrical wing section form. The following is a summary of the ideas in favour of this hull type with the specification of a boat designed to these principles.

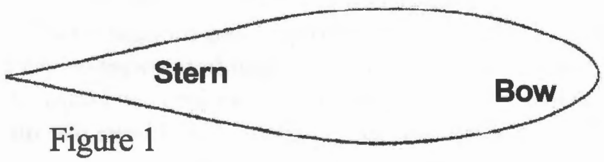


Figure 1

Figure 1 is the DWL profile.

The advantages could be; lift being generated by the hull and lower drag. The pointed stern could also improve self-steering. The maximum beam would move forward and probably the keel as well. This would shift the internal volume further forward, allowing for larger accommodation and a deeper and lower cockpit. At the bow, the good streamlines produced should offer less resistance especially in turns. The increase in buoyancy in this area would enhance the tendency to ride the waves and reduce the slowing which broader bow sections are prone to when encountering short, choppy seas. Windage on the hull would be improved and lead to weather cocking, so improving pointing when sailing to windward, and reducing the bow blowing off during slow-speed manoeuvring.

As the hull represents the end of a wing section, water travels under the hull as well as around it. Another symmetrical wing section is chosen for the hull centre line to match maximum draught, displacement and optimum LWL. The DWL and the hull centre line profiles have been blended together in Figure 2, producing the innovative shape of the hull.

Following the forward keel/stem down to maximum draught, the keel then splits into two parts, each going out to the buttocks at the stern. This has maintained the streamlined form from the bow through the outer hull at DWL by ending in a pointed stern at both port and starboard. After the maximum draught, the centre section forms a hollow which increases in volume as it goes aft,

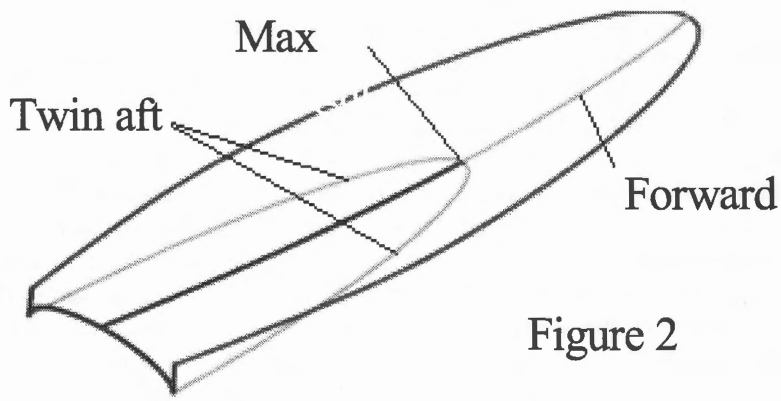


Figure 2

finishing with the centre rising to the waterline at the stern. This maintains the streamlined centre line from bow to stern under the hull.

The following waterline diagrams (Figures 3 and 4) are constructed from WLs at 100 mm intervals, and show the immersed hull at a progressive rate of heel to the same displacement viewed from below. In Figure 3, the buoyancy is triangulated forward of maximum draught along both buttock lines to each side of the stern. This stable platform would reduce roll when sailing downwind and also when being driven under power.

In Figure 4, the underwater sections take on the form of a conventional monohull, so twin rudders are needed. The centre of symmetry also possesses an angle of attack to the course. As the angle of heel increases, so does the hull symmetry. This would reduce the weather helm caused by conventional hull asymmetry. A heel angle of 15° might give an angle of attack of 4° to 5°, thus the hull itself would generate lift to windward along with the keel.

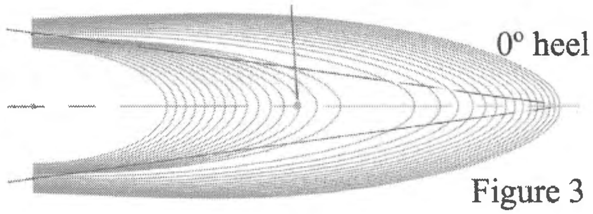


Figure 3

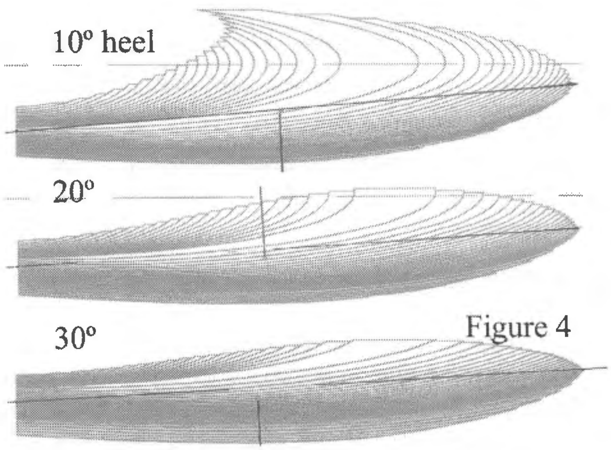


Figure 4

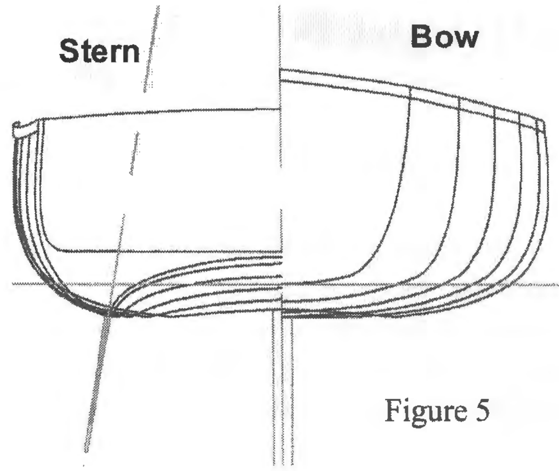


Figure 5

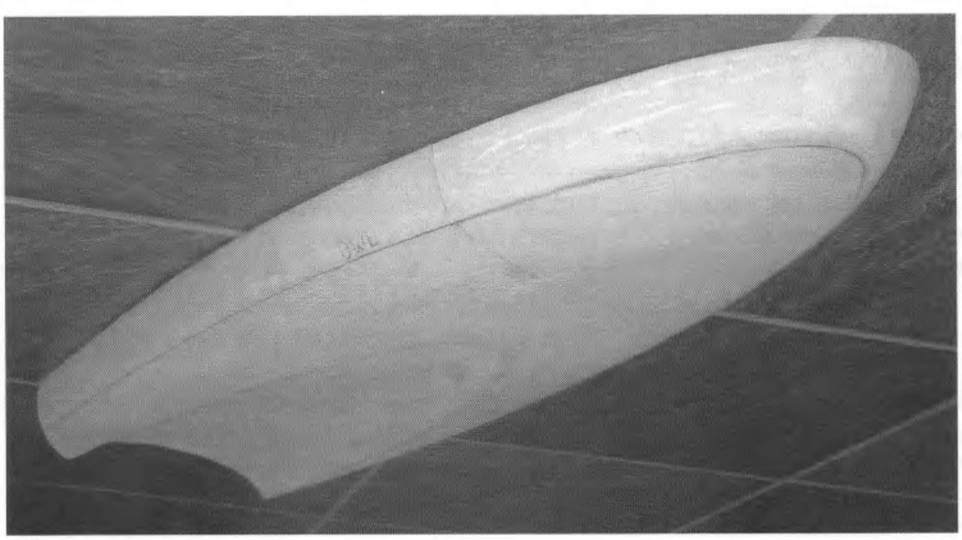
Early results on the stability diagram show a very stiff boat at lower heel angle, though further work is necessary to lower the CG to improve the results at the higher angles of heel. The concave section, between the keels rising into the stern gives a protected area for either an inboard or outboard propeller. With a lifting keel, the boat is beachable and will dry out upright. These latter elements make it easily launched and recovered from a trailer.

The following specification is for my 7 metre *Twin Tail* trailerable cruiser/racer, based on the principles of an aerodynamic hull. Figure 5 shows the full number of stations in the body plan with one of the twin rudders and single lifting keel.

7 metre TWIN TAIL
A trailerable monohull cruiser/racer

SPECIFICATION:

LOA	7.24 m	*23' 9"*
LWL	6.35 m	*20' 10"*
Beam	2.5 m	*8' 2"*
Draught (keel up)	0.15 m	*6"*
Draught (keel down)	1.28 m	*4' 8"*
Crew	4	
Displacement (light)	980 kg	*2160 lb*
Displacement (loaded)	1430 kg	*3151 lb*



The photo *(left)* is of a tenth scale model of the hull from the keel to the maximum beam halfway up the freeboard. This was produced by CAD/CAM and requires further finishing before actual testing can start.

All comments are welcome.

Chris Antcliff,
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Current Kite-boat Project

Emmanuel Roche

I first came to the *Weymouth Speed Week* in 1983, where I saw *Jacob's Ladder II*. I was very impressed by the simplicity of her rig, made of kites stored in a plastic garbage bin with holes in its bottom to dry! Twenty-five knots with a rig stored in a garbage bin! For the rope, he used common 1/4" polypropylene line available everywhere. The only special modification was additional stern buoyancy to the Tornado hulls. After use, the Tornado could be re-used as a standard Tornado. It was really impressive that you could break a world record simply by combining components available over the counter from several different shops. You just had to have the idea, and he did.

Ian Day was using Flexifoil kites simply because they were the most powerful traction kites available at the time. I then contacted the designers of the Flexifoil, and learned that, at the beginning, their idea was to make a flying mattress, and that they were amazed, when they tried it, to discover how much it was pulling. Impressed by this fact, they then had the idea to make a conventional wing-section in cloth, and the Flexifoil was born. Later, they just made variations of it.

After having had so much success with *Jacob's Ladder II,* holding briefly the C-class world record at 25 knots, Ian Day decided to build another kite-boat, but this time on hydrofoils. I warned him that he was going to have to master two wildly moving fields at the same time, but he went this way and has not been seen again since. Too bad. Me, I went back to France and wondered how to improve the kites, since you could break a world record simply using recreational kites designed totally at random.

You probably all remember the famous *flight* that *Jacob's Ladder II* made when she was ready to be launched and that a gust hit her while she was still moored... So, the number one problem of kites is their lack of power control. Ideally, you want the kites to pull just enough to stay vertically in the air, but pull more and more as they go horizontal. The more, the better.

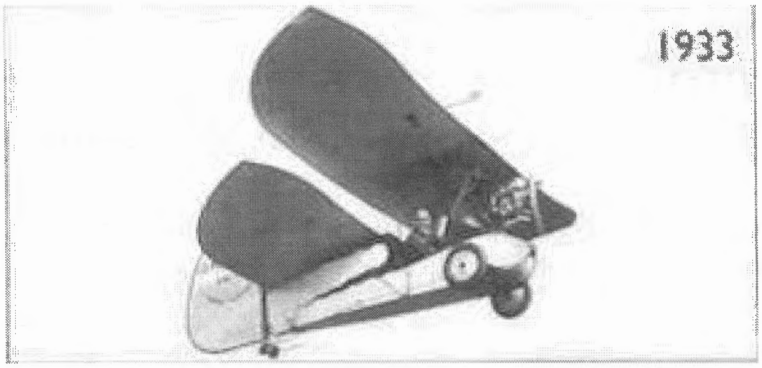
I spent quite a lot of time thinking how to do it, both for cloth kites and rigid wings. In 2004, in *Catalyst* an article titled *Autonomous Wing-Sailed Catamaran* decided me to restart working on the problem.

I wrote to the author, Gabriel Elkaim, a Moroccan now living in California, who is Assistant Professor in the Computer Engineering Department at the University of California, Santa Cruz. His research is primarily on applied control systems with a focus on Autonomous and Embedded Systems. His Prindle 19 catamaran is able to go anywhere alone, with a precision of less than 3 feet. In order to automate everything, he was obliged to design a wing, since nobody is selling wings for sailboats.

I was amazed by the characteristics of the wing he created for his sailing drone. According to him, in the data published in his PhD thesis, he has a symmetrical wing able to develop a Lift/Drag ratio of 3, when the well-known NACA-0012 cannot do more than 1.5! So, a total stranger to aerodynamics had invented a wing section generating twice the lift of the venerable NACA-0012 developed before World War II.

Needless to say, my search for a better wing section was over. I got the X-Y coordinates from him, since he did not publish them in his thesis, wrote a small BASIC program, and am now able to generate the X-Y coordinates for the wing and its *tail* for any size. His design uses a *tail* wing separate from the wing, instead of a 10% flap integrated at the end of the wing.

Now that I finally had a wing section, I then went to talk with one of my friend, who is an expert in Composites. He has several professional diplomas dealing with anything called *plastics* but is also an



Pou-du-Ciel, from 1933

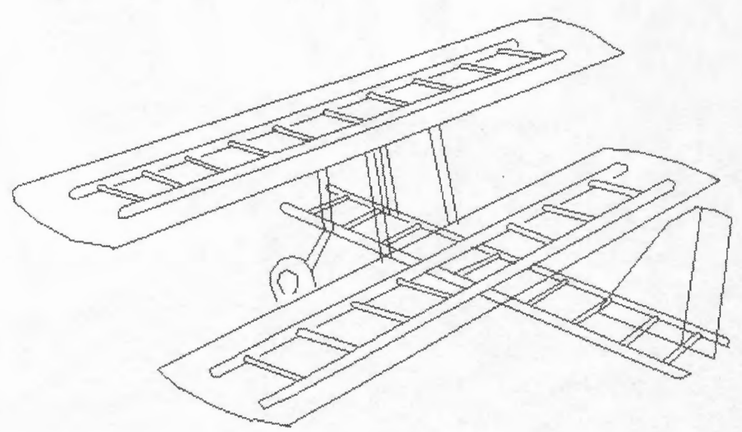
aviation fan, and is often asked to repair airplanes, since he is the only one with the technical diplomas in the area. I asked him: *This professor needed to wait 6 months for an American worker to build a plywood wing, which was too fragile and started to crack as soon as they started using it. What is the cheapest, simplest, yet still really usable way to build a wing?* He simply said: *POUCHEL*, then led me to a computer to show me what it is.

Airplanes are pretty standard now, but it is possible to use other geometries like, for example, the canard configuration where the wing and tail are reversed. Before World War II, a Frenchman named Henri Mignet created the simplest mechanically possible plane. He found that flaps at the end of wings were difficult to build, so removed them. He found likewise that a combined stabilizer at the end of the plane was difficult to build, so removed it. He ended by created a kind of airplane called *Pou-du-Ciel* (loosely translated as *Flying Flea* in English) that has been flying without any problem for fifty years in France. Of course, richer countries are not interested in the cheapest possible airplane, so it does not seem to be widely known outside of France. In fact, most people would probably prefer to be the owner of the most expensive airplane, even if it was a white elephant unable to fly, rather than to own the cheapest one. Marinas are full of *boats* of this kind.

Now, another Frenchman, Daniel Dalby, spent three years building a classic airplane. He managed to do it; but this got him thinking, so he critically studied what had been done before, and he re-discovered the 50 years old *Pou-du-Ciel* and, after a flying test, decided that, despite their different handling, they were as safe as his classic aircraft. He then wondered how to build them quicker. One day that he went in a big supermarket for self-builders, he saw a stack of aluminium ladders for sale for an unbeatable price. He had a flash of inspiration, and decided to register a patent. His idea is to use standard aluminium ladders for all the big parts of the airplane. Only the small parts are hand-made. The engine used is a standard over-the-counter engine used by Ultra-Light aircraft.

He had the luck of convincing a local School of Engineers to help: the students are making all the computations and technical checks for his design. When he applied for a licence, the engineers of the Ministry of Air Transport could not find any single error in the whole design, and gave him a prize for inventing such a simple aircraft.

