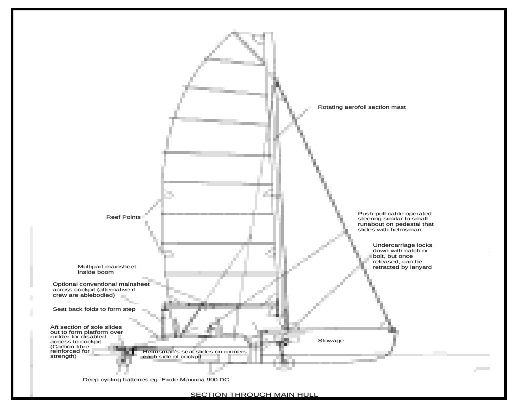
Catalyst

Journal of the Amateur Yacht Research Society

Number 15 January 2004

Features

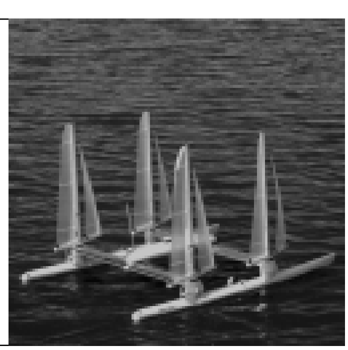


Regulars

Cover Photo

Jon Montgomery's Quatrefoil model under sail

Photo: Montgomery



Catalyst

Journal of the
Amateur Yacht Research Society

Catalyst is a quarterly journal of yacht research, design, and technology published by the Amateur Yacht Research Society, BCM AYRS, London WC1N 3XX, UK. Opinions expressed are the author's, and not those of AYRS. AYRS also publishes related booklets.

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AYRS is a UK Registered Educational Charity (No 234081) for the furthering of yacht science.

Website: http://www.ayrs.org

ISSN 1469-6754

Making a better wheel, or simply re-inventing it?

I was talking to a man in a bar last night who said he'd had this bright idea of building a boat with extra hulls, of putting aeroplane wings on it instead of sails, and then making it fly above the waves.When I suggested to him that a lot of this had been done before, he was astonished and said "But's it's *my* idea. I invented it. I've never heard of it before, so it must be new!"

It seems that people simply don't know that a lot of work has been done. They don't know if it's been written up, and they don't know where to look.. Let's face it, "yachting" is a fairly minority pastime, and "yacht research" is more so; but it's from the research, and from recording and spreading the results of that research - whether they be successes or failures - that all change is going to come.

But it's no good working in a corner, producing brilliant results, if you don't know what has been done before. And that's where AYRS comes into play - not just the few people listed on the left, but all of you out there. We are *all* part of the "ideas community" not only the people who are busy in their backyards making things work, but also all you sitting down puzzling how to make something better.

Research is about having ideas, trying them out, analysing the failures, improving on the successes, and then telling people about it. We on the Catalyst team can help you tell people about it, but only if you tell us first. Not many of you will know that AYRS gets a lot of letters and emails from people who simply want information. We answer these as best as we can. We can't answer them all, because sometimes we don't know the answers either; but we try.

I think I am trying to say that telling people about your idea is as important as having the idea in the first place. There's probably someone else out there who needs *your* idea to make *his* project work. If you keep quiet, he will not succeed. For his sake therefore, tell us about your ideas, so we can tell him, then we can truly be what we claim -

AYRS - where the ideas are!

AYRS - John Hogg Memorial Prize 2003

Report of the Judges - 29 November 2003

Although in this, the third year of the competition, there were only seven entries, the standard of those chosen for the short list matches those in the previous short lists.

The Entries

The entries, in inverse alphabetical order of surname, are:-

Peter A. Sharp. (Oakland, California) He has expanded his earlier entries and *Catalyst* articles into a '**General Theory of Sailing'**. He defines sailing to include any motion derived from the relative motion of two planar bodies, for example two sheets of ice separated by a space in which his vehicle moves. These, together with his Power Alternate Sailing, allow him to numerate a considerable quantity of forms of sailing. It is unfortunate that he dismisses the Newtonian analyses of sailing as most of us know it (wind over water or ice) as contradictory and untenable – a myth.

Ian Nicholson (Argyll, Scotland) reports a flash of inspiration as he left the AYRS stand last year and saw a U bolt on a yacht. His **'AYRS Bolt'** comprises **two** ordinary through-deck bolts, a suitable distance apart, connected on deck by a short length of chain. The middle of the chain connects to the shroud or whatever. The merits include, as against a U bolt, more readily available items, no need for accurate drilling, and no upstand to trip over when it's not in use. We have reservations about the strength (although a prototype has been tested to destruction), but consider that for emergency use this is a splendid idea.

It is worth noting that high tensile Spectra webbing strops have been available for some years for large ocean racing yachts. Attached to a strong point in the deck, we feel these are self-aligning and much lighter alternatives to chain. (See yalecordage.com and harken.com under 'loups'). Weight efficiency is a very high priority in cruiser as well as racer design and as fibre rope is available with tensile strength equivalent to steel wire rope and 75% lighter, it is beneficial to use it.

J.G.Morley (Southport, England) has devised an inclined sail (imagine a board sail) supported by its peak at the masthead and part way along the foot at the end of a projecting spar or swing boom. The sail can be angled relative to the swing boom (which is free in azimuth) to take up a stable position on it's own, when the sail becomes his **Self-Stabilising Kite Sail System.** He has used a one tenth scale model in steady and turbulent airflow to validate his calculated predictions. The performance figures have been expanded to examine the effect of applying his system to a Tornado catamaran. He compares predicted performance with both the conventional rig and his sail system.

In an 18 knot wind, the conventional Tornado is predicted to do 24.3 knots at 110 degrees off the wind, his rig (same area) gives 35.5 knots at 100 degrees. However in the latter case the beta angle we derive is 28.5 degrees, and the apparent wind speed 37 knots. His predictions for a 24 knot wind suggest a top speed of around 44 knots. As Stephen Bourn pointed out so elegantly in his 2001 entry ('A Fundamental Theory of Sailing' précis'd in *Catalyst* No 7, page 9,) inclining a sail, while reducing the displacement, increases the horizontal drag angle and therefore the beta angle, and it can be shown that beyond 30 degrees inclination the effect is increasingly adverse. We also wonder, if the hydrodynamic drag is reduced by lifting the hulls partially out of the water, whether Dr Morley has allowed for their increasing aerodynamic drag.

In the Weymouth Speed Trials the best Tornado speed over 500 metres, so far, was set by *Tango Papa* at 19.6 knots in 1972, with an added weight on a spar on the starboard quarter. *Jacob's Ladder*, a Tornado 'platform' with a kite set a C Class record of 25.03 in 1982.

It remains to be seen to what extent this rig is acceptable for practical use, noting that the folding (swing) boom he proposes is the same length as the mast when extended. For speed sailors this may not matter. Remembering the difficulties most experimenters have had controlling inclined sails, is this rig the breakthrough they need?

Jon Montgomery (Tenterden, England) has entered his ***Quatrefoil*** concept, represented by a 1.6 metre long, 1/25 scale model of the proposed 40 m, 131 ft long craft, 'capable of winning the Jules Verne Trophy'. This is a slewing-hulls catamaran with four balestron (e.g. Aerosail) rigs, one at each pivot point, and a knock-up leeboard inboard of each hull. The design draws on Jon's experience with his *Catapult* design, with the addition of a central accommodation pod The beautifully made model is radio controlled and the video shows Alex Montgomery sailing the boat at speed on relatively flat water.

Hull slewing allows the lee bow to move forward, the better to take the forward and sideways thrust of the sails. It is questionable whether the complication of the slewing bearings and so on is weight-cost effective and risk-acceptable. It would be vital to sail the model in truly scale Southern Ocean seas and winds to find whether the pod is as vulnerable as *Team Philips's*, and anyway to sail a crewed half-size model first. Even if no full size version is built, this model can provide inspiration and competition for other radio controlled yachts of comparable size, as well as stimulating full size designs.

M.K.Mitchell (Clovelly, England) has incoporated his **Gravity-Shift Keel** into his 15 ft cruising yacht *Explorer*, 'a plywood sloop for £1000 to explore the coasts of England'.

The keel comprises a steel 4-pin parallelogram with a streamlined lead bulb at its lower end, keel and bulb each weighing 100 lbs in a total boat weight of around 700 lbs. Keel and bulb fold up sternwards into a stub keel, so that the boat may take the ground and be easily wound onto a trailer. All the advantages of a deep keel and a retractable centreboard.

After design and making a scale model, building completed in Summer 2002 and the boat tried with a dinghy rig: this has been replaced by an improved rig which has proved to be oversize and weight, and which will in turn be replaced.

The video shows that the boat can be righted from total inversion by one person, even with the keel up, and that its buoyancy will support it even when swamped. There was not enough wind for a full demonstration of the sailing ability, but *Explorer* is seen to sail easily and quickly in the video, and will meet the design aims, as well as contributing a new and valid keel design.

Although a patent search showed that 4-pin parallelograms had been thought of before, this one is 'neater and more hydrodynamic' and does seem to be entirely novel. Was the target budget achieved ?

Charles Magnan (Horsham, England) has designed ***Free Spirit*** 'as a fast open **amphibious** trimaran daysailer capable of being launched and recovered by disabled sailors without assistance'. The floats fold by hinging aft to reduce beam ashore.

Outboard motor shafts and bevel gear boxes would be adapted to carry the two main wheels, being driven by electric motors at their tops. These would support the boat abeam of the mast, and retract once afloat. A smaller wheel on a hack rudder lying alongside the normal rudder would complete the three-point suspension and allow steering ashore.

For embarcation (ashore) from a wheelchair the crew would use a platform extended over the stern, and then manoeuvre themselves into one of the two tandem seats on the centre line of the cockpit. Steering is by wheel and all lines are brought to hand. The forward crew member's chair can be rotated in azimuth so that he can sit somewhat to windward and help the righting moment. We wonder to what extent the weight of the road equipment and batteries will compromise the sailing performance.

The full set of drawings show an alternative balestron rig with a solid wingmast, together with an ingenious arrangement for raising and lowering the rig - but not by the disabled!

Given a suitably slipway-equipped marina this design will provide an excellent and exciting craft for independent people whether disabled or not.

S. Newman Darby (Jacksonville, Florida) has over the years developed a number of small sailing craft, the latest being his ***Mini-Trimaran III***. This little trimaran is just under six feet long to fit into a (US) car 'trunk', the centre hull being capable of being pulled aft so the total length can be 10ft. Beam is just under four feet, the boat can be carried by one person.

The boat may be sailed either in a sailboard manner, excellent as a starter for sailboard beginners, or with a keel-stepped mast and single sail, when the crew can sit and use the rudder. The main and side hulls are quite deep and slab sided so no keels or boards are needed for lateral resistance, enabling sailing to windward in shallow water.

This is very much a 'fun boat' which can make for a safe introduction to the joys of sailing.

AYRS Booklet No 58, 1966, reprinted Mr Newman Darby's 1965 article from the US Popular Science Magazine in which he described his invention and development of the sailboard. This prior publication prevented the Windsurfer from establishing a monopoly in UK and some other countries in 1968.

The Winners

We have selected the entries of Messrs Montgomery, Mitchell and Magnan for the short list, and from these Jon Montgomery's ***Quatrefoil*** as the winner of the £1000 prize. The runners-up receive a free year's subscription to AYRS and a certificate. We congratulate them and thank all the entrants for their efforts.

It is encouraging that the standard of innovation and execution shown over the three years of the competition, particularly by the nine short-listed entrants, has been so high, and that between them they have conceived and realised ideas that are new to sailing. And indeed those not short-listed have been close behind! Amateurs can still show the way for the professionals!

The Judges

Cmdr George Chapman, RN Retd (Chairman of the Panel)
Mr Rodney Hogg, Director of Spinlock Ltd, (representing the late John Hogg's family)
Mr Michael Ellison, MM, (Chairman of the AYRS Committee).

Secretarial support is provided by the AYRS Hon. Secretary, Mrs S Fishwick BSc, to whom any queries about past, present and future awards of the John Hogg Prize should be addressed. Note that the decisions of the Judges are final, and no correspondence will be entered into on that aspect.

Summary of results so far

2001 - Winner - David Duncan: Swing Wing Rig and Twin Surfer

Runners-up - Bob Spagnoletti: Wind Data Logger
- Stephen Bourn: Fundamental Theory of Sailing and Hydrofoil Sail Craft.

2002 - Joint Winners - Michael Wingeatt: *Transcend* - Novel keel yacht.
- Mario Rosato: Windmill Design Program.

Runner-up - Giles Whittaker: Hapa stabilised craft.

2003 - Winner - Jon Montgomery: *Quatrefoil* concept for a large ocean- going catamaran.

