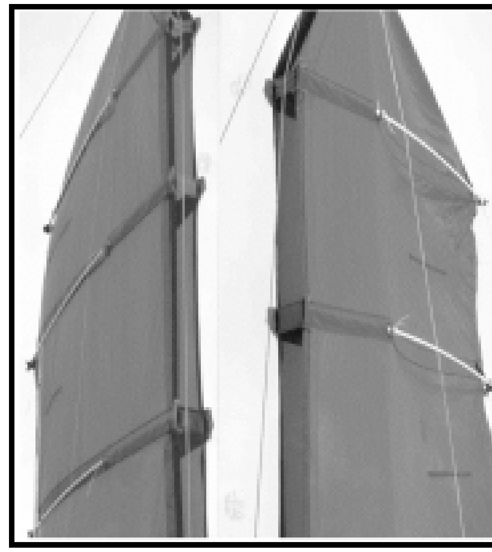
Catalyst

Journal of the Amateur Yacht Research Society

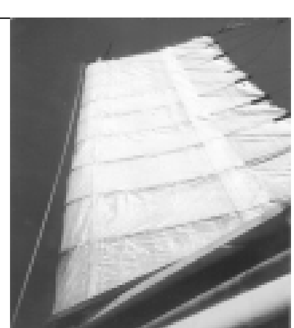
Number 8 April 2002

Rigs

Regular



Ken Upton's Eco-sail Mk 2
Ken's latest development ideas in river current power generators should shortly be available at www.ecofrogs.com



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.

Contributions are welcome from all. Email them to **Catalyst@fishwick.demon.co.uk**, or send (at your risk) disks or typed copy with illustrations to the Society's office. AYRS can take no responsibility for loss or damage.

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Special Issue on Rigs

This edition has come about more by coincidence than planning! A number of articles on rigs or rig-related topics arrived at the same time so it seemed sensible to put them all together. Indeed we have had to hold one or two over to future editions.

So we start with Peter Bell's survey of developments in wingsails for sailboards, on which as CEO of Dynawing (distributors of the Powersail range) he is well qualified to write. We follow that with two articles on derivatives from junk sails. The first by Robert Biegler describes his experiments in making a double-surfaced junk sail. The second by Jeff Doyle describes a similar development but this is a reconstruction of a sail that predated all the rest by many decades if not centuries. Originally built in China in 1897, Jeff learned of it in conversation with the builder's great-grandson, and he has reconstructed it from the plans he received plus some sensible interpretation.

Back in the early 1960s, a group of AYRS members derived a sail they called the "AYRS-sail" – a semi-elliptical fully-battened sail which they felt, from its shape and obvious power, would be the ultimate in effectiveness. Not many people made it work well, and it languished; but more recently the American designer Phil Bolger revived it for an experimental proa and wrote about it first in *Small Boat Journal* and later in his book *"Boats with an Open Mind"*[1] . From there it has entered into the proa repertoire. John Dalziel tried it and published a critical account of the problems he had. We include here a summary of that, and also the comments from two that have used it successfully – Phil Bolger, and Joe Norwood, whose proa Falcon was described in Catalyst No 3.

Finally, since no rig (or very few anyway) can support themselves, we have an account by Chris Evan's of the building of the wingmast for his canoe *Sunshine*.

Simon Fishwick

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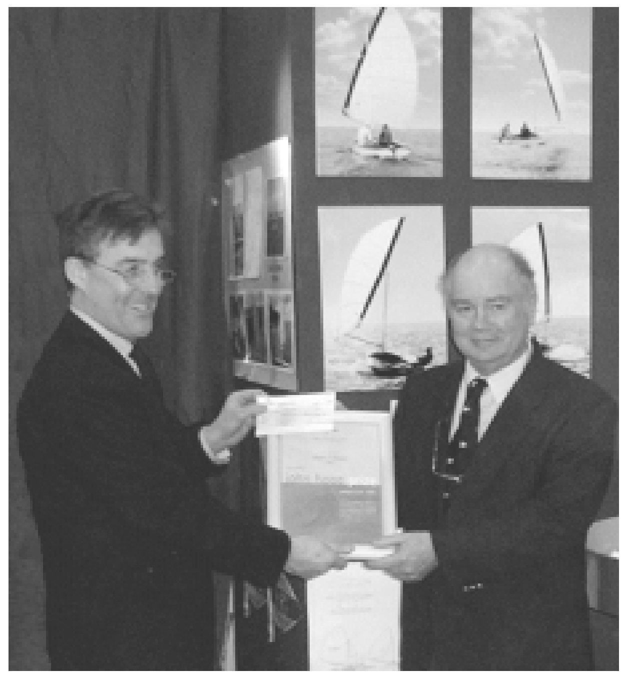
John Hogg Memorial Prize Award

As announced in the last edition of *Catalyst*, the John Hogg Memorial prize for 2002 was awarded to David Duncan for his Swing Rig.

The prize, including a cheque for £1000 was presented to David on the AYRS stand at the London Boat Show, by Rodney Hogg, Chairman of Spinlock Ltd, and son of the late John Hogg.



Presenting the prize, he thanked the Amateur Yacht Research Society for allowing John Hogg's family to celebrate John's life & work in this way; and the other judges for all their hard work and patience. He continued:

"This is a perfect opportunity to pay tribute to the achievements of all amateur sailors but especially to amateur yacht researchers - like my father, like the members of the AYRS and particularly, like the three successful finalists.

AYRS members are amateur only in the sense that the huge majority of other sailors are amateur - they are professionally employed in some other field.

The quality of the successful entries shows the range of professional skills these so-called amateurs bring to the better understanding of their sport. Just as amateurs invented football, cricket, car racing, skiing, and practically every other sport, amateurs invented sailing, and amateur researchers still continue to invent many of the really significant steps in sailing technology.

It's not too difficult to guess why:
• Amateurs are self-motivated
• They bring fresh insights into sailing from every other field of science and technology.
• They share them openly with each other.
• Their time is their own - so they can afford to be wildly radical,
and, as the Hogg family can testify ...
• Amateurs can put in unbelievable hours of work when things get difficult - or when they're excited.

Well done to David Duncan, and all three finalists, and sincere thanks again to the AYRS committee for all their hard work in making this new competition such a success."

AYRS has already announced that the John Hogg Memorial Prize will be awarded again in January 2003. The closing date for receipt of entries is 15th October 2002. Entries should be sent to the AYRS Secretary at BCM AYRS, London WC1N 3XX, UK.

Windjet claims British Landsailing record at 113.4 mph (182.46 km/hr)

©Windjet Project

On Friday 22nd February, the *Windjet* team were again out on the Waddington Airfield in Lincolnshire, UK. However, although fresh westerly winds prevailed (the preferred direction for *Windjet*), the day was fraught with logistical problems including rain and military flying requirements, which meant that time on the airfield was very limited.

Morning showers prevented any early testing, but after the runway had dried and a number of false starts due to aircraft movements, *Windjet* finally made it out on the runway at 3.30 pm. With a wind strength of around 23 kts the very first run clocked 113.4 mph. However, the gods were not smiling, for as *Windjet* sped around the taxiway in preparation for the next flying run, the skies cleared and the wind eased, meaning the next 18 runs were all between 85 - 100 mph as the wind fluctuated between 15 - 20 kts.

However, the day proved invaluable to fully test the new timing equipment and the impartial observer procedure required for the official ratification process. Hence, with triplicate raw data logging, filmed evidence and two impartial observers, the *Windjet* team is claiming an Official British record of the top speed for the day, 113.4 mph, a tantalisingly close 3 mph away from the current world record!

Windjet's speed is measured five times every second by Thales Tracs-TDMA equipment, an intelligent radio data network which integrates advanced UHF/VHF communications with differential GPS technology. This enables any one of the Windjet vehicles to be located, in a 15 mile radius, with a positional accuracy of better than one meter and a velocity accuracy of 0.1 mph.

The current World Wind Powered Land Speed Record stands at 116.7 mph and was set by Bob Schumacher in "Iron Duck" on 20th March, 1999. In order to "Officially" break that record certain standards must be observed, for example the timing equipment used must be acknowledged and verified by an independent observer.

[As Catalyst *goes to press, the landsailing world championships are in progress at Ivanpah Dry Lake, USA. Early reports suggest there is not very much wind. Ed.]*

© www.blokart.com

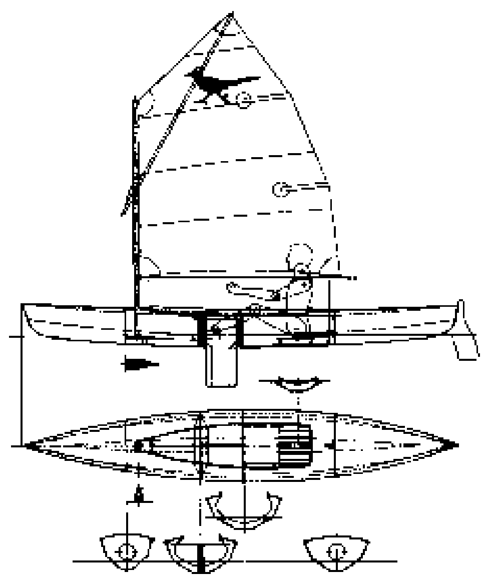
Show Reports

London Boat Show this year was disappointing for anyone looking for innovations. The only "different" boats on show were Ellen MacArthur's *Kingfisher*, and Roger Collin's *Swiftgig* (see Catalyst N° 7). Otherwise it seemed to be the same old story of small changes to existing products.

Amsterdam was somewhat better, or at least more interesting — less of the glass fibre gin-palaces, and more boats that looked as though they were designed to go to sea. Again not much new, although one boat did sport a standing lugsail. One stand had a small landsailer on show – the Blokart – 3m^2 sail, 4.2m long, steel and glass fibre chassis, one person, packs into a small bag, originally from New Zealand. The salesman claimed speeds of up to 90km/hr (55 mph)!

Also was of interest was the Family Boatbuilding event run by the Dutch sailing magazine WaterKampionen. Over the six days of the Show, some 20 families each built a *Strandloper* sailing canoe from a kit of parts manufactured by Cabra Yachting of Zeewolde, Holland. This 16ft canoe carries one person, and uses a rig taken from an Optimist dinghy. The kit is of precut 4mm and 8mm plywood, held together with epoxy fillets.

Not at either London or Amsterdam, although it may have been on show at Paris, was the *Defline 19* inshore cruiser/racer, from Defline Yachts of La Rochelle, France, distinguished as being the first production boat of which we are aware to carry a canting keel. In fact to minimise problems with the accommodation, it carries two, one in each bilge. Each has an asymmetric section (lifting surface inwards) and a ballast bulb at the tip, and the windward keel can be hoisted to a horizontal position where it sticks out the best part of a metre outside the gunwale; when the boat heels, it will lift from the water.

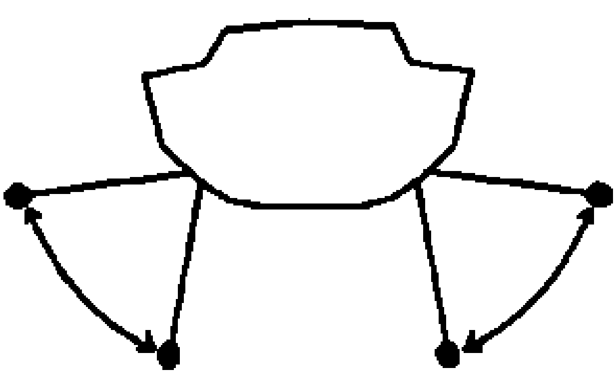


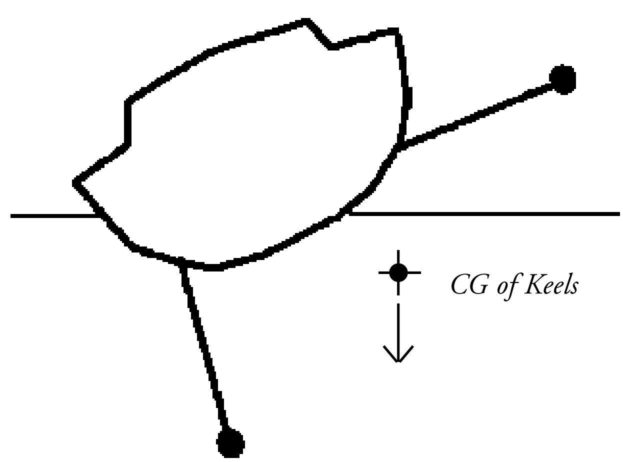
To beach, both keels can be raised, like a dancer in the splits, but as far as I can tell, neither can be retracted, so I don't know what happens if the boat has to take the ground against a harbour wall. Presumably it balances on both keels, but if the keels are not exactly vertical it must place more load on the control lines than I would want on my boat. Maybe this is a detail still to be resolved, although the boat – or at least a prototype – exists.

It will be most interesting to see how the yacht racing authorities react to this, and indeed what kind of handicap they allocate. Delfine propose to organise a racing circuit, but the boat will undoubtedly appear in club races sooner or later. The French tend to be more pragmatic about these things than, say, the British RYA, so I doubt that the idea will disappear.

SNF

References:
Swiftgig – www.swiftgig.com
Blokart – www.blokart.com
Defline 19 – www.defline-yachts.com.





Timber Frames and Crabclaws

On a dull Sunday in February, a bunch of people with a common interest gathered in an old timber-framed village hall to the Southwest of London. They had come to talk about building boats. Fred Ball had organised another Boatbuilding Day.

Like the last one (last year), Fred had got together a small number of people to start the discussions, but the real core were the audience, who were expected to contribute as much as the speakers, and who did so. Little groups collected in corners comparing details and balancing the pros and cons; various people brought books and models and drawings; Ian Huchinson brought a full-sized sailing canoe complete with outriggers and crabclaw sail; there wasn't a quiet moment all day.

But the stars of the show were the Joneses – Colin and David (no relative) – Colin the technology teacher, who uses boatbuilding a learning aid, and David the maker of fine furniture, whose boat would not look out of place in a drawing room.

Fred openened the day with a short discussion on the why, what and where of boatbuilding – why to build a boat (because you positively want to *build* one), and why not (because you think it might save you money - it probably won't); what to build (a very personal decision, but bear in mind the time you can give to it, and the overall time it will take); and where (if it's in your garden then you can spend spare moments on it; away from home may be handy for launching, but makes going to work on the boat more of an planned expedition). He himself was fortunate in that he had some land, but members knew of boats built in all sorts of unusual places, including upper-floor apartments!

Photo: Robert Downhill

Ian Huchinson's sailing canoe

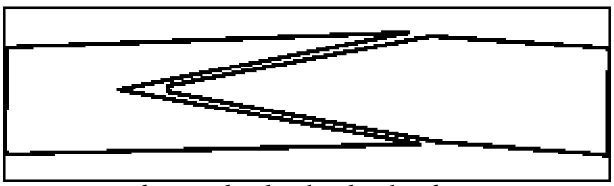
Photo: Robert Downhill

A discussion during a break

Michael Ellison advocated not building a boat at all. Get someone else to build the hull, he said, then concentrate of fitting it out. He pointed out that a professional yard can turn out a hull far faster than any amateur, citing the case of Mike Butterfield's new catamaran, the plugs for which wre started after Christmas, and which had to be launched and sailing by late-April to qualify for the Round-Britain Race. (At that time it was well ahead of schedule, and has stayed that way).

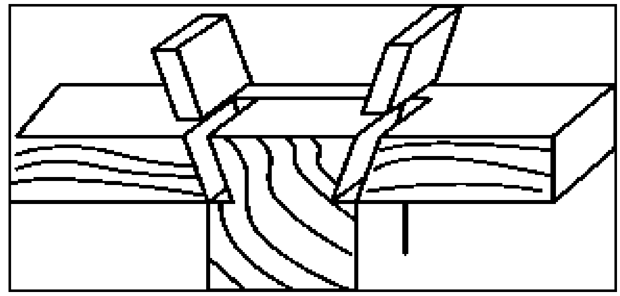
Colin Jones's boats range from the small to the very big. He brought along a test piece of timber knee for the 213ft long three-masted barque, *Tenacious* – a great lump of wood a thick as your leg. He also brought a number of finely-made models used to check that timber will go together to make boats. Colin is the builder of England's Escargot –

an 18ft pedal powered canal cruiser – as well as of a number of smaller boats built as youth projects. (Tip: a sewing machine can be adapeted into a useful and safe jigsaw for children's use.) He also told fascinating tales of the building of *Tenacious* – the world's largest epoxy-wood structure, and of its turning over. (It was built upside down. They could have turned it in a few minutes, but it was felt a much longer time would be much more spectacular for the press!)



Birdsmouth plank-plank edge joint

David builds wooden furniture. He has only built one boat, a lightweight Thames rowing skiff (Americans – think of a Whitehall); but he built it like the master craftsman he is. He used a computer program (FORM-Z) to determine the shape of all the planks (both inside and outside surfaces), which are joined to "birds-beak" joints cut so accurately that the hull would hold together without either fastenings or glue. (Details were in the February edition of the magazine *Water Craft*). At one point



Wedged mortise dovetail

we had an enthralling interplay between the two Joneses on the merits of sharpening tools with 1000 vs 6000 grit Japanese waterstones, and on joints like the double-wedged mortise dovetail.

John Thurston spoke about his multihull model, which requiredan extra hull to provide the displacement needed; Robert Downhill spoke of the structural problems of thin hulls; and we all went outside and discussed the pros and cons on Ian Huchinson's crabclaw rigged sailing canoe. 16feet long, with two outriggers, it was designed to the rules of the UK Open Canoe Sailing Group (sail area max 4sqm/ 44sqft, should be paddleable).

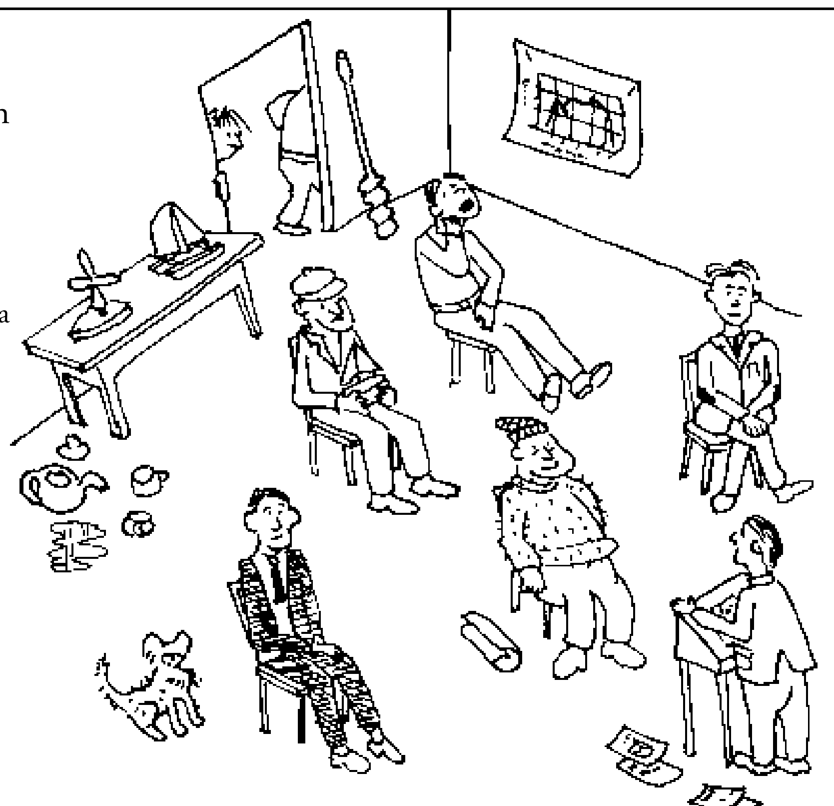
A great time was had by all, with many thanks to Fred and to Margaret who kept the coffee flowing while we all talked!

SNF

Comment by T.H.

Match each sentence with each member:

a. What on earth is going on in there?
b. So you see, if *X*=*Y*, then it works.
c. I like Cutty Sark because it has a sailboat on the bottle.
d. I don't understand anything he is saying.
e. I wish he would stop so I could speak.
f. I am not asleep.
g. These new fangled ideas are all bunk.
h. I'm leaving. These folks are all crazy.
i. Feed me, please.



Your Letters

AYRSupport - a scheme to provide practical help with projects.

I feel many of us undertake yacht research projects which go well in their early (garden shed) stages but which then grind to a halt when they are ready for in-water testing. The device or boat to be tested is probably very promising, and the difficulty is just lack of people to help - the difference between a successful encouraging test and a depressing or dangerous fiasco may be simply the presence or absence of a support boat and a couple of people in wet suits.