So, the problem of how to build a wing was solved. I then thought about the characteristics of the kite-boat to be used. I have had the chance of sailing most dinghies existing in France and



England. From all this experience, I decided to use the hull of a 470 dinghy for a two-seater, and the hull of an 18-feet catamaran for a single-seater.

After a few searches, I managed to find what I was looking for. Both boats are now stored near *La Rochelle*, in France. All that remains to do. . . is finish them, then move them here, to *Weymouth Speed Week*!

References:

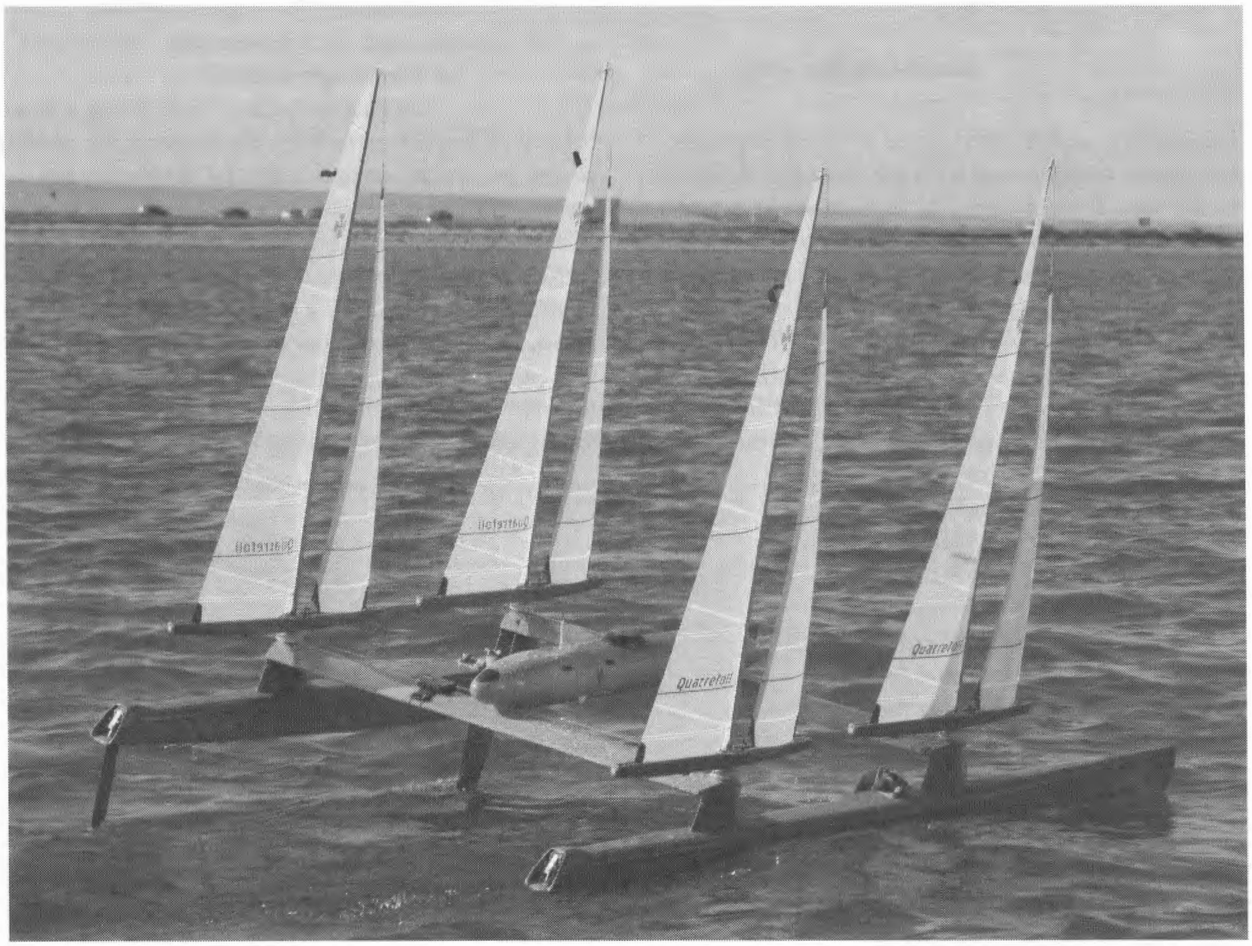
http://www.soe.ucsc.edu/~elkaim/elkaim/Altantis%20 Project.html
http://www.pouduciel.com/index.htm

Emmanuel Roche

Update on Quatrefoil

Jon Montgomery

AYRS members may remember reading about *Quatrefoil* in Catalyst, November 15th, January 2004, followed by a short update in October 2005. Since then, a new *Quatrefoil* has joined the fleet.



Quatrefoil Version Table

	L m	Beam m	Weight kg	Sail area cm^2	First sailed
1	1.6	1.175	3.1	8,230	05/03
2	2.0	1.214	4.2	14,000	05/05
3	2.0	1.304	5.0	16,570	06/06
				14,000	
				8,000	

The original sketches of the boat took shape during January 1998, and apart from subtle refinements, the general principles remain unchanged.

The first static 1:50 scale model looks surprisingly like the latest model *Quatrefoil* which has benefited from sailing development over the years.

Building models is something I have enjoyed doing for most of my life. The new challenge of making radio controlled models proved more difficult than expected. Light weight – but adequate strength, combined with the ability to control four sails, steering and hull slewing was testing. Construction from balsa wood, coated with 35 gsm glass cloth and epoxy resin proved most successful. Finding out where to purchase the various bits and pieces took a surprising amount of time. Materials for the three models cost approximately £3,500.

The enjoyable bit of drafting and making up the models probably took 9-10,000 hours over a five year period.

Confidence in the original concept certainly exceeds my expectations and the opportunity to build a full scale version of *Quatrefoil* rests with a fellow enthusiast who can bring experience and the necessary finance to prove the clear potential demonstrated by the models.

My models have been built without wind instruments. However, to marry up with data from the GPS that I attach to a cross beam, I have recently made up a wind indicator that also videos conditions on the shoreline. This undoubtedly helps to monitor the performance and allow further refinements in sail handling to be made.

The thrill of launching *Quatrefoil* is something special. On a breezy day, the acceleration takes your breath away and standing in the water when it sails silently past at some 10 knots makes my belief that a forty-metre version would comfortably achieve forty knots, and be able to better 800 nautical miles in 24 hours.

Jon Montgomery
jon.montgomery@virgin.net

Biplane Hagedoorn Craft — *updated*

Roger Glencross

[This is an updated version of the article in Catalyst *26, which I have included completely, rather than just the updates - Ed.]*

I do not need to explain Hagedoorn's dream of a manned windpowered seaplane working on the principle of the sailing yacht but with a very minimal 'hull', called a *hapa*, in the water. The hapa is now ready. Thanks to Fred Ball we have a large, stable, efficient, predictable low-speed *hapa* which produces sufficient sideforce at low speed to meet the requirements of the slow-flying manned paraglider. The *hapa* has been christened *harlequin.* So now the manned paraglider must be got ready and here I have met a problem.

The breakthrough that is needed is to build a light glider that is **compact**, that thus does not have 20 ft long kitelines connecting the canopy to the pilot and does not require dynamic kite manoeuvres to produce sufficient lift. This manned *seaplane* should first be tested on land as a glider in order to master flight control. Once it is employed as a kite, i.e. powered, it is a bit late to find it cannot be controlled. This is the technique successfully employed by the Wright brothers.

Failure to build a light 30 ft leading edge spar

For the last three summers I have been building a frame to take the 30 ft wingspan of my elliptical paraglider. This summer (2006) I finished building the frame for one wing of sufficient strength to fully withstand the forces on it (I think).

Unfortunately it proved to be too heavy, so I put it aside without building the frame for the other wing. This frame is only needed when the wind is insufficient to inflate the ram-air canopy; before takeoff or in a lull.

On inflation the air alone supplies sufficient rigidity to the wing to render the frame redundant.

Inflatable kites are unsuitable for this experiment because they are too small when bowed, too dynamic and too inefficient due to their thickness.

Hang-gliders are unsuitable because their takeoff speed is too high (for example 15 mph).

Advantage of a biplane

The advantage of a biplane is that it can be built lighter than a monoplane of the same wing area, since it is more compact. The two wings can be braced against each other. It thus directly addresses the main problem that I face, *viz* the long wingspan of the monoplane paraglider.

Disadvantages of a biplane

The disadvantages are:—

a) The loss of lift caused by the interference effect of one wing by the other. This is particularly bad if the wing is unstaggered and the gap is small. Unfortunately this gap cannot be made staggered or large due to weight and structural considerations.

b) Potentially double the induced drag, due to having four wingtips instead of two, mitigated in part by the beneficial effect on the top wing of ground effect received from the bottom wing.

Figures of lift for the monoplane

I know the figures for the monoplane and we will see if it is possible to get comparable performance out of a biplane of similar total wing area. The elliptical kite's lift figures at 10 mph are:—

Man+Kite+Frame = 150+10+10 or 170 lb, then

$$170 \text{ lb} = C_L \times \frac{0.0024}{2} \times 224 \text{ ft}^2 \times (14.67 \text{ ft/sec})^2$$

thus $C_L = 2.9$

I know the kite can fly at 10 mph carrying a man weighing 150 lbs. But the kite will fly banked in order to produce a horizontal as well as vertical force. Assuming a 10° angle of bank, 98% of the resultant force is vertical (cos 10° = 0.9848), and 17% of the resultant force is horizontal as cos 80° = 0.1736, so the vertical component of the resultant lift force of the kite is 98% × 170 = 167 lb.

So the amount of lift available to lift the weight of a kiteframe at various speeds is as follows:

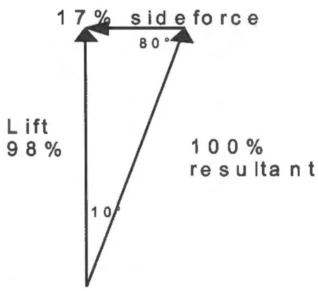


Figure 1

Airspeed	**Airspeed**	**Weight of Frame**
mph	ft/s	lb
10	14.670	7
11	16.137	42
12	17.604	80

Lift increases with the square of the velocity.

Figures of drag for the monoplane

Adequate lift is vital for the machine to work **at all**. Adequately low drag is vital for the machine to work **well**, so is not as important.

But I want to compute the drag as a reality check on the lift figures and because it is interesting anyway, I hope it is not a circular argument, since I use the C_L figure for both calculations.

The most dominant form of drag in a low aspect ratio plane such as this is induced drag, accounting for I estimate (which means, I read somewhere!); 75% of total drag. Induced drag is computed by the formula:—

$$C_{DI} = \frac{C_L^2}{\pi \times A} \quad \text{where A = aspect ratio, so}$$

$$C_{DI} = \frac{2.9^2}{\pi \times 4} = 0.67$$

Adding 33% for other types of drag (0.22) we get total drag coefficient of 0.67 + 0.22 = 0.89

Checking the lift/drag ratio we get

$$\frac{C_L}{C_{DI}} = \frac{2.9}{0.89} = 3.26$$

Since the published L/D ratio is 5.5 to 1, since manufacturers exaggerate, since the manufacturers figure is the best obtainable at the most favourable speed, since we are abusing the glider by using it as a kite (a powered plane), and since the frame adds drag, I consider my figures to be eminently obtainable.

Figures of lift for the biplane

I have a rectangular sports canopy of 121 ft², aspect ratio 1.5, span only 13.5 ft, chord 9 ft. Two identical canopies give 242 ft² compared with 224 ft² for the monoplane. It is not a foot-launched canopy, it needs a landrover to launch it; but it is foot-landed.

Assuming C_L is identical to the elliptical canopy (and it is a big assumption), we get a first calculation of lift for Man+kite(1)+kite(2)+frame as follows:—

$$150+10+10+10=180 \text{ lb} = 2.9 \times \frac{0.0024}{2} \times 242 \times V^2$$

therefore V, velocity = 14.62 ft/sec = 10 mph;

but there is a loss of lift due to the biplane interference effect. This is computed from the graph in Sherwin's *Manpowered Flight* page 53 which gives a graph of gap/chord ratio over lift correction factor. The wing gap is 5 feet, being the height of my tetrahedron (central to the wing structure) the wing chord is 9 ft, so gap/chord ratio is 0.55, giving a lift correction factor of 0.74. Therefore we get a revised lift equation of:—

$$\text{Lift} = 180\text{lb} = 2.9 \times 0.74 \times \frac{0.0024}{2} \times 242 \times V^2$$

therefore Velocity = 17 ft/sec (11.5 mph).

The angle of bank of 10° will reduce the vertical component of lift by 2% (see Figure 1). So the amount of lift available to lift the weight of the kiteframe at various speeds is as follows:—

Airspeed	**Airspeed**	**Frame weight**
(mph)	(ft/sec)	(lb)
11.5	16.871	6.5
12.0	17.604	23.0
12.5	18.338	39.5

To build a frame weighing only 6.5 lb would be a real challenge, and require exotic materials.

Following the triangle of forces above, at 11.5 mph the resultant force (the hypotenuse of the triangle) is 180 lb (100%), the vertical component of the lift force is 176.5 lbs (98%) and the horizontal force is 30.5 lbs (17%).

Towing tests on the *Harlequin* hapaboat at Weymouth Speedweek 2006 can be summarised as follows:

	Speed of towboat (mph)	Pull on hapa line (lbs)
	0	0
	1	1
	2	5
	3	12
	4	22
	5	34
	6	48
Measured	7	66
	8	86

The hapaboat does not come up onto the plane, nor is it designed to do so. A horizontal force of 30.5 lbs is produced at 4.75 mph. The *hapa* line is not exactly horizontal, but at small angles to the horizontal the reduction in horizontal force is not statistically significant.

Figures of drag for the biplane

The induced drag of a biplane with wings of equal span is computed by the formula:—

$$\frac{(1+K) \times C_L^2}{\pi \times A}$$

where K (a constant) is drawn from Sherwin's ground effect graph. (The biplane has twice the induced drag of a monoplane, but lessened by the downwash from the top wing being deflected by the bottom wing). Without it K would simply be 1 but in this case it is 0.80, based on the ratio of wing gap to wing span (5 ft to 13.5 ft) so:—

$$\frac{(1+0.8)\times(2.9\times0.74)^2}{\pi\times1.5}$$

therefore $C_{DI}=1.76$

Add 33% for other drag; 0.58

then $C_{DT} = 1.76+0.58 = 2.34$

Lift/drag ratio $= \frac{C_L}{C_{DT}} = \frac{2.9\times0.74}{2.34} = 0.9$ to 1

The triangle of velocities

The machine's L/D ratio being 0.9 gives a drag angle for the biplane of 48° (cotangent 0.9 = 48°). Assuming the hapa has a L/D ratio of 2 to 1, its drag angle is 26° (cotangent 2 = 26°). The beta angle is the sum of these two drag angles, so is 74°. So with a required apparent wind speed of 11.5 mph for takeoff and a hapa speed of 4.75 mph (for 30.5 lb as above) we get the following triangle of velocities (while **flying**, not sailing):—

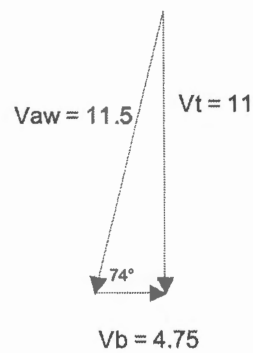


Figure 2

So we get a required true wind speed of 11 mph. This triangle of velocities seems eminently achievable, the formulae seem conservative and the underlying assumptions mainly reasonable. These are my figures, and I recommend them to the House!