Runners-up - Charles Magnan: Amphibious Trimaran.
- M.K.Mitchell: Gravity Shift Keel

The Amateur Yacht Research Society would like to thank the family of the late John Hogg, and Rodney Hogg in particular, for their generosity in establishing and supporting this Prize over the last three years.

It is anticipated that there will be no award in 2004, and that details of the next award will be announced in early 2005.

Kitesail Progress towards the America's Cup

New KiteShip Web Site. We've just revamped our whole site, added a bunch of new photos, new videos and new links—and a whole new Frequently Asked Questions page. Go to *www.kiteship.com*. I hope it'll answer your questions, but if it doesn't, we're always available. Just write us at: *info@kiteship.com*.

We're working on updating our Press links. We've been featured in Sail, Yachts and Yachting, latitude 38 and on any number of web sites. We've also included links to our various published papers on kite sailing.

What's happening with Kites. Well, we're waiting with more or less bated breath for the updated America's Cup sailing rules, due out "by mid-December." We expect they will either outlaw kites or remain silent, in which case we're gonna be looking for a syndicate to work our kite magic on! You may or may not be up on AC happenings (or you may not care?), but the 2007 event looks like it's going to be pretty exciting, with somewhere between 2 and 20 syndicates participating, depending on whose gossip you believe.

We spent much of the Summer and Fall traveling around the country, demonstrating kite sailing and taking orders. We were in Maine, Maryland, Florida, Nevada and all over California. Just now I'm holding down the fort in California while Dean's sailing somewhere off the coast of Florida in the Atlantic. See some of our kites on both sail and powerboats here: *www.kit-cats.com/kite_sail.htm* We're deep in talks with a number of boats and skippers; we'll have more news about shipping kites shortly (people are *so* secretive. It's almost like they were planning to race each other!)

Developments: We're working with a client on advanced boat and kite handling with Outleader kites. He's already "automated" gybing, using dual whisker poles and little else. Now he's working now on making the kites fly single-handed. No, don't ask for details yet. We'll be bragging about them soon enough, assuming we get it to work. The gybing trick looks a treat, so far.

Really big kites are still in the hopper, too. Our lOI with Adventure Spa Cruise is still hanging fire, waiting for funding. See: *www.adventurespacruise.com*. We're talking with a second cruise ship company who're also interested, see: *www.nwdir.com/cruiseshipcondos.htm*. There are several other commercially-sized buyers in the hopper as well.

New Pricing. KiteShip, like many young companies, is going through growing pains. Our latest should be a big plus for you, our customers. As we're ramping up production we're taking more and more advantage of bulk purchases, labor costs, etc. Our retail prices are falling as a result. If you haven't had a quote from us in the past several months, think about talking to us again. You might be surprised!

KiteShip Swag. Yeah, we're on it. Come visit the KiteShip Store. It's brand new today. You can buy shirts, caps, stickers, mugs, frisbees etc. all with the KiteShip colors—and our new logo. Hey, you can do all your holiday shopping from one site, eh? Go to the website *www.kiteship.com* and just click on "Swag"

Distributors. We're working with several groups on this, look for more news shortly. If you're thinking about representing KiteShip kites, drop us a line.

Winter Sale. OK, so it's Summer in OZ and NZ (—and SA. Hey guys, thanks for the interest in "ZA"! It'll be cool to see Outleader kites in the Indian Ocean, too). You Southern guys get all the breaks. Order now for (Northern) Spring and get your Outleader kites at 10% off. Yeah, really.

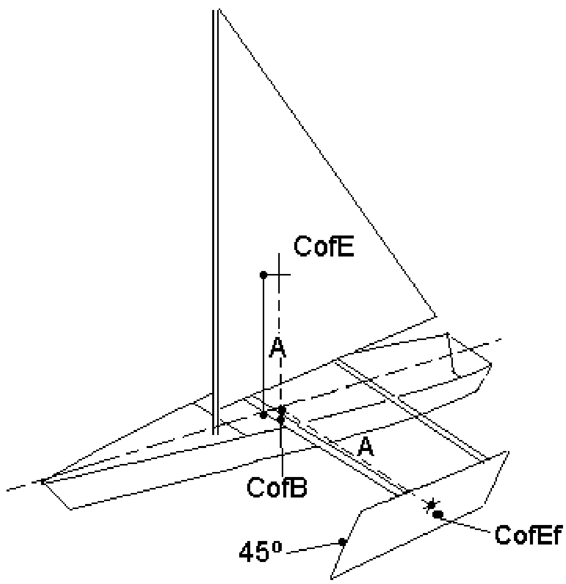
Club Visits. Were going to spend the Northern Winter visiting yacht clubs and sailing associations. If the group you sail with is interested, please drop us a note. If we come to you, and if we arrange a "bulk buy" with your organization, there are rumors of REALLY great deals. KiteShip wants to seed your fleet with kites, and "We're makin' deals!" in order to make it happen.

What else? Write to us and tell us what you are doing with your KiteShip kites. We keep sending them out, then not hearing back about them. We've got kites flying in the Pacific Ocean (both sides), the Atlantic (just one side—Europe, are you out there?) and it looks like soon in the Indian. What else is there to conquer? What are YOU doing with kites?

All the best for the holidays. Cheers,

Dave Culp and the gang at KiteShip

Foil Stabilised Sailing Craft.



DIAGRAMATIC SET UP OF BRUCE FOIL

Following the publication of Giles Whittaker's article on Hapa Stabilised Sailing Craft it is with some diffidence that I give details of some work I did some twenty years ago. My own work was on foil-stabilised craft that differ in a number of respects from Whittaker's work and I believe offers a more practical solution.

The foils used on my 1983 craft were low aspect ratio Bruce foils. Low aspect ratio foils were selected as the boat was to work off the beach and a high aspect ratio foil system would prevent this. I also opted for the support to be carried out by the leeward foil as opposed to the windward configuration of the hapa. This, it seemed to me, to be a more dynamically reliable system and not liable to being snatched out of the water.

The foil, which is 10% of the sail area, is set up at 45 degrees. Its centre of effort being in line with the centre of effort of the sail and the same distance outboard as the centre of effort of the sail is above the plane of the centre of buoyancy. They were made of 4ft x 2ft x $^3/_8$ plywood and set up parallel to the centre line of the boat.

This configuration resulted in an overall beam of sixteen feet on a sixteen foot grand banks dory hull that had a twenty inch bottom and carried a rig of some 120 square feet.

It was very easy to handle and behaved admirably under most conditions and performing on the Solway Firth often in choppy water and up to Force 5-6 wind speeds. The only weakness that was apparent was that if when coming about the turn was performed too abruptly the lee foil could be sunk as it no longer had forward speed and hence lift. Providing the turn was made with a reasonable radius, there was no difficulty.

She spent some two seasons on a drying mooring in the Firth with no damage to the foils.

John Bull
Cumbria, UK

QUATREFOIL

A large ocean going catamaran concept

Jon A. Montgomery

What is *Quatrefoil*?

Quatrefoil is a concept for ocean racing catamaran, capable of winning the Jules Verne Trophy. It needs to be big and powerful, but also capable of being handled at speed by a relatively small crew.

The proposed size of *Quatrefoil* is a length of 40 metres (131ft), a beam of 27.5 metres (90ft) and a sailing displacement of about 22 tonnes.

It is a unique concept with some revolutionary features, as well as cleverly mixing what we already know.

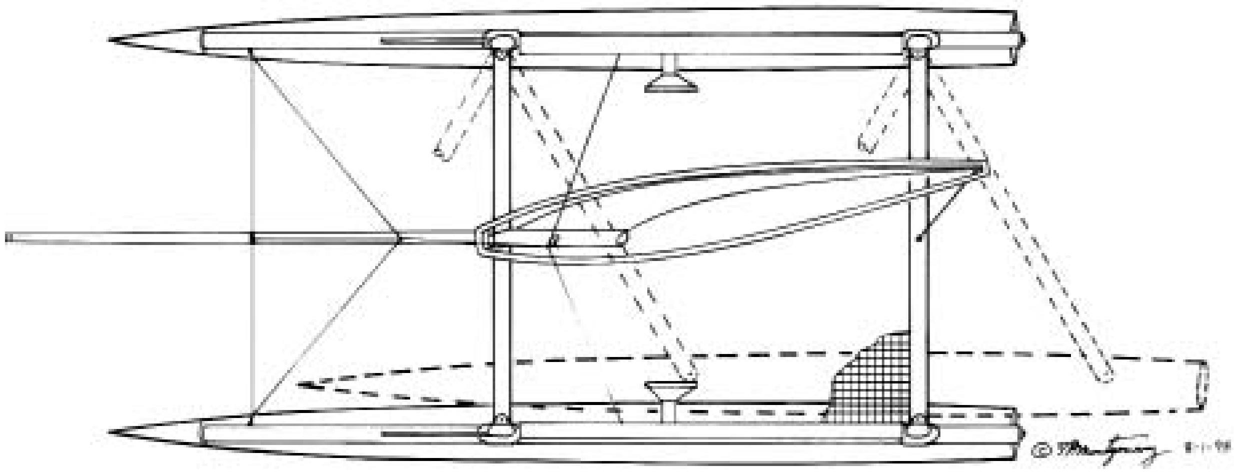
But, it's been done before?

At first glance, it is possible to assume there is nothing too revolutionary; Two hulls (Polynesia), aerodynamic hulls and beams (*Team Philips*), central nacelle for living (*Enza, Team Philips*), free standing rigs (*Team Philips*), multiple rigs (*Team Philips, Mari Cha IV*), ballestron-rigs (Various production boats) and flip up rudders (60 foot trimarans, beach cats).

Whilst many elements of the design are evolutions of existing ideas, there are some truly revolutionary elements. The aim of this document is to highlight the unique attributes of *Quatrefoil* and demonstrate why certain directions have been taken with the overall concept.

The following sections of this document will:

- Identify the three key revolutionary attributes of *Quatrefoil*
- Explain what research & development has been undertaken
- Show how the three key revolutionary attributes have shaped the overall concept
- Identify future development potential



*Plan of 18 foot prototype (*Slewcat*), to demonstrate hull slewing, via vertical hinges attached to crossbeam ends.*

Unique attribute 1: Hull Slewing

A catamaran's slender hulls have poor fore and aft stability, and sail setting for windward or leeward work upsets hull balance. Slewing hulls allow the leeward loaded hull to be trimmed by movement forward or aft of the windward hull.

Hull slewing is beneficial for the following reasons:

a) Hull trim

Catamarans are vulnerable to nose-diving and often a skipper would wish for more buoyancy forward when reaching.

With a beach catamaran, the combined weight of the crew can weigh as much as their boat, and they trapeze anywhere from the forward cross beam to the transom, according to conditions. Larger vessels may use water ballast tanks, combined with shifting of sail inventories to achieve a similar result.

Hull slewing allows the centre of weight to move aft of the loaded leeward hull when reaching. When beating, by moving the windward hull forward, it helps the loaded leeward hull punch into oncoming seas.

Experience suggests that the windward hull only needs to be moved forward or aft by about 15 degrees to make a substantial difference to trim. This amount hardly makes any difference to the overall beam.

The following table illustrates the comparatively small loss of beam when slewing to various sample degrees, using a 27.5 meter beam boat as an example;

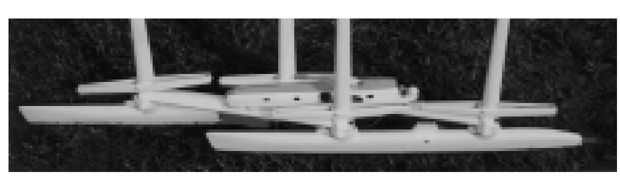
Slew degrees	Beam reduction (meters)	Windward hull & rigs movement forward or aft (meters)
10	0.42	4.57
15	0.91	6.88
20	1.64	9.15
25	2.50	11.43
30	3.60	13.50

With *Quatrefoil*, the most dramatic weight transfer is achieved with the windward hull and its rigs. The weight of the centre nacelle and cross beams only moves half as much as the windward hull (by virtue of being in the centreline of the boat).

b) Capsize recovery

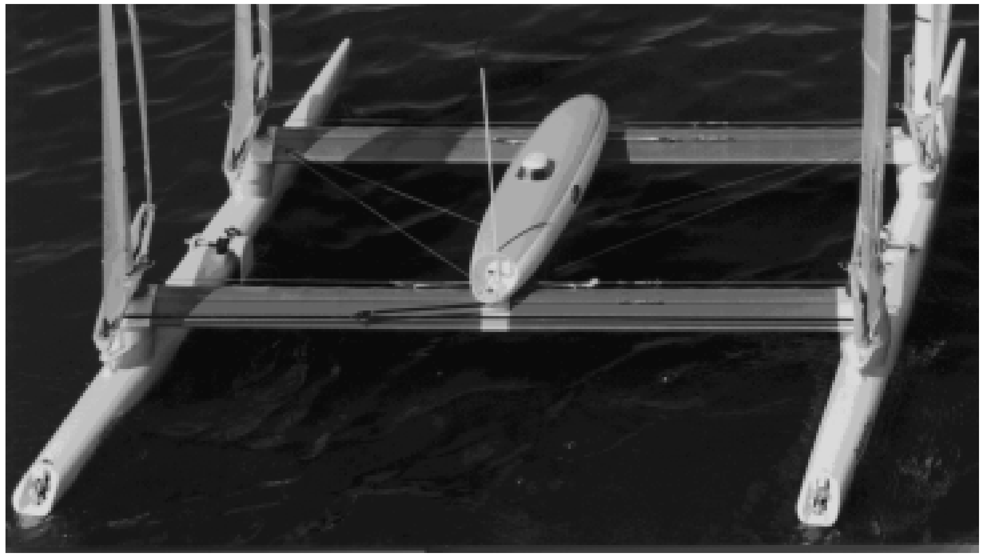
Catamarans are just as stable upside down as the right way up. Whilst a capsize would likely be catastrophic, the ability to narrow the beam by winching the hulls together, would allow a chance of self recovery.