This was shown very clearly at Speed Week 2001, where Fred Ball with his dory and Arthur Lister with his small RIB were extremely helpful to several of our projects, e.g. recovering Patrick Mayne and his foiler after a high-wind capsize, helping Jean Hurtado and Alan Blundell to make their runs, rescuing Didier Costes after his encounter with a moored boat, and tow testing Bob Downhill's craft and my hapas.

But except for brief outings at Speed Week and Winds of Change (where similar help is usually available), interesting projects tend to sit ashore gathering dust or leaves while there are probably several AYRS members currently without their own projects who would be very pleased to help to test them in the water.

The answer seems to be to put the people wanting help in touch with the potential helpers, and I would like to propose to set up a scheme for doing this, provisionally called "AYRSupport". (One is reluctant to introduce a military note into our peaceful Society, but whenever modern soldiers get stuck they ask for air support to let them move forward, and I'd like to see our project leaders doing the same).

The idea would be to provide a single contact point (me, initially) where people wanting or offering help with projects would ring or email with brief details of who, what, when, where. I would then try to match offers and needs, and encourage mutual contact. If this simple approach proves successful we can extend it later, probably by having a help offered/help wanted section on the AYRS website, but I feel less formality may be better to start with.

As explained above, it seems to me that the main need is for practical help with in-water testing, but the scheme could obviously include other kinds of help too, if people need or can offer say workshop facilities or boatbuilding skills. We should perhaps stipulate that this is a strictly amateur scheme, i.e. none of the people involved should expect to pay or be paid for help.

To get things started and "put my money where my mouth is", I have a Catapult catamaran with a 15 hp outboard which I'd be happy to use as a support boat for any suitable project during 2002, anywhere between Weymouth and Chichester or inland in the south of England. This should be adequate for light towing up to about 12 knots, model testing, kite sailing trials, etc. Where a bigger or more powerful support boat is needed in this area, Fred Ball and his dory with 28 hp may also be available sometimes, and there is also a faint possibility of getting the use of a Zapcat with 50 hp (40 knots?).

Please contact *Catalyst* with comments on this AYRSupport proposal or ideas for improving it, and **ring or email me (tel:01497 831687 or 01276 472208, email slade@penoyre.freeserve.co.uk) with requests for or offers of help with projects.**

Slade Penoyre.

PS I'm based in UK but that should not prevent people in other countries volunteering/asking for help!

One request for help!

Well, it's got to the point where I going to build a small working river power generatror craft of about 7mts, but there is one problem.- I cannot work out the maths on the amount of power it will give. I can build, design,and have a good idea how it all works, but when it comes to these sort of maths, I am out of my depth. So I can calculate the weight and power of the generators etc

I have asked a few others, and nobody can give me a real opinion, as there would be a water slip factor, so the traction could be taken off. That's the trouble of new ideas.

So?? do you know any member who would like to help with this problem?.

Please read the basic article *[next edition. Ed]* first it will help you understand the drawings and how it works why.what etc.

all the best Ken Upton
cyberlifeboat@wanadoo.es

[Ken is based near Alicante in Spain, so if someone wants to spend some time during the Summer . . Ed]

Route des Moules

31st May - 2nd June 2002

The Route des Moules is a fixed time 12 hour race event from Cowes to the beautiful island of Alderney. organised by the Royal Thames Yacht Club in aid of the Jubilee Sailing Trust. It includes IRC, Cumberland (local handicap) and Sail and Power divisions.

It will be followed on 2nd June 2002 by a race round the island of Alderney before an exclusive fundraising champagne reception and supper.

The evening reception will be held at 1900, followed by a Supper of 'Russell's Mussels', a fundraising auction and disco. The Round Alderney Race is organised by The Alderney Sailing Club.

Please register your interest by 30th April 2002 to secure a berth in Alderney.

Entry fees £25 per boat and £20 per person including supper

For more details contact Kate MacDougall, Events Manager Tel: 023 8044 9108; email katemac@jst.org.uk

[The Jubilee Sailing Trust (JST) is a unique UK charity that aims to promote the integration of able-bodied and disabled people through the adventure and challenge of tall ship sailing. The JST own and operate two specially designed tall ships - the LORD NELSON and the brand new, TENACIOUS.]

British Model Multihull Association Meetings

The plan for the BMMA this year is to have four informal meetings and the last meeting of the year at Yeovil will be a 1-day National Championship for the Mini40 class. It is hoped that a more informal format will encourage increased participation and doesn't limit the meetings to just the Mini40 class. The aim will be to have a number of races over the day but with breaks to allow beginners and interested onlookers to have a go. During the breaks there will be more time to help set up and trim boats. We also hope this format will encourage people to experiment more without worrying about affecting their championship campaign.

VENUE	DATE	CONTACT
Yeovil	14th April	Robbie Nevitt 01963 370058
Portishead	18th May	Mike Dunkley 01252 721439
Guildford	16th June	Mike Dunkley 01252 721439
Cotswold	6th July	Mike Dunkley 01252 721439
Yeovil	15th September	Robbie Nevitt 01963 370058

Start times will be 10.30. Sailing fees are reduced to £3 for members. Non members will be offered a choice of joining the association on the day (£5) or paying a £4 sailing fee. Entry fees mainly cover a donation to the host club for the use of the facilities and perhaps a few prizes. Spectators are welcome. Please contact Mike or Robbie prior to the event. This gives us an idea of how many boats may be attending. It is also wise to check that the event is on. Directions to the venues can be supplied on request.

They are also planning to attend the Child-Beale Model Boat Festival at Beale Park over the Bank Holiday weekend of 4th –6th May. Both Mini40 and 2 Metre boats should be on display.

Further information on the association and the Mini40 and 2Metre classes is available from the secretary.

Robbie Nevitt.
40, Yarnbarton, TEMPLECOMBE,
Somerset. BA8 0 JJ, UK
Tel:- 01963 370058; Email:- bmma@talk21.com

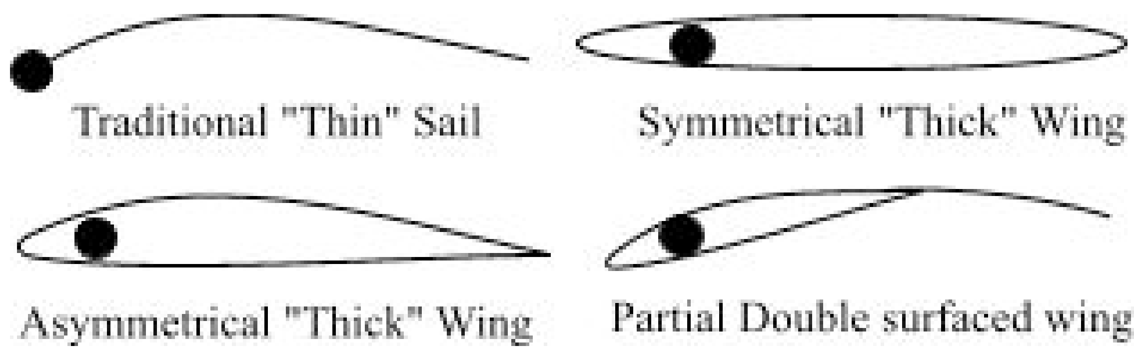
"New Rudder Design"

Peter Hopkins <Email: beachbum@surf.net.au> is cliaming to have developed a new rudder design that reduces drag over conventional designs by up to "as much as 40 to 50%".If there is anyone out there who can help to find a potential rudder maker who would like to sell rudders to the world, please contact him directly.

The History of the Double Surfaced, Asymmetrical Soft Wing Sail in the Sport of Windsurfing

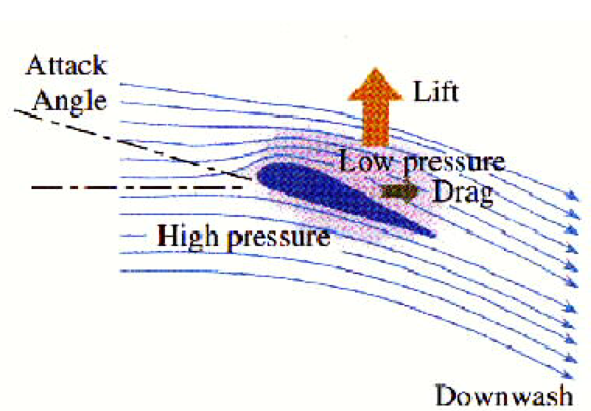
Peter Bell

Double surfaced, asymmetrical soft wing sails produce more drive, induce less drag, point considerably higher, are much smoother to sail and produce much less heeling moment than a traditional sail plan. However, they come with an inherent weight penalty as they have two surfaces and are more expensive to manufacture, as there is twice as much material involved. Most modern windsurfing sails have an efficient foil shape and the drag induced is minimal as the luff pocket design really helps to clean up the airflow. Most modern sails have progressive twist control cut into them to handle gusts and are soft enough to glide for long distances on puffs. So why are people still fooling with double surfaced, asymmetrical soft wing sails and what is the potential of this technology?

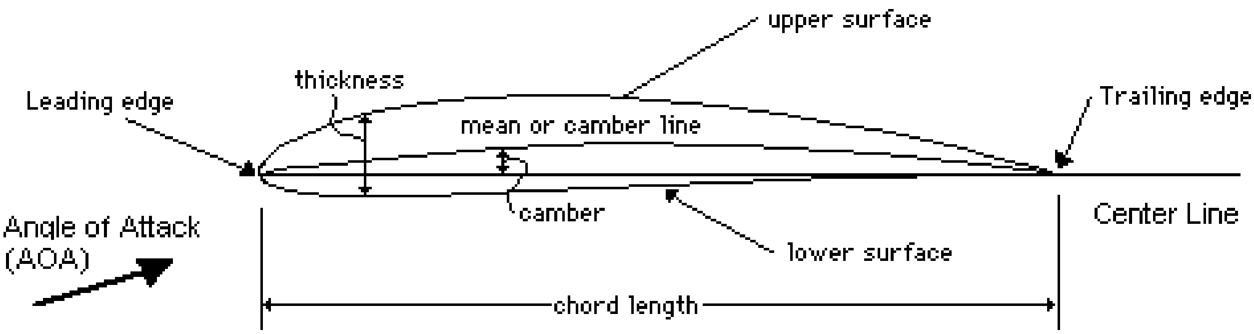


To understand what a Double Surfaced, Asymmetrical Soft Wing sail actually is, it is important to get a get a feel for the different sail shapes used in the sport today. The first concept to grasp is the fact that a wing sail uses **two** sail surfaces, an upper (leeward) surface and a lower (windward) surface as opposed to a single, thin surface used on a conventional sail. The **asymmetrical** shape is important as this creates a longer upper surface than the lower surface of the wing shape. The final component of a modern wing sail is the fact that these wings are **soft** which means they are made of conventional materials that can be rolled up and put away in a sail bag.

To understand why windsurfing is on the cusp of the "Wing Age" and why this is such a technological leap for sailing, it is important to understand how a wing works. There are three main forces at work when using a wing, with the first being the most commonly known effect of the air-pressure differential between the two surfaces creating lift according to the Bernoulli principle. The second effect at work on a wing is its Angle of Attack, forcing the air-flow around a wing's surfaces and generating the maximum amount of lift. The third and final effect at work results from the downwash generated from a wing generating a opposing powerful lift in reaction to the wings downwash according to Newton's 3rd law, (every force has an equal and opposite reaction).



The diagram (next page) shows the major elements of a wing, its associated terminology and how the double surfaces create a different shape from the traditional "Thin Sail".



What gives a wing sail a huge top end potential speed advantage over most thin sails comes from their ability to greatly reduce the amount of drag induced when compared to the drag typically penalizing a traditional rig. The top end performance for a wing sail can see theoretical lift to drag ratios elevated as high as 50:1 when compared to the 20:1 ratio achieved by the best race sails available today. Most of the drag induced in a traditional sail comes from the luff of the sail as the flow of air separates from boundary layer flowing on surface of the sail from the back of the mast. One way to solve this drag problem is to use a wing mast as shown in the diagram below.

Fred Haywood used wing mast technology in 1983 to push the ultimate speed record over the 30-knot threshold and gave us a glimpse of the potential for the top end performance of wing-masted sails. Fred set the record at the Weymouth Speed trials in the UK on a 7.5m, Barry Spanier designed rig, with a NACA 0080 shaped wing mast fitted with boltrope slot and locking mechanism to rotate the wing on each tack. Fred mentioned that he had the top 30 fastest runs of the day over the 500m timed course, so the actual record setting run was not just a "one off Purple Patch" run. Fred found the wing-masted rig one of the smoothest sails he had ever sailed and still to this day has never felt a rig produce so much forward drive for such little torque.

Cleaning up the leading edge flow with a wing mast is only half the story, as this does not greatly help a sail's upwind pointing ability. Using a thick aerofoil section like a double luff that spans more than the first 2-3% of the chord goes the next step and increases the Angle of Attack a sail can sustain, before it stalls out. San Diego based Aeroforce and the Mark Reynolds, Stan Pleskunas and George Greenough combination successfully used big luff pocket sails back in the early 1980's. They found them smooth, great when overpowered, very fast indeed, but harder to water start, slightly heavier, more work to rig and expensive to make. Mark Reynolds originally designed the Aeroforce wings, and later Peter Jones bought the fledgling Aeroforce division from Mark (now Quantum Sails) to market these double luff sails back in the 80's.

Mark started by just making a single tack, asymmetrical sail to see if it helped fairing in the windward side of the mast. They found this worked well and they also discovered that they could stabilize

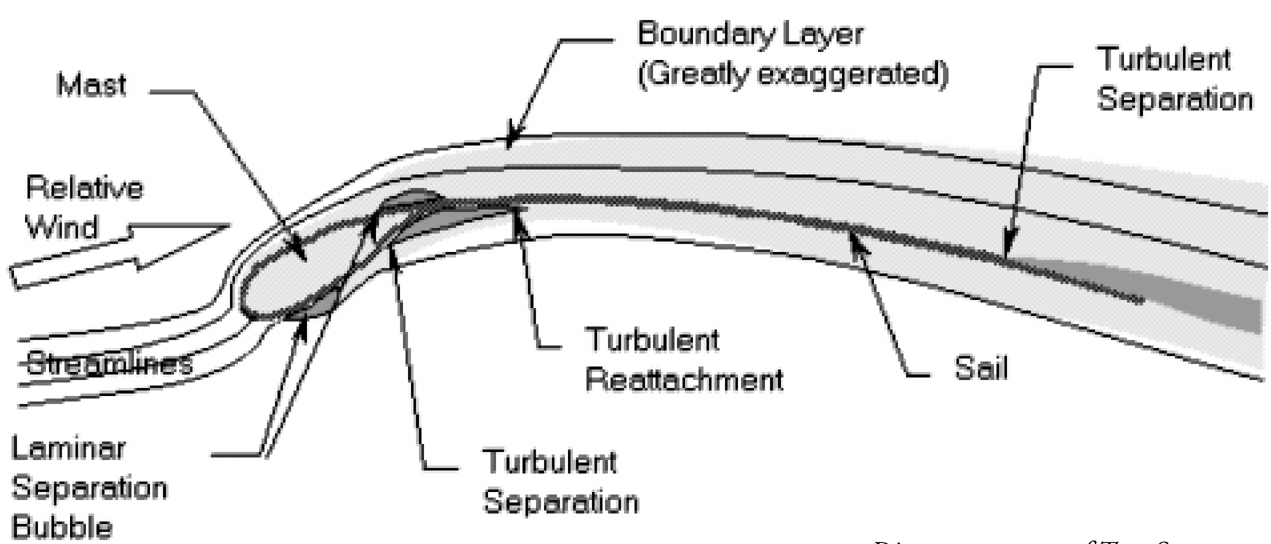
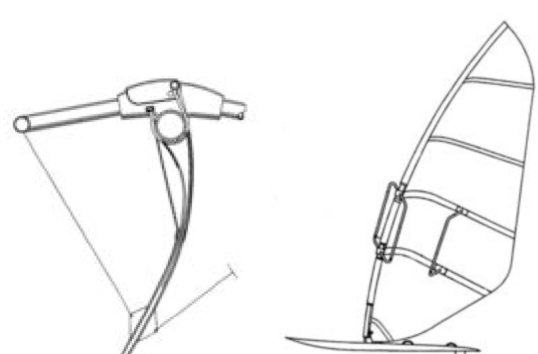


Diagram courtesy of Tom Speer

the draft of the wing using the double luff design. It took more luff tension to get the double luff right but with two layers of strong fabric, they found that this would pre-bend the mast and opened the upper leech. At first they thought that the limp upper leech was a problem, then they discovered it was actually an advantage that all sails could benefit from. As they continuously refined the design, to make them lighter and lighter, the sails ended being made entirely of polyester (Mylar) film and polyester laminates. Their battens were originally made of glass fiber tubes, with a split forward end that fitted snugly around the mast. Later iterations of the batten designs, fabricated by the legendary surf cameraman George Greenough, were all carbon with an added frame on the front end to further shape the leading edge into an efficient shape.

Many different people have tried to make double surfaced wing sails over the years with varying degrees of success and used them in many different sailing applications. Here are a few that we know of that successfully got their ideas off the drawing board and into the Windsurfing world in some fashion.

Thomas Nishimura of Honolulu Hawaii came up with an ingenious camber control system and patented it in 1995. In this design, a pair of control battens extends across the sail, a forward camber control handle attaches to the mast and second handle secures to the aft of the sail. The rear handle attaches to the aft of the sail's center of effort in such a manner that rotation of the forward handle relative to the aft handle causes the control battens to bend. The forward and aft control handles allow the sailor



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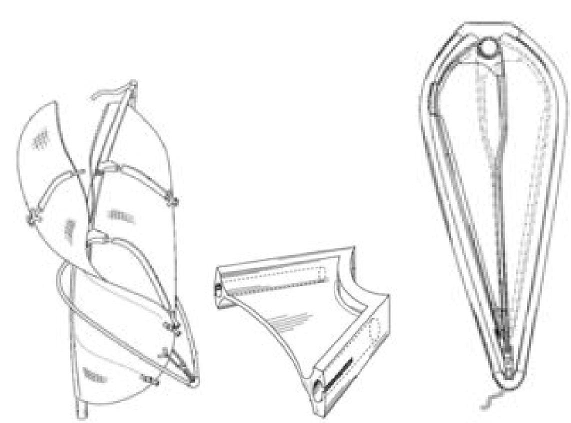


This information was gathered thanks to the US Patent Office web site

Picture thanks to Tom Ross.

to alter and control sail camber instantaneously for various sailing objectives without removing their hands from the handles. This unique camber adjusting system also allows the alignment of sailor's body mass with the sail system's center of effort during wave jumping so making this a truly flexible system. Unfortunately Tom lost the battle to cancer back in 1999, so the sport is no longer blessed with his talent and he is sorely missed.

Michael Peay of Logan, Utah invented a simple but very clever camber inducer for a double surface wing sail in 1998. The camber inducer, in cooperation with battens and the first and second surfaces of a double surfaced sail, provides an efficient and easy to use airfoil sail.

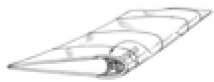
Tom Ross based in Waikoloa, Hawaii has done very well with his A-Wing design and patented the "permanently attached rib" concept to produce a very light weight wing. The A-Wing provides a driving force at a lower angle of attack than the traditional single surface sail because of a significant reduction in aerodynamic drag. The heeling force of a sail is related to sail drag and the A-Wing requires less sailor static torque to balance the heeling force in the sail. This means that the sailor can stand more upright on his board than a sailor using a single surface or traditional sail who has to have his butt hanging out to increase sailor static torque. Tom calculates that his A-Wing could be sailed fast enough to push the world speed record above the 50 knot barrier and his design is light enough for normal use by the recreational rider.

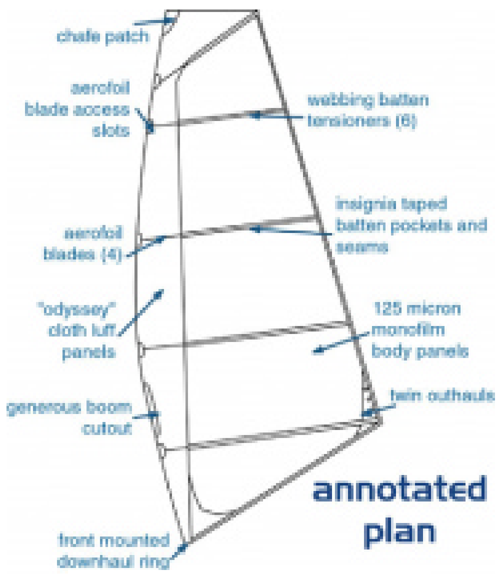
Gordon Ross of Glasgow (and no relation to Tom Ross) in bonnie Scotland invented the Aerofoil Blade and a patent for this design was granted in 2001. The technology is marketed by his company, Powerfoil Ltd. and distributed in the USA by Dynawing.com. The aerofoil shape inducer and batten combination brings a lot of the ideas developed over the years, into a single concept and the simplicity enables a commercially viable, asymmetrical, soft wing sail design.