Conclusion

The biggest doubt that I have is whether I can transport the C_L of the elliptical kite (2.9) to the rectangular kite. In other words, is there a direct correlation between C_L and aspect ratio? (the lower the aspect ratio the lower the C_L). Also is there a correlation between the age of manufacture of a canopy and C_L? (or do more modern, more sophisticated, more efficient canopies produce a larger C_L than old canopies?) Perhaps I could retune the kitelines to produce a higher angle of attack, and thus a higher C_L? This is where I need your help. If as I fear my older rectangular canopy has a C_L nearer to 1 than the 2.9 that I have used, then I am finished.

The coefficient of lift increases in a linear correlation with angle of attack over a wide range. Design angle of attack for the rectangular canopy is 15° and let us assume $C_L = 1$. At angle of attack of 30° it is 2, but at the required C_L of 2.9 it would be 43° and clearly stalled.

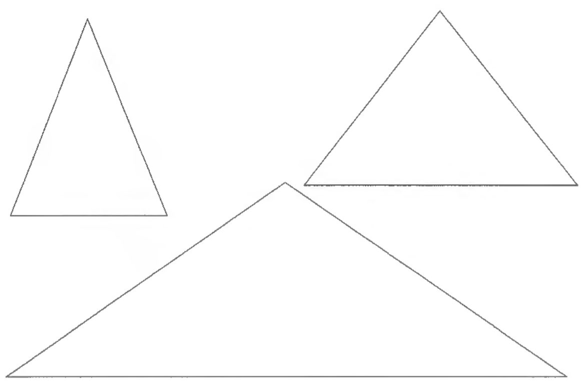
Another doubt I have is concerning the lift formula. The full formula is in fact:—

$$\text{Lift} = C_L \times \frac{1}{2} \times \rho \times V^2 \times S \times \frac{A}{2+A}$$

where A is the aspect ratio.

Clearly low aspect ratios are heavily punished. The suffix (A/(2+A)) does not apply to delta wings, which are by nature of low aspect ratio. Presumably this is due to the greatly beneficial effect of vortex lift on such wings such as the *Concorde* airliner and crabclaw sails.

But when does a delta wing cease to be a delta, and start to require the suffix on the lift formula? Presumably gradually, but I can find nothing about this in the aerodynamic literature. Take the following delta wingplans:—



All are deltas. This illustrates the weakness of the mathematics which treats aerodynamics as two-dimensional when it is in reality three-dimensional. What is actually happening is that wing vortices produce a resultant force working more or less vertically upwards but also somewhat to the rear, by a small angle if the system is efficient, and by a large angle if it is inefficient.

The present methods of aerodynamic mathematics have been sufficient to design successful aeroplanes in the past, but are not adequate for us because we are at the cutting edge of science with our very low speed aerodynamics. The present system is a parable: "how to bluff your way in aerodynamics", and does not accurately portray what is actually happening to the airflow. We need a system that can be understood by people with school-grade maths yet which deals with the real world of three-dimensional vortices, as a vital tool for the amateur inventor.

Amateur yacht research is hindered by this lack of a suitable mathematical system in the same way that the science and mathematics of the ancient Greeks and Romans was hindered by their dreadful number system, which rendered multiplication and long division extremely laborious. If they had possessed our number system algebra might have been invented a thousand years earlier. One can only boggle at the scientific advances that would have been achieved by Pythagoras, Archimedes, Eratosthenes and Ptolemy.

We in AYRS should treat this new simple three-dimensional mathematics system as the top priority inventive goal for the next decade.

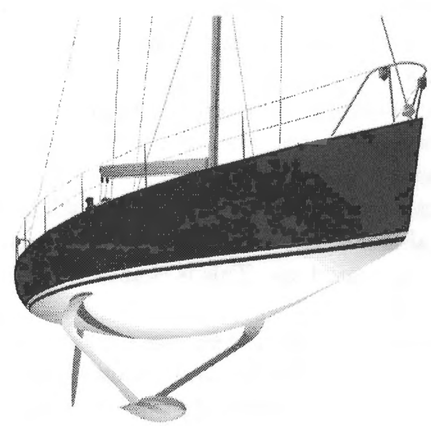
Roger Glencross

[A few items that I noticed under the radar — Ed]

Wot Rocket — If you are interested in fast sail attempts, Google Wot Rocket and see what turns up. The beast was unveiled in late December 2007. Its a 9 m long and 9 m wide foil-born Atlantic proa with a wingsail, said to not need calm water, and hoping for 50 kts.

Loop Keel — BoatDesign.net has an interesting forum, and on the *Sailboat* section of the forum is an interesting and informative discussion about the keel shown below *(picture lifted from the forum, and worth a thousand words)*. This has been invented and patented by Jon Howes and James Macnaghten, developers of the *Monofoil* project.

The www.hmtmarine.com website has the latest on the *Monofoil* project as well as this fascinating loop keel.



HMT Marine's loop keel

Electrotide

Curly Mills

The Problem: — There is an urgent need to find clean ways of generating that essential foundation of modern civilisation: electricity. Burning coal and oil generates CO_2 and we are all now aware of the adverse changes in weather which that is producing. These fossil fuels will also be running out by the time our own grandchildren have grown up.

Which Green Source to Use

The tides have enormous energy but because they are quiet and undemonstrative, they have been relatively neglected as an alternative source of green power. Unlike wind, wave and falling water which are more obviously energetic, the tides are totally reliable, predictable and not given to the extremes which can wreck the wind and wave-driven systems.

Concentration

Wind and wave energy is spread across a wide front but rainfall is collected and concentrated by hills to produce hydro-electric power.

Like wind and wave, over the ocean's tidal energy is spread over a wide front. But it is concentrated by the geography of the coastline into strong tidal currents particularly through channels between islands or in sea lochs around the Scottish coastline.

These locations are clearly the easiest places to tap into this power source.

Designing a tidal power system

Water is heavy compared to air but the tides move relatively slowly. Kinetic Energy is defined as $= \frac{1}{2} \times m \times V^2$

So to extract a useful amount power from this slow-moving seawater, a massive volume must be slowed down.

The resulting thrust and drag forces will be very high but also slow moving and the thrust must therefore be geared up. This is best done hydraulically.

As far as is possible, the sensitive equipment (which includes installation and maintenance engineers) should be kept out of the seawater and strong tides.

The Solution: *Electrotide*

Electrotide consists of an array of many large aerofoils which in a typical installation might be 25 m high × 4 m wide × 0.5 m thick floating vertically in a tidal channel.

The foils are angled to the flow and hence are driven by the tide across the flow for 10 to 20 m or so. The foil angle to the flow is then reversed and the foils shunt back again and the process is repeated. Each cycle might take perhaps 10 seconds.

The reciprocating action of the whole array drives one or more hydraulic pumps which pump fresh water through turbines which then power an electrical generator. The fresh water will be recycled to and from a reservoir topped up from a local stream or from desalinated seawater produced on site.

The Foils

Steel or reinforced concrete are suitable for the foils as they are economical and durable. The foils are ballasted to float upright with the right degree of bouyancy to maintain a midwater position held down by the seabed anchorage.

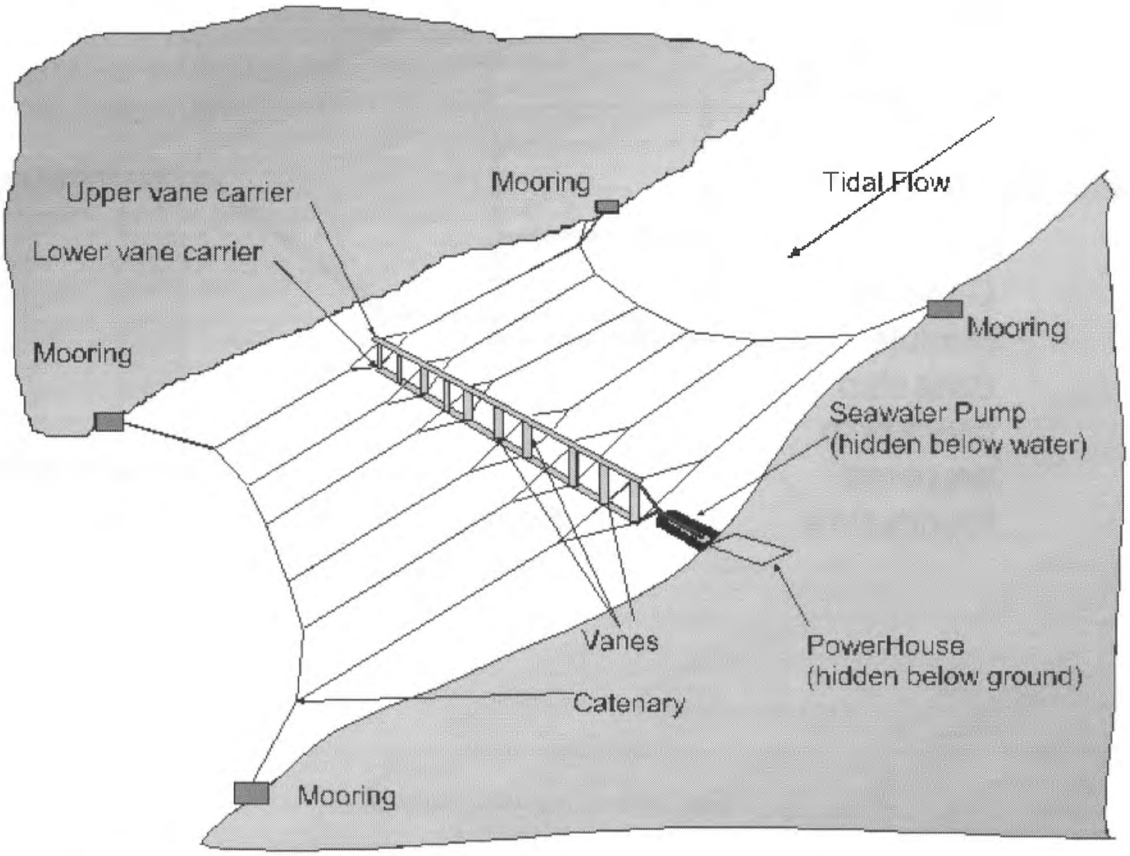
The foils are easily turned 180° to face the new flow direction during the slack tide period and hence can have an efficient aerofoil section.

The foils will have a constant section from top to bottom as they will then be easier to build and to fit with automatic scrapers to remove fouling.

Why do it this way?

The cost of connecting to the grid, staffing and providing a power house dictate that it will be most cost effective to abstract the maximum permitted power at each site. So the area of the foil array must be accurately matched to the cross section of the tidal channel (usually large) to prevent the tidal flow (and hence power) bypassing the foils without making its contribution to the power generation.

The reciprocating motion of the whole array is used to operate a large submerged (and rather simple) fresh-water pump which pumps high pressure water to a sophisticated multi-stage turbine which then drives the electrical generator. These are housed in the generator barge module which can be



N.B. the vanes and vane carrier are hidden below water and move as a complete assembly which then actuates the seawater pump and hence the generator

Typical installation in plan

built in a shipyard, towed to site and then ballasted down onto prepared foundations.

All the delicate equipment is thus concentrated in a safe and dry environment where there are no adverse corrosion or maintenance problems. (Unlike with other systems, where the complex hydraulic and electrical equipment is frequently immersed in the strong tidal streams where both installation and maintenance are difficult).

The Opportunity

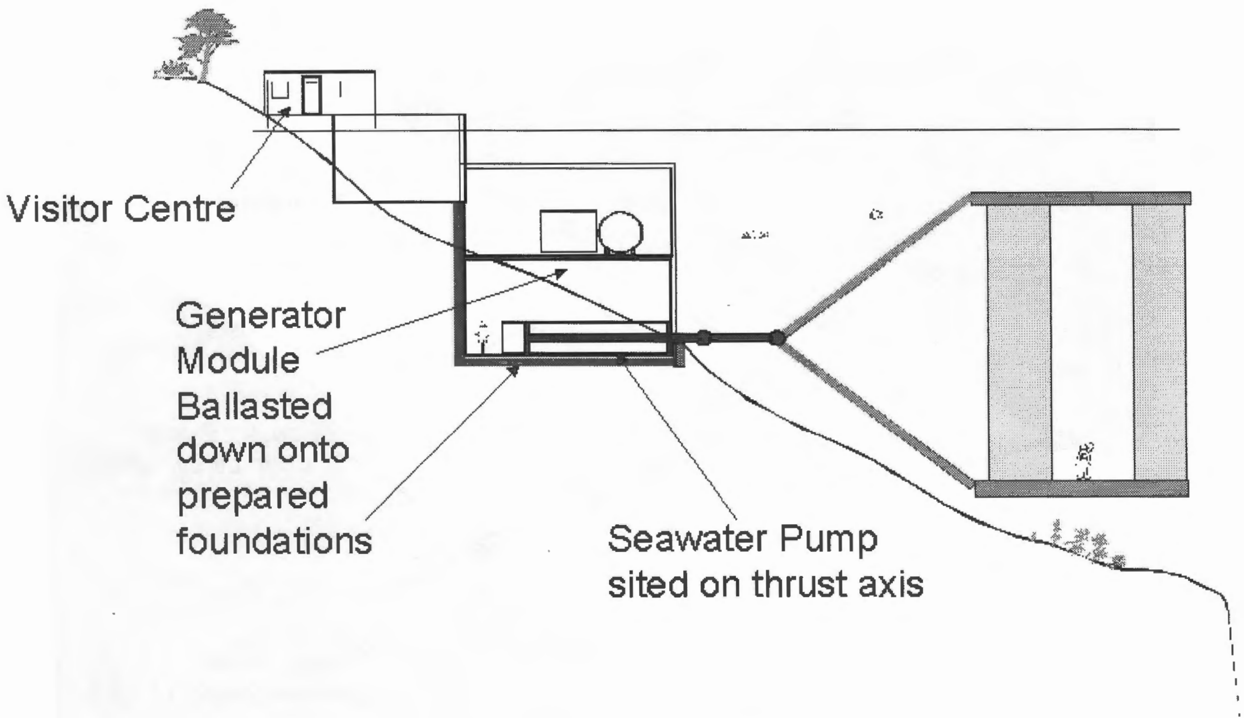
Cuan Sound is just 200 m wide and cuts off the island of Luing and the communities of Cullipool and Toberonochy. The existing ferry service is unsatisfactory and a bridge incorporating a tidal generator has been proposed.

Electrobridge

Cuan was selected as a good demonstration site before the need for improved access to Luing had been appreciated. Incorporating a bridge into the system is relatively easy as the hydro-electric generator can be housed within a floating bridge structure which is restrained in position by the moorings of the *Electrotide* array.

Boats can pass because the oscillating movement can be stopped to open a temporary navigation channel. There would be little loss of power generation as the reduced resistance will allow the tidal stream to build up speed and the enhanced flow will allow energy to be recovered.

The annual average power generation here may only be about 6 MW but there will be cost savings by eliminating the present ferry. There is also a handy power line crossing the sound close by and



Cross Section of a typical Installation

the Cruachan pumped storage facility is just a few miles away.

But the prime purpose of this site is to develop the system and confirm the engineering design details for the larger and more commercially valuable sites which lie close by.

The Forces which Result

At Cuan, twenty 30 m × 2.5 m fully submerged foils will produce a drive load of about a 4 MN or 400 tonnes to give peak power of 15 MW which will be abstracted by the foils reciprocating a large submerged hydraulic pump. This will pump either recycled fresh water or open cycle seawater to avoid pollution problems and the turbines which power the electrical generator will be sited in the generator module sited below water close to the shore and hence totally quiet and hidden from view.