If the boat inverted, the nacelle would act like the central hull of a trimaran. The next stage is for the hulls to be winched together, so reducing stability. This would allow the boat to rest on its side if the masts are buoyant. Wave action or assistance from inflatable buoyancy appropriately positioned could allow righting, before moving the hulls apart again.



50th scale model demonstrating amount hulls can be drawn together

Optically, it is difficult to spot there is approximately 15 degrees of slew. The radio controlled model uses a winch under the central nacelle to control slew. A line is run from a central point on the aft beam, onward to a block attached to the forward beam mast spigots, then returns to the central nacelle winch.



c) Construction / storing ease

The hulls can also be drawn together to assist harbour mooring. Docking a long boat is often more attractive than a wide boat.

Being able to draw the boat down to a narrow beam allows for more flexibility when manufacturing, storing, or maintaining the boat.

Development of hull slewing

e) Back to back model testing (1989)

I have undertaken tests involving two identical simple models (non radio controlled) and set them off on a reach across open water; one slewed, the other not. The slewed vessel invariably was faster, through avoiding nose dives.

f) Catapult 18 foot boat

An 18 foot catamaran was engineered to give up to 45 degrees of hull slewing. This prototype proved reliable, sufficiently rigid and strong, as well as fast (17 knots at Weymouth Speed Week, 1998). The design had the forward cross beam relatively far forward, to provoke the need to slew the hulls. But, it was found that if you have one central rig, then balance of boat will change (inducing either weather or lee helm); not noticeable on, say, 10 degrees of slew, but certainly evident on 20 degrees of slew.

g) Quatrefoil radio controlled model

This working model does slew, but time on water and radio controlled skill has not allowed *Quatrefoil* to be pushed hard in stronger winds. Testing is ongoing.

Unique attribute 2: Supporting the Free Standing Rigs

Quatrefoil has a unique method of installing its four, free-standing, rotational wing masts.

The benefits of reducing rigging windage, as well as allowing 360-degree rig movement are huge gains to have.

To keep the centre of effort low, as well as make sails of a manageable size for the crew, *Quatrefoil* would have four separate boom furling rigs. Total sail-mast area would be 514 square metres (5528 square ft).

The free standing rigs work well with a self tacking foresail balancing the main sail so their angle of attack can be adjusted with little effort. They also have the major advantage of being able to ‘feather’, whatever the boat angle is to the wind.

The following approaches are unique to Quatrefoil;

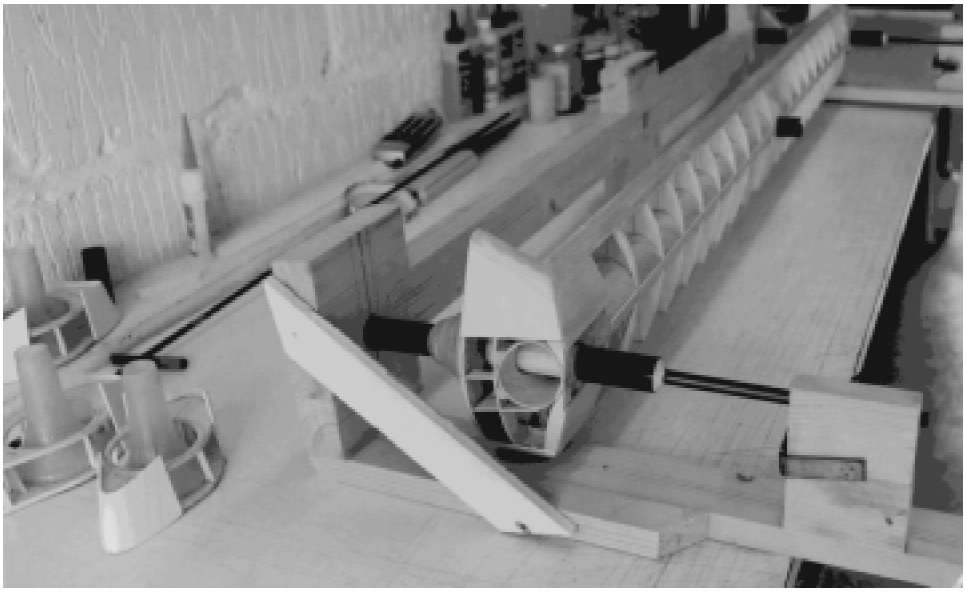
a) Utilising cross beam joints

To secure a 20 metre high free standing mast in a 1.85 metre wide hull is a considerable engineering challenge. *Quatrefoil* chooses to avoid this difficulty and use the cross beam ends to mount the masts on.

The benefit is that the hull is preserved primarily for its floatational and torsional properties, rather than as a local high load bearing structure.

b) Mast spigot (short mast)

One can think of a spigot as a fixed short round mast. The spigot fits inside the tall wing mast and



Picture shows a forward cross beam under construction. Wing mast sits on the mast spigot, which is located above the hull spigot. The bell shaped housings (front left of picture) are glued to the deck of the hull to mate with the cross beam.

has a bearing on its top, upon which the wing mast rotates. This bearing can be much smaller and lighter than if the wing mast loads were taken from its base.

The wing mast rotation point can be made to coincide with the centre of sail effort. This substantially reduces the loading taken at the base of the mast.

Importantly, the spigot is firmly secured to the crossbeam, not needing the necessity to revolve. As the above picture shows, a further spigot is attached to the underside of the crossbeam to mate with the hull. This arrangement reduces loads being taken by the hulls from the rigs.

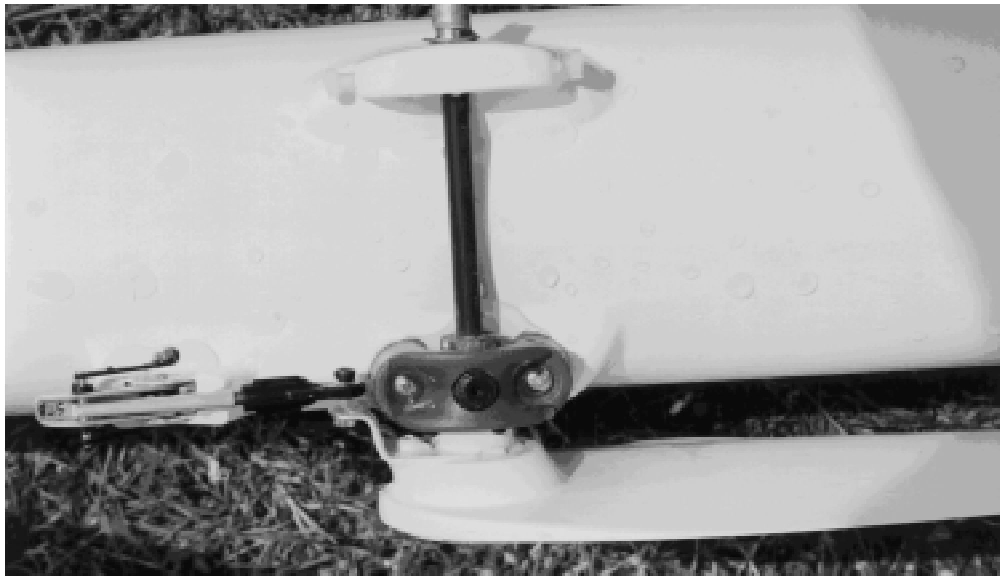
c) Rig booms

Inside each boom is a bearing that slides over the mast spigot. These bearings have bosses that take the load from the boom, and this arrangement allows fore and aft balance between foresail and mainsail loads.

It is envisaged that the sails will furl into the booms on rollers neatly and quickly stowing unwanted sails when reefing.

First boom deck on left shows the bearing with its bosses seated in side plates. The second boom deck (centre of picture) is ready to be assembled with its boom base (top of picture).

A view of the top of the hull with the foil in a retracted position. A horizontal shaft is connected to the board. The shaft runs through a bearing that allows the angle of attack to be taken up. Control of the angle of attack is achieved at the end of the shaft (top of picture), where it runs in a slot.



Unique attribute 3: Knock-Up Self Jibing Foils

Most fast multihulls at one time or another hit submerged objects causing damage of some sort. *Quatrefoil* has taken the engineering of knock up foils further forward. A self-jibing action for the centreboards has been achieved.

a) Self jibing centreboards

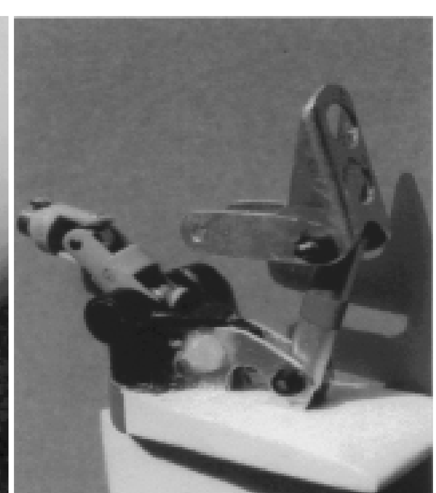
Quatrefoil has externally mounted foils, which rotate aft on impact. The key advance is that the system allows self jibing control. The value of self-jibing foils is being able to introduce an angle of attack to the foil, aiding lateral resistance of the hull.

The top of the board is fixed to a twin linkage that is held in place by a shock cord. With this arrangement the board can be moved fore and aft to affect the balance, or one can run with the boards swept aft, retracted out of the water.

The board has conventional sections under water, but the leading edge above water is sharpened to aid surface piercing.

b) Lift up rudder solution

Flip up rudders are not a common feature for big boats. *Quatrefoil* has an engineering solution that allows one rudder to continue steering in the event



From Left to Right: First picture shows radio controlled model rudder in lifted position. Centre photo shows rudder in lowered position. Final picture shows twin universal joint.

of the other being knocked up after an impact. This means that it is possible to remain in control with only one rudder down immediately after an incident.

Quatrefoil has Ackerman geometry steering. On the working radio controlled model the tiller moves a vertical shaft attached to bevel gears and that drives a horizontal shaft, which in turn picks up at the stern. Through twin universal joints the rudder can be steered if it is in the vertical or horizontal position. Holding the rudder in place is achieved by linkage held in place by a shock cord.

Development history

So far, research has been undertaken using the following methods;

a) Non-radio-controlled sailing models

Two 600mm long fibreglass catamarans used for back-to-back testing of the potential of slewing. These were sailing in August 1989.

b) Catapult 18 foot prototype

This inflatable catamaran was built in 1993 and achieved over 17 knots in the 1998 Weymouth Speed Trials.

c) *Quatrefoil* 1:50 non-sailing model

In 1999 a 1:50 scale model was constructed, which was enormously helpful to visualise the drawings.

d) *Quatrefoil* 1:25 radio controlled model

On retirement, I was able to devote the time to build a 1:25 scale sailing version that is radio controlled. Details can be found in Yachts & Yachting, the Multi Mad article, 29th August 2003.

Summary

The *Quatrefoil* concept is a significant step forward on existing ocean racing vessels, offering efficient speed and a relatively safe and comfortable crew environment.

For reaching across an ocean, hull slewing could maximise the speed potential, whilst preserving the reliability of the vessel. When reaching, nose-dive problems could be reduced, and when beating excessive slamming off the top of waves minimised.

The four rotational wing masts, with manageable high aspect ratio sail plans, would offer awesome power and low down centre of effort. The four masts will utilise the strength of the cross-beam joints, and spread loads sympathetically throughout the structure.