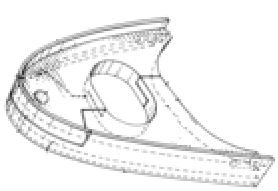
Gordon's patented "Aerofoil Blade" technology is a very clever luff panel shaper that induces an aerodynamic leading edge shape into the wing at the luff of the sail. The cut of the wing's covering material gives the wing sail its design shape and the amount of batten flex, controls the camber of the wing.

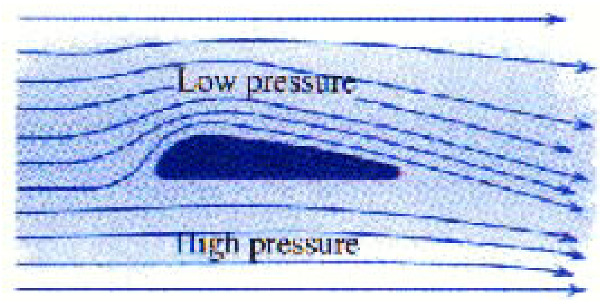
The checkered history of the double surfaced sail, was that they were always very heavy, hard to handle once dropped in the water, expensive to make and they have never caught on in the market place. So what are the other advantages of using a double surfaced wing, besides out and out speed, that keep driving these inventors to tinker with these asymmetrical wing sails in the sport of windsurfing, time and time again?

One reason might be a desire to get more people over the sport's "barrier to entry" and get more people windsurfing. The market statistics are staggering, millions of people have tried the sport but only hundreds of thousands actively partake in it. Windsurf schools love these wing sails, as









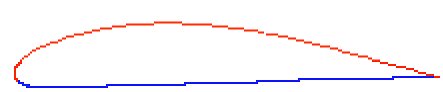
they do not impose the traditional backbreaking experience that most learners can still vividly remember from their first day on the water. The reason for this is that a double surfaced wing does not collect water in the sail, they actually float, so a small double surfaced training wing becomes a lot easier to uphaul for the beginner than a traditional sail with all that water in it.

Double surfaced, asymmetrical soft wing sails can cope with a much bigger wind range that the typical single surfaced, thin sail can handle so reducing the number of sails a rider needs keep in their quiver. Gordon Ross's Powerfoil is a fixed symmetrical section, with diverging battens which change shape automatically according to the air speed and pressure the wing is experiencing. A soft wing, like the Powerfoil, can thicken and thin its profile according to wind pressure, which greatly increases the wind speed range a rider can handle before having to change rigs.

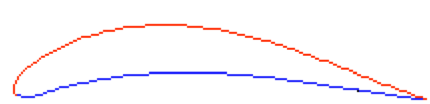
The upwind ability comes in handy for most riders but is especially important for the beginner as they can self-rescue themselves, even when the wind is blowing straight off the beach. The diagram above shows the way the air flows over an asymmetrical wing profile and how the air pressure differential responsible for the lift is generated, even when one of these wings is sheeted directly in line with the wind.

Double Surfaced, soft wing sails can change shape much more effectively in response to air pressure changes resulting from a gust of wind. This makes gust control a much easier thing to deal than a traditional sail can deliver and the rider has a much smoother time of it. We have seen a rider actually take their hands of the booms and the wing still flies on just like a glider riding the thermals on a hot day, super smooth.

Double surfaced, asymmetrical soft wing sails can cope with a much bigger wind range that the typical single surfaced, thin sail can be used in. The range of wind speeds that soft wing sails can operate is so great due to the fact that the wing will thicken its profile according to wind pressure. The Powerfoil changes shape automatically according to the air speed and pressure the wing is experiencing and the concept behind the Powerfoil is the desire to reduce



Normal asymmetrical shape prior to a gust.



Here the wing cambers up and thins under a gust.

Yellow Pages Endeavour

the number of wing sails a rider needs keep in their quiver.

You can extend the range that these Powerfoil wings can operate in by adjusting the hardware fitted. Install a soft set of battens and the wing is great at low wind speeds, but the wing will start to collapses at higher speeds. Over-sleeve the battens with a second set of tubular battens to stiffen them and the soft wing now has tremendous top end speed potential, but it is no longer soft and responsive low down. Like any other sail, even double surfaced, soft wing sails are a compromise design and each wing needs to be specifically honed for its intended use or environment, as there is no magic sail that can deliver in all conditions.

The current state of the art in double surfaced, asymmetrical soft wing sails sees most of the mechanical design problems overcome, so that wings up to 5 or 6m^2 in size are competitive, affordable and practical in today's market place. Speed sailors will see these double surfaced wings as a way to overcome the current drag wall that is encountered the faster a rider goes. This has kept the current sail powered, world speed record pegged at 46 knots, set by the boat Yellow Pages Endeavour in 1993 with Simon McKeon at the helm taking the previous record from the French windsurfer, Thierry Bielak.

It is now a materials issue to see if bigger, double surfaced wings, sized from 6m^2 up to 12m^2 in area, can be made light enough to overcome the inherent design penalty of having two sail surfaces. In combination with using lighter sail material, it might be possible to use a design with what Gordon Ross is calling a partial double surfaced soft wing sail. This is a combination single and double surfaced design all in one wing. This partial wing would use something like the patented Powerfoil aerofoil shaper to create an asymmetrical drag reducing luff pocket, with the rest of the sail being a single surfaced sail to keep the weight down.

The single surfaced area would act as a huge, asymmetrical flap to give the wing lift at the low end and would follow the trend in Hang Glider wing design, towards lighter, partial double surfaced wings. It is a logical evolution of the original Powerfoil design, to add a flap section, which builds in a pre-designed amount of twist into the sail. Now, the wing section can fly at the same attack angle all of the time because the flap section is providing all the twist control. This enables a wing sail to get maximum power from its double surfaced foil shape, but still have enough wash-out (to handle gusts and rider maneuvering) provided by the flap portion of the sail.

The future for the double surfaced, wing sail seems to rest with many different sail makers adopting this kind of core foil shaping technology and using it in their own range of wings to meet their customer's needs. If this adoption occurs, you can be sure that double surfaced, soft wing sails will become a more common sight on your patch of water in the very near future. Welcome to the Wing Age !

Peter Bell is the CEO of Dynawing.com, distributors of the Powerfoil range of Asymmetrical, Double Surfaced Soft Wing Sails.

References:

Tom Speer	http://www.tspeer.com
Fred Haywood	http://www.fredhaywood.com
Gordon Ross	http://www.powerfoil.com
Barry Spanier	http://www.gaastra.com
Tom Ross	http://www.rossengineeringast.com
Mark Reynolds	http://www.quantumsails.com
Dynawing	http://dynawing.com

Aerodynamic junk rigs

Robert Biegler

There is a school of thought that proposes that any attempts to improve the aerodynamics of the junk rig are fundamentally misguided, on the grounds that too much of the original's simplicity is lost and that really, the junk rig is a way of life. If you choose it, you choose to wait until the wind shifts, instead of trying to make the rig go to windward like the wing of a C-division catamaran.

Although that is a valid approach for long distance and long term cruisers who do not have to get back to work in time, others may be interested in improving the aerodynamics of the junk rig while retaining as many as possible of its virtues: easy reefing, low loads, simple components and therefore low costs.

Both the easy reefing and the low loads depend on having full length battens that are all sheeted. The leech of a conventional sail is suspended between headboard and clew like a tightrope, and must be kept under high tension to control its shape. Imagine you have a 5 m long tightrope that you want to sag no more than 10 cm, which would be 2%, when you pull the rope down at the centre with one unit of force (insert your favourite unit). Then simple vector addition shows that the tension in the tightrope must be 25 times as high as the force with which you pull on the rope (Figure 1, top). Then divide the tightrope into 5 sections of 1 m each. Take into account that wind pressure would distribute itself over the panels of a junk sail, and pull on each of the five sections of rope with one fifth of the force, i.e. 0.2 units. If you still allow only 2% sag, then the tension in the rope will be 25 * 0.2 units = 5 units. Those 2% sag are now only 2 cm. What if you continue to allow 10 cm sag? Again, vector addition shows that then the tension in the rope is only 5 times the force you apply (Figure 1, bottom). That would then be 5 * 0.2 = 1 unit. Dividing the rope into 5 sections, distributing the load over those five sections and allowing the same absolute sag cuts the tension by a factor 25. Although wind pressure on sails does not act as such a point load, a more sophisticated treatment gives basically the same result. The junk rig puts a lot less load on the sail fabric. For a practical illustration, Annie Hill reported that the first set of canvas junk sails that she and her husband used still brought them through a gale when the fabric had rotted to the point that it tore when they took the sail down and tried to carry it away. On the other hand, the Bermudan rig must stretch the sail tight to maintain shape, and feeds all the resulting loads into the rig and hull structure.

An application of load reduction through multiple support points that is even more impressive than in the junk rig can be seen in paragliders and traction kites (Figure 2). Their bridles also attach to many points on the wing. The wing can be stretched out merely by a little ram air pressure, it does not need spars for the purpose. The Chinese way of sheeting each batten acts like a kite's or paraglider's bridle, taking loads out of the mast, the hull and the sail fabric.

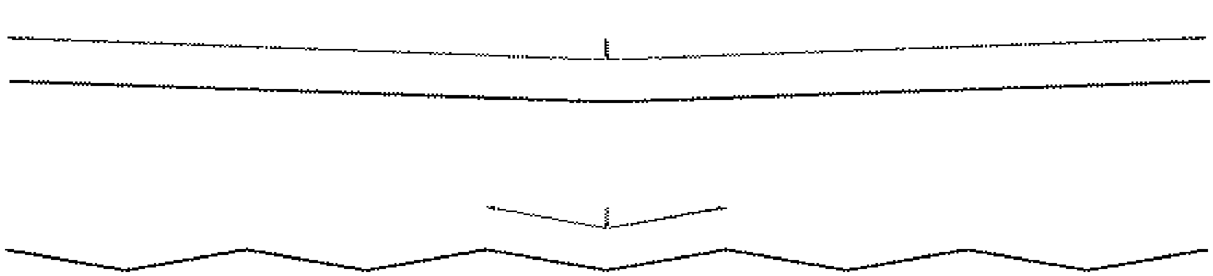


Figure 1. For a given amount of allowable sag, the greater the unsupported span of a structure, the greater must be the tension.

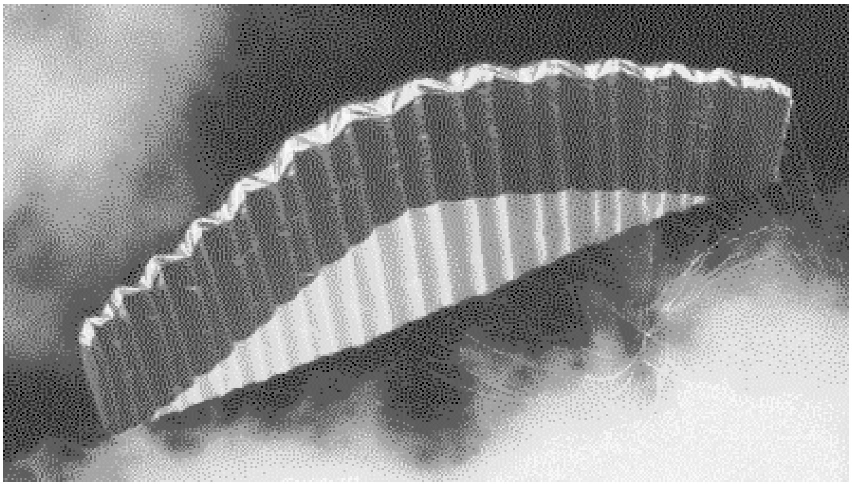


Figure 2: Andrew Beattie's Chevron traction kite. Photo by Beattie, reproduced with permission.

length battens also keep the sail under control when reefing, letting it fold down accordion fashion. That removes the need for complicated, highly loaded and expensive roller reefing mechanisms.

One final design criterion is that, when reefed, the sheetlets or sheet spans (the bits of line that distribute pull from a part of the sheet to several battens) from battens on unreefed sail panels must not foul on the battens already stacked up below. The ends of upper battens should always be aft of the ends of lower battens. The lengths of the diagonals of the panels and the angle of the panels restrict the possible movements, as shown in Figure 3.

A paraglider or traction kite also distributes bridle points longitudinally. Because a sail must be sheeted through a wide range of angles, that is not practical. Therefore the battens must be capable of taking the maximum bending load they will experience under the most extreme conditions without bending to the point where they give the sail too much camber. Consequently, the battens must be far more rigid than in a sail sheeted in the western style. The full

The Chinese also have low tech, low cost ways of attaching the sail to the mast. I will not discuss these in detail and will not even go to the trouble of drawing them in. They are described well in 'Practical Junk Rig' by Hasler and MacLeod, and can be used on all the sail designs I will discuss unless I explicitly say otherwise. Hasler and MacLeod also explain how the sheet spans should be designed.

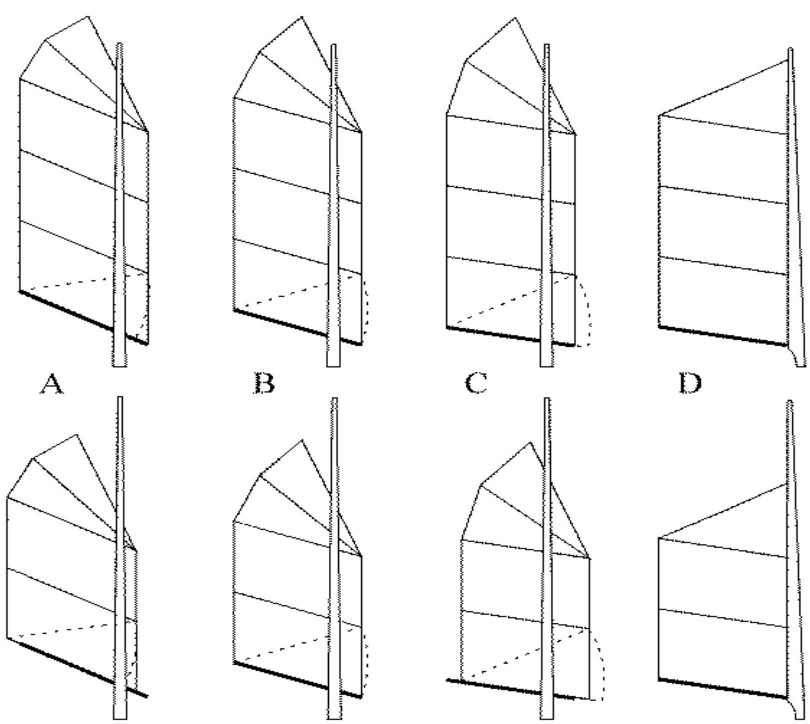


Figure 3. The sail panels are ridiculously broad, just for the purpose of illustrating the effect of batten angle on stacking. When reefing, the sail tends to go forward as far as it can. I don't know why, it just does. In ***A****, the diagonal from the aft end of the boom to the forward end of the next batten is shorter than the boom. The sail is pulled back when reefing. In* ***B*** *there is no movement, in* ***C*** *the sail can move forward, the boom sticks out and the upper sheet spans will get tangled in it. The conventional junk must have arrangement A or B, one set on sliders* ***(D)*** *has no play and must use arrangement B or C.*

In summary, the features of the junk rig that are essential to its easy reefing and low structural loads are the full length rigid battens, all of them sheeted and set into the sail so that they stack up tidily when reefing. These are the features that must be kept, everything else can be changed. The resulting rigs may be more complicated and expensive than the conventional junk rig, but should be cheaper and easier to handle than conventional Bermudan rigs. They may offer a compromise that suits some purposes better than currently available rigs.

Two features of the junk rig are the main sources for its comparatively poor aerodynamics. One, the necessarily quite rigid battens are usually straight. The simplest possible sail is thus flat. Two, the sail normally sets on one side of the mast, like a standing lug, and when the mast is to lee, it interferes with air flow. The obvious ways of improving junk rig performance are to give the sail some camber and to reduce interference from the mast. (Wind tunnel tests carried out by Joddy Chapman indicate that with a flat sail there is actually less drag with the mast to lee: the mast disappears in the separation bubble behind the sharp leading edge. If the sail has camber, there is more lift and less drag with the mast to weather.)

Several ways of giving a junk sail camber are already in use. One is to cut camber into each individual sail panel (Figure 4). This is called quilting and reproduces the effect of the rather stretchy fabrics that were traditionally available. As I understand it, the totally flat junk sail is a modern western invention. Quilting is probably the cheapest and easiest way to produce camber. Letting the sail cloth sag between battens also reduces wind loads, and all other loads on the sail are carried by bolt ropes in the luff and leach. This is probably the simplest way of putting camber into a junk sail, and it even has structural advantages. If reliability and low cost are the most important criteria, this is probably the best option.

A second method, which has recently become the main area of development, is to use jointed battens (Figure 5). Although the joints produce sharp bends not only at the battens, but to some extent in the sail as well, the resulting sail shape is still better than a flat sail. Another possibility is to use battens that are permanently curved and that flip over on each tack (Figure 6). To make sure the battens do flip, they must never be allowed to come down to the horizontal. Instead, they must be restrained so that they can rotate to perhaps 45° either side of vertical.

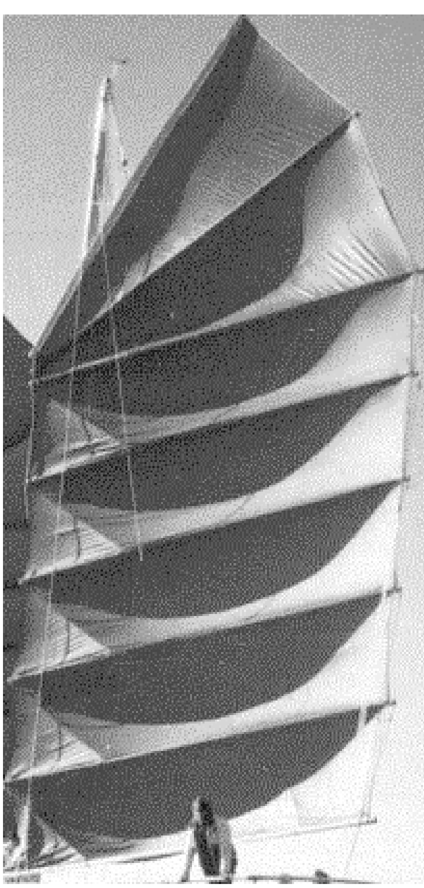


Figure 4 (left). Quilted junk

Figure 5 (above). A junk sail with jointed battens, made by Christopher Scanes. Photo Richard Gubbins.

Figure 6 (right). A model sail with flipping battens. The lower end of the fabric loop is well above a straight line from the forward to the aft end of a battens. That prevents the batten from rotating down to the horizontal, which would stop the batten from flipping over for the other tack. Batten tension is high enough that some battens have not reached this stop anyway.

That can be done either by a batten pocket that has a lower seam that curves up, or by a loop as in my model sail. A close look at Figure 6 shows that several of the battens have not actually flipped over to the maximal extent allowed by the loop. The reason for that is that batten tension is too high. Under high batten tension, the sail tries to stretch out flat between the luff and leech attachment points of the batten, and the sail fabric will push the batten up towards the vertical. That means camber can be adjusted to some extent by batten tension, though not while sailing. I have not tried this design at full scale, this model is all there is. However, the flipping battens could be fitted to existing flat sails, with some alterations, and it would not be necessary to replace the sail.

For best shape, some broadseaming in the very top and bottom panels would probably be useful, though. Finally, the flipping battens work in the same way as Bierig's patented Camberspar, so if this idea works well to improve junk rigs, anyone wanting to exploit it commercially would have to check the legal situation.

It may be possible to attach the flipping battens by sliders to a conventional mast. The problem is then to keep friction down. The rigid flipping battens may also be more likely to get jammed on a fixed mast when reaching or going downwind, so a rotating mast should be better. If it works, this rig should be aerodynamically nearly as efficient as a conventionally sheeted fully battened sail, while offering faster reefing and lower structural loads. That potential may be worth some development.