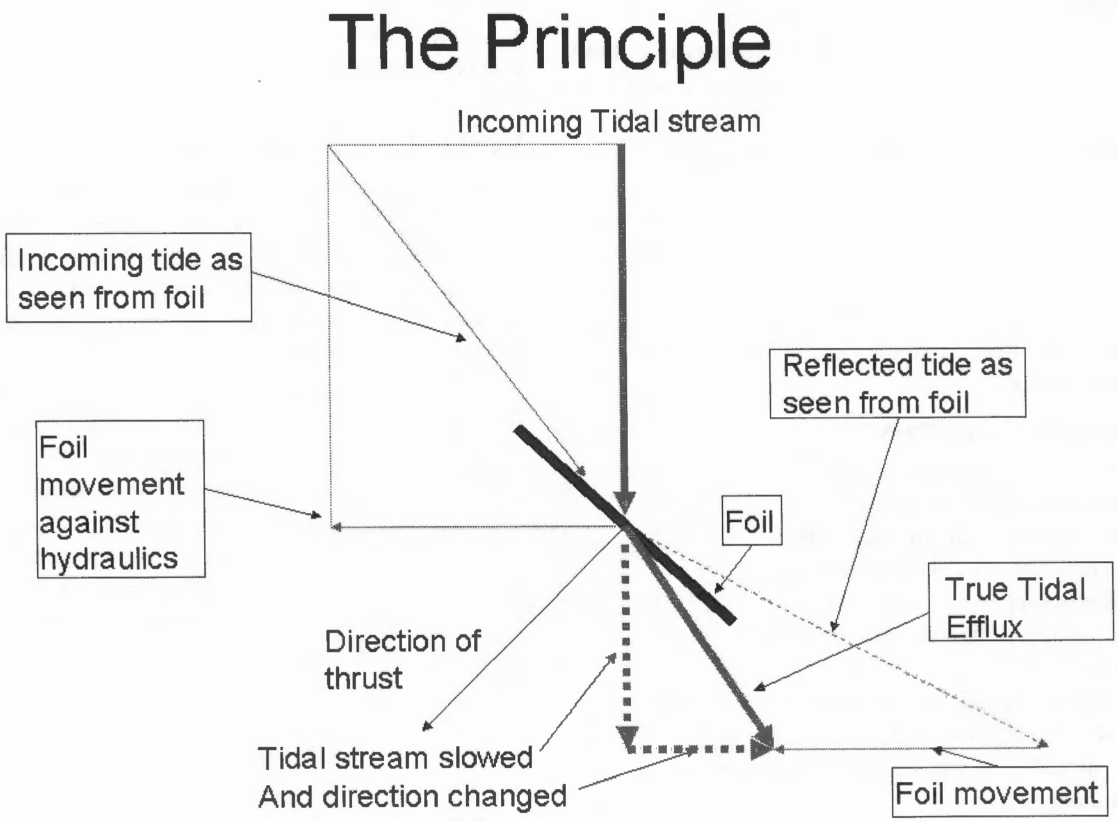
The maximum drag load on the foils will be 75 tonnes on each foil which gives a total anchor load for the system of about 1500 tonnes. Rather than use chain, the catenaries may be formed from solid steel bars each perhaps 10 m long linked by pins and terminating ashore for easy installation.

So how do you get from 'slow and powerful' to fast and electrical?

Gearing up is rather more difficult than gearing down but by using hydraulics we can relatively easily and efficiently convert the very high forces and slow speed of the foils in the tide to a powerful flow water at moderate pressure (or of hydraulic fluid at higher pressures). This is then passed through turbines which drive the power generator(s).

This is directly analogous to using the high pressure water flowing from a dam and by selecting the power cylinder size, the flow can be equivalent to either a high head with low volume or a low head with high volume. 'Off the shelf' packaged generators using Pelton wheels or crossflow turbines may therefore be used at Cuan.

Using water in a tidal system has the great benefit of overcoming potential pollution problems in the event of malfunction or leakage. Because leakage would not then matter, we can use larger piston and seal clearances in the power cylinder to give reduced friction and wear. This will bring a much longer trouble-free life at the costs of a slightly larger foil area.



Catering for the Variation in Tide Speed

As the tide speed drops from its peak, the thrust from the foils reduces and unless the resistance of the hydraulics is also reduced to match the thrust, the array would eventually come to a stop and no power would then be generated.

To avoid this, the power abstracted must be reduced to match the reduced tidal power available but the generator must still be driven at the correct speed.

This is a key engineering problem (known as `impedance matching' in electronics where it is better known).

Matching the Impedance

The water pump produces pressurised water and this can feed a Pelton Wheel whose bucket speed is fixed by the required generating frequency. To maintain high efficiency, the jet speed must be matched to this speed and this means the operating pressure must also be fixed. Power reduction to match the lower power available from lower tidal flows can be achieved by reducing the volume and this can be done by reducing the pump volume e.g. by using smaller displacer pistons in the water pump which will then give the same pressure to suit the turbine but lower volume and hence power whilst maintaining the foil speed.

Alternatively, at lower tide speeds and power, lower pressure nozzles can be brought into use and the full power Pelton Wheel can be replaced or supplemented by lower pressure wheels with a gearbox to gear back up to generator speed. The system can then operate effectively on a fixed pump cylinder displacement but at lower pressure (and hence input and output powers).

Thus very close matching of the impedance can be achieved by using either a fixed pressure, a fixed volume or indeed a combination of these two parameters. Cross-flow turbines may also be used as these have a high degree of adjustment to cater for lower powers.

Tidal Power is not a New Idea!

Tide mills used to be common. As an example there is one at Burntisland in Fife. A small bay would be enclosed by a dam so that as the tide filled and emptied the resulting tidal basin it would have to pass and rotate a paddle wheel.

The Rance tidal power station built in France in 1966 operates on a similar basis but this power station required a vast dam to concentrate the energy and boost the speed of the water flow in order to operate the specially developed turbines which deliver 240 MW.

Dams are Expensive

Electrotide can abstract power from the regular low speed tidal flows without need for a dam. But one advantage of a dam is that it enables power to be delivered continuously unlike the tide which is cyclical.

Tides are completely dependable . . .

Fortunately, the tides along a stretch of coast do not all ebb and flow at the same time and so by strategic siting, the peaks and troughs of output can be cancelled.

Thus several *Electrotide* power stations spaced around the coast and feeding the grid will together provide similar continuous base load electrical power to that of a dam but without the massive civil engineering works of hydro-electric systems.

Wind/Watermills

Up to now, using windmills to generate electricity has been much simpler than building marine installations and they can also be sited relatively near to the grid. But they suffer from the low power density and unpredictability of the wind.

Tides are completely dependable and this has led to some attempts to produce the marine equivalent underwater. Windmill-like `Watermills' have been proposed with marine propellor equivalents and electrical generators at the hub.

But such Watermills have Problems

It is difficult to anchor, protect, and maintain hydro-electric generation systems submerged in the aggressive and corrosive marine environment especially in strong tidal flows where diving is hazardous.

Barnacles and weed quickly foul surfaces at sea but high speed foils have to be kept clean to maintain their performance and this is difficult to automate when the blades have changes in section and twist (as horizontal axis blades must do to be efficient).

Vertical Axis Watermill?

This would certainly enable the electrical generator to be sited above water but the power still has to be taken ashore and the problems of marine fouling remain. Although the blades may be of constant section, they are even more sensitive to fouling due to their higher speed.

But the prime problem with both horizontal and vertical axis watermills or any other discrete device is that the tidal flow will divert around the resulting resistance (Helped by its 'streamlined' shape in the case of the vertical axis mill). To match the coverage given by *Electrotide* would require a closely packed `farm' of such discrete devices which would be far more complex than an equivalent area of *Electrotide* array which concentrates the power mechanically and locates the delicate equipment in the dry.

Electrotide overcomes the Most Serious Windmill Problems

By choosing a narrow strait, the anchorages, generation equipment and most of the control gear can all be sited ashore above water rather than immersed in corrosive salt water.

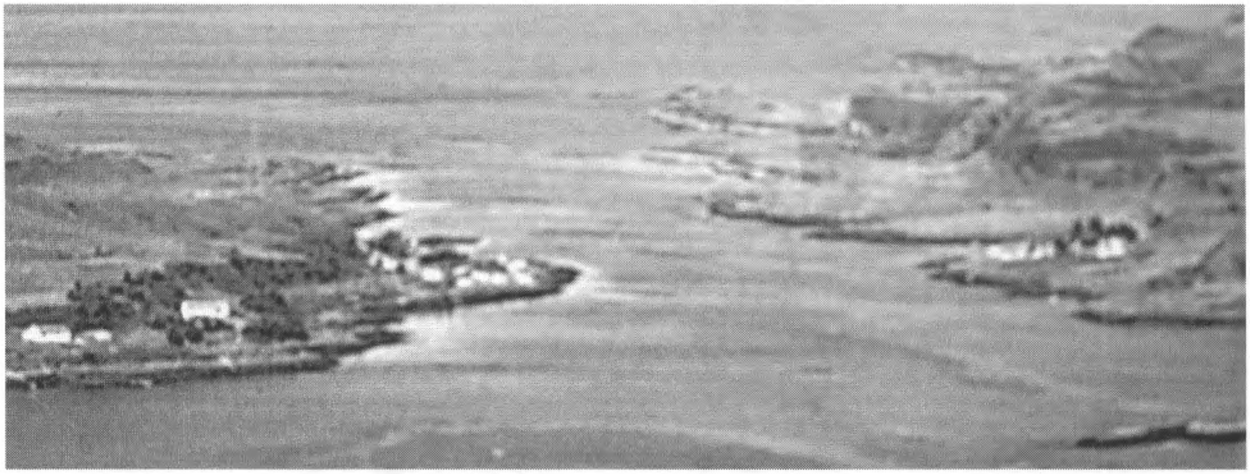
The *Electrotide* foils can fill the cross-section of the strait and prevent significant losses due to bypassing. The low speed foils are less affected by fouling and can also fitted with automatic cleaning gear.

The foils can be hidden below navigation depths and the shore installation can also be disguised.

Electrotide versus Watermills

Because *Electrotide's* foils move relatively slowly, they can be thick and hence strong and have a high angle of attack. This produces a big momentum change in the tidal flow with only modest foil stresses and hence the drive and power abstracted can be high and yet the equipment is undemanding.

The high speed rotating foils of watermills have to be thin, have a low angle of attack (and for horizontal axis mills, have both variable angle and section along the blade). But the drag loads on the



Cuan Sound

foils are high so they need to be clean and strong and hence are expensive both to make and to maintain. There is also a physical limit to how long these cantilevered foils can be, whereas *Electrotide* foils can be both thick, of constant untwisted section and are supported at each end which means that cheaper materials such as steel and/or concrete can be used for the foils with low cost per square meter of intercepted flow.

Electrotide can abstract a lot of energy with relatively little energy wasted in friction and in the vortices produced by the many high pressure gradients which occur at the high speed edges/tips of an equivalent area `watermill' farm.

The Corrievreckan

Far greater power is available just a few miles away from Cuan in the Corrievreckan, where the spring tide runs at 8.5 knots (4.3 m/s) and the channel is 1.2 km wide and 450 m deep. But there are many other sites around Scotland which offer commercial quantities of power without this combination of extremes. The Corrievreckan would not make an ideal setting for one of the early tidal power stations! This is one of the more energetic and hence challenging sites.

The peak power from just one of the 120 x 40 m foils which could be accommodated here would equal that from the Rance project and the channel could easily accommodate six or more even larger foils which could then give an average output of over 1,000 MW. These foils may seem large but compared to dams, ships and suspension bridges they are well within the range of current design, manufacture, materials and technology.

Even so, the available power in the Corrievreckan is far greater than we could capture without unnecessary risk at our present level of experience. Hence the need to start more modestly at Cuan and build experience via some of the less challenging sites. But the above offers a glimpse of the tidal power potential around Scotland and despite the suggested caution, the considerable engineering challenges are still well within present knowledge levels (unlike the constantly distant prospect of fusion energy).

Competitive Methods

Discrete devices such as windmills will 'work' i.e. produce power, but putting sensitive equipment underwater makes them more difficult to install, more likely to fail, more difficult to service and it is costly to get the power ashore.

But the prime problem is that they cannot be simply scaled up like *Electrotide* to match the tidal flow i.e. you need a farm of devices to abstract significant power and this obviously multiplies the above maintenance problems still further.

Other problems

Some devices produce high overturning forces on their foundations which therefore need to be large and heavy unless they can be bolted to rock (not always present and lying nice and flat just where you want it). Even then, installing them will be a difficult undertaking in a strong tideway.

There will inevitably be large gaps in the 'farm' and the pressure distribution upstream of the generators then causes the tidal flow to be deflected through these gaps thus reducing the velocity through the foils and hence the power which can be abstracted.

Potential *Electrotide* Sites

The west coast of Scotland has many tidal streams with peak speeds exceeding 6 knots.

The sites shown [right] are all within 50 miles of the 400 MW Cruachan pumped storage facility.

Potential Sites shown by grey haze, and pumped storage scheme at Cruachan

Conclusion

Cheap energy from coal, then oil and gas has been the foundation of the industrial productivity of the UK and hence of our modern high standards of living. But these high standards now require a great deal of electrical energy.

Even successful economies are still vulnerable to increases in the cost of energy and just as our coal eventually ran out, our gas and oil will soon follow and nuclear is no longer an attractive option.

We need to build *Electrotide* facilities today whilst we still have the energy sources to do it. *Electrotide* will then help to extend the length of time that British gas and oil will last.

Unlike wind and wave power, *Electrotide* does not need standby facilities for the many times when these natural sources are absent. By careful siting of the installations around the coast, there will always be tidal power available.

There are many good tidal power sites around Scotland and so it is an ideal place to develop *Electrotide* for ourselves. But having developed this system for our home market, it will then become a new export business which could rejuvenate shipyards, help to reduce pollution and global warming but will also ensure that we will have the electrical power to ensure we have a good life in the years ahead.

Curly Mills
liomills@googlemail.com

Newt, a totally amphibious, er . . . yacht?

Tim Glover

The problem to be solved was how to sail on land and also on water. Let me explain. Where we go sailing is on an estuary in North Wales that is tidal. So when the tide is in I sail my Hobbie Cat and when it is out I sail my Mk VI home-made land yacht (figure 1).

Figure 1 — the Land Yacht

However when the tide is either half in or half out I am stuck. My dream was to build an amphibious land yacht I could sail at any time.

Some time ago at an AYRS meeting I met Kim Fisher. He had some large 52 inch *[1.32 m]* diameter buoyant wheels that he no longer required (see figure 2, over page). Being given these wheels saved me a considerable amount of time and expense.

These wheels were then fitted to my Mk VI land yacht (see figure 3). They worked well in water but not on land, because of their shape they sank into the sand. So 4 inch *[100 mm]* wide flat tyres were fitted (see figure 4).

These worked well on land (see figure 5) and also they worked in the water. (see figure 6).

My next task is to modify the wheels further so that they can run over very soft sand.

Figure 2 — Kim Fisher's 52 inch wheels

Figure 4 — Flat tyres fitted for sand

Figure 3 — Wheels fitted to land yacht

Figure 5 — . . . works well on land . . .