Flip up rudders and centreboards will increase the chance of being able to continue racing if collision occurs. Experimentation with self-jibing centreboards will increase windward efficiency.

Existing work on *Quatrefoil* is encouraging further development.

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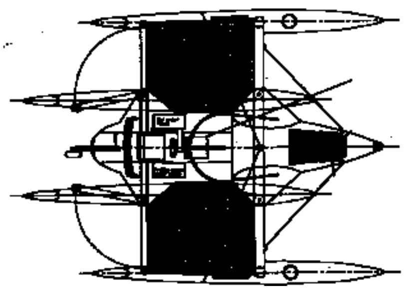
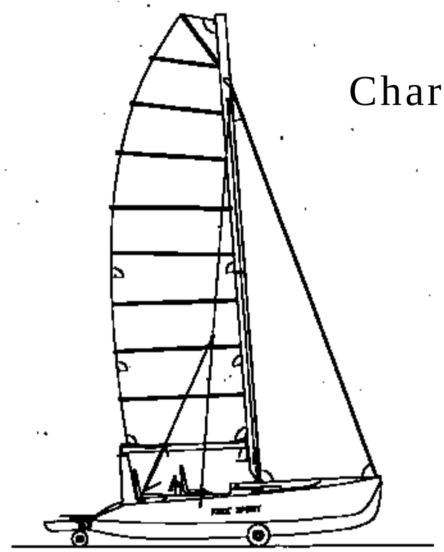
"Free Spirit"

Charles Magnan





Summary of Concept:

Most able-bodied sailors take it for granted that they can travel to the place where they keep their boat, get on board if she is kept afloat, or if kept ashore, first rig her and then launch down a beach or slipway, park the launching trolley ashore and then get aboard and sail off. Returning from a sailing trip is the reverse of the above, except that considerably more athletic ability may be required to haul a large dinghy or catamaran back up the beach or slipway.

For a disabled person, of the above items *only travelling to and from the place where the boat is stored is possible unaided.* While boats have been either specifically designed or adapted for use by disabled sailors, this is still only possible with the help of a keen "ground crew" of dedicated helpers to launch and recover the boat and to get the disabled person in and out of the boat. Even larger boats kept in marinas or on moorings can be quite daunting for a disabled person to get to, never mind climb on board.

Free Spirit is intended to address this issue by enabling a disabled person to be able to drive to a dinghy park or other area of hard standing, park their car, decant themselves in to a wheelchair, travel in the wheelchair to the boat, get into the boat, then rig and launch the boat down a suitable slipway and go sailing just like the rest of us would like to do, without being tied to the availability of other people to help. Naturally, this is only practical if the recovery operation after sailing can be similarly managed unaided.

Additionally, this boat addresses another problem for performance oriented disabled sailors in that most boats designed to be sailed easily by disabled people have to sacrifice much of their potential performance. This was brought home to the designer some years ago at the London Boat Show when he met a young lady who was a member of the Disabled Water-Skiing Association and who sailed Hobie cats because she had found the boats currently being used for disabled sailing were much too tame. *Free Spirit* aims to provide performance on a par with the best of the beach catamarans without requiring the sailor(s) to have the same degree of athleticism.

To achieve this, *Free Spirit* has been designed to meet the following criteria:

- *Truly amphibious, i.e. capable of being launched and recovered from a slipway using retractable launching wheels which are attached to the boat and which remain part of the boat while sailing.*
- *Selfpropelled and steerable both on land and water.*
- *Capable of being boarded unaided by a person in a wheelchair while parked on hard standing ashore.*
- *Capable of being safely sailed by an unaided disabled person.*
- *Capable of being stored ashore with a relatively small footprint to minimise storage costs and trailable with a minimum of preparation.*
- *A speed potential under sail in the vicinity of 20 knots.*

Free Spirit has been designed as a folding trimaran with a retractable undercarriage based on the legs of small outboard motors with wheels attached in place of propellers and driven by electric winch motors attached to the top of their propeller shafts. A retractable tail wheel is attached to the rudder and is thus steerable. Batteries supply the electric power and a trolling motor (also retractable) for auxiliary propulsion while afloat. Battery charging is by means of solar panels on the deck which could be augmented by a portable petrol generator if an extended range under power is required.

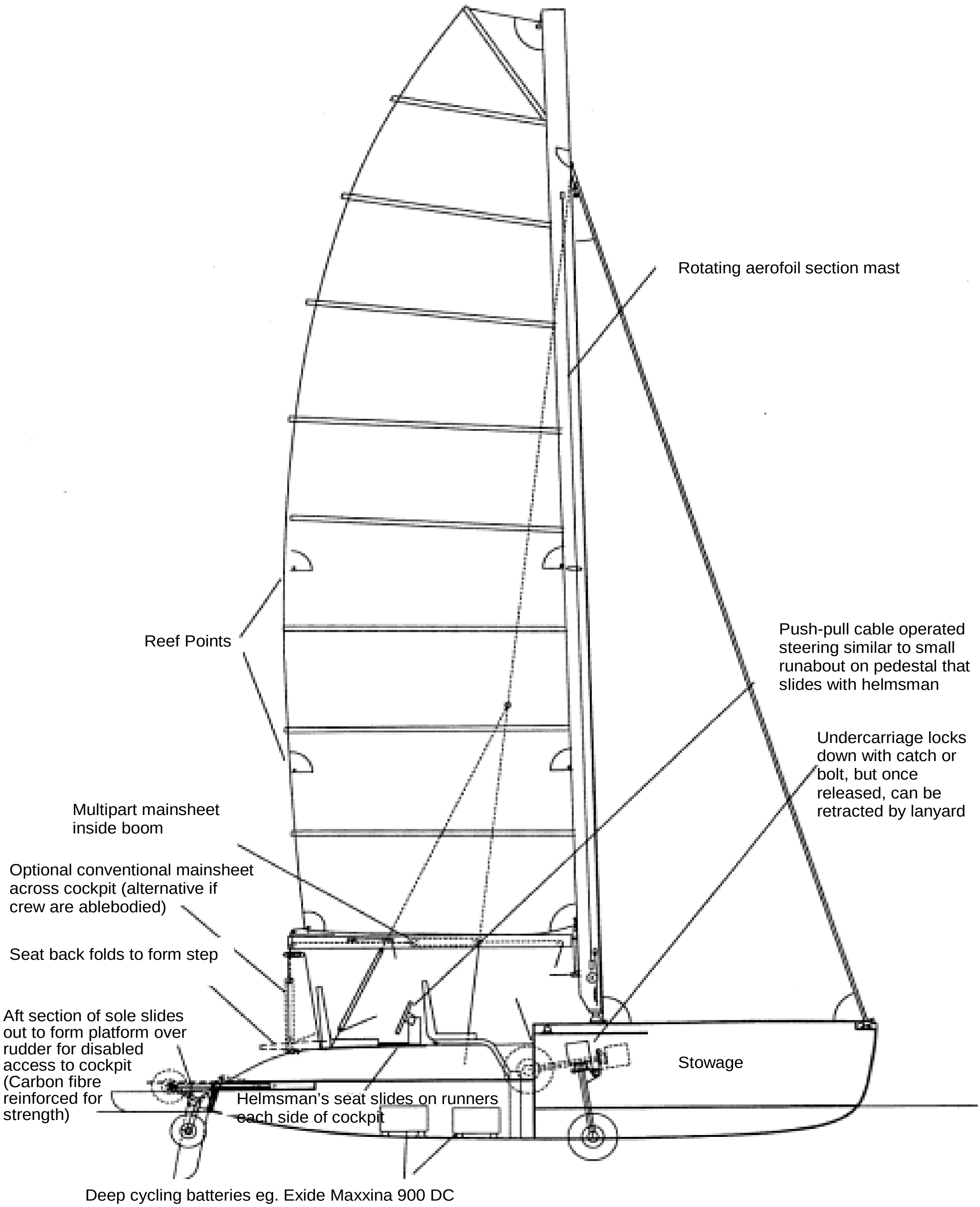
Under sail, the long buoyant floats and wide beam (features proven in racing trimarans) allow a powerful rig to be carried which when coupled with careful attention to the aero/hydrodynamic cleanliness of the whole boat should give the potential for an exhilarating performance. As a capsize or major gear failure such as dismasting, or even a chafed halyard, can have very serious consequences for a disabled crew on their own, *Free Spirit* is designed to be as safe as practicable. She has a self-draining cockpit and auxiliary propulsion to get home without requiring paddling. Resistance to capsize is provided by the high stability due to the wide beam and the combination of large floats with buoyant bows and rounded tops providing resistance to a diagonal capsize induced over the lee bow.

All lines and other controls are led to the cockpit so as to be within reach of a relatively immobile crew. The mainsheet is located above the rear of the cockpit thus allowing unobstructed crew movement between rudder and the forward end of the cockpit. A pull-out shelf at the stern just above the height of the seat of a wheelchair can extend over the rudder allowing boarding over the stern from a wheelchair “parked” beside the rudder. There is stowage space on board for a collapsible wheelchair to be carried aboard if desired.

Additionally, to increase the usefulness of the design to a wider public, the basic boat is able to be built without special motors etc required for self propelled launch and recovery, should these items be deemed unnecessary in particular circumstances. Thus able bodied crews or clubs/associations with plenty of helpers available for assisting disabled sailors may choose to save the weight and cost of batteries and motors and still have a fully functional high performance boat.

Similarly all special equipment specifically aimed at disabled crews should be can be omitted/removed if the boat is to be used by able-bodied sailors. Thus windsurfers or beachcat sailors who are used to the exhilaration of high speed sailing, but who are not as young as they once were, may find a high performance boat that does not require either trapezing or musclepower for launching and recovery to be very useful. In this role the boat could be modified slightly to allow people to walk beside her while guiding her as she drives up the beach or slipway, in a manner similar to some power driven walk-behind motor mowers, reducing the weight and hence the power requirements.

She is also capable of being used as a camping cruiser with the addition of a boom tent.



Rotating aerofoil section mast
Reef Points
Push-pull cable operated steering similar to small runabout on pedestal that slides with helmsman
Undercarriage locks down with catch or bolt, but once released, can be retracted by lanyard
Multipart mainsheet inside boom
Optional conventional mainsheet across cockpit (alternative if crew are ablebodied)
Seat back folds to form step
Aft section of sole slides out to form platform over rudder for disabled access to cockpit (Carbon fibre reinforced for strength)
Stowage
Helmsman's seat slides on runners each side of cockpit
Deep cycling batteries eg. Exide Maxxina 900 DC

Notes on Detailed Design:

Propulsion

Electric winch motors have been chosen for propulsion ashore as they are standard off-the-shelf items which are easily available, designed for a marine environment and designed for low speed/ high torque operation. A hydraulic drive system would also work well, but is likely to be prohibitively expensive.

Once an electrically powered system with its requisite batteries has been selected as the means of getting the boat up and down a slipway, the use of an electric outboard such as a commercially available trolling motor is an obvious choice for auxiliary propulsion afloat. Should there be fears of a long journey back to the slipway under power draining the batteries to the point where there is insufficient energy left to successfully recover the boat up the slipway, it is possible to carry a small portable generator and operate under power in a manner similar to a diesel-electric train. Under normal circumstances charging is done by means of solar cells on the foredeck which keep the battery charged up when not in use.

Transmission System

The driven wheels are located amidships, just forward of the centre of gravity of the loaded boat where they take the majority of the craft's weight and are complemented by a steerable, retractable tail wheel attached to the rudder and thus able to be steered by the normal system used when afloat. The driven wheels are connected (welded?) to a vertical outboard motor drive shaft within the leg of a small outboard motor, (again a standard off-the-shelf item available at a reasonable cost) which also acts as a column to take the weight of the boat when ashore and is built of marine grade materials. The skeg below the gearbox will need to be removed. The bevel gears in the outboard motor leg provide a horizontal drive to the propeller shaft which is connected to a hub mounted with a suitable wheel such as a boat trailer wheel. The outboard motor legs pivot up into bays under the cockpit seats and above the waterline.

People wishing to launch from open beaches may need to use larger wheels (e.g. Cat Trax™ launching trolley wheels which have aluminium hubs and balloon tyres or aluminium ATV/ quadbike wheels – competition models tend to use aluminium for lightness – which also gives adequate corrosion resistance for marine use) may need to modify the design to accommodate the larger tyres. This can be done by allowing the shafts and wheels to rotate axially for stowage or by increasing the height of the wells, by raising the cockpit seats.