One important difference regarding design is that, in contrast to junk sails attached to the mast in the Chinese manner, the sail panels must not be designed so that the upper battens are forced back when they stack up on reefing. Battens attached to the mast by sliders do not have enough horizontal play to accommodate this movement, and for the same reason they do not need to be pulled back.

The rotating mast of this hypothetical hybrid junk sail would not interfere with airflow as the conventional round mast does, especially when it is to the lee of the sail. The other obvious solution for reducing mast interference is to wrap the sail around the mast. This has been done previously: the Swing-Wing rig was invented by Robin Blain and marketed by Sunbird Yachts in the early 80's. The Swing Wing was basically a junk sail with a single hinge,

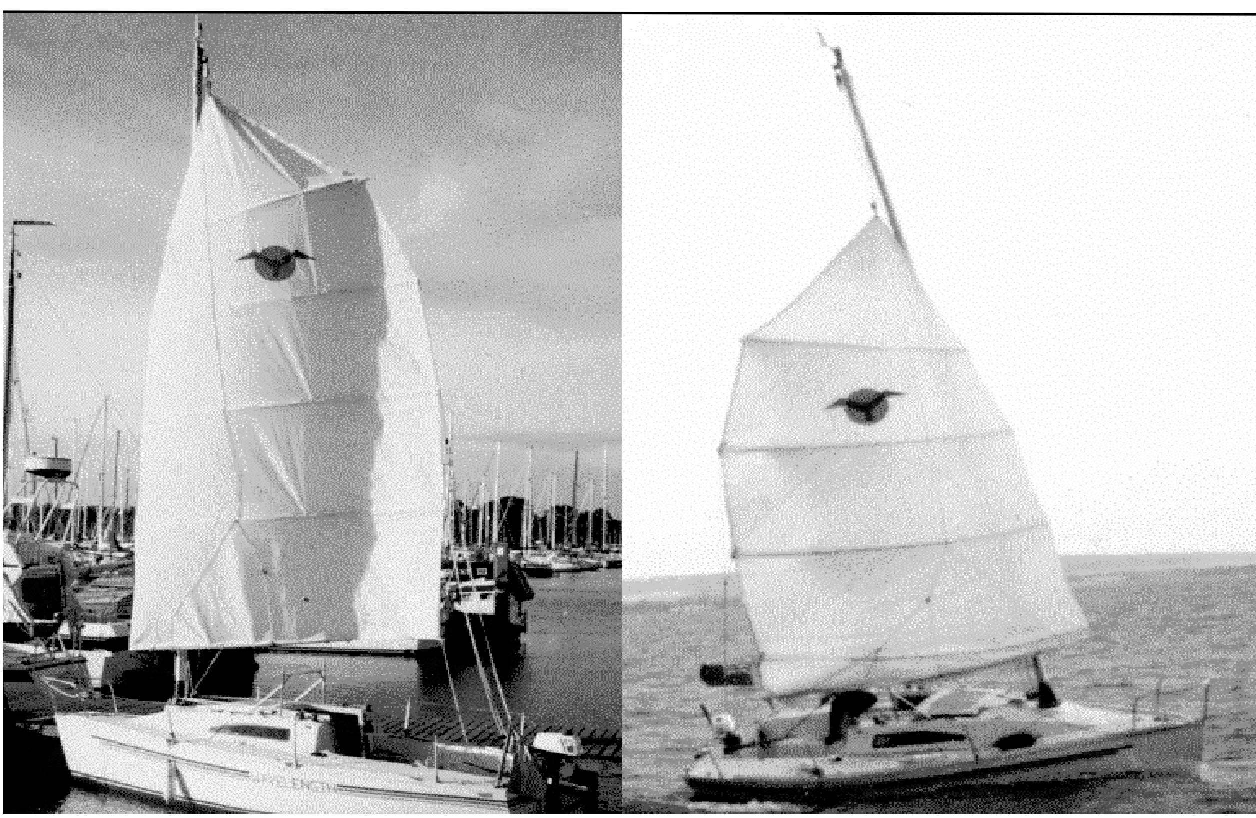


Figure 7. Swing Wing rig at dock an underway, showing hinge and smooth lee side. Photos by Robin Blain.

and the forward section of the batten, and of the sail, wrapped round the mast. This created a soft wing sail, but with junk-style sheeting (Figure 7). I asked Robin Blain how well it worked upwind. He said it was better than the conventional junk, but not good enough to be worth the trouble of sheets fouling on the battens. All pictures of the rig I have seen showed a design that let battens stack up so that the lower battens protruded, ignoring design requirement number three in the list above. However, I see no reason why the Swing Wing could not be designed to stack with the upper battens further aft. There is still the extra complexity of building teardrop battens and fitting them to the sail.

I tried to design a sail that would stack up correctly and be easier to build than the Swing Wing. The idea was to create an asymmetrical, double-surface wing with all the handling characteristics of a junk rig. The sail should use simple straight tubes as battens, without a hinge. The resulting sail combines the design principles of the junk rig with those of paragliders and soft traction kites (Figure 8).

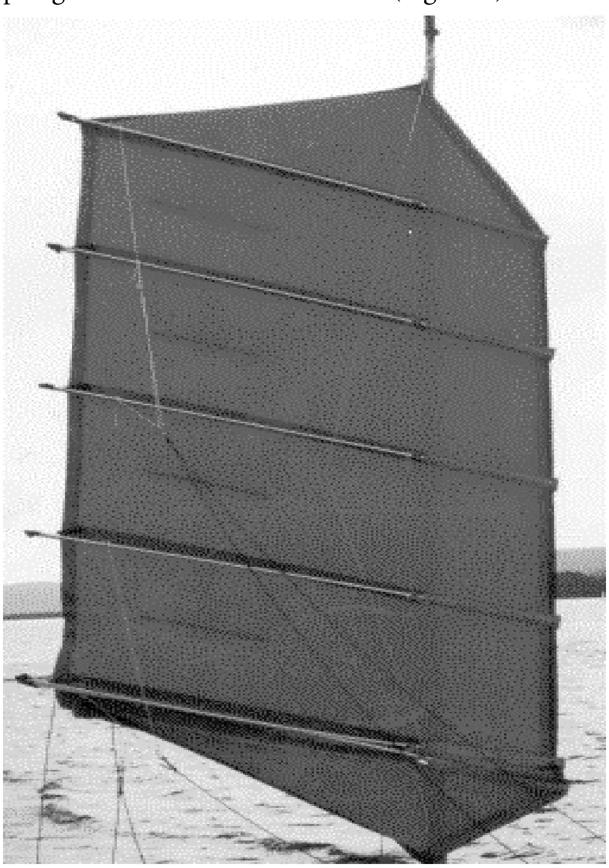


Figure 8. A double-skin junk sail. The bit of mast sticking up held a nylon sock for attaching halyard block and lazy jacks. I only borrowed the boat. Because I failed to consider how much height this would cost me, I had to tie away the lowest panel.

The sail gets its shape from double battens, going either side of the mast and kept apart by a spreader just over 25% aft from the luff. Fabric covered wings can oscillate at the transition point on the lee side where the pressure changes from positive to negative, which seriously disrupts flow on the lee side. I assumed that the problem would be even worse in a junk sail that has little luff tension. The easiest way to avoid this flutter is to build a ram wing, with air inlets at the leading edge, and so I made the leading edge out of mesh. That has the additional advantage that I don't need to shape the leading edge into a nice curve, and it is not even necessary to join up the battens there. The two sides of the sails are kept apart and the mesh is tensioned a bit just by joining the battens at the aft end and spreading them somewhere in between.

The battens are in pockets in the first 25% – 35% of the sail. In my original design the batten pockets stopped just forward of the spreaders. As can be seen on Figure 9, that leads to a bit of a kink in the profile on the weather side. I had hoped that would smooth out a bit between the battens, but it looks like it is necessary to extend the batten pockets a bit beyond the spreaders and flare them out gradually.

On the lee side the sail pretty much follows the curve of the battens (Figure 9). I had intended to get something like 8% camber on the lee side, but forgot that for a double surface sail I needed to increase the length of the spreader, so the sail is flatter than intended. I could also make the front opening a bit narrower.

When the sail is feathered, the pressure of the air flowing in at the luff would make it bag out at the leech between the battens, if I had not put in some fabric ribs there, just like in a paraglider or soft kite (Figure 9).

The luff parrel runs inside the sail. Later I put the halyard inside as well.

I avoided the complication of building a wishbone yard by doing away with the yard entirely. The top battens still have more compression load than those below, but they do not have the bending load a yard would have. It means I need a slightly longer mast for the same sail area.

I closed off the foot of the sail as well, thinking I might need that to keep some pressure in the sail. I forgot to put in some drainage holes. Without those, the sail fills with water in a capsize. I should also not have sewn up the leech entirely, but left some bits unsewn so that the two fabric layers can part for drainage. It would mean losing some pressure, but it would need some experimenting anyway to determine how much inside pressure the

Figure 9. The internal spreaders go through the sail to the battens just behind the ends of the short batten pockets. To get rid of the sharp kink on the weather side, the batten pockets could be extended beyond the spreader a little, and flared out gradually. The mesh covering the front opening is not clearly visible in this picture.

sail should have for best performance. In paragliders and soft kites there must be pressure to prevent the canopy from collapsing, but in this sail the battens and mast do that job already.

The way I joined the battens at the leach works only with double sheets, and even then only once I used elastic around the luff of the sail, to keep the sheets away from all those protruding bits. I should have put short luff pockets in the leach, and something for adjusting batten tensions at the luff.

While sailing on a rather small boat I could not observe the shape of the lee side of the sail. What I could see of the weather side, and of the lee side while the boat was on the beach, did not look as good as I had hoped it might be, but good enough that I consider this concept worth more experimentation.

I do not expect any variety of junk rig to replace the rigs now on Open 60 trimarans, but I do think that junk rigs can be designed to be more efficient, easier to handle and cheaper than the bog standard Bermudan sloop rig with triangular planform that is found on the vast majority of sailing boats today. Those who want the last bit of efficiency should read Jeff Doyle's article on the wing sail he is working on, after he talked to the great grandson of the Chinese fisherman who invented it.

Robert Biegler, Trondheim, Norway

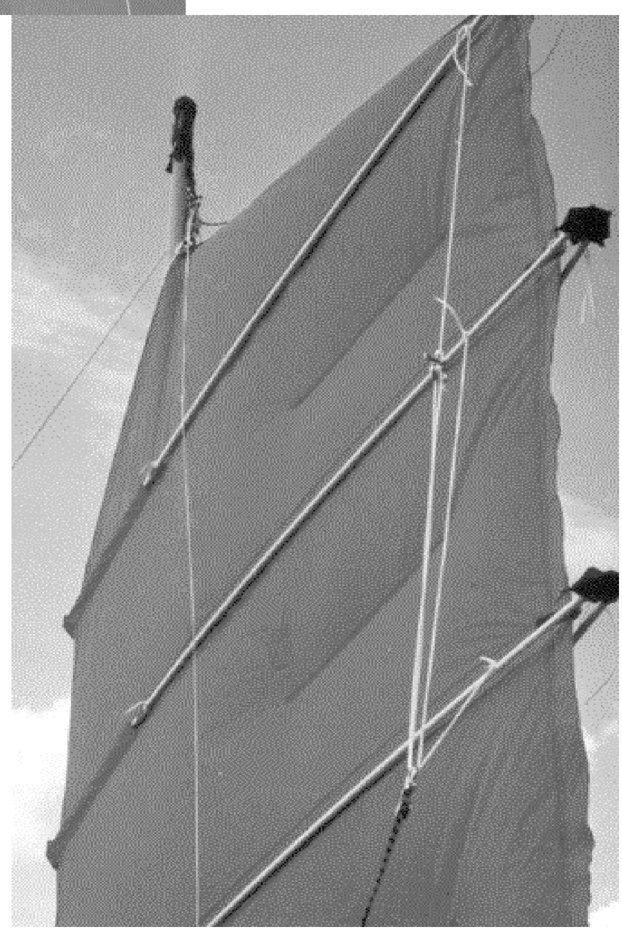


Figure 10. Internal fabric ribs prevent the sail from getting baggy when feathered.

A Cheap Junk Wingsail

Jeff Doyle

This variation of the double surface junk rig comes from a fisherman who built a rig he called Dragon's Wings back in 1897 in China. I learned about the rig in 1998 from a descendant of the builder. I was only able to converse with the great grandson for a few hours and I was never able to get in touch with him again when I decided to build my version of the rig a few years later. There were a number of details that were left out on the plans so I had to improvise with the little knowledge I had of junk rigs. What follows is my rendition of that rig. I have not settled on a name for the rig but I currently classify it as a cheap junk wingsail. The rig has only been built on a small scale; the current sail area being only 24 sqft used on a small 8 ft pram.

Figure 1. A cheap junk wingsail of 24 sqft on an 8 ft pram. Wind is coming across port side and the wing has feathered into it.

Although the rig takes its origins from the traditional Chinese junk sail, it does not look like or behave like one and there are enough differences between the two rigs to say that the junk wingsail is not a junk rig. It is more akin to the Swing Wing by Robin Blain or the Gallant rig (Aero-junk) by Jack Manners-Spencer of Aerosystems Ltd. All of the running rigging, standing rigging, and the mast are between two sail surfaces. The mast and rigging do not interfere with airflow around the sail and you don't see the mess of rigging that is a nightmare to view when the wing opens up. The rig makes use of flat flexible battens that can be bent under control. The rig must be vertically tensioned to give it rigidity, reduce twist, and keep the two sides together. Although I do not think the rig was designed to be a wingsail, with a few minor modifications, it makes a great poor man's wingsail to experiment with since it is easy to construct and uses cheap common materials.

The sail gets its shape from the thin, flat, flexible battens on either side of the mast. The battens are hinged at the leading edge and the trailing edges are left free (see figure 3). Two slide sticks located at the foot control sail shape. The slide sticks induce camber into the sail surface by pulling on the sheets connected to the battens. The sail can be cambered from 0% to about 18% just by sliding the controls up and down a few inches with the use of one hand. Airfoil thickness is set by another control and is variable between 6% and 14%. A thickness of about 9% is normally kept.

The camber control system is quite simple in how

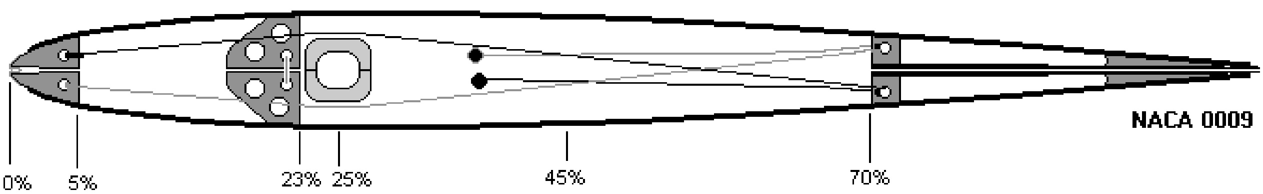
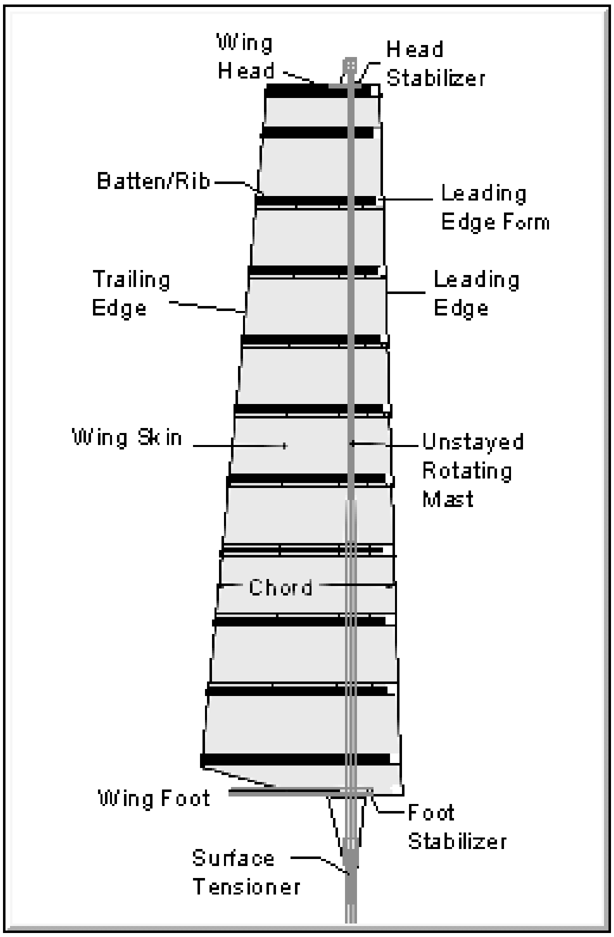
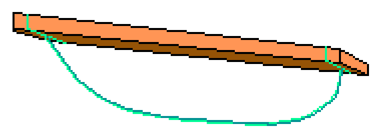


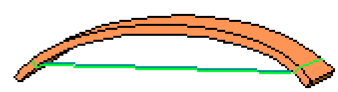
Figure 2



it works but is difficult to understand when you look at the rigging mess between the two sail surfaces. It is best to look at how one batten assembly is controlled and to start off with a simplified batten and then build up.



The drawing above shows a simple batten with a string tied to either end.



Shorten the string while it is connected between the two ends of the batten and the batten will bend, forming an arc. The maximum deflection point will be located half way between the connection points of the string, if the batten is of uniform thickness. This shape is an okay airfoil that produces more lift than the flat shape but there is considerable drag. The shape can be improved so that lift is increased and drag is reduced. The curvature of the batten can also be called the camber of the airfoil.

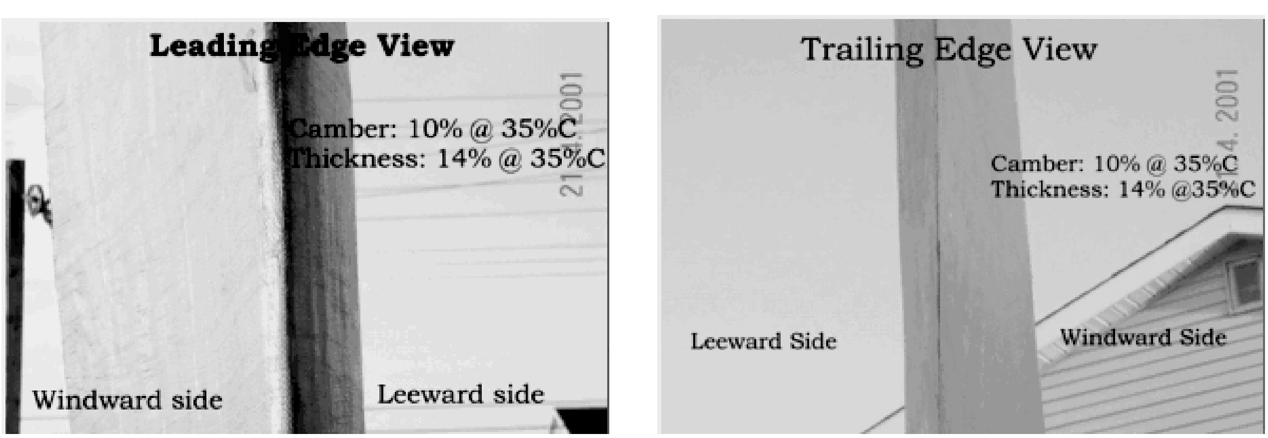
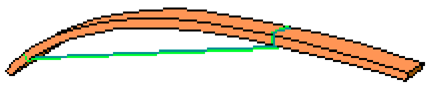
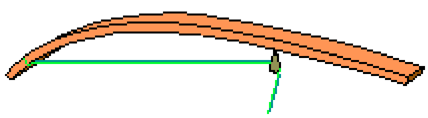


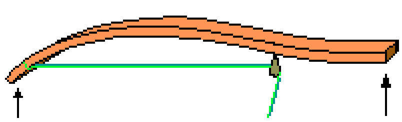
Figure 3



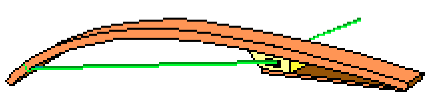
One way to improve lift and reduce drag is to move the position of maximum camber towards the leading edge. To change where the maximum deflection point is or position of maximum camber, move one end of the string closer to the other end. Another way of changing the position of where maximum deflection occurs is to thin out the batten at the position you want. The batten will bend easier at the position that is thinner. This method makes batten construction more complicated and time consuming.



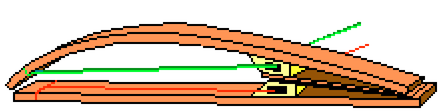
To make the curvature of the batten adjustable, a pulley is mounted at one position and the string passes through it. Pulling on the string increases curvature or camber of the batten and releasing the string lets the batten go flat.