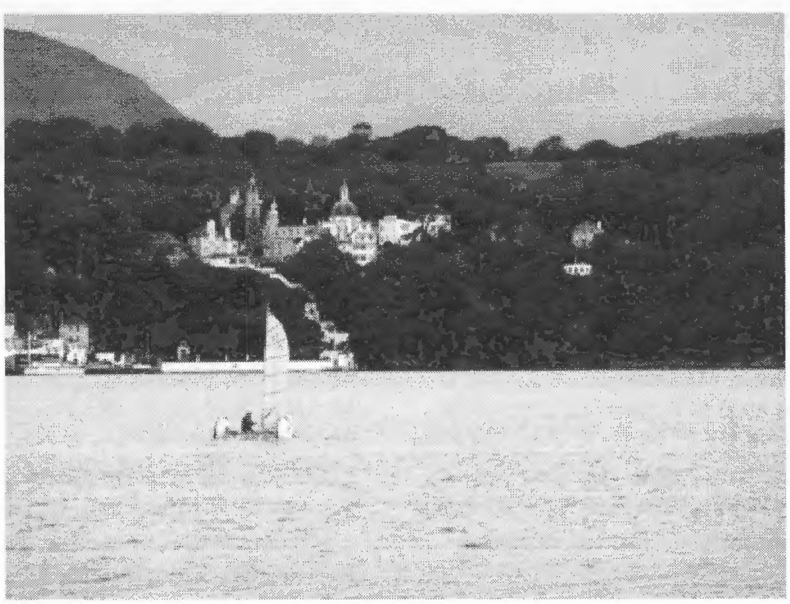
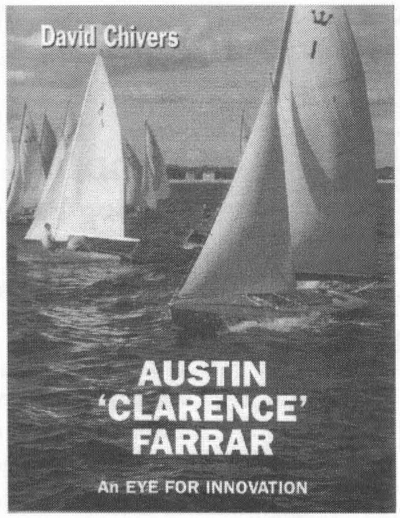


Figure 6 — . . . and on water . . .

Books that have pleased — a few ideas for reading

Simon Fishwick

Austin "Clarence" Farrar – an eye for innovation: David Chivers



Austin Farrar, vice-president of AYRS, died in 2006. In his time he'd been an inventor, dinghy and keelboat sailor (International 14s, 12metres, etc), engineer, designer, and finally innovative sailmaker (founder of Seahorse Sails) and developer of C-Class catamaran wingsails. This book tells the story of his life, some of it in his own words, and comes from the pen of one of his close friends.

Austin Farrar was born in 1913 from Essex yeoman stock, his paternal family having made a fortune in the West Indies before returning to UK, his mother's side owning a substantial amount of faming land. Austin broke with those moulds though, and, following a family passion for sailing, went into marine engineering. He earned his nickname "Clarence" in the first days of his apprenticeship, the name being given to him by the shipyard workers in response to his "posh" accent, so different from their Devon burr. He served his time in a number of yards, and on a number of projects for fast (military) powercraft. In his spare time he sailed; initially in a local one-design class, but later in International 14s where he soon decided he was a better crew than helm, and that he would get more sailing as such!

Coming from a family where invention was encouraged, Austin was fortunate to be yacht and dinghy racing in the heyday of the 1930s. He worked on the design of cutting-edge offshore racers and developed torpedo nets to guard ships during the war. After the war he was the most successful of the designers of the International 14 class and Seahorse Sails became synonymous with excellence and design development.

Among many other design ideas he invented the Pushpit, and the Clamshell folding dinghy (still being made today). He was also responsible for introducing polyurethane coated spinnakers, and was probably one of the first sailmakers to apply science to his craft. To AYRS members he is probably best known as the man behind the C-Class catamaran *Lady Helmsman*'s wingmast/sail, with its distinctive concave luff that ensured that the sail set without any twist. His work on the design of spinnakers and wing rigs is still current and many of today's sailmakers learnt the trade under Austin. In this book the author tells the story of a fascinating man from personal experience and knowing him over many years.

However Austin's inventiveness was by no means confined to sailing. He applied much of what he knew about building light boats to building lightweight special cars and at one point cold-moulded a sports car body. Indeed he owned a succession of 'different' cars including a 1924 Bentley he found in a scrapyard before the War and rebuilt.

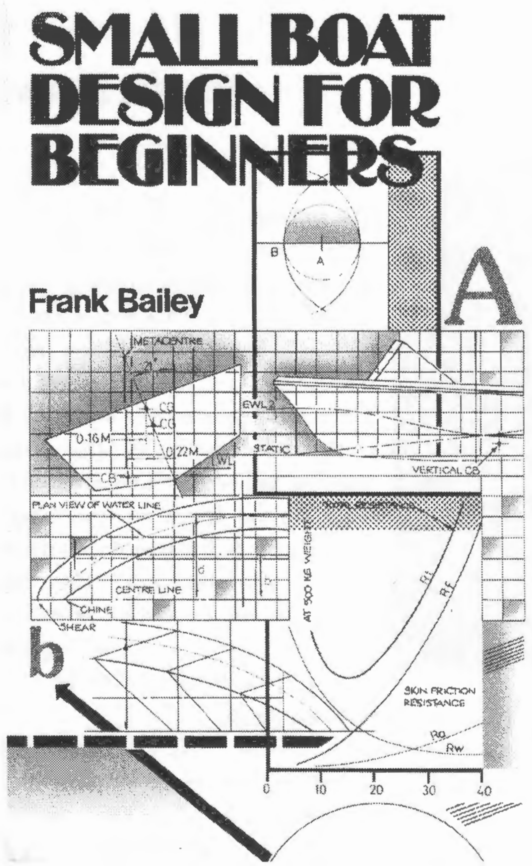
Although not a well-known public figure, he was respected by those who met him and worked with him. He never did join the AYRS, as he felt strongly that, as a professional, he ought not to. He did however provide much help and encouragement in the early years and accepted the post of Vice-President.

The author – David Chivers – works in the sailing world as a judge and technical official, measuring boats and writing rules. He sails dinghies and yachts and has a deep passion for the history of the sport and its people. He also works as a musician in both the classical and jazz fields. He knew Austin Farrar for many years, and was one of his closer friends.

An Eye for Innovation is a good book about a fascinating man. I wish I'd known him. **snf**

Austin "Clarence" Farrar – an eye for innovation: David Chivers; Published by Bosun Press 236 pages. ISBN: 0-9554243-4-8. Price £14.99

Small Boat Design for Beginners; Frank Bailey



No, not that Frank Bailey, this one's an Australian!

Frank Bailey was, in the 1970s, one of Australia's better small powerboat designers, responsible for the de Havilland range of small boats amongst others. Now he is more or less forgotten. His book however, remains to us.

It starts with the basics. It assumes zero knowledge; so the first chapter considers why boats float, and subsequent chapters go on to consider types of powerboat, hull shapes and the factors that control their behaviour and performance. It ends by telling you how to put your ideas down on paper, and produce a lines drawing.

The area it doesn't consider is how strong you can/should make it; or how to construct it. So it doesn't look at loads on skins (which can be substantial in a planing craft) or scantlings. (There are other books on that – Dave Gerr's Elements of Boat Strength for example.) This is a pity as the knowledge gained in Bailey's early career as an aircraft designer made his an excellent designer of lightweight but strong small craft.

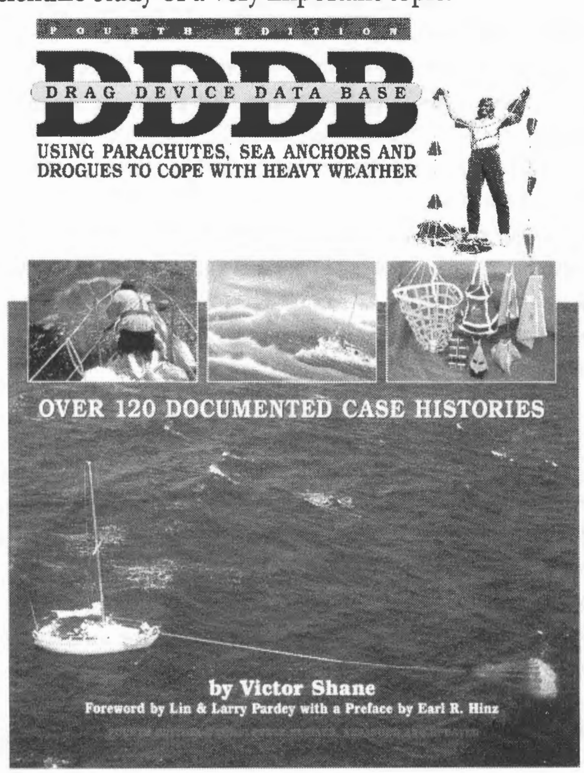
A small book, but it's an effective introduction to powercraft design. It's a pity it's out of print, but it *is* obtainable – I found mine though an Internet second-hand bookstore.

(If you can't find it, alternatives you might like to consider include John Teale's High Speed Motor Boats – it's also out of print!) **snf**

Small Boat Design for Beginners; Frank Bailey, Published AH & AW Reed Pty Ltd, Sydney (1980); ISBN 0 589 50203 4

DDDB – Drag Device Data Base; Using Parachutes, Sea Anchors and Drogues to cope with Heavy Weather; Victor Shane

This book grew from a collection of tales on the CompuServe Sailing Forum on the Internet back in 1990. Its core is a collection of 120 reports from skippers and crew of their experience using various drag devices to ride out heavy weather – from gales to hurricanes. It covers all kinds of boats, monohulls and multihulls, sail and power, both yachts and commercial craft (e.g. fishermen) and all waters. Each report is carefully considered and compared with its fellows, and conclusions drawn. It's a serious and scientific study of a very important topic.



The author does not attempt to lead you to any conclusions but lets the facts speak for themselves. It becomes clear to the reader quite quickly that the 'conventional' small conical sea anchor is almost useless, and that if a sea anchor is going to be used as an anchor then it must be BIG, and deployed properly. That is not to say that drogues don't have their uses, but that holding a boat head to wind in heavy weather is not one of them.

I found it a fascinating read. I may never now find myself facing a storm on the fringes of the North Atlantic, but the lessons here are as equally applicable (suitably scaled) to me trying to handle a Force 5 in my sailing canoe, as they would be to someone facing a Force 11 in the Southern Ocean. Useful reading I should think to those of use who stay in coastal waters within a few hours of safe havens, because, although weather forecasting is infinitely better than it used to be, you can still get caught out. Highly recommended and probably essential reading to someone planning a deep-water voyage. **snf**

DDDB – Drag Device Data Base; Using Parachutes, Sea Anchors and Drogues to cope with Heavy Weather; Victor Shane; Para-Anchors International (December 2000) ISBN 1-878832-03-4

AYRS 2008 Annual General Meeting

The 44th Annual General Meeting of AYRS will be held on **Sunday 27th January 2008** at the Village Hall, Thorpe, Surrey, starting at or after 4.00 pm (after the all-day AYRS meeting).

The AGM is open to all paid-up members and their guests, but only members may vote.

AGENDA

1) Apologies for Absence.
2) Minutes of the 43rd Meeting held on Sunday 21st January 2007 at the Village Hall, Thorpe, Surrey.
3) Chairman's Report. *See inset in this Catalyst [No 29]*
4) Treasurer's Report and Accounts *See inset in this Catalyst [No 29]*
5) Confirmation of President and Vice-Presidents, Election of Officers and Committee Members. *[See below]*
6) To appoint a Reporting Accountant for the year.
7) Any Other Business
8) Vote of thanks to the helpers of the society.

Previous Minutes: The draft minutes of the 2007 AGM are on the AYRS website http://www.ayrs.org.

Officers and Committee Elections: Under our rules, the Chairman (Fred Ball), Treasurer (Slade Penoyre), and Committee Members John Perry, Michael Ellison and Robert Downhill have completed their current terms of office. They are all willing to serve again. Any late nominations should be submitted, preferably in writing, to the Hon. Secretary, Sheila Fishwick, by or on 21st January 2008.

Reporting Accountant: The Committee propose that Robin Fautley be re-appointed.

Any Other Business: No matters have been submitted for this Item. Any items for formal consideration should have been submitted by 22 December 2007, but items for informal discussion may be notified to the Secretary up to 21 January 2008.

Sheila Fishwick Hon. Secretary Fax: 08700 526657; email: hon.sec@ayrs.org

Note: Thorpe Village is close to Staines (and Thorpe Amusement Park), easily reached from the M25 Jn 11 or 13. The Hall is off Coldharbour Lane (follow signs to TASIS).

Chairman's Notes

Fred Ball

I suspect by the time you read this my *Christmas greetings* will be late and the appropriate ones will be for *fair winds and enjoyable boating during 2008.*

The London Boat Show at Excel is almost upon us, I hope you will visit our stand (NO58L) if you are making the effort to get to Excel. Not only can you and your friends (potential members) come and have a browse through past publications you can meet some of the regular helpers: in particular ALL the Fishwick family whom I have to thank for doing almost all the work and teaching the rest of us how to sell the society.

Project *steel protection* was launched 14th December and is already beginning to suffer the effects of Chichester seawater and mud, so maybe I will have a preliminary report on the stand for you to comment on.

Project *surface area and underwater shape article* is being written and may have been completed in time for publication *[not quite, Ed],* but surface area is far from the only factor in reducing drag.

I'm also moving ahead with my kite launching control system and hope to have a suitable boat as a platform ready for the April *Barton Broad* meeting. It's a trimaran using a 3.5 meter hull I built some time ago, but I never got round to building the beams or floats, I've got some ideas for those , possibly incorporating inclined foils to improve stability as I'm planning on reclining in the main hull and will not be providing a great contribution to righting moments if kite control goes haywire and applies a lifting lateral force! I am also considered providing planing surfaces well forward in the floats and using water ballast to windward.

I also have to do some fence replacement in the ponies field and remove a large fallen oak tree from the adjacent stream (the pony field does flood and I don't want to increase the risk) so I've got plenty to do.

Remember if you have any suggestions for the future of AYRS please get in touch.

Fred Ball, 1 Whitehall Farm Lane, Virginia Water, Surrey GU25 4DA UK +44 (0) 1344 843690
frederick.ball@tesco.net

AYRS John Hogg Memorial Prize 2008

The AYRS announces another award of a £1,000 Prize in memory of John Hogg, the distinguished amateur yachting researcher, who died in 2000.

The aim of this international award is to encourage and recognise important amateur contributions to the understanding and development of sailing performance, safety and endurance. Preference will be given to on-going work where the prize money is likely to benefit further development. Other than nominations for a 'lifetime achievement' award, the work should have been performed within the last few years. Work that has previously been entered for the John Hogg Prize is not eligible, unless in the intervening period significant advances have been made.

Nominations, whether of oneself or another, should be submitted to the Honorary Secretary, Amateur Yacht Research Society, BCM AYRS, London WC1N 3XX, UK, to arrive by 30th October 2008. Nominations may be made by or for anyone, whether or not they are a member of AYRS. Those nominating someone else must obtain the written agreement of the nominee and forward it with the entry.

'Amateur' in this context means primarily work done as a pastime and largely self-funded. Details should be given of any grants or other funding or assistance received. Work carried out as part of normal employment is not eligible, neither is paid-for research where the researcher does not own the results, but subsequent commercial exploitation of research need not debar work carried out originally as a pastime. Projects carried out as part of a course of education may also be admissible. A significant factor in determining the amateur status of such work is the ownership of the intellectual property rights in the results. Those with ongoing projects are as eligible to apply as those whose work is completed.

Whilst it is not essential that any innovations embodied in the work be demonstrated and 'debugged', the work must have some practical application, which should be made clear in the entry.

The submission shall cover the following:-

- A summary, of not more than one page, identifying the nominee and the work submitted, and including a short statement of its merits to justify its submission.