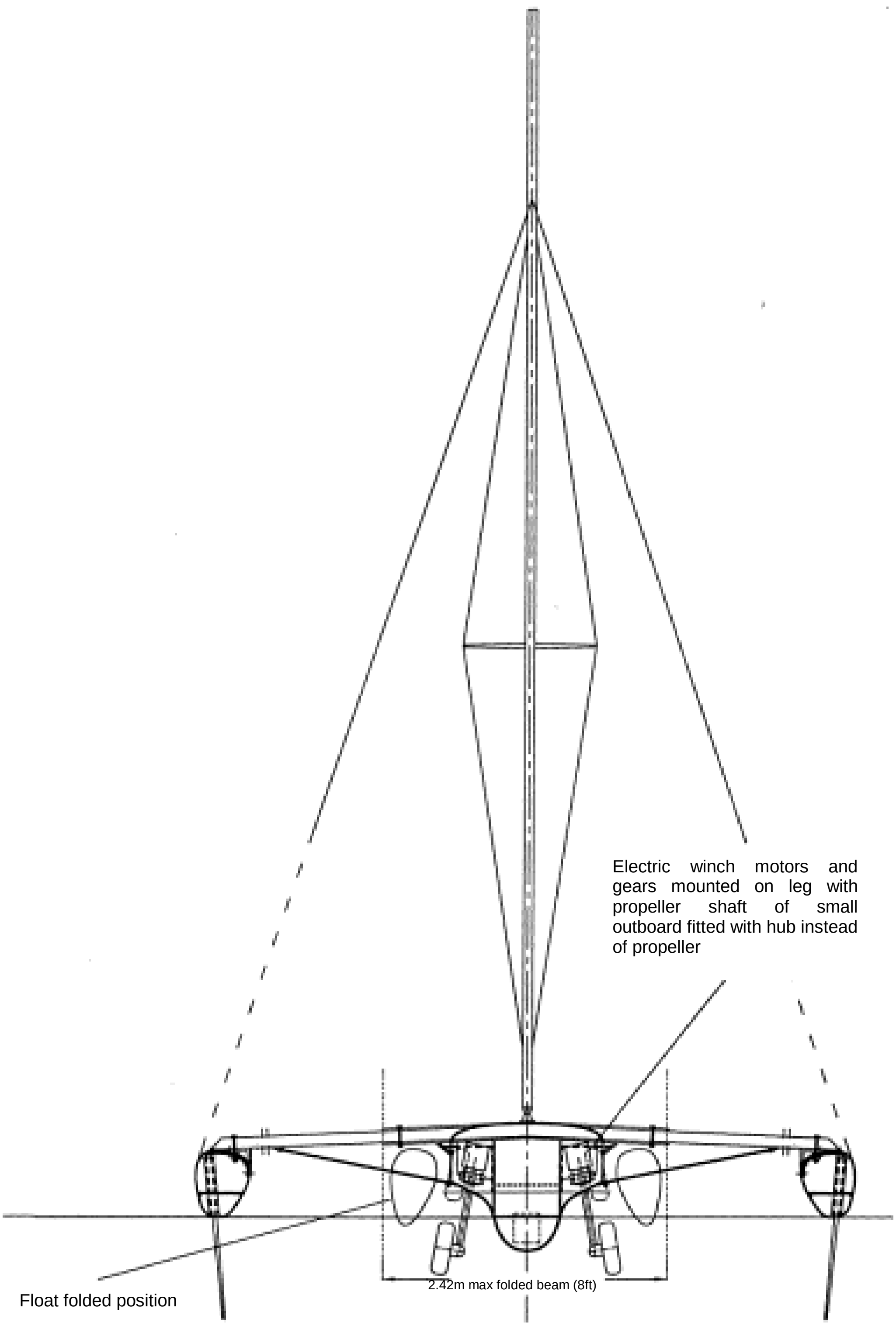
It should be noted that to launch from open beaches is not advisable for unaided disabled crews because of the risk of putting a wheel in a soft spot (e.g. an area of rotting seaweed covered by sand) which may require the crew to get out and push. However it may be very useful for able-bodied crews who could motor over longer distances than they would want to have to push a boat on a trolley, thus allowing launching at low tide.

Brakes

Low speed (walking pace) bearings and brakes only are required. The use of mountain bike style cable operated disc brakes (with aluminium or stainless steel discs) on the top of the vertical drive/ propeller shafts as illustrated are one possible solution which will prevent the boat careering out of control while descending a steep ramp.

Choice of Rigs

A conventional stayed sloop rig with a rotating mast Tornado style, but with the added efficiency of a tighter forestay due to a more rigid staying base and of a jib which closes the gap between its foot and the foredeck has been illustrated as this is likely to meet the performance criteria while still being within the capability of a disabled crew.



SECTION AT MAIN BEAM LOOKING AFT

An optional bowsprit with an asymmetrical spinnaker or reacher may be used, depending on crew ability and if this is provided with roller furling its use should be within the capability of an experienced disabled crew.

Alternatively, a balestron boomed rig similar to the AeroRig™ may be used. While likely to be more expensive and heavier, it is very easy to handle. It should still be possible to use an optional bowsprit with an asymmetrical spinnaker or reacher as in the case of a more conventional rig, if a masthead spinnaker set from a swivel is used.

Additionally, AYRS experimenters and other like-minded people may wish to try flying a traction kite from the vicinity of the lee bow, as this would generate additional driving force without significantly increasing the heeling moment and the lift from the kite would also reduce the effective displacement of the boat.

Notes on Displacement:

Draft quoted is fairbody draft with foils retracted (i.e. the minimum amount of water required to float in). Design displacement and draft shown are optimised for a crew of two, although the boat is designed to be able to be sailed single-handed or with up to four people aboard. With four adults aboard, the boat will float below her DWL, but since the floats, which are barely immersed at all at the DWL, will take up some of the extra load this is unlikely to create a problem. All structural calculations to determine crossbeam sizes etc. have been based on the weight of the fully loaded boat with four 75 kg adults aboard.

Notes on Stability and Buoyancy:

Main hull buoyancy sufficient for a displacement of 514 kg as calculated by the Hullform™ program. Similarly floats are designed to each have a fully immersed buoyancy of approximately 170% of design displacement. Note: design displacement is optimised for a crew of two adults.

The long buoyant floats and wide beam (with a righting arm of over 2.75 metres) provide adequate stability allow a powerful rig to be carried; the combination of large floats with buoyant bows and rounded tops providing resistance to a diagonal capsize induced over the lee bow.

Notes on the Status of the Project:

At the moment "*Free Spirit*" only exists as a design, and it is accepted that some of the details of the powered undercarriage will need further experimentation before they can be got to work effectively, although they are based on concepts which the designer believes to be sound. It is the designer's intention to make the design available on a royalty free basis to bona fide charities and other groups operating on a non-profit basis for the benefit of disabled sailors.

What is now needed is for a group to be formed for the purpose of building a prototype which can itself be used by disabled sailors and also from which moulds could be made should it be desired to produce more boats in the future.

Ideally, such a group should be managed by disabled people themselves wherever possible and should seek corporate sponsorship for the project. It would be best if the detailed development of the powered undercarriage legs which are driven by adapted electric marine winch motors should be done in conjunction with winch manufacturers such as Lewmar or Harken themselves, if they could be so persuaded.

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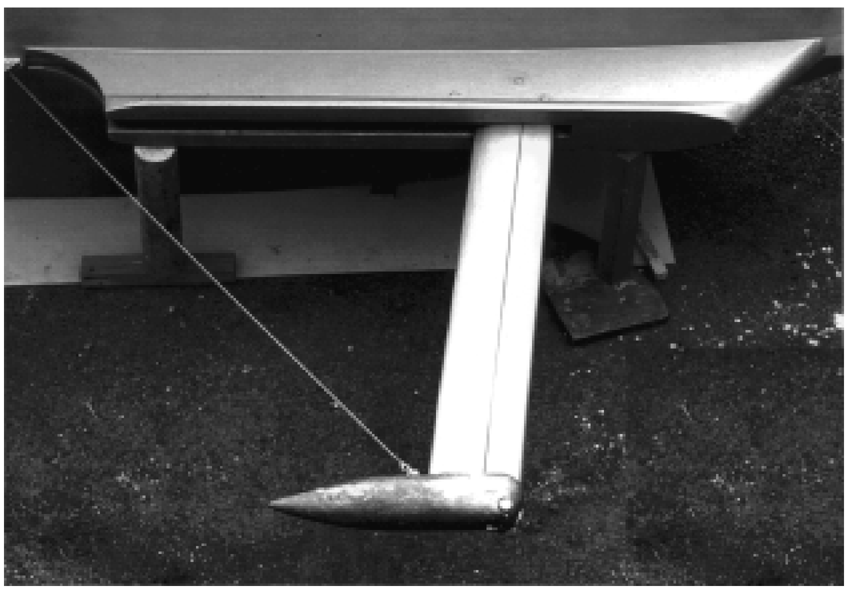
Gravity-Shift Keel

Incorporated in prototype sailing vessel *Explorer*

M. K. Mitchell



Introduction

The Gravity-Shift Keel concept was born during a passage from Florida to the Azores on the 63ft Ketch *Silurian*. The Captain told me of the Russian Engineer, Evgene Gvodjec, who built a 12ft yacht from scraps and sailed around the world. I decided to build a 15ft plywood sloop for £1,000, to explore the coasts of England.

I wanted a monohull able to right itself after capsize. It should be light enough to plane, sail well in light airs, and handle onto a trailer, but seaworthy. To best use ballast I would put it low down, but as I live in the Bristol Channel it would need to take the ground. This seemed simple, I would have a fin bulb keel, but would be able to haul it up because the bulb would be suspended on two shafts, one right behind the other, with a pin each at the top and bottom, the whole thing being, effectively, a parallelogram.

The captain thought this a neat idea, and said to show his father, Jeremy Rogers, builder of the famous Contessas. Jeremy made an interesting observation: Racing fine-nosed J24s was great to windward, but when running it was hard to stop them nose-diving, even with all the crew sat on the transom. My keel, when retracted, moves the bulb aft, which could solve this problem, and reduce drag into the bargain!

A few months later I was at my window, looking over the bay from Clovelly. There was a light swell, and my attention was drawn to the boats on moorings outside the harbour.

There were four motor vessels rocking gently and a big old Gaffer, which was rolling heinously through 90 degrees like a horse gone wild. Its motioned seemed quite disproportionate to the gentle swell. I suddenly realised that its low COG was behaving like a pendulum, and the small swell was working it up to a great oscillation. Eureka! I thought. My keel raises the centre of gravity when retracted, preventing such rolling when lying ahull or running!

Thus the idea gathered force through discovery as much as invention. Design and scale model tests took four months in Spring 2001. The prototype was built by Summer 2002 and tested with a dinghy rig. The keel seemed to work well, as we kept up with a Merlin Rocket and a Laser Stratus to windward, and Explorer would self-right from 135 degrees with the keel extended or retracted.

The CofE (Centre of Effort) of the dinghy rig was too far aft so a masthead cruising rig was built, with roller reefing Genoa and sheet tracks, and other improvements. But I was over-ambitious and increased the size and weight of the rig excessively, so the second lake trials in September 2003 found the vessel too tender by far. Calculations for a smaller, lighter rig have been completed, and a theoretical solution found to redress the .stability. The next phase is to re-build the rig and continue with trials.

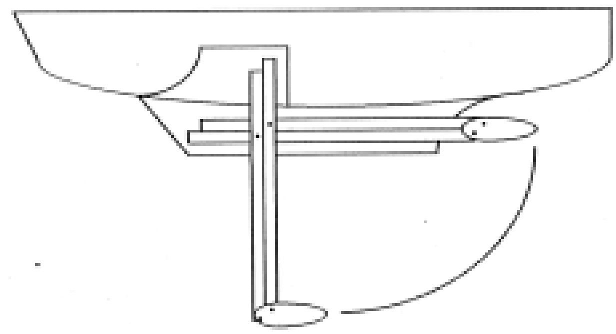
A patent application was filed in February 2003 and I found that though 4-pin parallelogram bulb keels in various embodiments had been patented, the concept had not been applied in the same way as mine, which is neater and more hydrodynamic. (N.B. Until this point I thought that my invention was original, and so did other yacht designers and builders including the keel expert at the IRC, Lymington. It is likely that these other patents have never been realized.)

Concept — The Gravity Shift Keel

Background to the function of keels

The function of a keel on a sailing vessel is as follows: 1) To stop the vessel being pushed sideways through the water by the wind. 2) To reduce rolling and weaving. 3) To keep the craft upright by providing ballast. 4) When sailing Upwind, to 'suck" the craft to windward by creating hydrodynamic lift.

The centreboard and the Fin Bulb Keel are two



common keel types. The centreboard is a flat board which drops Into the water when necessary, through a box in the hull. It has the advantages of being retractable to reduce drag when sailing downwind, and enables the craft to enter shallow water or sit on land.