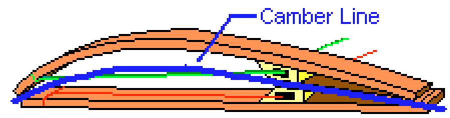
A problem occurs with this set up though. An inflection point is induced in the batten where the pulley is attached and the batten's curvature changes to the other side when a force is exerted at each end.



The overhang end must be stiffened so that it does not bend the other way. The pulley can be incorporated into the stiffener. The batten forms a better shape now but the side that has the stiffener and camber control interrupt smooth airflow. Another problem is that the batten can only be curved one way.

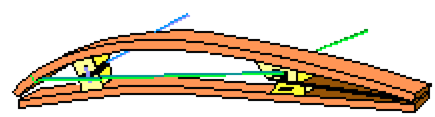


Airflow around the batten can be improved by adding another batten with camber control. The battens are hinged at the leading edge and are free at the trailing edge. The airfoil can now be cambered either way. But the maximum amount of camber is limited to about six percent. The percentage is the maximum deflexion divided by the length of the



airfoil. As curvature on one side is increased the other side stays fairly flat.

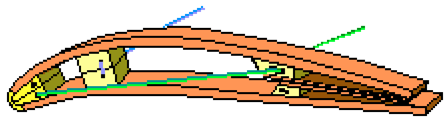
Note that the camber of the airfoil is no longer just the curvature of one batten but is the average between the two battens. Increasing the curvature of one side increases average camber up to about 6% but also increases foil thickness since the two battens move apart from each other where maximum camber occurs. A thick foil operating in low wind speeds performs poorly compared to a thin foil of the same camber and length. The performance degradation decreases though as the length of the foil section increase and or wind speed increases. The limited range of camber also limits the performance of the wing to a narrow range of points of sail. An airfoil with 6% camber works well for close-hauled sailing since it provides good drive with low drag. When sailing on a close reach to a broad reach, a sail with only 6% camber provides inferior drive when compared to a sail with a camber of 15%.



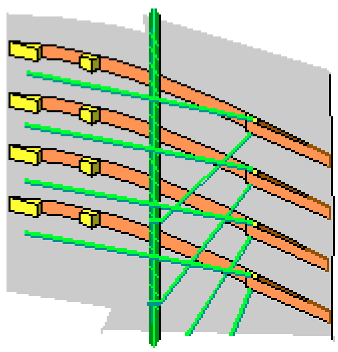
It is possible to increase camber without increasing thickness by the addition of a control line and two small blocks attached to the battens about 23% from the leading edge. By preventing the two battens from separating from each other, the thickness is limited but camber can continue to increase. The thickness control line is used to limit airfoil thickness by keeping the two blocks that are attached to the battens from separating. This configuration allows a maximum camber of about 12% to be set without increasing thickness above the limit set.

The leading edge of the batten airfoil is rather sharp and limits the good production of lift to a small range of angle of attack. The sharp leading edge also leads to instability when the airfoil is at a neutral angle of attack and has camber. This can lead to violent shaking of the wingsail when it is feathered into the wind. The angle of attack operating range can be increased and instability reduced simply by increasing the radius of the leading edge.

The radius at the leading edge is increased by the addition of leading edge forms glued to the battens. Each half is glued to its associated batten and the leading edge is hinged. I found that a leading edge



radius of 1.75% of the chord worked well. Note that the camber control line is attached to the opposite side leading edge form. These additions allow the camber to be adjustable up to about 18%. This large amount of camber develops lots of drive when sailing on a reach.



The drawing above shows four battens taped to the inside of the wingsail material. The drawing does not show the horizontal camber control lines attached to the opposite leading edge forms that are mounted on the battens attached on the other half of the wingsail. All of the batten camber control lines on one side of the wingsail are connected together by a single vertical sheet so that they can be controlled at the same time. Tuning is required after initial construction so that the desired camber offset is set uniformly from the head of the rig to the foot. Having a gradual increase in camber from foot to head was found to improve performance. The change is small though. A difference of 3% max was found best when a taper ratio of 0.5 was used for the plan form. So if the foot has a camber of 6% set then the camber will gradually increase until it is 9% at the head.

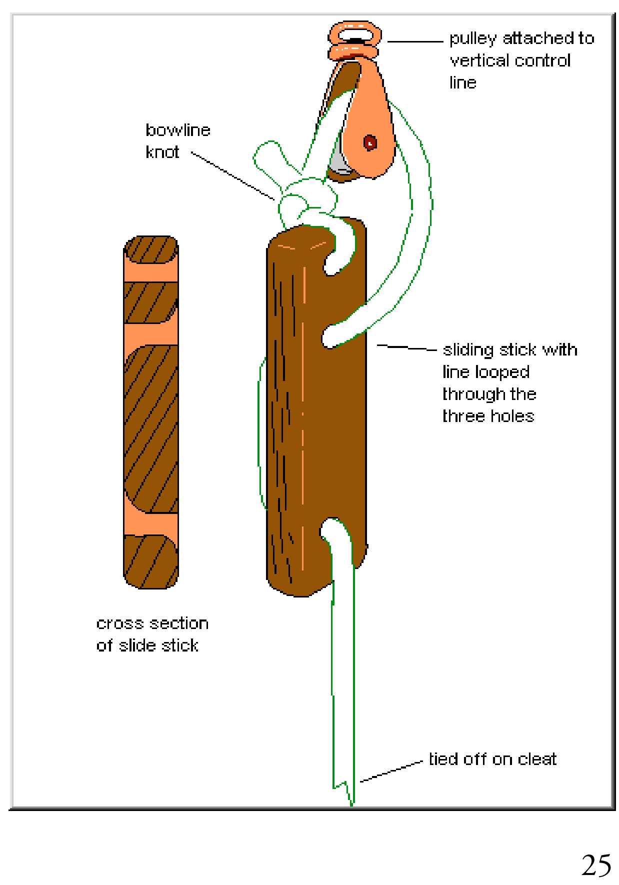
The vertical camber control sheet is attached to a pulley, which is attached by another sheet to a slide stick at the foot and then tied to a cleat on the mast. To increase camber on one side, it is just a matter of pulling down on the slide stick. The slide stick stays in position when let go so the camber stays set.

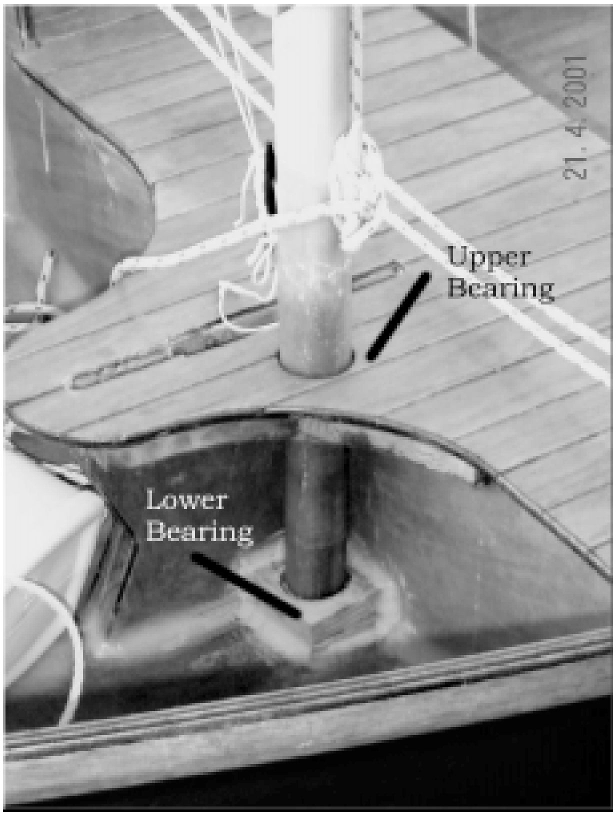
The thickness control sheet is attached in the same manner as the camber control sheets. As mentioned before, the thickness control is not used a lot. In light winds (<8 kts), I set thickness to the minimum (6%). In stronger winds I increase thickness a bit to about 9% but I don't know exactly what it is since I don't use any instrumentation that measures thickness or camber. I sail by trial and error and over the last couple of years I have learned by experience where to set the camber and thickness controls for different points of sail and wind conditions.

The drawing shows how the foot of the rig is attached to the mast. Each foot stabilizer is attached to its own tensioner handle on the opposite side of the mast.

The top of the rig is attached only to the halyard, which passes through the block on top of the mast.

The wing is hoisted and dropped just like a conventional fully battened main sail or junk rig by the use of a halyard. The wing adopts the same position as a junk rig when it is lowered and is not normally removed from the mast. The picture at the bottom of page 28 shows the rig hauled down. To set sail, pull on the halyard to raise the rig. The picture above it shows the rig raised but not tensioned. When hoisted, the sail has no stiffness and will flop around, especially when heading into the wind. The rig is then stretched taught by engaging the port and starboard tensioners located at the foot of the wing. The third picture shows the rig in wing mode - the surface is smooth and tight. The sail is now a semi rigid wing capable of handling high wind pressures with very little deformation of shape.





The mast is unstayed and rotates with the sail so sufficient mast bury is required along with journal bearings to allow the mast to rotate. Simple wood bearings coated with epoxy graphite are used in the pram.

The mast is not located at the fold that forms the leading edge but is positioned about 25% of the foot length (just behind the thickness control) from the leading edge so that the center of effort of the rig acts at or close to the mast. The mast is positioned very close to the hulls longitudinal position of its center of lateral resistance.

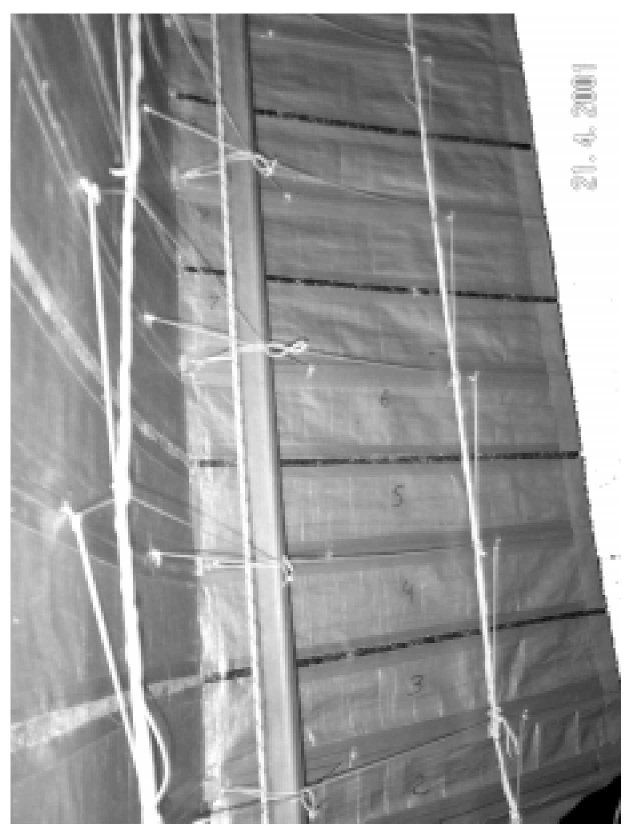
Sail drive is normally reduced by decreasing angle of attack and or by reducing camber. The rig does not luff like a marconi rig, therefore it makes no flapping noise when feathered. Reefing is used as a last resort when the rig becomes unmanageable.

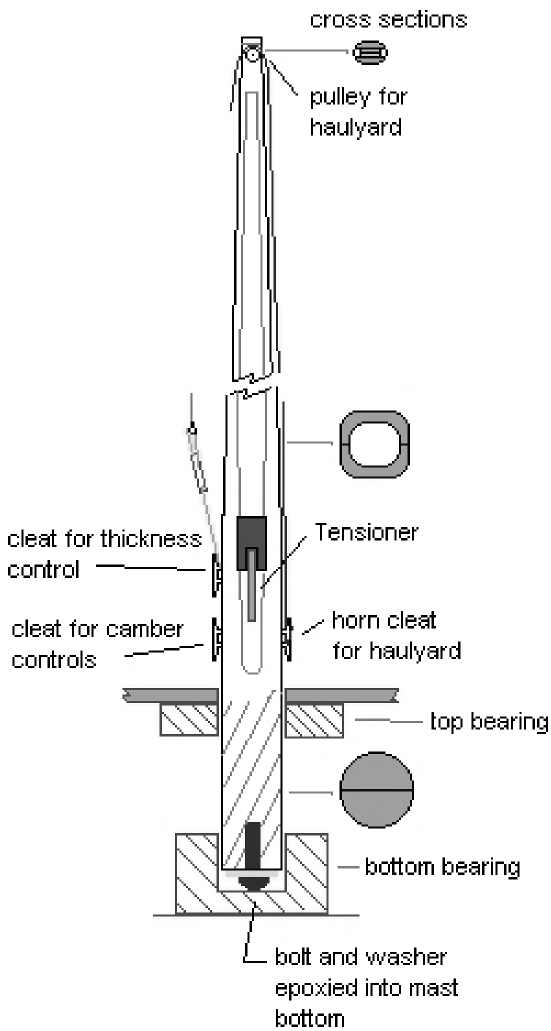
A unique feature of the rig is that it opens up to double its sail area when sailing on a run in light winds. This mode of operation is very similar to the Lapwing rig and Ljungstrom rig. The camber controls are used to control the shape of the opened area and the main sheets are used as braces to stabilize the sail and to set the angle between the two sides.

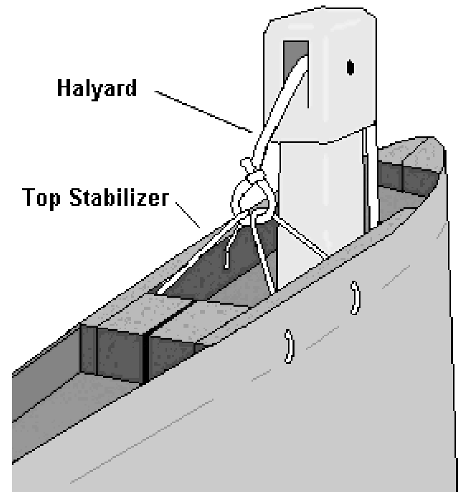
The rig was built from cheap materials. PolyTarp was used for the sail material. Battens were constructed from hardboard as a core material with epoxy/glass encapsulating the hardboard. The epoxy/glass skin was used to increase stiffness, durability, and keep the hardboard from absorbing water and turning to mush. The battens were attached to the inside surface of the polytarp using double sided exterior carpet tape and duct tape. The 24 sqft rig that is shown in the pictures weighs in at 4 lbs.

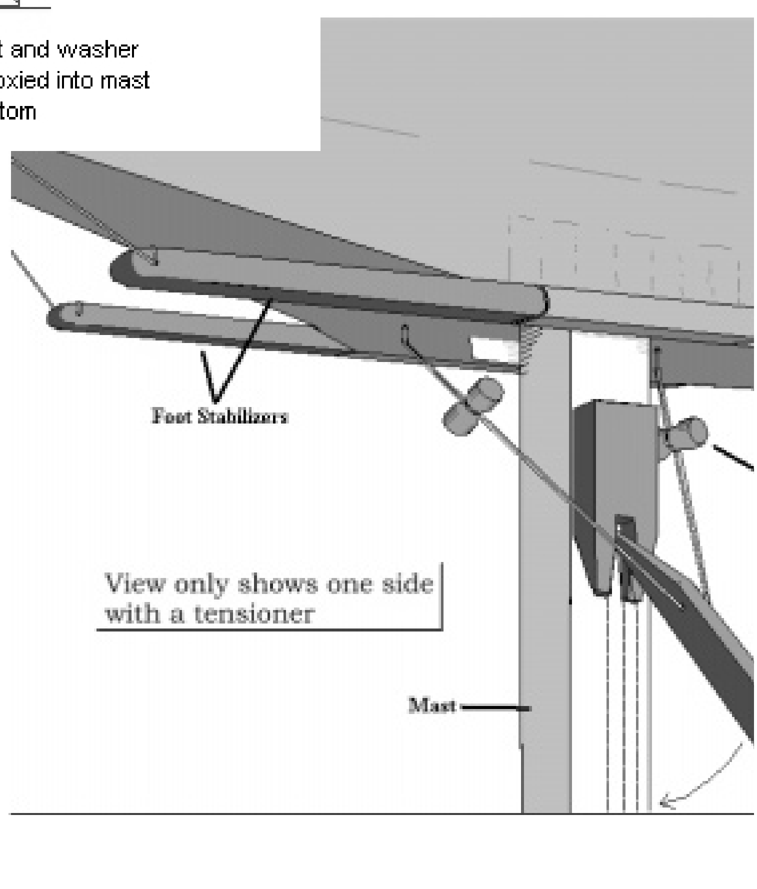
There are still a few areas needing development. The batten is the critical component of the wingsail since it makes up 80% of the rig's weight and about 60% of the total cost. Reducing the weight of the battens without losing stiffness and durability is the key area of development right now. It is the excess weight of the rig that may put people off from using this type of rig. A junk wingsail with the same sail area as a Marconi rig will weigh about thirty percent more but will provide higher performance. Reducing the sail area of the wingsail can bring down the weight without to much loss in performance.

The 24 sq.ft. wingsail rig provided a considerable performance improvement over the 35 sq.ft. Marconi rig I had used on my pram. The wingsail generates about the same sail drive as the Marconi sail when in wing mode for upwind sailing, but with considerably less heel even though the wings CE is about 2 ft higher. When sailing on a run, the 35 sqft Marconi cannot compete with the wingsail when it is opened up to provide over 45 sqft of area.









The drawing (right) shows how the foot of the rig is attached to the mast. Each foot stabilizer is attached to its own tensioner handle on the opposite side of the mast.

The top of the rig is attached only to the halyard, which passes through the block on top of the mast.

Broaching is significantly reduced with the open wingsail since the area is centred over the boat and further back from the bow.

Accidental gybes are a thing of the past with this rig. When sailing off the wind in wing mode, the foot of the wingsail is over the bow area. When tacking downwind, the foot travels across the bow and there is no head ducking.

Future plans are to try bigger rigs on bigger boats. I have recently tried the wingsail rig on a 15-foot plastic Coleman canoe and I am now hooked on canoe sailing.

Although the rig I used was only 24 sqft of sail area in wing mode, the canoe really moved well in ten kts of wind. Sailing on a run with the wing open was exhilarating and because of the balance of the rig, the canoe always sailed straight and never wanted to turn up into the wind. I used a paddle as a rudder but hardly ever used it since angling the dagger board worked well enough when sailing into the wind.

I think the rig has a narrow application range mainly because of where the mast has to be located and the requirement for a bearing housing. If the wingsail rig is to be used on a boat that used a marconi rig, the mast will have to be moved aft and modifications would have to be made to the mast support structure. A boat built from scratch can be modified to accommodate the mast - which is what I did. A canoe is the easiest hull to set the rig up in since mast position is easily adjustable.

Jeff Doyle

The wing is hoisted and dropped just like a conventional fully battened main sail or junk rig by the use of a halyard. The wing adopts the same position as a junk rig when it is lowered and is not normally removed from the mast. The picture at the bottom shows the rig hauled down. To set sail, pull on the halyard to raise the rig. The picture above in the middle shows the rig raised but not tensioned. When hoisted, the sail has no stiffness and will flop around, especially when heading into the wind. The rig is then stretched taut by engaging the port and starboard tensioners located at the foot of the wing. The picture above and at the right shows the rig in wing mode - the surface is smooth and tight. The sail is now a semi rigid wing capable of handling high-pressure gusts with very little deformation of shape.

The AYRS-Sail

In an article on Michael Schacht's website *http://www.schachtdesign.com/proafile/volume_3/options_bolger.html*, John Dalziel gives a summary of his series of experiments with a semi-elliptical squaresail on his proa *C. L. Brock.* He calls the sail the "Bolger rig" as he found it described in a number of articles by Phil Bolger, first in an issue of the late ***Small Boat Journal***, and was later in ***Boats with an Open Mind***, (International Marine, 1994). In fact the rig was first described by AYRS back in the early 1960s and it was named the AYRS-sail. Unfortunately, we have been unable to reprint John's article here, but a summary follows.