- The description of the work itself, its novelty, its practical application, its degree of success to date, and (briefly) your hopes for the future. The work will be judged on the results achieved to date. Please spare us a complete history of your researches except to the extent that they are truly relevant. The use of your already published material, whether or not peer reviewed, incorporated in an entry, is welcome.
- Submissions must be made in English, IN HARD COPY sent by post, to arrive by the due date. FOUR COPIES ARE REQUIRED one for each of the three judges and one for the Secretary.
  Electronic transmission, the use of website pages, and of direct extracts from patent applications (which are written by and for lawyers and can generally be shortened) have resulted in unsatisfactory presentation, hence the need for hard copy of a dedicated paper.
- Diagrams, graphs and photographs may be used, video material on VHS PAL videotapes or DVDs can be helpful supporting material. Programs and presentations on disk may be entered as part of a submission (accompanied by explanatory text etc). Appendices may be used, e.g. for mathematical workings. Direct reproduction of pages from an author's web site has generally proved unacceptable (due to formatting variations) and is not welcome.
- Entries should be printed on A4/letter paper in a legible font.
  Successful short-listed entries to date have ranged from about 22 A4 sides of text with 6 of photos, to one winner with 5 sides, 3 of photos and one A3 drawing. Clarity, legibility and brevity pays!
- Separately, a brief biography of the nominee(s) should be included, and their amateur status and qualifications should be explained.
- Nominees may care to say how they will use the prize should they win.
- AYRS will wish to publish brief summary accounts of entries, and may also seek further articles from entrants. Grant of permission to publish such articles is a condition of entry. To this end it will be helpful if entries can (if necessary) readily be abridged for publication in *Catalyst*, and if a computer disk copy of the entry is included. However any information received as part of a submission will be treated *In Confidence* if so marked.

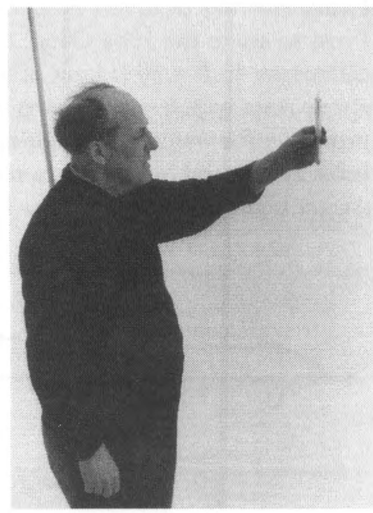
The winner and runners-up will be announced at the London Boat Show in January 2009. All short-listed entrants will receive one year's free membership of AYRS and a certificate; the winner will receive a cheque for £1,000.

The Judges, whose decision shall be final, will co-opt experts as required to assist their deliberations.

Submission of an entry will be taken as signifying the entrant's acceptance of these rules.

Queries concerning possible entries may be made by phone or e-mail to
the AYRS Honorary Secretary on tel/fax +44 (0)1727 862 268; e-mail office@ayrs.org

John Hogg and the AYRS



A gifted professional engineer and keen amateur sailor, John's special interest was in measuring and recording the interaction of wind speed, wind angle and sail trim and their effect on optimal boat speed. He contributed seminal papers to the AYRS journal describing his work based on data from innovative electronic equipment developed and built in his spare time.

During the sixties he produced polar diagrams for a wide range of racing yachts and particularly for wing sail, multihull and hydrofoil projects. In 1962 he built and evaluated radio-controlled scale models under sail to validate tank test data for the *Kurrewa V* America's Cup challenge.

From the Society's creation until his death in June 2000, John encouraged and assisted members to support published work with hard quantified evidence in the interest of the science.The John Hogg Prize, to celebrate John's life and work, is funded by donations.The aim of this international award is to encourage and recognise important contributions to the understanding and development of sailing performance, safety and endurance.

Multihulls — A Design Progression

Walter Schofield

Usually in AYRS we are trying to evaluate devices by reducing them to the barest essentials. This design and build is not a scientific exercise but rather a narrative based on the experiences and prejudices of one amateur DIY sailor. If that has any value this account will try to address each decision in the order in which it was taken and to try trace the project from concept to evaluation.

This account is really the story of two cats. The spectacular demise of the wide cat *Glaucometer* and its reincarnation as the narrow cat *Vamp of Savannah*. *Glaucometer* was designed by Lock Crowther for Simon Frost to sail in the 1984 Ostar. It was an open deck catamaran 45 ft × 30 ft built of foam, kevlar, glass and epoxy resin with a tiny sleeping pod amidships and provision for water ballast but not much else in the hulls. It featured bulb bows, a rotating wing mast, dagger boards and very narrow hulls. (Fig 1.)

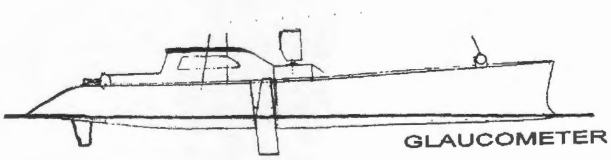


Figure 1

As a preparation for the OSTAR *Glaucometer* took part in the 2-handed Round Britain race with the designer aboard. He wrote with some pride of hour after hour of speeds in the mid 20s on the way to Ireland. On the last leg of the race, despite there being fog on the English south coast, they kept on going, only to be rammed and capsized by a cargo boat off Newhaven. Happily no-one was hurt but the boat was badly damaged. The wreck was towed into Newhaven harbour where space is very scarce so that the choices were to block the river, or block the marina, or prevent the channel ferry from doing its daily 180° turn. In the end they chose to drag it up the slip, and to hack off the sails and rigging and to chainsaw the rest into 6 ft sections which were manhandled into the furthest corner of the boat yard. Time passed and the long grass grew over the wreckage. Just about then I was plotting to retire early and start building my last boating folly when I spotted the bits! To cut a long story short they ended up in my front garden in

Delivery of chainsawed Glaucometer

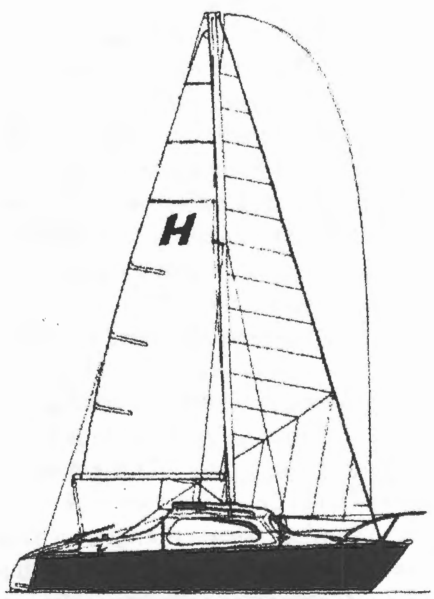
London while I wondered what on earth, if anything, I could do with them.

I suspect that most AYRS members are amateur designers like me in that they know what features of a boat they like and what they would like to change. Nothing gives as much pleasure as sketching a new boat layout or a wacky new sailing device on the back of an envelope. How else could we get through the rat race? But at the end of the day designing and building a boat is a daunting and scary project. Faced with a blank sheet where do you start? Increase the headroom but what about the windage? Make it plenty strong enough but what about the weight? Save cost on the hatch covers but could your 16 stone *[100 kg]* friend jump on it? Apart from my own catamarans I have sailed at least twenty others and often with their designers on board and in each I have found much to admire and to learn. The first thing I learned was there is no such thing as the perfect design because every boat design is a collection of compromises. A good design is one that optimises the compromise for a specific purpose. That means that some very careful consideration of the intention and the priorities of the user should precede the putting of pencil to paper.

Previous 'Baggage'

Sailors are known for having deep prejudices and superstitions and for giving the benefit of their views to anyone who would listen. Designers too reflect their experience and convictions in their designs, so you need to know where they are coming from. My own involvement started on our first ever family holiday with three kids under five in the Isle of Wight. One beautiful summer evening I saw a small sailing boat come into harbour with a happy band of bronzed crew members and I was hooked! About five years later once the children could swim, we got our first dinghy.

After a few eventful hilarious years sailing dinghies I got a windfall of some royalties and blew it on a *Hirondelle* Kit, a 23 ft × 10 ft *[7.5 m × 3 m]* 5-berth cat.



Hirondelle

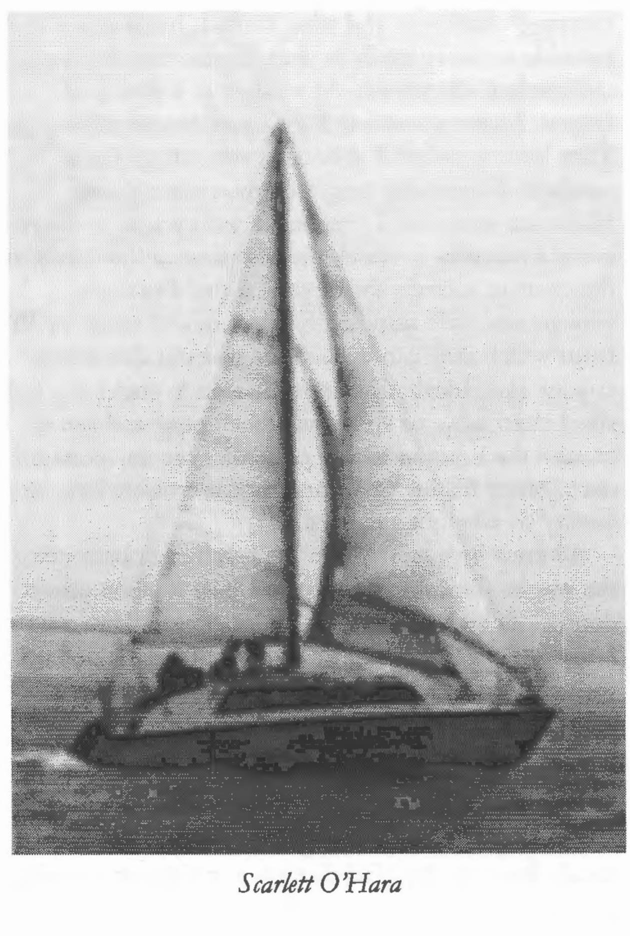
It was Mildred, my wife, who chose it, mainly because it was like our old caravan in that it had big windows and you could see out. I didn't realise at the time that I was joining at the pariah end of the sailing scene. There is something about multihulls which irritates monohull sailors who typically say *I don't know much about cats except that they don't go to windward and they capsize.* To this day that attitude persists but I hope it is less common now than it was then. I never stop trying to prove it wrong.

In the *Hirondelle* I scared my wife and children half to death learning to sail and navigate across to France and Holland. With twin dagger boards and lifting rudders, the *Hirondelle* sailed well in sheltered waters but she slammed and dived in a seaway. After a couple of years she became too small for the five of us.

My second cruising cat, *Scarlett O'Hara*, was a rescued boatyard wreck. She was one of two similar 28 ft × 12 ft catamarans very skilfully made in wood, one for each partner of a Harlow furniture manufacturing company. When the company went bust the boats went into receivership and were left to fill with rainwater in Fox's yard at Ipswich. Above the water *Scarlett* was a little blunt, but below the waterline she had a very elegant cold moulded shape with twin daggerboards. Polystyrene foam buoyancy inside and polyester/glass coating outside ensured that the wood would rot to bits, which it did. Each year for twenty years I rebuilt part of it in the winter and sailed it in the summer.

The weight of the finished boat at five tons was twice what it was designed to be, so I re-rigged her as a cutter and raised the mast 2 ft from the bridgedeck to the back edge of the cabin top. The extra sail area did the trick and in the right conditions she could outpoint many cruising boats. (see below.)

It was like having a rusty souped up van, which, in the right conditions, could beat the sports cars away from the lights! At the Gala Regatta to open the Brighton Marina, based mainly on her appearance, *Scarlett O'Hara* was given too favourable a handicap. Although it was amended downwards every day, at the end of the week she scraped ahead on points of



Scarlett O'Hara

Richard Pendrin's trimaran *Bucks Fizz*. Needless to say he was more amused than disappointed. Sadly Richard became a casualty in the 1979 Fastnet race. We still miss his sunny personality.

The Brief from the Client *(Me, my son Carl and our long suffering family)*

We are coastal sailors who given a choice prefer to sail in daylight hours in winds of force 4 or less. We want to be able to navigate the French canals down to the Med. The overall length needs to be less than 12 m to enable it to be built in our back garden and to avoid the regulations which seem to multiply for boats over this length.

Ideally, a crew of 6 or 7 should sleep in wide beds not using the saloon. They should be able to all sit in the cockpit and see forward so that they can be involved when sailing. The sail handling should be possible without leaving the cockpit. The accommodation layout is not critical with a crew of only 2 or 3 but when 7 are living on board for more than a couple of days, the best of friends or family can get cabin fever i.e. they get overfaced by being eyeball to eyeball for too long. It helps if crew can withdraw to cabins which are private spacious places having doors, standing headroom and wide beds. It helps too if it is possible to move easily in shared areas like the deck, cockpit and the saloon. As a fidget in a family of fidgets, I have a loathing for saloon dinette tables. They look wonderful at boat shows, set up for a candlelit dinner with long-stemmed wine glasses. However, everyone I ever sailed with wants to move every 5 minutes to check the mooring or the depth or the chart or to redo their eye shadow. I prefer a wheelhouse with standing headroom and seats for all from which they can each move without disturbing anyone else. Ideally I want to be able to stand at a full sized chart table or sit in the wheelhouse and see all around the horizon and in particular see any crew on deck. Many fishing boats and motor cruisers have that facility so why not a catamaran?

All crew love to stand in the hatchway obstructing the way to the cabin but how we hate it when others do it! Conclusion? Have more doorways! (The *Hirondelle* had 2 and *Scarlett* had 3 — *Vamp* ended up with 3 doorways, a sliding hatchway, two opening skylights and two under-bridge-deck escape hatches! Plenty of choices!)

The Design

The requirement to navigate the northern French canals down to the Med dictates a maximum overall beam of 16 ft *[4.8 m]*. This limitation has consequences for many aspects of the design of the boat. In such a narrow cat sailing speeds in the teens of knots will be rare and less relaxed than they would be in a wide beam cat. Most coastal cruising is done in moderate conditions and other design features must be optimised so that good sailing speeds in the range 7-10 kt are routinely reached without strain. Since I could not make the boat wider I started by deciding to push the length overall to near my upper limit of 12 m.

To maximise the righting moment within the 16 ft beam limit, the distance between hull centres needs be as wide as possible which calls for the width of each hull to be as narrow as possible. At this stage I had available the hulls of the ocean racing catamaran *Glaucometer*, which had been rough cut into 2 metre lengths. They had a lovely underwater shape and the last word in bulb bows. They were made of PVC foam, epoxy resin, kevlar and glassfibre and they were 30 inches *[750 mm]* wide. The question was whether I could save weight, time or cost, or gain structural strength by repairing and using the hulls. I would have preferred a hull beam of 3 ft *[900 mm]* but I found the *Glaucometer* hulls irresistible. I decided to use Lock Crowther's way of maximising width by inclining the hulls inwards so that the sides of the boat do not overhang the waterline. Using these hulls the distance between hull centres would be 13 ft 6 inches *[4 m]*.

When it comes to windage, shape is king over size, so I planned to have at least a 3 inches *[75 mm]* radius roll to all panel joins. It also gives a pleasing softness to the appearance of one-off constructions.

Thus the main parameters of the design emerged.

- A 'narrow' cat (length > 2 × beam).
- LOA 12 m, Beam 4.8 m, Hull beam 0.75 m
- Full standing headroom in hulls and in saloon/wheelhouse
- Coastal cruiser with good handling in marinas, confined channels and shallow water.