The Fin Bulb Keel is a fixed wing with a weight at its lower end (usually lead). The advantages of this type of keel are: 1) It has an efficient hydrodynamic shape, creating a larger lift to drag ratio which helps the craft sail to windward. 2) Its deep "bulb" weight does more work to keep the vessel upright. However it cannot easily be taken into shallow water, nor allowed to sit on the bottom without support; and when sailing downwind it creates unnecessary drag.

How the Gravity-Shift Keel works

The Gravity-Shift keel combines the advantages of the Fin Bulb Keel with the advantages of the centreboard, thus being superior to both. It improves performance further by enabling the centre of gravity of the vessel to be adjusted.

The Gravity-Shift Keel is a Fin Bulb Keel which can be retracted to reduce drag when sailing downwind and enable the craft to enter shallow water. By virtue of the parallelogram configuration the bulb remains streamlined to the flow of water in all positions. The keel can be used at any intermediate position, giving the user control by degrees over the positions of the centre of gravity and the centre of lateral resistance of the vessel.

When extended, the bulb weight moves *forward* and *down*, thus moving the centre of gravity of the vessel forward and down. When retracted, the bulb weight moves *up* and *aft*, thus moving the centre of gravity of the vessel up and aft. *It is this highly significant factor, the moving of the centre of gravity of the vessel from forward and low to aft and high, at the times when this is exactly what is required by the dynamics of sailing to windward and downwind respectively, which makes this keel unique among all existing keels, and gives rise to the name the "Gravity-Shift Keel".*

The Advantages of the Gravity-Shift Keel

1. The Gravity-Shift Keel moves the centre of gravity forward when sailing to windward, counteracting the force of the oncoming wind lifting the bow of the vessel.
2. The Gravity-Shift Keel keeps the centre of gravity low when sailing to windward, increasing the stability of the vessel.
3. The Gravity-Shift Keel moves the centre of gravity aft when sailing downwind, counteracting the force of the following wind lifting the stern of the vessel and burying the bow.
4. The Gravity-Shift Keel keeps the centre of gravity high when sailing downwind, preventing excessive rolling caused by the pendulum effect of a heavy keel.
5. The Gravity-Shift Keel keeps the centre of gravity high when on a mooring or at anchor, preventing excessive rolling caused by the pendulum effect of a heavy keel.
6. The Gravity-Shift Keel adjusts the centre of lateral resistance fore or aft to balance the centre of effort of the sails, according to the point of sail.
7. The Gravity-Shift Keel adjusts the centre of lateral resistance fore or aft to balance the centre of effort of the sails, according to the number of reefs in.
8. The Gravity-Shift Keel is easily retracted, causing less drag than a fin bulb keel when sailing down wind.
9. The Gravity-Shift Keel has a very low draught when retracted, enabling you to enter shallow waters, beach or sit comfortably on land.
10. The Gravity-Shift Keel provides an ultra light vessel with the stability of a displacement vessel.

Construction

Shafts

The keel shafts are made from mild steel, with an aft fairing in wood and epoxy. The shafts are made up from commonly available mild steel sections. Moving from fore to aft, these comprise 40mm half-pipe, box section and angle-iron, followed in the rear shaft by angle-iron, box section and flat bar, the latter being faired off to a hydrodynamic shape with wood and epoxy. The shafts are encased at top and bottom so no water can enter, preventing rust from the inside. 316-grade stainless steel bushes are then welded into the shafts at the right places for the stainless pivot pins and nylon shear-pin. The shafts are painted externally, but investigation is taking place into the effectiveness of galvanising or the new “E-coat” rust protection.

Bulb

The bulb itself is lead, which is cast around a 316 stainless steel shoe. The shoe houses the bottom ends of the shafts and incorporates bushes for the pivot pins. The pins in turn are held in place by stainless steel grub screws.

Keel Casing

The Keel Casing is partly external and partly internal to the hull of the vessel. When retracted the keel lies suspended in the casing below the hull. When extended the upper end of the shafts enter the box, which is interior to the hull, in order to contain the leverage of the keel and conduct the righting moment to the hull. The Casing interior to the hull is bolted with angle iron to the “strong-section” of the hull at its rear end. This section is 1" ply and also forms an arch on which the mast is deck mounted. At the fore end of the casing it is again bolted by angle iron to another strong section of the hull. The casing itself is 1" ply, and is protected from being scratched inside by the keel shafts with 0.8mm stainless steel sheet. The keel casing is also bolted together with 8mm stainless bolts and mild steel plates, to prevent it from being split in two by the great leverage of the keel.

Keel Retraction

The keel is retracted by a 2.5mm flexible stainless steel wire, which stretches from the bulb to a roller behind the keel casing, then to a roller at the base of the transom, then another roller at the top of the transom. From here it passes in through the transom and is linked to a 4-part purchase. The purchase runs the length of the cockpit, situated just below the seat edge on the starboard side, and through-bolted to the hull at the fore end of the cockpit. The purchase runs 8mm polyester line and works just like the mainsheet. When the aft block has reached the fore end of the cockpit the keel is up. The rollers are built in 316 stainless steel.

N.B. In another embodiment, it may be found that a hydraulic ram situated inside the keel box is a preferable means of retracting the keel. Other methods may also be used.

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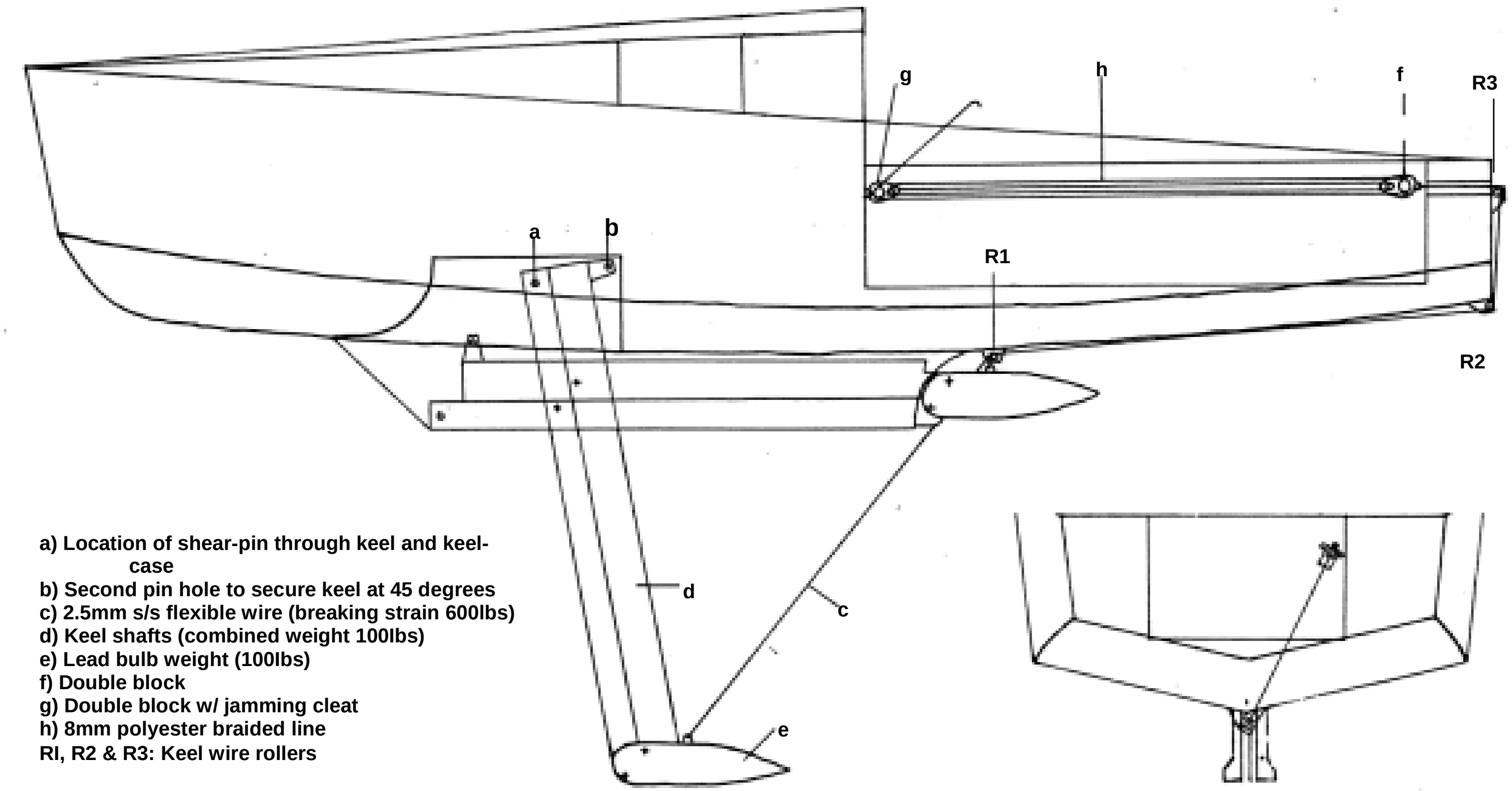
Explorer

Side and rear elevations showing interior of cockpit and cabin to illustrate keel retracting gear and shear pin to secure keel in extended position



Explorer has a Douglas-fir skeleton, 9mm marine ply bottom and 6mm marine ply sides and deck. The method is glue and screw, with resorcinol and epoxy resins and over 2,000 6-gauge brass screws! The mast and boom are Douglas fir.

THE AYRS-BOLT.

Ian Nicolson

What is an AYRS-Bolt?

An AYRS-bolt is like the common U-bolt but vastly better. It consists of a short length of chain held down at each end by a common bolt, with the appropriate metal and half-hard washers. See sketch on last page.

How It Got Its Name

At the London Boat Show on the AYRS stand there was a leaflet about the John Hogg Memorial Prize. As I left the stand with a copy of the leaflet I saw a U-bolt fixed to a yacht, and its disadvantages were obvious. The idea of a chain-plus-bolts came into my mind instantly.

At first I thought of calling the gadget a V-bolt, but that was obviously wrong, as a V is the wrong way up. Then I thought that the name should be A-bolt, as there will normally be a washer plate [or two], which is akin to the crossbar of the A.

Further thought made me realise I needed a name which exemplifies ingenuity with adaptablity, economy with utility, practicality with ruggedness. AYRS was the obvious name, so this gadget is an AYRS-bolt.

Why AYRS Bolts Are So Good.

AYRS bolts are available in a virtually unlimited range of sizes, widths, lengths, angles and strengths. The only limitations are the available chain and bolt sizes.

AYRS-bolts automatically align themselves to the angle of “pull” in any direction.

They can have their bolts close or far apart to suit the structure and the obstructions on deck and under the deck.

They can be fitted in pairs to give double strength.

Comparing U-bolts with AYRS-Bolts:

1. U-bolts come only in a limited range of sizes. This size limitation applies to the “rod” thickness, length of threaded part, width, and height. [See Appendix 1 for the limited number of sizes] AYRS-bolts have an almost infinite range of sizes. Their limitation is just the available size of chain and bolts. The strength, height, width, length and angle can be arranged to suit the situation.

2. U-bolts will not self-align. AYRS-bolts self-align in all directions, sideways, lengthways, and diagonally. They can be at any angle to the deck from 0 to 90 degrees.

3. U-bolts stand up when not in use and trip up crew, besides being liable to be damaged. AYRS-bolts lie flat on deck when not in use and can be walked over.