Pros and Cons

Dalziel found that the AYRS-sail has many powerful advantages:

- Because the mast is well away from the leading edge of the sail, airflow to the sail is smooth.
- He used rigid battens giving "ironclad control" over the sail shape, allowing precise tuning and twist control.
- The elliptical shape provides optimum span loading, meaning that unlike conventional rigs the top third of the sail can operate at full power.
- Tacking the sail down from about 20% along its foot gave low sheeting loads and excellent sail shape off-wind.
- The sharp leading edge provides near-perfect flow separation and in combination with the curved battens grants unheard-of ghosting ability.
- Lift/drag ratio is exceptional, about the same as a full-battened wing-mast.
- In theory, shunting is dead simple; harden the sheet, release the tack; the old sheet becomes the new tack, the old tack the new sheet.

Unfortunately, during the entire developmental history of this rig, nobody has ever fully tapped its potential, for along with the above advantages there come a host of disadvantages. Dalziel relates these directly to the rig concept.

AYRS Sail
Early experiment with "semi-elliptical square sail", by George Dibbs. Circa 1963.

1. While the sharp leading edge provides the best L/D ratio, it is extremely sensitive to angle of attack.

Theoretical best angle for highest L/D on this sort of single-surface sail is all the way down at 4-5 degrees. But at such shallow angles, the airflow on the sail, just behind the leading edge, is such as to distort the sailcloth between the battens, reducing drive. In addition, the lowered pressure on the windward side leads to an early and severe collapse of the sail *to windward.* Dalziel estimates that 6-7 degrees was as close as it was possible to trim the sail, but note that there is only a one or two degree difference here! In real-world conditions, it is impossible to control the sail well enough to keep it on that knife-edge, and the sail routinely "bluffs", or collapses to *windward.*

2. The top of the sail can become over-balanced.

When not under load, the sail pivots neatly along a line between the halyard and the tack. But once the sheet is hardened, the pivot line moves aft towards mid-chord, at least for the top third of the sail (see illustration). Now the line of sail centres of pressure is ahead of the effective pivot, and when the boat is hard on the wind the top third can to pivot to windward. This further reduces the sailor's control over the rig.

3. Dalziel reports that shunting* the rig "is a mixed bag".

In light winds the sail performs as advertised, changing ends with ease. (Cleat sheet, release tack line, harden in new tackline (old sheet), sheet sail with new sheet (old tackline)) But in moderate or higher winds it is dangerous to shunt in this manner for several reasons:

a) Since the sail shunts power-on the proa will stop and restart with tremendous acceleration, with the potential to injure someone or knock them overboard.

b) There is simply not enough time to accomplish all the tasks needed to reverse the boat, so one is left with finishing up the shunting process while the boat is screaming along at a rate of knots.

c) During the power-on shunt, the sail swaps ends with enough force to damage rigging and fittings.

4. Heaving to, or simply slacking the sheet, can cause unexpected problems.

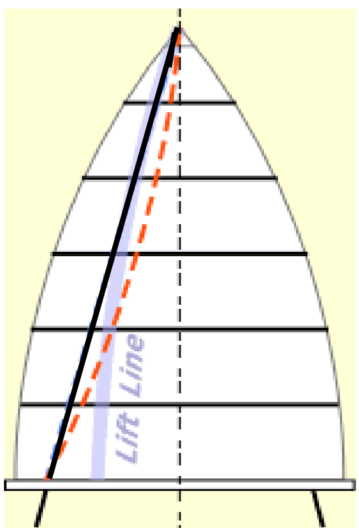
The permanently curved battens mean that the sail, when at zero drive, is actually balancing a "negative" force (on the nominally windward side of the sail) located just behind the leading edge against a "positive" force farther back on the sail chord. The effect is that at zero drive there is a strong and consistent force rotating the boat to windward!

***Dieter Schulz** and his little AYRS-sail rigged proa on launch day. 1999*

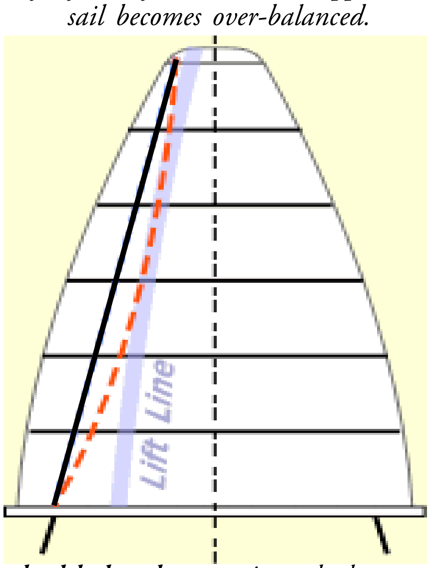
The unusual forces created by this rig would literally spin Dieter's proa in circles, and on more than one occasion left him helpless and extremely frustrated out in the middle of the lake, powerless to control it!

* Shunting - the action on a proa of changing tack by reversing direction

5. There is one final problem with the sail, and it relates to having the sheet and tack simultaneously handled during every shunt. If **both** lines get out of control at the same time - and Dalziel says *this is guaranteed to happen at some point* - then the sail in effect becomes a huge and unstable spinnaker. He reports it can - and will - fly up in the air, and come back at the rigging and crew with tremendous force, easily enough to cause serious injury. This all happens so fast that there is literally no time to react once it begins.



Collapse in the upper third *of the sail is caused by the actual line of rotation (dotted line) being well aft of the theoretical line (solid). This puts the line of rotation aft of the lift line, and the upper third of the sail becomes over-balanced.*



When a ***dual halyard system*** *is used, the actual line of rotation stays forward of the lift line, and the collapse does not happen.*

Possible Solutions

Dalziel proposes that *some* of the problems presented by the sail can be addressed as follows:

1: Add a short yard and turn the sail from one with three sides into one with four sides. Dalziel believes that the three-point suspension of the sail, which has inadequate control over the leading edge, is one of the chief problems. The yard will need two halyard locations, one for each tack, which unfortunately adds considerably to complexity. He tried the alternative, leaving out the roach, and reports that it works but leads to a poor sail shape of low L/D and little power.

2: A Chinese Junk-type sheeting arrangement to each of the lowest three batten ends was the best way he found to control the luff, although nothing was entirely successful. This stopped the "bluffing" completely and allowed the highest pointing angles of all arrangements tried. He found that the tension on the front end of the batten then kept it from diving to windward as the angle of attack decreased, and it moved the vertical line of rotation forwards. The downside was that the sail was no longer balanced, and therefore twist control was difficult and the off-wind shape of the sail was not good. Shunting also took much longer due to the additional length of line that had to be handled.

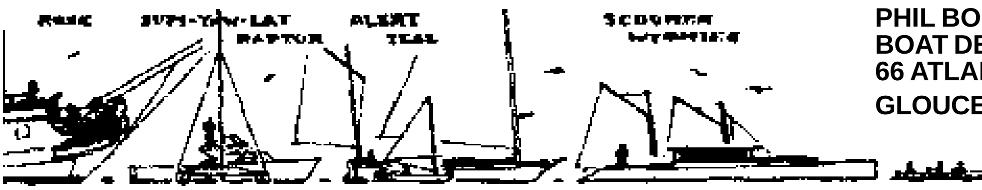
Unsolved Problems

1: Dalziel has yet to come up with a solution to the problem of **the sail spinning the boat into a backwind** when at zero drive, and suspects that the only real solution is to invent some way of immediately straightening the battens when the sheet is released.

2: Some solution must be found to the problem of **both sheets getting out of hand** at the same time, or else the rig in his opinion is simply too dangerous to use.

The sail size on his proa was 125-175 square feet (12 to 17 square meters).

Comments from Phil Bolger and Joe Norwood follow.



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Joe Norwood April 30, ’01
By Fax

Dear Joe

Thanks for passing on the Dalziel paper. I’m unclear whether he built a boat or a sail to my sketch or continued the AYRS experiments. However:

The stalling problem due to the sharp leading edge is no different from that encountered with any staysail. He says, in effect, that if it’s not precisely aligned it will luff or stall. (I experimented with a local small racer, giving her a stern stepped mast and “staysail cat” rig. This rig had extraordinary power when perfectly trimmed but was so difficult to trim and sail exactly that it usually lost out to classmates with tracked jib-headed cat rigs.) Since, like a staysail, the proa rig continues to function when stalled, by the flow on the high-pressure side, and since a sail set on a spar is always more or less stalled, we’re no worse off. Thicker foils have their own set of problems, both aerodynamic and functional.

The sail I tried out did not have an overbalancing problem. With increasing roach there is bound to be one. Rather than multiplying halyards and other gear, the cure may be less roach, recovering the area and head angle by a longer foot. Attention to L/D is misplaced since induced drag is a small if not negligible component of total drag in a sailing boat.

Stress on the sailcloth is no doubt high, somewhat mitigated by the fact that tension of the order now common in staysails is not especially important. I would have thought that some reinforcement would be possible along the lines of “staysails” set flying.

Taking all the stress on the halyard is unfortunate. I worked only with the “squaresail” configuration in the conventionally manoeuvred boat, in which the sail was backed round the forward side of the mast in tacking (the original object was to see if the sail might be practical in a cruising monohull). So handled, it was possible to use parrels, and the tack point was closer to the mast, which reduced the stress. In our proposed revised proa design we were working on a more effective staying system, but would not flinch from simply making the mast stiff enough. The staying arrangement in the cartoon was not good.

The diagram on the sail plan shows my proposed shunting procedure. I don’t see why there is uncontrolled acceleration. After securing the new tack, the sheet can be flattened at leisure. I don’t see how all this violence in the shunt is produced.

I expected a problem of instability when the sail was luffed to feathering point, but in fact it was if anything more docile that a conventional fore and aft sail. Possible there is a problem with excessive roach? I did not experience the “rotation into a backwind” and do not see what the forces involved can be. A proa with a jib-headed sail swung around a vertical midships mast was said to weathercock into irons before she gained way enough for her lateral plane to be effective. The shunting manoeuvre I suggested was intended to avoid this problem.

Losing control of the sail is worse than with a spinnaker on account of the action of the boom. Various precautions will no doubt be developed if the idea is pursued: e.g. normally-slack preventer lines to control the possible path of the boom.

Schemes to vary the camber do not appeal to me as I’m temperamentally unwilling to trade off simplicity to gain efficiency, unless the trade is extremely favourable. One of the principal reasons for investigating this rig was that the battens and boom could be stiff, avoiding the problems of flexibility.

Judging from your experience, Joe, this rig has some possibilities. We're sorry that it's impossible for us to concentrate on it for the present, but we would appreciate hearing from people who have done work based on our version of the idea. We gather that several people have picked up on the original SBJ essay and its reprinting in OPEN MIND, but so far we have only heard from you, who we gather find some promise in it. We were unaware of the earlier experiments along these lines, so can't say how our version differed.

Sincerely

Phil Bolger

Susanne Altenburger

Extract of reply from Joe Norwood, dated 1 May 2001

Dear Phil

…

I certainly never experienced problems in heaving-to. I agree that the head of the sail needs to be restrained from kiting on lowering the sail or reefing. This is easily handled by tying the head to a small block, which rides a jackstay. This keeps the peak close in to the mast all the way up or down.

Joe Norwood's Falcon

I anticipated that stalling of the upper 1/3 *might* be a problem, and so I arranged the entry angles from bottom to top as follows: 20°, 21°, 22°, 23°, 24°, 22½°, 21°, 19½° and never saw the problem. Incidentally (and this may be helpful to you), if the half-chord is *l* and the draft is *b*, and $w = l/b$, the radius of curvature of the batten is $R = l(w^2+1)/(2w)$ and the entry angle is $f = \arctan(2w/(w^2-1))$.

The figures for the sail I built are:

Batten #	*l*	*b*	R	ϕ
1	5.146	0.907	15.045	20
2	4.781	0.886	13.340	21
3	4.375	0.850	11.680	22
4	3.917	0.797	10.025	23
5	3.427	0.728	8.426	24
6	2.781	0.553	7.267	22.5
7	2.083	0.386	5.812	21
8	1.229	0.211	3.682	19.5

I completely agree that the battens need to be of permanent curvature. I laminated mine of 5-9 layers of 1/8" fir. There was essentially no spring-back at all and the curvatures are quite accurate.

Dalziel's topping lift idea (for a larger rig) did not look bad. So far as losing both sheets at the same time, that does not look at all a legitimate worry to me, at least not with the way the sheets are run on *Falcon*.

Cheers, Joe.

Mast construction for *Sunshine*.

Chris Evans

I think there is little doubt about the efficiency of rotating Wing masts. How much is not something I would try to quantify, but I have been assured by the American boat builders Gougeon Brothers that one can count upon 16% improvement to upwind performance - well worth having. With this in mind I set out to improve the performance of my sailing canoe *Sunshine* by constructing my own rotating wing mast.

There is a fair amount of information about concerning wing mast and sail design[1] so I will not dwell on such details but concentrate on the methods and materials I used to build one.

First I considered what dimensions my mast would have, and settled for about six meters long with a chord of 21 cm. The chord ratio would be 3:1 which means the width of the mast at its fattest point would be 7cm. That would be one third of the distance from the front of the mast. To attain the actual half section drawing I drew a scale drawing of an oblong 21cm. x 3.5cm. At the luff end I drew in half the luff rope aperture but oversize. (The luff rope would be 8mm dia so I drew 10mm.) This was to allow for the fiberglass. I then simply adjusted a drawing curve to get what I considered to be a fair half wing section. Based on the scientific fact that a good guess is better than a bad measurement. (See Diagram).

Sunshine (photo G Koegel)

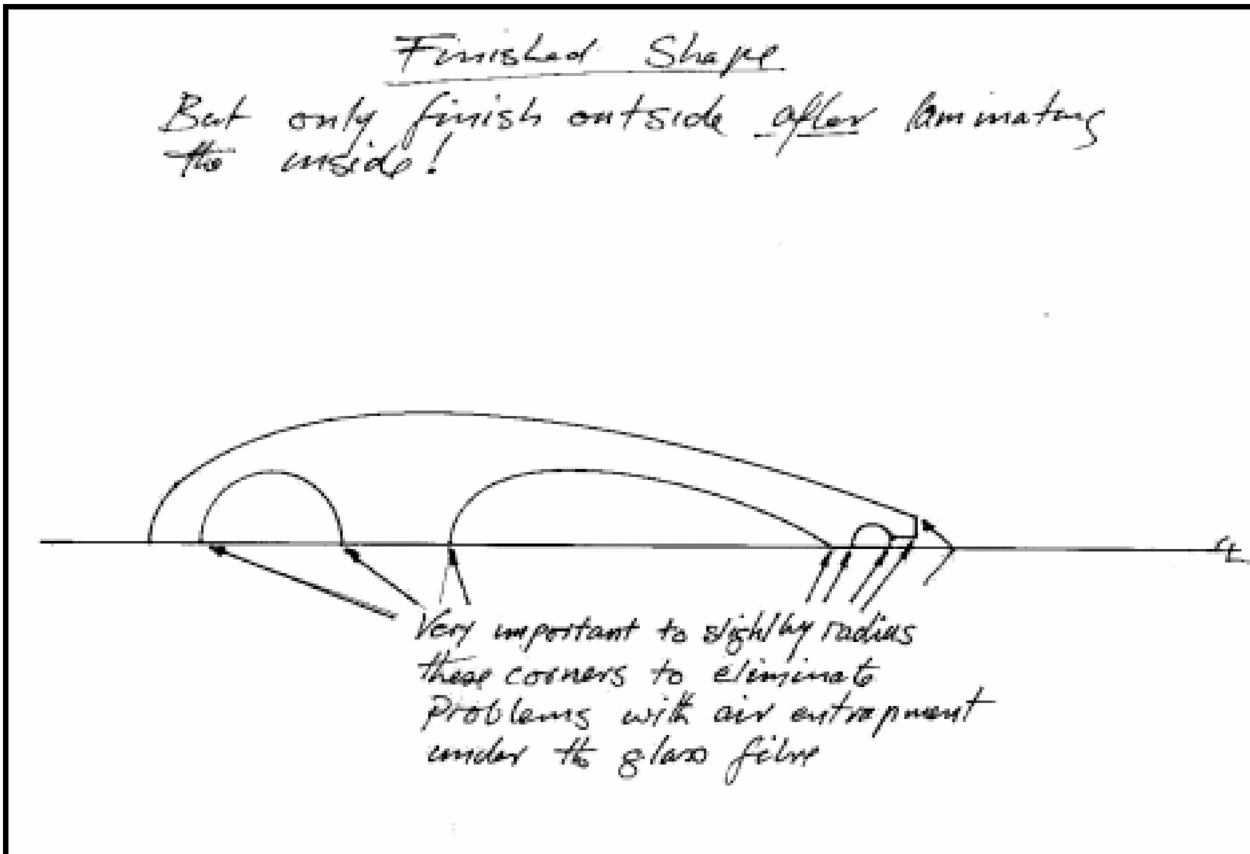
Taking that drawing and a piece of carbon copy paper I transferred it to a piece of plywood. This was then carefully cut out and cleaned up to make my template.

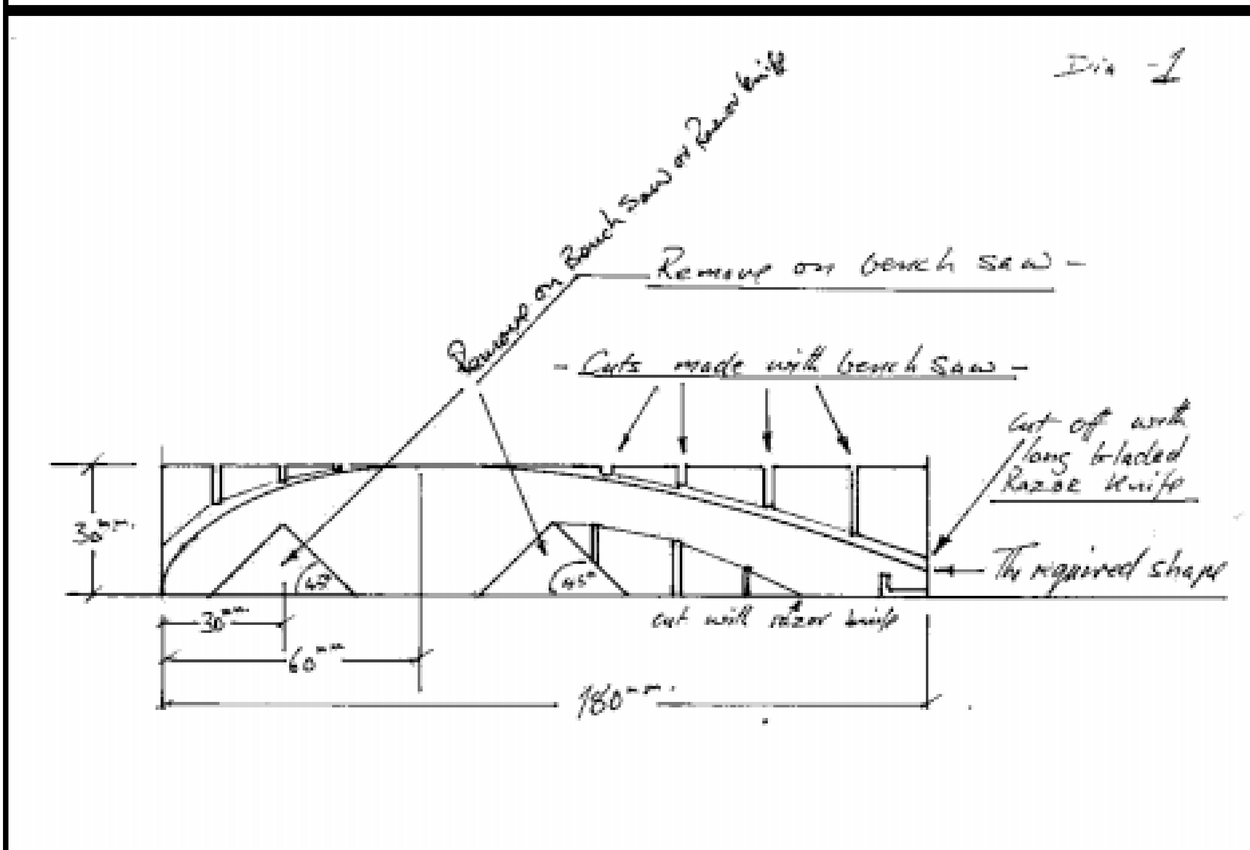
Using this template I marked out and cut sanding blocks from the PU (Polyurethane) foam I would use to construct the mast shape (see Dia.2).

I then fixed the roughest sanding paper I could find to the sanding blocks with double sided tape. However, later I found it better to use an epoxy resin in conjunction with the piece of foam that had been cut out to form the sanding block. (See dia.2a)

A quick word about this material: the stuff I used came from a factory that uses it to insulate refrigerated lorries, but I believe it is readily available at builders merchants. It is different from polystyrene in two particular respects. Firstly, it is not adversely affected by polyester resin - Polystyrene will dissolve - and it is also very easily sanded and cut to shape. It is possibly heavier, but it comes in various densities so that might not be a factor. If you have a choice of density choose a light one. There is very little strength in it but as it is only to obtain the shape, that is not really important. The strength will come with the glass and resin and the tubular shapes incorporated within the mast.