Boat Weight and Construction Materials

Narrow hulls are not good weight carriers so the boat structure had to be kept light. Also as the boat was to be built in my back garden with limited weather protection, epoxy resin would be more tolerant of the conditions than polyester. In view of this I planned to build the rest of the structure using epoxy resin, 18 mm PVC foam, glass rovings and kevlar reinforcement, to match the *Glaucometer* hulls. I judged that the continuity of the elastic properties would have advantages for the cohesion and integrity of the structure. By using vacuum bagging and careful control of the epoxy resin content I hoped to save about a quarter of the weight compared to a polyester resin layup. I would not use any chopped strand mat nor any filler on internal surfaces, both of which can greatly increase the weight. Epoxy was 3 or 4 times the cost of polyester resin but it puts only about 10% on the overall cost of the boat. In the end I used only the bows, the board, the rudders and the hull sections below the waterline from *Glaucometer*, but much of the other kevlar/foam came in handy in the construction of tanks etc.

Accommodation and Layout

I sketched out a number of alternative layouts including versions with rear cockpits, centre cockpits, two cockpits and raised cockpits. They all had pros and cons. I was surprised to find that the layout that attracted me most was one which I had never seen on the water or on paper, that is a central cockpit with a rear saloon/wheelhouse. The centre cockpit although unconventional allows easy safe access to the mast and all sail controls and allows all the crew to sit down or move around whilst being able to see ahead.

When it is really rough, the crew can retire to the wheelhouse where the motion is least, again having an all round view of the boat's progress. (see right, top)

I feared there might be good reason why this arrangement was not viable in terms of weight distribution or overall aesthetic appearance. Would it look like a marine camel? Anyway I found the idea of doing something different was very motivating and very much in the tradition of AYRS.

The design featured a wheelhouse measuring 12 ft × 10 ft *[3.6 m × 3 m]* with 15 ft *[4.5 m]* of seating at the back and with the instruments, wheel and chart table, and sliding door at the front. There is no fixed table but that allows free movement of the crew. There is an all round view of the horizon whether standing or sitting. The cockpit (10 ft × 8 ft) *[3 m × 2.5 m]* is 4 ft *[1.2 m]* deep and well protected and can seat all the crew but in practice they move between saloon and cockpit at the same floor level which makes the boat feel more spacious. (see following page.)

Mast length	45 ft	*14 m*
Boom length	18 ft	*5.4 m*
Mainsail	450 ft^2	*40 m^2*
Jib	150 ft^2	*13 m^2*
Reaching genoa	400 ft^2	*36 m^2*
Assymetric spinnaker	400 ft^2	*36 m^2*

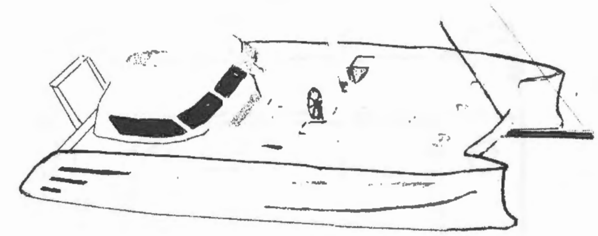


Figure 4

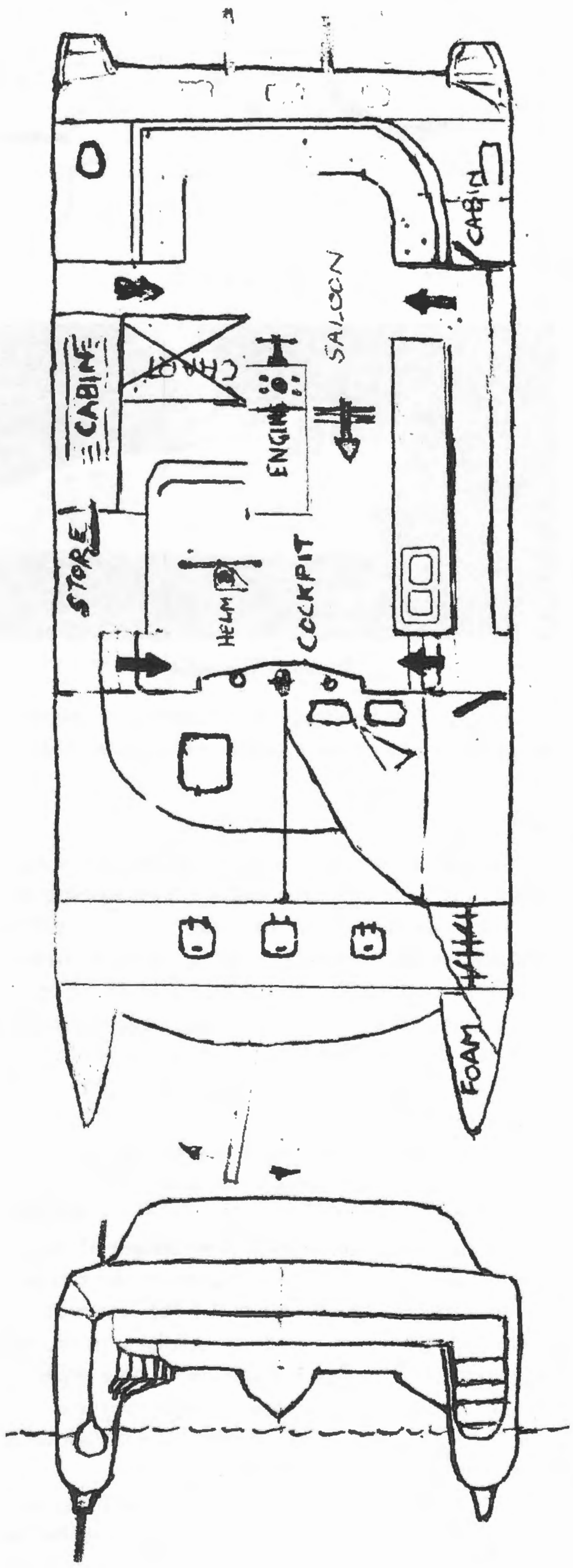
Vamp of Savannah

The mast can be stepped or removed by a crew of two using the boom as a cantilever in about four hours.

Sail Rig

In moderate winds to windward a fractional rig with a fully battened main and non-overlapping jib gets the most drive from the limited stability. Off the wind and in lighter wind conditions there is surplus righting moment and this can be made use of by having convenient means of setting large overlapping areas of sail. Originally in addition to the jib the boat was given a short fixed bowsprit with a light downwind masthead genoa of about 400 ft^2 *[37 m^2]*. It worked well, so well in fact that we used it in stronger and stronger winds and at apparent wind angles down to 40° and of course it broke. Realising its potential we rigged a 10 ft *[3 m]* length of very substantial mast section pivoting under the bridge deck and projecting about 5 ft [1.5 m]. It can be positioned in any position from one bow to the other and is particularly effective and stable on a broad reach in a seaway. It is strong enough to give a straight luff for fine reaching and it has transformed the boat's light weather performance.

In the very lightest of winds (<4 kt) cruising cats do badly relative to monohulls and trimarans because of the resistance of their larger surface area in contact with the water. If you still want to sail – and we often do – the answer is even larger and lighter sails and the



Vamp accommodation

means to control their shape. We use a fairly flat asymmetric spinnaker set between the bowsprit and a 5 m pole and broad reach wherever possible. If we have to go dead downwind we drop the main and set the spinnaker and the genoa wing and wing.

Bulb Bows

Lock Crowther was a pioneer of bulb bows for sailing craft. He wanted to eliminate the periodic pitching 'hobby horsing' in quite small waves which he felt interfered with the low wind speed performance of multihulls. He tested a large bulb version in a racing trimaran *Sanskara* but it pounded when the elevated float hit the tops of waves. For *Glaucometer* he designed integral smaller bulbs which on catamarans tend to remain immersed. I like to sit at the bow of Vamp and watch the transparent flow of water over the bulbs and very sharp bows above them. I believe, but I couldn't prove, that they cut down on the pitching. He later dropped the feature from his designs – I don't know why. [The bows do occasionally slam and one day I will cure that by putting a Vee-shape on the underside where the hull flattens out.] Incidentally 'bulb' sterns are claimed to be equally advantageous but could you draw their shape?

Keel or Dagger-boards?

As a Thames Estuary sailor I needed skegs to take the ground safely to protect the rudders and at the same time I did not want a fixed deep draft. However, good windward ability requires an efficient keel to resist leeway and to act as a pivot to turn the boat through the wind on tacking.

I settled for two shallow skegs and a single 3 m long daggerboard in one hull allowing the draft to be varied from 3 to 7ft *[0.9 to 2 m]*. This freed up one hull to provide an uninterrupted galley. Contrary to what one might expect the asymmetry makes no difference and works well on both tacks. In fresh to strong winds and when running in waves, pulling up the board eases the strain on the boat and softens the motion.

Stability and Sailshape

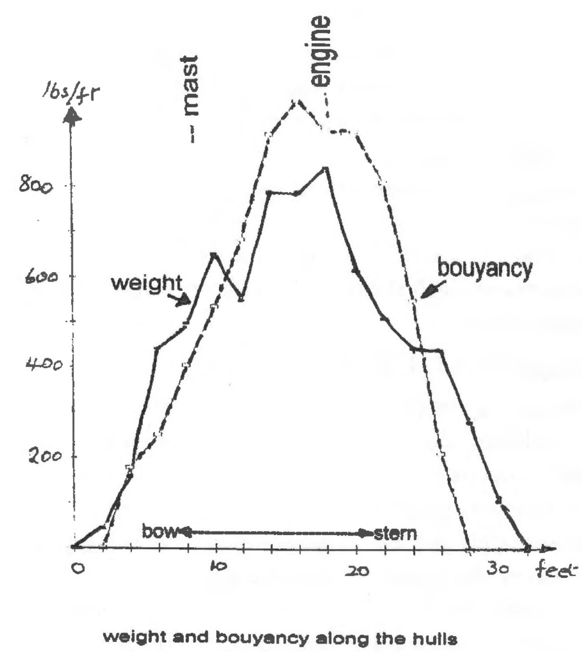
The stability of a multihull is calculated in terms of the wind speed V on the beam that would capsize a stationary boat with its sails sheeted along its centreline. In very general terms:—

$$V^2 \propto \frac{\text{beam} \times \text{displacement}}{\text{sail area} \times \text{rig height}}$$

In order to allow for wind gusts 50% above average exerting twice that force, a lower 'safe' steady wind speed is calculated. For Vamp the critical capsize wind speed is 28 kt true and the 'safe' cruising limit is 18kt. true. In a dynamic sailing situation boats almost never capsize in that simple way. Before it capsizes a catamaran probably accelerates to its highest ever speed. The leeward hull will be depressed to a point where its displacement has doubled. If the buoyancy of the immersed hull has increased more at the stern than it has at the bow, relative to its centre of gravity, then the bow will depress and plough into the next wave. Any hint of a broach will cause some of the forward momentum to become lateral momentum and add to the instability. Meanwhile the forward thrust from the wind in the sails continues to be applied well above the water level. Capsizes are often described as half pitch – half roll over the buried lee bow. Thus in dynamic situations capsize can occur before the critical wind speed as calculated above has been reached.

The graphs (see right) drawn with the aid of a spreadsheet show the distribution of weight and buoyancy for one predicted waterline position. In this case the areas under the two curves are about equal and the centres of the areas are the same distance from the bow so the boat is in equilibrium. Repeating the exercise for different angles and positions of the waterline will move the buoyancy towards bow or stern and predict the restoring forces. It is not an exact science because of all the interactions of wind and water, but two situations are important for a catamaran; the extremes of pitch and the transfer of all the displacement to one hull. The widest part of *Vamp's* hulls occurs 1/3 of the way back from the bow. Whereas the centre of buoyancy and of course the centre of gravity occurs 2/3 back from the bow near to where the hulls are deepest. Thus the waterplane area is greater forward than aft of the centre of gravity and in any degree of heel the stern sinks more than the bow keeping on average a bow up attitude.

In the dynamic situation pitch angles are much greater and the angular momentum impacted by wind and waves must be dealt with more strongly. Having given *Vamp* a plumb bow to maximise waterline length there is no scope to add forward over-hanging clipper bows, hence the somewhat exaggerated flares. The sterns are narrow (500 mm) and of the now almost standard sugar scoop with step variety which retards the build up of bouyancy and any bow burying tendency.



Vamp's Weight and Buoyancy distribution

Solid Bridge-deck or Net?

Solid bridge decks extending towards the bow add weight where you least want it, but they add strength exactly where it is most effective to give stiffness to the structure. Netting and spars at the bow are lighter but attract more windage. The balance of advantage favours net and spars for wider cats and favours solid decks for narrow cats. I estimated that the best compromise for *Vamp* was to end the bridge deck 3 ft *[900 mm]* from the bow.

The other role for the extended bridge deck is to resist pooping or bow burying or capsize, either by the action of waves or of windforce. By adding mass at the extremes of the boat the bridge deck may add to the pitching tendency. At the same time it can provide enormous buoyancy to resist the immersion of the ends of the boat. A bridge deck can sometimes reduce the spray from the bows sweeping over the decks and at other times it can scoop the top off a wave and convey it solidly across the boat.

There is a view that a breaking wave crest could fall onto an extended bridge-deck and contribute to a capsize which is possible, but I have no experience of that and I defer to others who have. However, Prout Catamarans made some hundreds of narrow full-bridge-deck catamarans and less than a handful of them have capsized. That may not be conclusive evidence but it does suggest that bridge-decks extended to the bows are resistive rather than conducive to capsize. Perhaps members can contribute to this debate. In that regard I do appreciate the part Prout played in the early days of multihulls in countering the widely held view that catamarans will inevitably capsize.

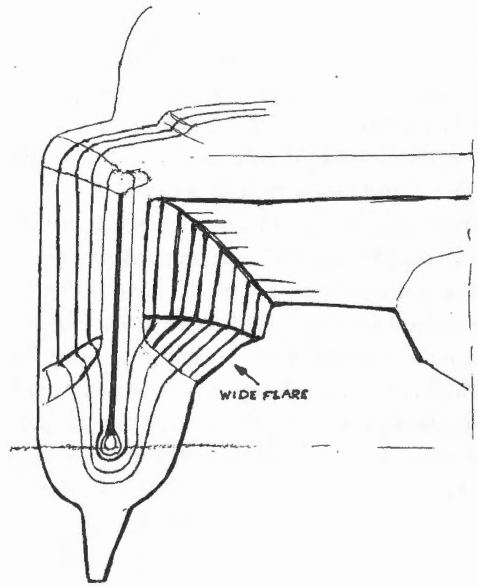
In general skippers know their craft and they can read the signs of wind, weather and boat behaviour and when in doubt they can achieve good sailing performance well short of the safe cruising limits calculated above.

Bridge-deck Clearance

Reducing the bridge-deck clearance allows a cat to have a lower more elegant profile, less windage and more convenient access between hull and bridge-deck. It is very tempting for a designer to do that but unfortunately the less clearance you have the greater the waves slam under the bridge-deck in a seaway and the greater the drag. The noise it makes is possibly more stressful than it is threatening to the structure but it is best avoided. Wave slam tends to be greatest forward where the boat meets the waves and where pitching motion is more pronounced. The placing of the saloon aft with its full standing headroom at the point where the bridge-deck clearance can be least is a good compromise that keeps the boat profile low; to about 8 ft *[2.5 m]* above the waterline.

Knuckle and Flare

Vamp was given a wide flare and knuckle on the inside of the hulls just above the waterline and meeting the bridge-deck. (see right).