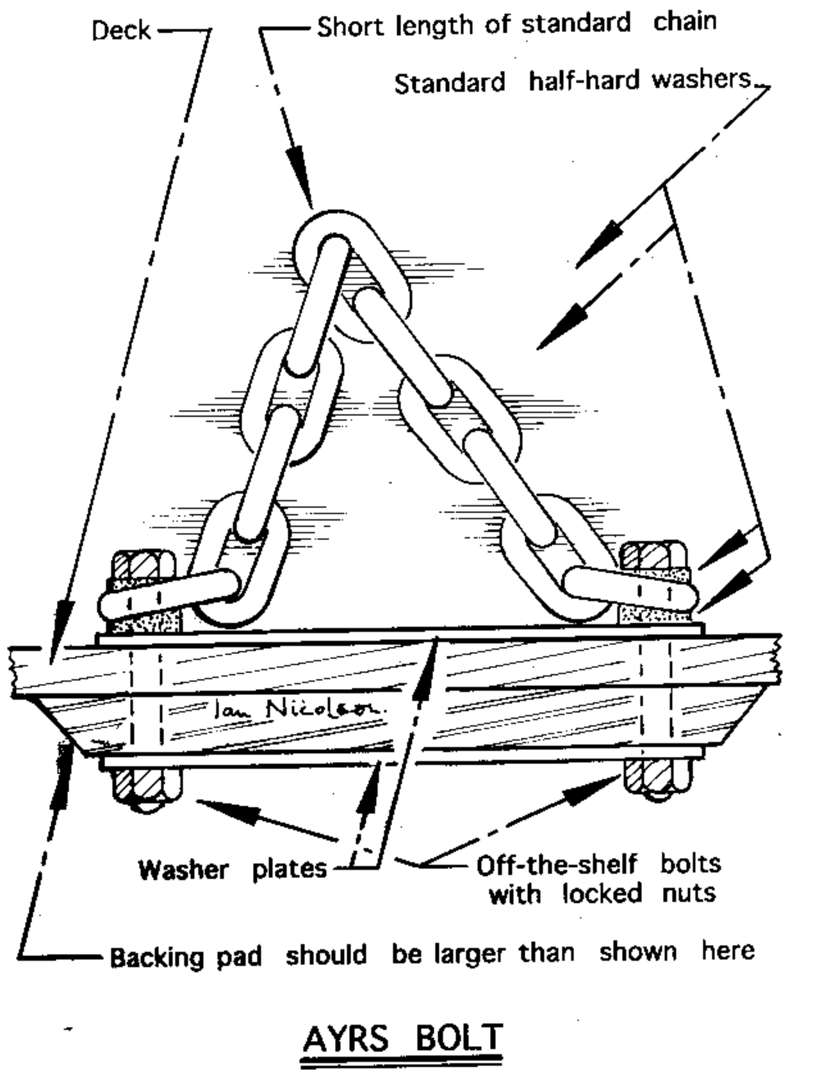
4. U-bolts give little warning of failure. AYRS bolts start to bend at the heads of the bolts and in this way give warning of over-stressing. Repairs are quick, easy and cheap.

5. U-bolts have to be drilled exactly right, whereas an AYRS- bolt can be drilled with far less exactitude if large round washers are used instead of washer-plates. On a cluttered deck, or under-deck, the bolts for an AYRS-bolt can be located to suit the situation.

So far as an inexpert shipwright is concerned, or anyone in a hurry in an emergency, this available variation in bolt location and spacing is a boon.

6. U-bolts cannot be bought in every port. The components of an AYRS bolt are available just about everywhere, including in the garages and workshops of many boat owners.

7. U-bolts are seldom available in sizes which suit highly stressed situations on large vessels whereas AYRS bolts can be made for such situations.



How They Are Made [See sketch]

Take a length of good quality chain such as a piece of anchor chain. Cut off a suitable length so that when finished the angle between the two “legs” of the chain is normally between 40 and 60 degrees. Greater and lesser angles can be used to suit special situations.

Take two bolts which just fit through the end links. Drill the base structure, such as the deck, for the bolts. Put each bolt through a metal washer, then a half-hard washer, and then the chain end link. Push each bolt through another half-hard washer then the washer plate or a large round washer. Next the bolts go through the holes in the structure such as the deck. Apply ample bedding under the washers. Fit a substantial backing pad with more copious bedding. This thick pad must extend well beyond the AYRS-bolts. Put “penny” washers on the ends of the bolts, with more bedding between the washers and the pad, then put on the nuts and tighten them. Add locking nuts or hammer over the bolt ends to lock the nuts on. Alternatively use Nyloc nuts.

There can be full width plate washers above and below deck as an enhancement to the AYRS bolts, as shown in the drawing, but these are not essential.

Materials For Fabrication

An AYRS-bolt can be made from stainless steel, mild steel, bronze or aluminium. A principal asset of this gadget is that it can be made with any suitable chain and bolts bought “off the shelf” from standard suppliers anywhere. There are few things more common in the world of engineering and hardware than bolts and chain. As both are made by mechanical means, untouched by human hand, the quality and strength of bolts and chains tends to be high and consistent.

Some Of The Different Uses

1] In place of U-bolts, especially where self-aligning is required.

2] For chain plates, backstays, and forestay anchorages on small vessels.

3] For lifting eyes on ships boats or other craft which have to be lifted by davits or cranes.

4] For holding down a stowed life-raft, or dinghy.

5] For securing anything heavy on deck or down below, such as anchors, batteries, outboard engines, etc.

6] Instead of mooring cleats or bollards on a small vessel, especially where an unobstructed deck is needed.

7] For the outer end of a bobstay where it is not convenient to fit a metal band with eyes round the bowsprit or bumpkin.

8] For the bottom end of a bob-stay where the fastenings through the stem [or stern in the case of a bumpkin] have to be wide apart or very close together.

9] In all sorts of emergencies where something has to be secured to a structure and there is no existing "joining link".

Different Versions

A] Ultra long chain type, e.g. if a chain plate has broken and an emergency one is needed.

B] Four bolt type with two chains, and extensive washer plates where extra strength is needed. A shackle or something similar is put round the two up-standing chains, so the load is spread over four bolts.

C] Alternatively where it is required to spread the load over a bigger area of deck, a pair of AYRS-bolts can be used.

Summary Of Special Assets

Self-aligning, unlike U-bolts. Cheapness. Versatility. Ease of use. Brilliant in a crisis far from resources.

The components can be carried on any vessel, and in an emergency a length of the vessel's anchor chain can be used.

ADDENDUM. The sketch does not show the metal washers which should be fitted between the bolt heads and the top half-hard washers.

Ian Nicolson
Linnfield Cove Argyll G84 ONS

APPENDIX 1.

U-bolts only come in a limited number of sizes. The standard source listing information about such equipment is "BOAT DATA BOOK" 5th edition [ISBN 0-7136-6502-5]

This book lists U-bolt sizes of 4, 5, 6, 8,10 and 12 mm diameter. However in practice few chandlers stock more than 6 and 8mm sizes. In particular 4mm and 12mm sizes are extremely hard to find.

APPENDIX 2.

The prototype AYRS-bolt was tested at Strathclyde University. It was tested to destruction and the following lessons were learned:

1. Fabrication time is short, as the gadget is so simple.
2. AYRS-bolts self-align effortlessly.
3. Failure at an extreme loading was not sudden during testing, and there was ample warning before it occurred. The bolts slowly bent as a severe load was applied.

Thanks are due to the University for the use of their test rig to advance the knowledge about AYRS bolts.

APPENDIX 3.

The strength of an AYRS-bolt depends on the material used, the distance apart of the bolts, the length of chain, the quality of the materials, and so on. An approximate guide is given below indicating the sort of safe loads which might be expected provided good quality mild steel or an equivilent is used, and the angle between the legs of the chain is about 40 degrees. No guarantee can be given at this stage that these figures can be relied upon, but further tests are planned to obtain more data.

Bolt diameter.		Approximate safe working load
Millim'trs.	Inches	[Mild steel] in tonnes
4	5/32	0.36
5	3/16	0.52
6	1/4	0.92
8	5/16	1.43
10	3/8	2.06
12	1/2	3.67

Some Thoughts on the Polar Curve

Frank Bailey

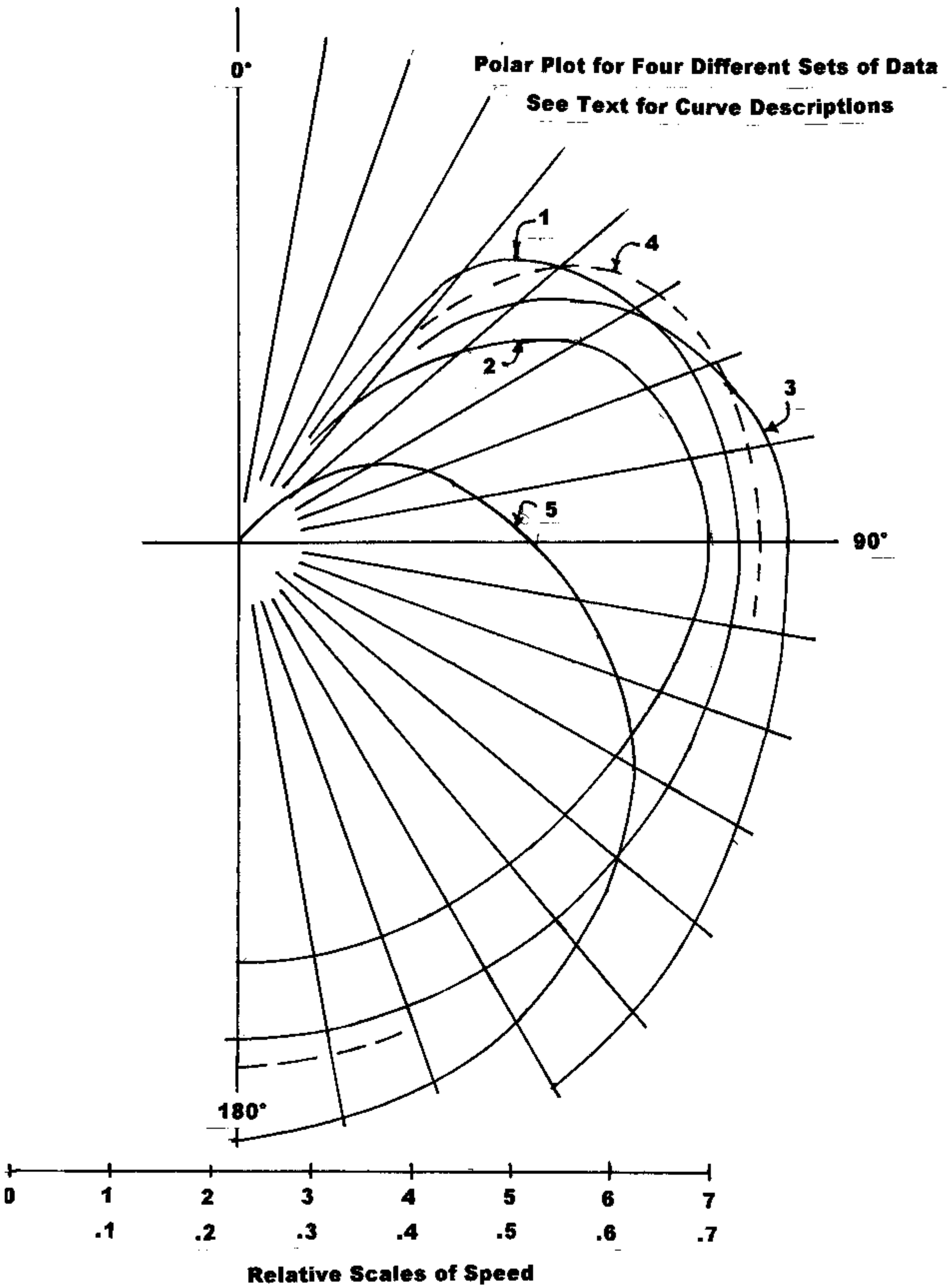
The Polar Curves I wish to comment on as you may recall are the curves plotted, generally, showing boat speed for various headings from 0° to 180°, that is from as close to the wind that the boat can sail and on to a full running or 180° degree course, the radius vector being the speed of the boat. All plots are based on a constant wind speed. Some plots are referred to the apparent wind and some are plotted to the true wind. Also, to make matters a bit more complex, some plots plot as the radius vector V_b/V_a or V_b/V_t, velocity of boat divided by velocity of apparent or true wind (a dimensionless number); and sometimes knots or mile per hour are used.