[1] *For example, see Catalyst No 2*

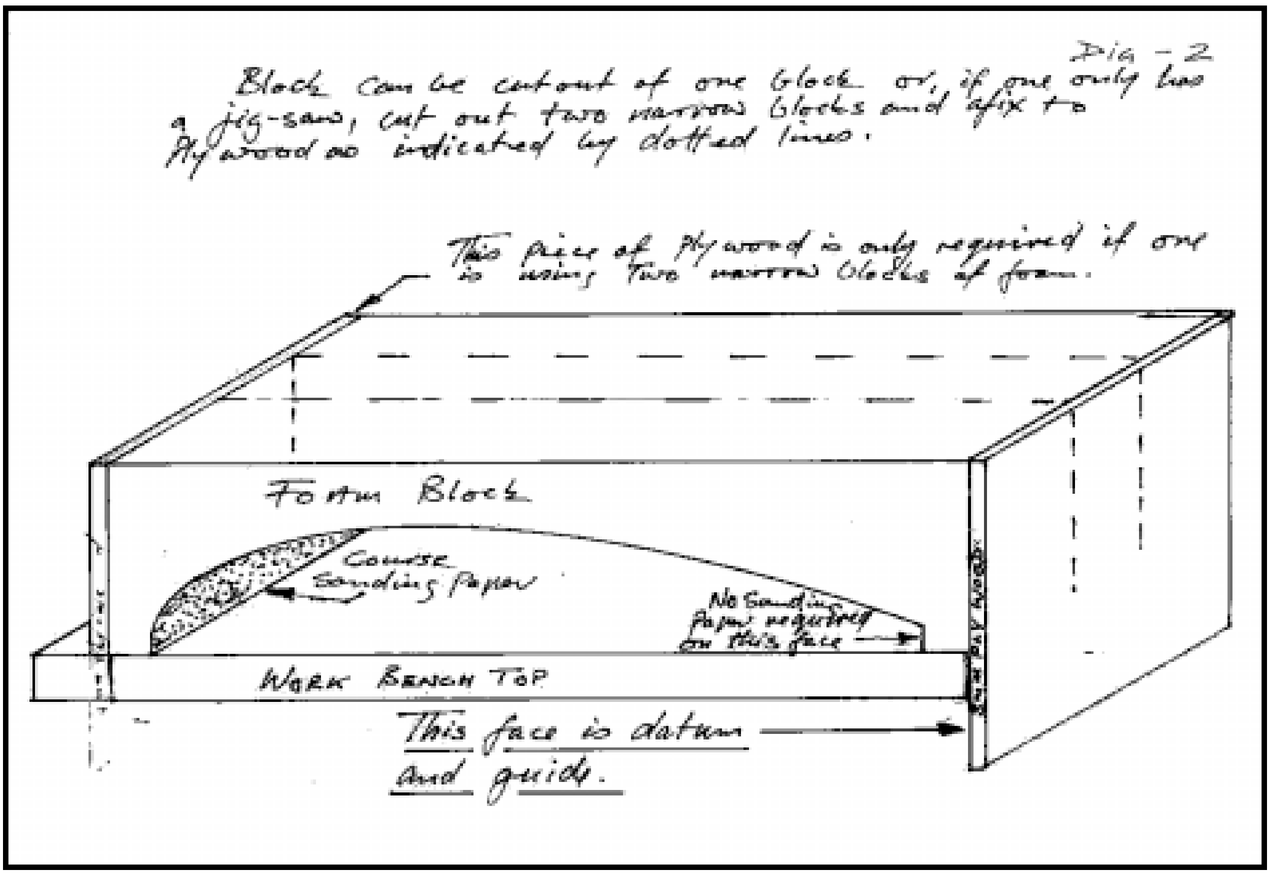

Finished Shape
But only finish outside after laminating
the inside!
Very important to slightly radius
these corners to eliminate
Problems with air entrapment
under the glass film


Dia 1
Remove on Bench saw or Razor knife
Remove on bench saw –
– Cuts made with bench saw –
Cut off with
long bladed
Razor knife
The required shape
30mm
45°
45°
cut with razor knife
30mm
60mm
180mm

You will require a *straight* bench as long as the mast. I constructed mine from melamine-coated chipboard found in the builders market for shelving. The boards need to be at least a couple of cms wider than the mast. These I set up on trestles using wedges to set the boards nice and level and straight. This is important and the more stable and robust you can make it the better. I used steel box section tubes running lengthways under the boards to support them and remove any sag. This was convenient because they were exactly six metres long. Timber could be used equally well.

Once the sanding blocks are finished and the foam set upon the table and fixed in place with double sided tape one is ready to start on the shaping. I recommend most earnestly that dust protection is used throughout all machining and sanding operations. Polyurethane dust is not nice to breathe.

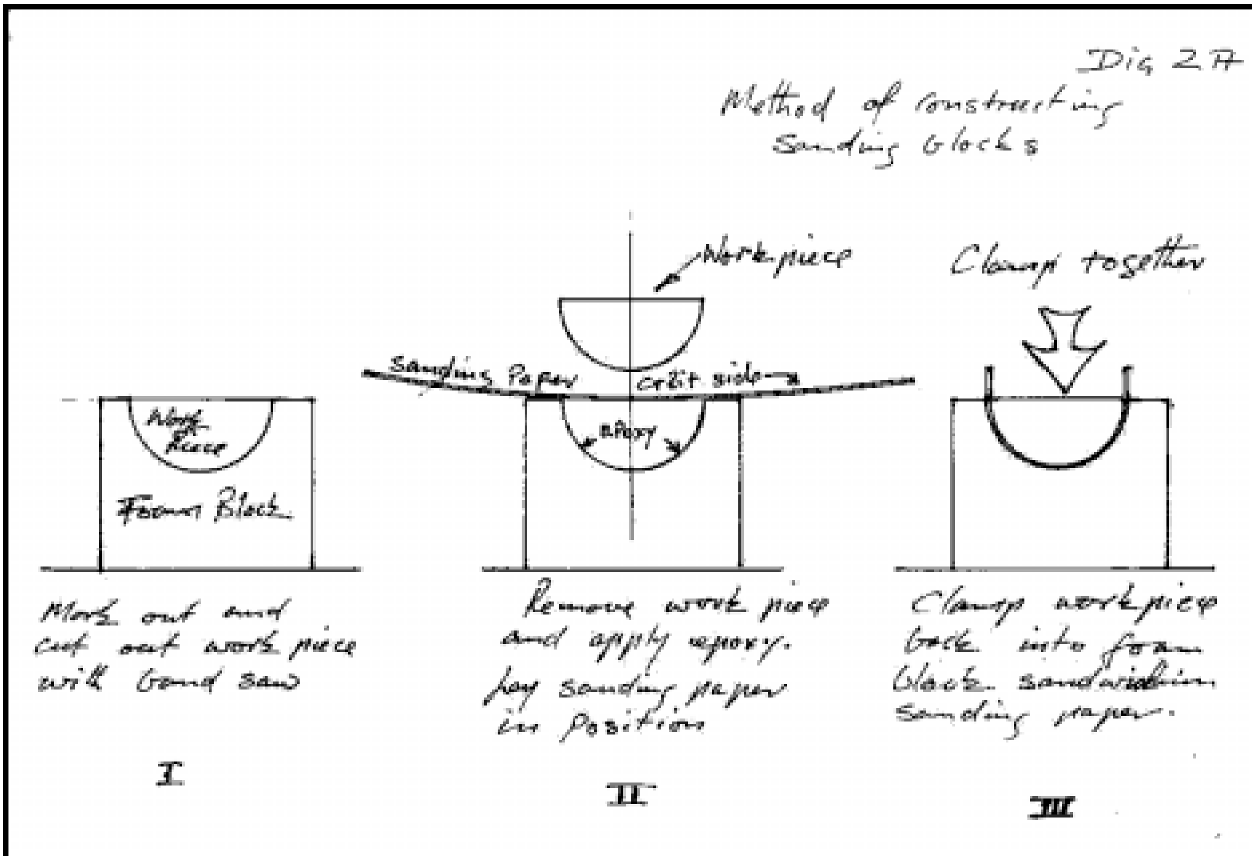
The first stage is to shape the inside of the mast. This will be the upper face of the workpiece on the bench. The rough cutting out of unwanted foam is easily carried out at this stage. One can use a bench saw to cut out a Vee section as indicated in Dia 1.

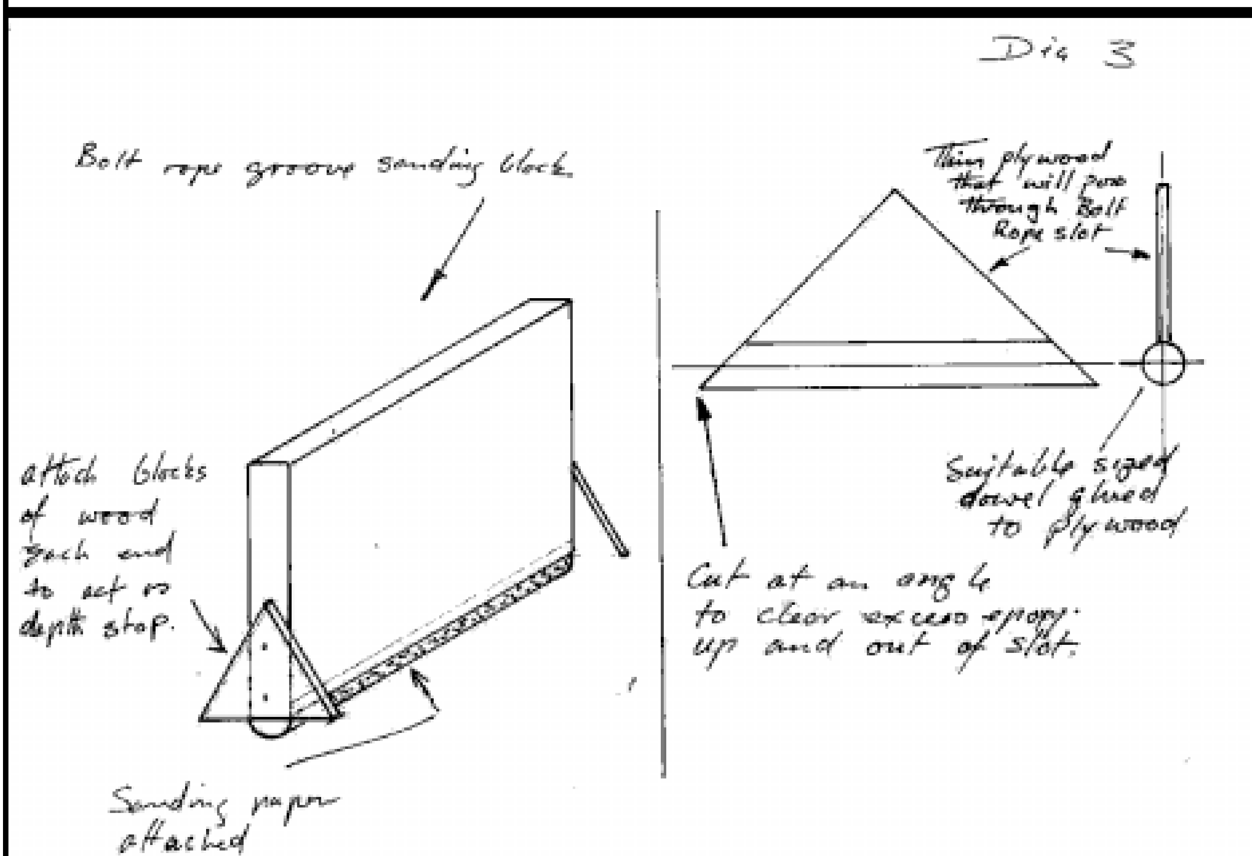


The large slabs of PU foam were cut on the bench saw to a size suitable for my mast's dimensions (21cm. x 3,5 cm. by as long as the board.) I also used the bench saw to make some pre-set depth cuts along the length that would guide me when cutting away unwanted foam with a long bladed razor knife.(Dia.1) It important to remember that we need to retain the square shape of our block to give us a flat edge to place on our datum line which is the workbench. Therefore do not do any shaping at this stage to the face that will be the outside of the mast other than cutting some pre-set saw cuts that will guide the rough shaping later.

Alternatively, use the straight bench to guide one's hand with the razor knife. (One could easily knock up a wedge of wood or even foam to rest the knife against to maintain a steady angle.)

The Luff rope groove is formed with a piece of suitably sized wood rounded with sanding paper glued to it (Dia.3). It is helpful to have a pre-set saw cut running the length because this will guide the sanding block in a straight line. If this is not possible then construct the sanding block with a 'fence' that will guide it straight alongside the trailing edge of the mast.


Dig 2A
Method of constructing Sanding blocks
Work piece
Clamp together
Sanding Paper
Grit side
Work Piece
Epoxy
Foam Block
Mark out and cut out work piece with band saw
I
Remove work piece and apply epoxy. Lay sanding paper in Position
II
Clamp work piece back into foam block sandwiching sanding paper.
III


Dig 3
Bolt rope groove sanding block
Thin plywood that will pass through Bolt Rope slot
attach blocks of wood each end to act as depth stop.
Suitable sized dowel glued to plywood
Cut at an angle to clear excess epoxy. up and out of slot.
Sanding paper attached

The two hollows that will form the central void are made one at a time, which is why the sanding block appears to be made back to front.(Dia.4) Of course, if you are feeling particularly strong you could do them both together.

The sanding blocks, if constructed correctly, will remove only the required amount of foam. As the foam is removed the block settles lower until eventually it is resting on the bench and cannot cut anymore. One needs to take some care, especially at the beginning, to keep the block square to the work but the longer the block is the easier that is to achieve. One does not have to press very hard and it is surprising how quickly this proceeds.

When the inside shape has been created and sharp edges have been slightly radiused to allow the glass to flow over easily without encouraging an air bubble, one can now consider the positioning of any halyard sheaves to be installed later. It is straightforward at this stage to use the sheave as a guide and to cut away enough foam to provide the necessary aperture required, allowing a couple of millimeters all round for the laminate to follow (dia.4). Do ensure that edges are lightly radiused to facilitate the glass laminate. It is also necessary to consider the area of attachment for the stays. I cut a piece of thin aluminium - the strength will be added later with laminate - (see Dia.5) that would be installed between the sandwiched halves on assembly and would then form a basis for extra laminates that would be applied in the final stages.

It needs to be vacuumed clean, and now it is ready for glassing. I wanted maximum strength and opted for epoxy resin but it is possible to use polyester if cost is more important than weight. For this inside laminate I used two layers of 165 grams/m^2 woven roving, which is rather thin, but I wanted to keep it as light as possible and counted on the strength of the tubular shape of the inner void. Allow the laminate to pass over the edge of the foam and cut it away close to the foam after it has partially cured and is still "green", in which stage it is easily cut with a razor knife. Actually Stanley make a special blade that consists of a small hook like blade that is just perfect for that job and well worth searching for.

When I made the mast for Sunshine I was not aware of the advances in technology by way of 'peel ply'. This is a material which comes in a roll of various dimensions and available from your supplier of fiberglass and resin. It is applied to the laminate as a final cover and wetted out not so much with the application of more resin but by soaking up excess resin from the laminate. (Resin rich laminates are not the strongest and therefore not desirable.) I apply it to finish off using my laminate brush to ensure that any entrapped air is expelled. One can apply resin to dry looking areas of the peel ply but try not to overdo it. The colour of the laminate when finished should be a nice even matte with no white areas which denote entrapped air or not enough resin. When the resin has cured this peel ply can be torn away leaving a fine neat matt finish that is perfect for secondary bonding after a simple roughing up with sanding paper. However, it is best to leave this peel ply attached until one wants to either finish the piece or make a secondary bond. It costs, of course, but it pays back in improved laminate and better secondary bonding and most of all it saves lots of tiresome paper clogging sanding.

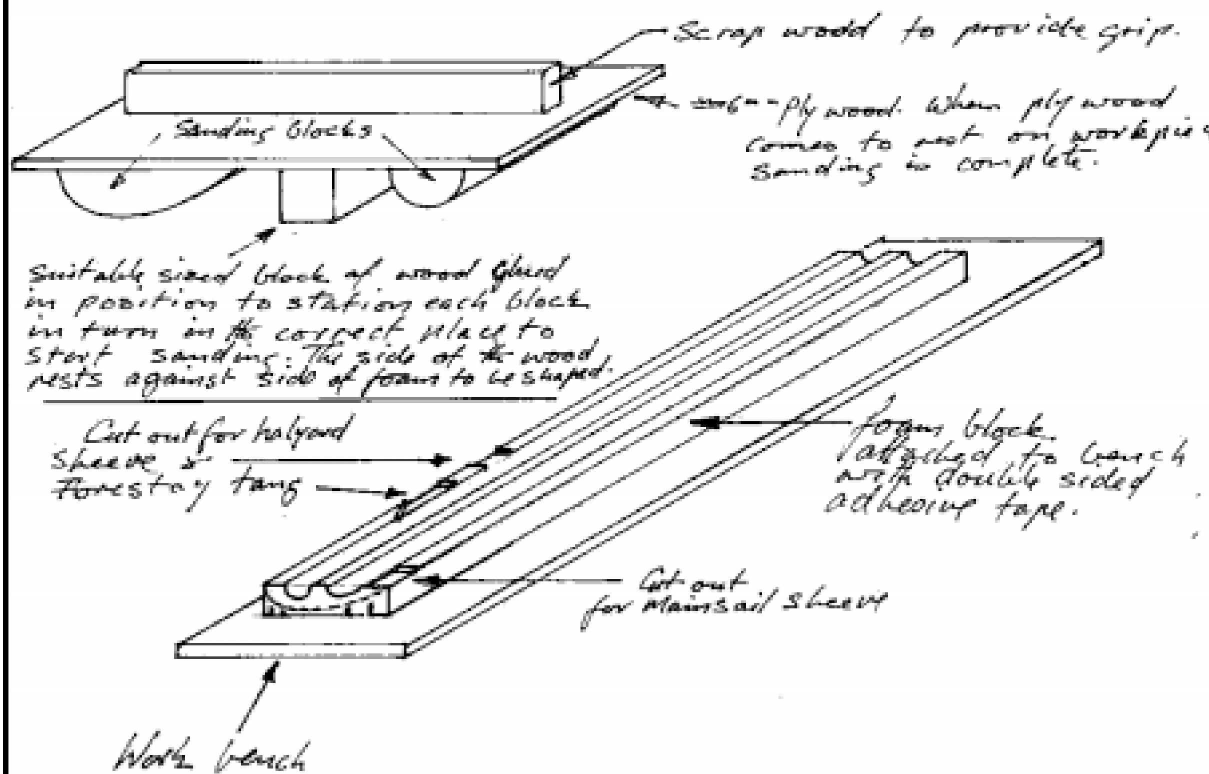
When I built *Sunshine's* mast I used a bi-axial woven roving which has a conventional weave at right angles. Now I would use bi-axial woven rovings at 45° to each other. My reasoning is that whilst we consider most stresses on the mast to be from step to truck there are other stresses too. By canting the weave to 45°, stresses that are trying to buckle the mast are shared with stresses that are compressing the mast. In other words instead of having one roving that is stressed and its 'partner' doing almost nothing, we now have both rovings sharing the stress. (At least, that's my theory.)

It is well worth keeping an eye on the luff groove while the laminate gels to ensure that the it remains adhered to the foam and does not spring away at any stage, thereby cause a narrowing of the groove, and problems with the sail binding when assembled.