Vamp's Knuckle and Flare

It is at its widest at about 8 ft back from the bow and then diminishes aft and finishes well short of the stern. The effect of the flare is to increase the buoyancy forward rapidly as the weight of the boat is either transferred to one hull by the action of the wind on the sails or by the sterns being lifted by a following wave and depressing both bows. In practice the flares are kept quite busy in waves but the angle of slope and smooth entry allows them to swish rather than slam. These flares as well as providing strength to the bridge deck, provide storage in every compartment of the boat, under bunks and work tops. They also house the escape hatches in the front bunks and four sets of angled stairs from the hulls into the cockpit and wheelhouse.

Engine Nacelle

Having suffered much in the past from unreliable outboards we wanted an inboard engine. At the same time we wanted to be able to sail without the drag of a propeller. That indicated a single engine with lifting drive leg. To keep the weight low and central we fitted a 1.6 litre diesel engine under the cockpit in a nacelle with a long propshaft to a Sonic out-drive. The nacelle is about half the length of the boat and gives useful low down storage for heavy items like batteries and inflatable dinghy. We made the nacelle narrow with a deep Vee-shape to avoid slamming in waves. However nacelles add weight, viscous and wave resistance, and restrict the air flow through the tunnel and so are best minimised. I have never been convinced by claims that nacelles can increase a boat's speed by allowing it to plane on its own bow wave but it is a cute marketing ploy.

Evaluation and Modifications

Despite my best efforts the dry weight of the boat came in at 4.5 ton (5 ton with water, fuel and cruising supplies) which is ½ ton more than intended. With the 10 ft dinghy in davits the transoms which were designed to touch the surface are depressed about 4 inches *[100 mm]*. Space exists to build fuel and water tanks forward of the mast but I have not so far bothered to do that. Because of the trim down at the stern the boat had slight lee helm which was corrected by tilting back the mast and by reducing the cut-back at the front of the fixed keels.

Perhaps the biggest miscalculation we made as amateur designers was in the electrical wiring and installation. One might have guessed we would require about three times as much wiring and time as we had on our 28 footer. In fact *thirty* times would be nearer the final outcome. The cost also escalates as the longer runs need thicker wires to avoid voltage drop and nickel plating to avoid connection failure in the damp.

For one season the steerable outdrive leg and the rudders were not linked and it was difficult to control the boat in tight corners with crosswinds. Linking them up made a big difference and by using full dagger board as a pivot we can shunt the boat through 180° is little more than her own length. However, it does call for skill and anticipation compared to the child's play of having twin engines or a bowthruster!

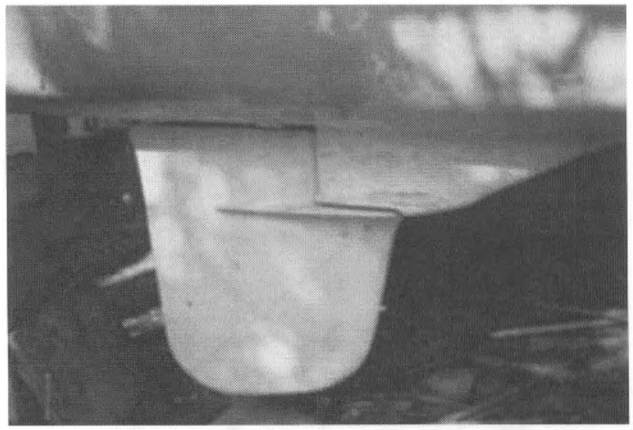
Home Construction

I estimated that 3,000 hours labour, equivalent to three full-time man-years, would be required to complete. In fact it took twice that time including some help from my son Carl, but I enjoyed it and at no time did I doubt that I would complete it. However I would not do it in the same way again and I would not recommend it to others. Concurrently with my project a friend bought a cat design from an experienced designer, built the hull under cover and then fitted it out in less than half the time. Designing the major features of a prototype may be exciting but designing the thousands of other details is sometimes tedious and always time consuming. Worse than that is the fact that lack of specification causes amateur builders to build over-strong and overweight. Even experienced designers make mistakes so that prototypes need modification before going into production. If you are sailing on a production boat on rough dark nights at sea, it's nice to know that dozens of other similar boats have dealt with worse.

When friends and relations come to inspect your creation they will judge is by the standards of their BMW fascia or the latest boat show Sunseeker. So don't hold your breath! One can appreciate the advantages of having a different designer to do the interior finish who is unencumbered by concerns about sailing qualities or strength of construction. Using the internal mouldings and factory machined woodwork available for production boats makes a big difference too.One low cost way in which a home build boat can be the equal of any factory build is in the style and perfection of its name painted on the hull. So have fun, make it bold, make it flamboyant and let the world know that you are unapologetic about the many sins you committed in the construction!

For four years I took liberties handling the epoxy resin before I developed an allergy to it. After that, despite two pairs of gloves, mask and protective clothing my skin would start to fizz the moment I opened the tin. I got others to handle the epoxy and for the less demanding work I used vinylester resins which are half way between epoxy and polyester in performance. The moral of this story is to take great precautions against exposure to epoxy from the beginning, even if at first you do not appear to be sensitive to it.

I was scared about picking up ropes in the gap between the rudder and the hull, so I designed a double collar on the rudder and the skeg which indeed has never fouled a rope. However it was difficult to make and there must be simpler solutions.



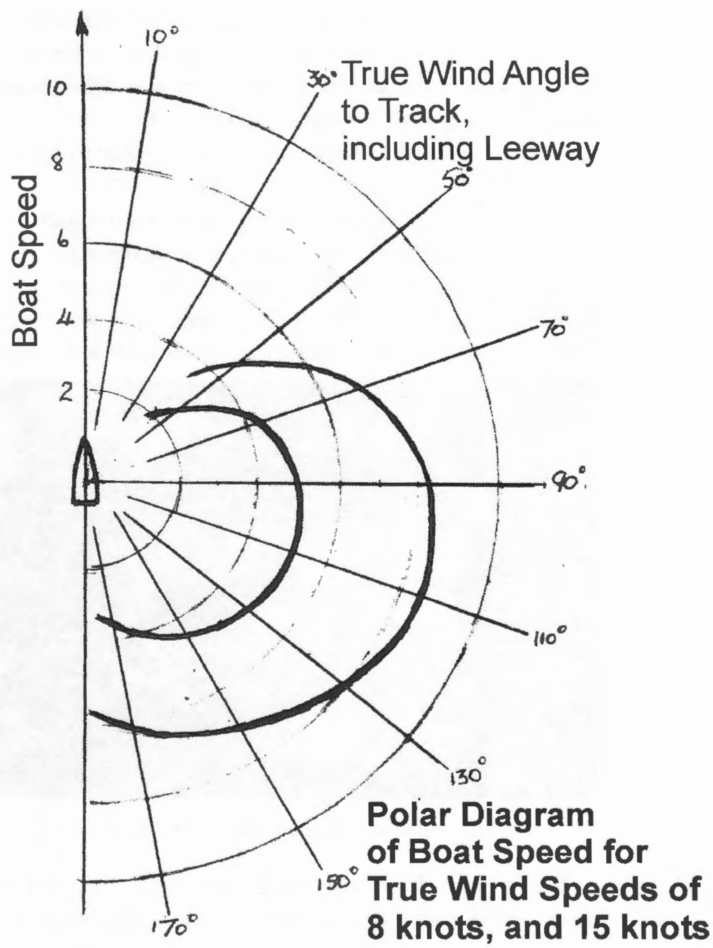
Rudder anti-foul arrangement

Engines on the bridge deck tend to be noisier than those in the hull and benefit from more attention to sound insulation. Changing to spiral gears in the outdrive made a significant improvement. The 1.6 litre engine gives us about 7 kt but that reduces to 4 kt in a very strong headwind. More power would be useful.

Conceived as luxuries but proved to be essentials are a power winch and a diesel air heater. A recently installed ceramic pedestal WC with electrically controlled pumps and macerator is brilliant even when compared to our old trusty Baby Blake.

Coping with Waves

The very fine plumb bows do not provide much lift for depressions into small waves. So they feed less energy into the pitching motion characteristic of cats which have high centres of gravity compared to keel boats. Larger waves produce lift when they reach the very substantial lateral overhang or flares starting about 4 ft *[1.2 m]* back from the bow. On the rare occasions when the boat reaches at 12 kt in strong winds and flat water, the boat heels and the bows dip noticeably as more of the weight is transferred to the lee hull up to the point where the flare resists further depression.



Finally waves of 5 ft *[1.5 m]* or more occasionally reach the bridge deck where the buoyancy is very high and so far we have not taken green water over the bridge deck which we did routinely in our previous cats. If we were to be pooped the centre cockpit is capable of holding several tons of water. We have six or so 2 inch *[50 mm]* diameter drain holes but I am not certain that would be sufficient and I am considering fitting a 4 or 5 inch *[100 or 125 mm]* drain pipe.

Sailing Performance

To compete with fin-keelers to windward *Vamp* needs about 15 kt of wind. Given that wind we can sail at about 5 kt at 35° to the apparent wind with a few degrees of leeway and make 90° to 100° between tacks. We can point as high as 30° apparent with less V_{mg} which can be useful in confined waters. Off the wind in force 4 we expect to do between half the true wind speed and half the apparent wind speed. e.g. 8 or 9 kt in 18 kt apparent. Inside the windward 90° quadrant well sailed fin keelers will outpace us. Outside that quadrant from a fine reach to a run we will have the edge. However in light winds below 4 kt true we cannot match the monohulls, especially on a dead run, although we don't stop trying.

The polar diagram (see left) attempts to represent the boat's sailing performance but they are based on too few readings of inaccurate instruments – particularly wind values. Sometimes we cannot reach the boat speeds on the diagrams and sometimes we exceed them by several knots. I wonder if any AYRS members have produced polar diagrams that they can rely on reproducing on the water? *Vamp's* highest sustained non-surfing speed is about 12 kt. At that speed the weather hull is raised about 5 inches *[130 mm]* but still it has a substantial wake. In a rising wind we could clearly go faster but we are cautious souls and at that point we reef down so that we are cruising at 8 to 10 kt.

Our best compliment to date was to receive written protests from three separate monohull competitors in the annual Nore Race in the Thames estuary. They claimed that we were using our engine during the race. Their evidence was that we were going too fast not to be doing otherwise! Fortunately the race officers noticed that as we crossed the line at 9 kt our propeller was visible tipped up clear of the water! We laughed!

The Future?

I am sure that in the not too distant future integrated yacht instrumentation will be able to generate sailing polar diagrams which will become more accurate as the boat covers more and more miles. The sailing performance will be quoted routinely alongside the tonnage and waterline length when buying a boat. At any time when sailing you will know what fraction of the optimum performance you are achieving under the present set of sailing conditions. I would guess that America's Cup contenders already have it. In the meantime owners and magazine reviewers of sailing performance will continue to be wildly impressionistic and optimistic.

Sadly my review is no different but maybe next year . . .

Walter Schofield
London E12

Catalyst Calendar

This is a free listing of events organised by AYRS and others. Please send details of events for possible inclusion by post to Catalyst, BCM AYRS, London WC1N 3XX UK, or email to Catalyst@ayrs.org

January 2008

11th - 20th

London International Boat Show
EXCEL Exhibition Centre, London Docklands. AYRS will be on Stand N058L, at the East end of the North Hall, next to the Start Boating feature. Helpers are wanted to staff the stand, selling publications and recruiting new members. If you would like to help (reward: free ticket!) please contact the Hon Secretary on +44 (0)1727 862 268 or email office@ayrs.org

27th All-Day AYRS Meeting
9.30am - 4pm, Thorpe Village Hall, Coldharbour Lane, Thorpe, Surrey (off A320 between Staines and Chertsey follow signs to Thorpe Park, then to the village). Details from Fred Ball, tel: +44 (0) 1344 843690; email frederick.ball@tesco.net

27th AYRS Annual General Meeting
4pm, Thorpe Village Hall, Coldharbour Lane, Thorpe, Surrey (as above). Details from the AYRS Hon. Secretary tel: +44 (0)1727 862 268; email: secretary@ayrs.org

March 2008

28th-30th

Broad Horizons AYRS Sailing Meeting
Barton Turf Adventure Centre, Norfolk UK, NR12 8AZ. Contact AYRS Secretary, BCM AYRS, London WC1N 3XX UK; email: office@ayrs.org Note: All boats limited to 1.2 metre max draft!

April 2008

27th Beaulieu Boat Jumble
The National Motor Museum, BEAULIEU, Hampshire, UK. AYRS will be there!

May 2008

Date to be fixed
Meeting at the Castle Cove Sailing Club in Portland Harbour, Dorset, UK. We are looking towards the end of May or possibly the beginning of June. As you all probably know this is the warm up for Weymouth Speed Week and we will be doing towing trials on the model of Icarus3 and more testing on the new timing systems. The format is we use the club Monday to Friday during the day and they tend to invite us to use the club in the evening if members don't need it. Tea and coffee with biscuits is on tap all week and we ask for a donation of £30 each for the CCSC. Contact: Robert Downhill, email: icaruswsr@tiscali.co.uk

24th - 26th UK Home Boat Builders Group Rally
Barton Turf Adventure Centre, Norfolk UK NR12 8AZ. For details see http://uk.groups.yahoo.com/group/uk-hbbr/ message 543 et seq.

June 2008

6th - 8th Beale Park Boat Show
Beale Park, Pangbourne near Reading, UK. Open-air boat show with a number of boats available to try on the water. AYRS will be there again selling publications. Contact: Fred Ball, tel: +44 (0)1344 843 690; email frederick.ball@tesco.net

October 2008

4th - 10th Weymouth Speedweek
Portland Sailing Academy, Portland Harbour, Dorset UK.

8th AYRS Weymouth meeting
Speedsailing. 19.30 for 20.00hrs at the Royal Dorset Yacht Club, 11 Custom House Quay, Weymouth. Location Map: www.rdyc.freeuk.com Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX; email: office@ayrs.org

Sticky:—**How to supply information for publication in Catalyst:**

The **Best** way to send us information:— An electronic [ascii] text file (*.txt created in Notepad, or Word, with *no formatting at all,* we format in *Catalyst* style). Images — picture or graphic files — logically-named please as *.jpg, *.gif, or *.tif.

Any scanned image should be scanned at a resolution of at least 300 ppi *at the final size* — assume most pictures in *Catalyst* are 100 by 150 mm [6 by 4 inches]. Digital photographs should be the file that was created in the camera. A file from a mobile phone camera *may* be useful. Leave all files in colour, and save them as *clear_and_complete_title.jpg* with just a bit of compression. If you are sending a CD, then you can be more generous with the file sizes (less compression), than if emailing, and you can then use the *.tif uncompressed format.

For complex mathematical expressions send us a fair copy and an extra copy or extra scan of your text with any mathematical characters handwritten (we can typeset them), but add copious notes in a different colour, preferably red, to make sure that we can understand. Include notes or instructions (or anything else you want us to note) in the text file, preferably in angle brackets such as <new heading>, or <greek rho>, or <refers to 'image_of_jib_set_badly.jpg'>.

Otherwise:—If you write in longhand, and sketch or include photographic prints, and trust to snail mail (a **copy**, never the original) then all can and will be dealt with. If you have trouble understanding anything in this section, email to ask.

As examples, the polar diagram on p16 of *Catalyst 28* was re-created from a second generation photocopy, photos of shunting in the *Champion* article in *Catalyst 27 (pp19-21)* were screen grabs from a video supplied on DVD, the rest of the images in that article were scanned from photographs, and the text was OCRed (Optical Character Recognition from a scan) or keyboarded.

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Catalyst — *a person or thing acting as a stimulus in bringing about or hastening a result*

On the Horizon . . .

More sources and resources: review, publications and Internet sites

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Amateur Yacht Research Society
BCM AYRS, London WC1N 3XX UK

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