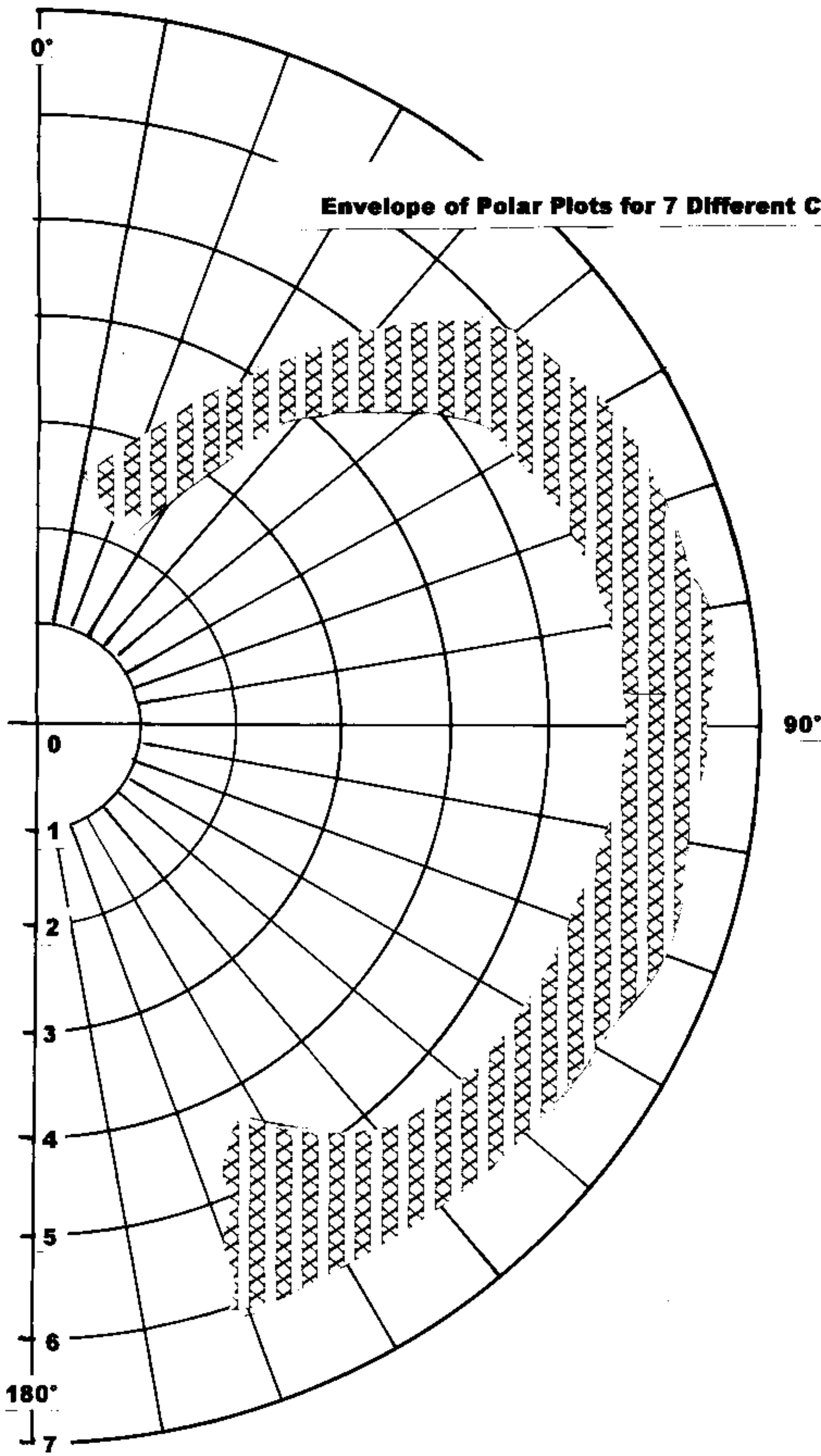
A.Y.R.S. Publication No. 81, Design for Fast Sailing, 1976, by Edmond Bruce and Henry A. Morss, Jr., edited by John Morwood, was a collection of previous Society articles that just about said everything quantitatively (and qualitatively) about this subject. I think the time and effort put into these experiments is truly astounding. I doubt that much has been done since then to improve on the techniques employed. For those of you who do considerable competitive racing, I suggest understanding Mr. Bruce's methods of determination of optimum position of boom angle is a must Next, are a few additional observations.

Mr. Bruce assembled all of his data apparently all by himself, slowly and painstakingly but joyously. He tested his boat, a 12 foot International One Design dinghy, by taking measurements while the boat was tethered, while the boat was towed, and while the boat was moving under sail. While the boat was tethered the windspeeds were of course true winds, and the force in the tether was measured by a spring balance. While the boat was towed, with a spring balance in the tow rope, there was no wind, except for windage which was handled separately so the hull drag forces were measured, again with windage adding to the complexity. While the boat was actually sailing, the apparent windspeeds were recorded along with boatspeed. Mr. Morss did about the same thing. Indeed, Mr. Morss states he had to take many readings to get one point on his plots because of the variation in the readings of his instruments, the vagaries of the wind, etc. After all of this on water data was recorded, then a tremendous amount of time was spent sorting out all of the geometry, which is rather complex. It may also be mentioned here that while sailing, the boom angle was adjusted for maximum speed or maximum sail force and the angle recorded. No doubt the wind did not cooperate by being constant and coming from the same direction.

When these two gentlemen did their work, or play, there were none of the cell phones (believe it or not) that are so pervasive today. I suggest instead of a single individual doing the above testing, that the sailboat being tested have a crew member with a cell phone so that he/she can contact a stationary boat nearby with another crew member also equipped with a cell phone. For instance, on the sailboat, when readings are taken of apparent wind angle and boat speed and boom angle, at the same instant, the stationary boat can record the true wind direction, bearing, and windspeed. This procedure should allow a tremendous amount of data to be assembled in a much shorter period of time than previous to the advent of cell phones and would I hope make it unnecessary to try to untangle the apparent versus true wind problem. However, we would still have the windage entangled with the data but this might be no big deal as some might vernacularly say.

On the plot included here, I have shown 4 polar curves. No. 1 is taken from page 35 of D.F.F.S. and show boat speed in a 10 mile per hour apparent wind and is for Mr. Bruce's 12 foot dinghy. Plot No. 2 is taken from page 36 and is the same thing except plotted against true wind. No. 3 is from page 57 and is the same except the plot is V_b/V_a. No 4. is from page 139 and is by Mr. Morss showing his plot of V_b/V_a for his 24 foot Arrowhead trimaran. Although there are two speed scales involved here, we can see the close similarity of the curves. In the real physical world, many


Polar Plot for Four Different Sets of Data
See Text for Curve Descriptions
0°
90°
180°
1
2
3
4
5
0
1
2
3
4
5
6
7
.1
.2
.3
.4
.5
.6
.7
Relative Scales of Speed



Envelope of Polar Plots for 7 Different Cruising Boats
0°
90°
180°
0
1
2
3
4
5
6
7

motions and static conditions can be represented by equations which I am sure is obvious to all of us. For example, a chain suspended between two points can be defined as a catenary and its shape plotted on paper by a formula. I suspect there is also somewhere "out there" a formula which could represent the "heart " shape of the polar plots. The closest I could come is the cardioid, which I have plotted as plot No. 4 from the formula $R=3(1-\cos\theta)$. The text books usually represent this formula in a slightly different form. It is not too close to the actual data in the windward direction but perhaps someone could figure out a closer approximation. Is it possible there is actually a simple or relatively simple cosine relationship here with a dominant but changing constant? Whether a closer approximation could be of use, I don't know but it could be used to measure the speed computationally rather than picking it off with a pair of dividers graphically. My plots are only close approximations to what is shown in the books as my hands have grown a bit palsied in the service of the A.Y.R.S.

I am somewhat embarrassed to include here the other polar plot but it may be instructive never the less. Somewhere I have misplaced, lost, or may have been stolen, or thrown out, the details of the data such as windspeeds, boat speeds, true or apparent wind, knots or M.P.H., etc. but this I remember: All the parameters were similar and was for seven different cruising boats, I assume around 20 feet length or longer. I have not shown the individual plots but have shown the envelope of the seven curves. It appears there is not a whole lot of difference between the curves. For instance, at 90° to the wind, the variation from minimum to maximum speed based on the midspeed is only about 13%. It is a bit less to windward but quite a bit more toward the running condition.

I would like to consider one other aspect of this subject. This aspect may or may not have any merit. We are all familiar with the Portsmouth Number. My recollection is that it is an assemblage of many race results for some particular type or class of sailboat. No doubt, the more race results available, the more representative this number is of the class. This no doubt takes a lot of time and effort to crank out the results. I suggest that from a good polar plot of a sailboat a *Performance Number* could be calculated once and for all for any particular boat. It might be "the area under the curve" familiar to you Calculus buffs. It could also be a summation of, say the radii at 10° intervals. The radii could also be weighted by incremental or decremental * percentages to favorably weight the windward performance. Since racing courses are triangular, this added factor might not be appropriate.

In conclusion I suggest the following for further research. We could all gather for our boats polar plot data, say in a 10 knot wind, and at some time all of this data could be assembled and plotted and perhaps we could find what characteristics lead to the best windward performance and so on around the compass rose. I suggest windward performance is the most pertinent. It would be extremely interesting to see a polar plot for the 60 plus footers now going around the world in profusion. I surmise size of course may be a big factor in all of this. On the other hand, speed may not be the sole criteria for the individual sailor. Anyway, I hope you get the main thrust of this article.

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@fishwick.demon.co.uk**

January 2004

8th - 18th London International Boat Show
New venue – EXCEL Exhibition Centre, London Docklands. Those who can give a day or two, from 15th December onwards, to help build/staff the AYRS stand (reward - free entry!) should contact Sheila Fishwick tel: +44 (1727) 862 268; email: ayrs@fishwick.demon.co.uk

17th AYRS Annual General Meeting at a NEW VENUE somewhere in London Docklands
Call: AYRS Secretary mobile: +44 (780) 820 0987 for latest information!

February

4th AYRS London meeting
Boat Design (methods & tools). 19.30 for 20.00hrs at the London Corinthian Sailing Club, Upper Mall, London W6. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX, UK; tel: +44 (1727) 862 268; email: ayrs@fishwick.demon.co.uk

February

22nd Project Day
9.30am-5pm, Thorpe Village Hall, Coldharbour Lane, Thorpe, Surrey (off A320 between Staines and Chertsey – follow signs to Thorpe Park, then to the village). Bring your project along, or if you cannot bring it, bring some pictures (OHP or 35mm slides) and be prepared to talk about it! Also discussion of multihull capsize recovery, Brains trust, etc. Details from Fred Ball, tel: +44 1344 843690; email fcb@globalnet.co.uk

March

3rd AYRS London meeting
From sketch to realisation.
19.30 for 20.00hrs at the London Corinthian Sailing Club, Upper Mall, London W6. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX, UK; tel: +44 (1727) 862 268; email: ayrs@fishwick.demon.co.uk

April

7th AYRS London meeting
Materials. 19.30 for 20.00hrs at the London Corinthian Sailing Club, Upper Mall, London W6. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX; tel: +44 (1727) 862 268; email: ayrs@fishwick.demon.co.uk

25th Beaulieu Boat Jumble
Beaulieu Abbey, Hampshire - the AYRS stand will be in the usual place (so we are told!)

May

(Date to be confirmed)
Weymouth Warm-Up Week (AYRS Sailing Meeting) at Castle Cove Sailing Club, at the end of Old Castle Road, Weymouth; sailing in Portland Harbour, all boats welcome, but please note that neither AYRS nor the Sailing Club can provide continuous rescue facilities (just the RNLI), so please ensure that you and your boat are capable of looking after themselves. There will be a charge for temporary membership of the Club and use of their facilities (launching, changing room, showers, bar, etc). Contact: Bob Downhill; tel: +44 (1323) 644 879

October

2nd-8th Portland Speedweek
Portland Sailing Academy, Portland Harbour, Dorset UK. Contact: Bob Downhill; tel: +44 (1323) 644 879

6th AYRS Weymouth meeting
Speedsailing. 19.30 for 20.00hrs at the Royal Dorset Yacht Club, Upper Mall, Weymouth. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX; tel: +44 (1727) 862 268; email: ayrs@fishwick.demon.co.uk

SPONSOR WANTED FOR UNIVERSITY PROJECT

(or a small hull for a hydrofoil boat)

I am writing on behalf of a team of nine engineers from the University of Warwick. We are involved in a group project for coming academic year, and are hoping to construct a working (test) watercraft by mid-2004.

Of the team of nine, seven are in their fourth year of Masters degrees in engineering (including Mechanical, Manufacturing and Electrical Engineering) and two are in their third year (one Civil Engineer- myself, and one Manufacturing Engineer). The project is expected to run for at least two years, with this year's findings being extended and improved upon next year.

The aim is to construct a small hydrofoil craft with a crew of one, that is easy to sail and capable of reaching relatively high speeds in low wind conditions. We believe this is possible on the grounds of research into hydrofoils carried out last year in a one-man project by one of our number. Also, several members of the team have extensive sailing experience and are sure that there would be a market for such a craft, and with this in mind we hope to prove that such a craft can be built (in the form of a prototype) and sailed.

The bulk of the effort in the project is going to go into designing, testing and building the hydrofoil assembly so we are looking to obtain a small hull to use as a base for our design.

At the moment, we are looking for any kind of sponsorship, be it through money or materials, and have plans to visit several boat-shows of sorts to display our aims.

We would be very grateful if you had any suggestions for companies that you thought might help us through sponsorship or materials, or if you could forward this email to somebody who might be able to help. Any support would be gratefully received since this is already an ambitious project.

Thanks a lot for your time and help!

- Tom Gleadall
(3rd Year Civil Engineering Student, University of Warwick)
tommy_g003@hotmail.com

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

On the Horizon . . .

Mini-Trimaran - S Newman Darby

Flying Proa - Roberto Rampinelli

More sources and resources: reviews, publications and Internet sites

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

Printed by Direct Image Systems & Communications, London N1 6DL.