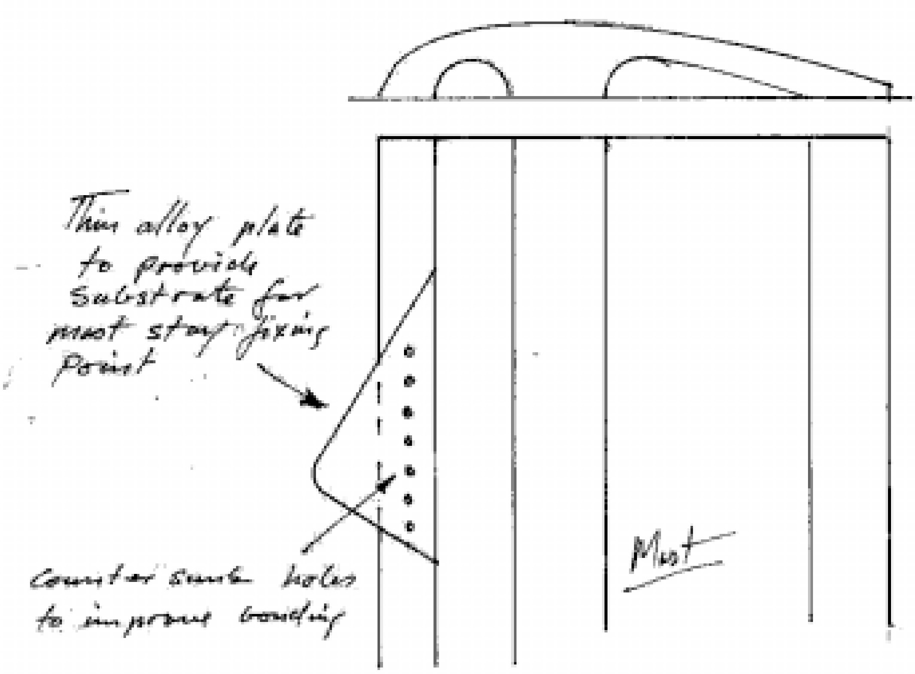
When the laminate has cured (at least 12 hours) the work piece will be fairly stable and can be moved to another place if you have the room. But it must be kept in a flat position otherwise it will become distorted and take up the shape it has been stored in. Alternatively one can flip it over and start prepping the other side . This will consist only of creating the shape. The glass laminate will be applied later when the two halves are completed.

Assembling the two halves is straightforward. A dry run is well worth the effort, which is very little, and will allow one to check that both halves align properly. Clamping arrangements are satisfactory and the tool (Dia.3) for clearing the Luff groove of excess resin passes through the sail slot, bearing in mind there will another layer of laminate as explained later. If not one can consider if it is necessary to sort out that problem now or later when the two halves are glued together.

For me there is no question that thickened epoxy should be used to join the two halves together.


Scrap wood to provide grip.
ply wood. When ply wood comes to rest on workpiece sanding is complete.
Sanding blocks
Suitable sized block of wood glued in position to station each block in turn in the correct place to start sanding. The side of the wood rests against side of foam to be shaped.
Cut out for halyard sheeve &
Forestay tang
Foam block attached to bench with double sided adhesive tape.
Cut out for Mainsail sheeve
Work bench

Dia 5


Thin alloy plate to provide substrate for mast stay fixing point
Counter sunk holes to improve bonding
Mast

Polyester resin will stick very well sometimes but it is not reliable, and certainly not compatible with epoxy. First though make sure that the surfaces that will come together are clean and grease free - this includes finger marks. In fact it is best to wear a pair of cheap cotton industrial gloves to prevent any contamination. I like first to apply to both faces by brush a film of straightforward resin with the correct amount of hardener. At the same time I apply some glass tape to each half where the luff groove is. The tape should be comparable in weight to the finishing laminate and wide enough to cover the half luff groove and then continue around the outside of the mast for about 25 mm or so. This is to ensure the integrity of the laminate at this point because it is virtually impossible to apply the glass into the groove after assembly. Then I mix up a batch with thickening agent as recommended by the resin supplier. This is then applied to one or both surfaces to be mated and the two halves are joined. Make sure not to forget the piece of aluminium that will be the basis for the mast stay attachment and should be sandwiched between the halves. It is useful to construct some simple stands (Dia.6) that hold the two halves together, and the mast in such a position that the Luff rope groove is uppermost. In this position one can check that the groove is not blocked with resin putty oozing out of the joint between the mast halves. To do this use the special tool made for the job.(Dia.3) Take care when constructing these stands that you allow for the aluminium tang that will be protruding from the mast, and it is worth laying strips of plastic between the mast and the stand to stop them becoming stuck together with excess resin oozing from the joint.

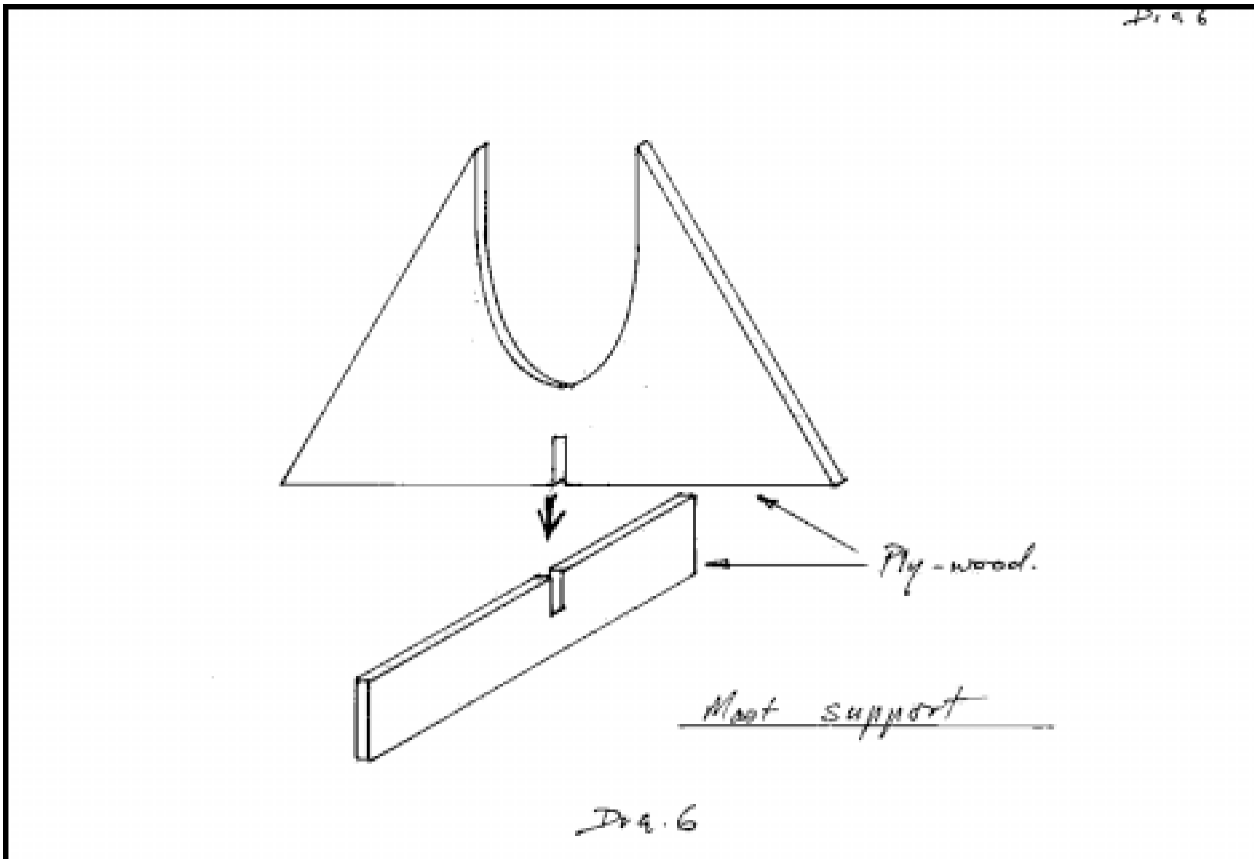
Whilst the epoxy is curing one can prepare any spreaders required. Wingmasts are very rigid in the fore and aft axis but do need diamond spreaders. The line of the wire stay should be in line with the fattest part of the mast which is one third from its leading edge. With this in mind I constructed my spreaders from solid PU foam and shaped them to form a tapering symmetric foil shape.(Dia. 7) I then adjusted them to fit snugly against the mast at the position they would be mounted, and with the outer end in line with the fattest part of the mast. It is easiest if one draws a plan view of this and then uses that to create the required shape. I then finish these with a laminate of about 400grams/m^2 weight, covered with peel ply. Once cured, drill a suitable sized hole at the tip to accept a piece of stainless steel tube that will in turn receive the wire diamond stay. The tube should be overlong and protrude top and bottom. This will allow one to attach a seizing after the stay has been positioned to prevent it coming out under extreme circumstances (Dia.7). The steel tube is to stop the wire from 'sawing' through the spreader. The tube is secured with epoxy resin and left to cure. After it has cured I cut a slot in the end of the spreader and the tube and then clean up the burrs. One needs to take care that the tube does not become too hot and soften the epoxy. Application of water from a squeezy bottle does the trick but if one does overheat the tube it is not a great problem because the resin will harden again as it cools and this joint is not one demanding great integrity.

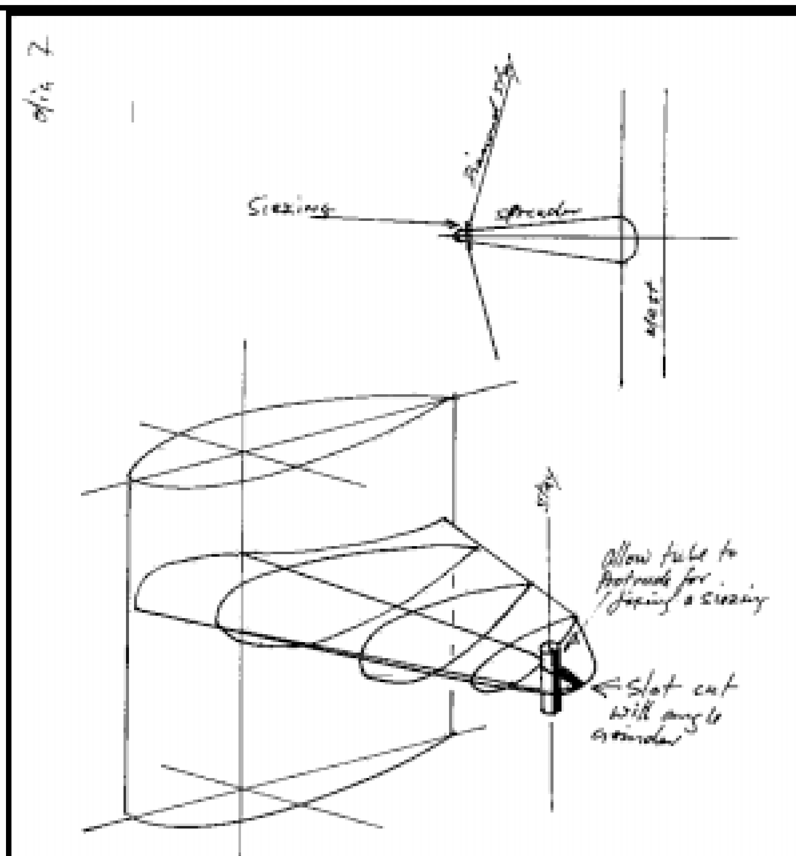
Actually, it is handy to remember that when one wants to remove an item that has been embedded in epoxy, heat is a good way to ease the job.

When I laid up the laminate for the mast of Sunshine I was unaware of peel ply and therefore anxious to avoid secondary lamination, therefore I laminated the mast in one messy session. However, having worked with peel ply I would now lay up the mast laminate in sections. First I would prepare some foam wedges to hold the mast in a stable position on one side laying on the bench. (Incidentally, it would be well worth waxing the melamine bench to stop any drops of resin from sticking. Alternatively cover with a plastic membrane.)

Then, I would have a dry run and make sure that the spreaders have been cut and shaped to fit squarely and neatly to the side of the mast. At the same time I would construct the necessary wedges and props that will securely hold the spreaders in their correct position when required.

I would then begin laminating an area of the mast where the spreaders are to be positioned. I finished *Sunshine*'s mast with a laminate of about 600 gms/m^2. I would make this first laminate the same, and I would extend it above and below the spreaders about 25 cms each way, which means we will have a laminate of half a meter wide. On this freshly made laminate I would position the spreaders with some thickened resin, making a neat fillet at the mast joint. It might be convenient to use the stands as before to hold the mast with the leading edge uppermost. If you are going to let all this now cure you should apply peel ply to the laminate area. Alternatively you might just wait an hour or so till the resin is gelled enough to continue with the laminating. In either case you will now have two areas laminated, one above the spreaders and the other below. If you have a helper you can each tackle different areas. Make sure that you also laminate a substantial area around the mast stays' tang and onto the thin aluminium tang itself, sandwiching it between laminate.


Ply-wood.
Mast support
Drg. 6


Sizing
Mast
Stay
Allow tube to
Slot cut

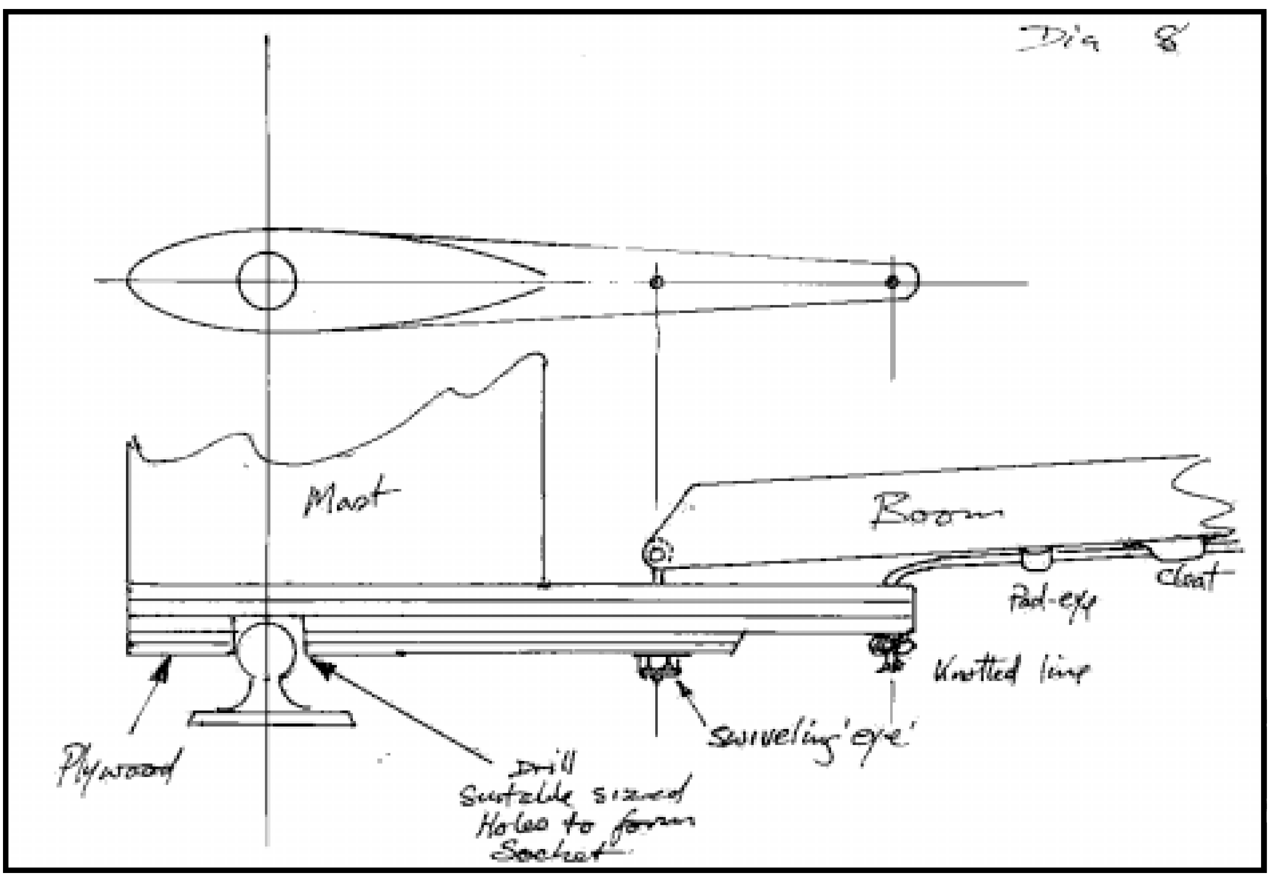
Some people may not be content with this arrangement for attaching the stays to the mast. Well, one pays one's money and one makes one's choice. If done well it is substantially stronger than an eye pad pop riveted or even bolted to the skin because it spreads the load much more. Just make sure that you use woven roving strips in the laminate that spread out like a star. Do this part first, and then cover it all with the final lay up - it will blend in much more neatly. You should end up with a tang protruding from the mast that is about 1 cm thick. It can be trimmed to shape after curing.

Finish the lay up with peel ply if you want to save work on the prepping for painting.

The truck was made from plywood attached with epoxy and the mast step was constructed from a few pieces of plywood sandwiched together to provide a cup for the ball step that would allow the mast to rotate. These are best attached before the final outer laminate is applied so that one can extend that laminate and enclose these attachments. I extended a tang of plywood aft from this step that would provide a fixing point for the boom, and the system is that one only requires a line from the aftermost point of this tang to a boom mounted cleat to control the rotation of the mast. When one tacks the mast will rotate to the same setting on the new tack automatically. (Dia 8).

Chris Evans

[A description of Chris Evans sailing canoe Sunshine *appeared in* Catalyst *No 4, April 2001]*



For dinghy sailors only?

Boom Vangs or Kicking Straps

Frank Bailey

"Ex nihilo nihil fit." (G. C. Lichtenberg, 1742-1799)

If you have never run around the marks in, say, a 9 to 14 foot dinghy, perhaps this article is not for you. If you have not capsized numerous times while jibing or just pulled some boner and found yourself in the water with the other boats rushing past you hurling epithets because your boom lying horizontally in the water is in their way, then don't read this pastiche. On the other hand, if you do read this, you will find there is very little in the way of a conclusion except in one important respect.

The subject of this article is boom vangs as we call them, or used to call them, here in the U.S. or kicking straps, as I understand they are called in the UK. I will stick with "Vang" as I am used to that word. (Webster's Unabridged Dictionary defines a vang as a line steadying the tip of the gaff to the deck. Isn't that interesting? At this moment I do not have access to the Oxford Unabridged Dictionary.) The vang is essentially a device consisting of blocks so arranged as to hold your boom down when you are on a run and your main sheet is of no use as the boom is about 90 degrees off the centerline of the boat to port or starboard. See sketch A. The object of this article is to see if we can find the best place to attach the upper end of the vang to the boom. The correct answer is, as usual, a bit uncertain.

Let us examine the geometry first so that we can analyze the problem with some simple mathematics, which we will mostly avoid explaining here. To keep things simple, the boom will be 10 feet long, and we will assume, for want of something better, that there will be an upward force on the boom halfway out on the boom, or 5 feet from the mast. The magnitude of this force, say 100 pounds, is caused we will say by the sail wanting to belly out, and the fabric pulling the boom up. (We are only interested in the vertical force here.) We will examine the magnitude of the pull force of the line through the vang when the upper end of the assembly is attached a distance L feet from the mast horizontally and the lower end is attached to the mast a distance B feet down vertically from the point where the boom foot meets the mast. Our physical sense of reality tells us of course that we want the B distance to be as great as possible for downward pull, but our physical sense deserts us when we wish to place the upper block somewhere on the boom. The best location is not necessarily the point where the line makes an angle of 45 degrees with the boom as past experience might indicate. We might say that the governing criterion that creeps in here is "How much do we wish to tug on the line, assuming our original assumptions are anywhere near reality?" Even though you may be big and brawny, it might be useful to you if you could keep your vang line pull at a reasonable magnitude, because, no doubt, you are tugging on lots of other lines as you round the marks in a tense race, and you wish to keep your time well spent in the motions you make.

Very briefly, so as not to lose too many of my readers, if any, I will discuss a bit of the math involved. Look at the situation this way: The point "0" is the rotation point. There are two moments working around this point where the boom foot meets the mast. A moment is the product of a force and a perpendicular distance to the point of rotation, measured in foot-pounds. The counter-clockwise moment of the upward force times its distance from the mast is balanced by the clockwise moment of the vang line force times its perpendicular distance from the intersection of the mast and boom foot, as shown by the dotted line marked X in sketch A. Unfortunately you have to do a bit of geometry to figure out this distance which must always be perpendicular to the line pull, but this works out when you pursue the formulas. (Albert Einstein said: "Politics is for the moment but a formula is forever.") When you work through the various combinations of B and L, holding the upward force constant at 100 pounds half way out on the boom, the plot titled Line Pull vs. B and L is developed. Examining the plot we see the line pull varies anywhere from something around 200 pounds on up to 1000 pounds when the upper end of the vang is attached close to the boom foot. This is exactly what you would expect, I hope. I have examined four cases where B is equal to 1, 1.5, 2, and 3 feet. I have calculated the line pulls to beyond the center point of the boom just to see what would happen. It appears that the line pull tends to reach respectively from B=1 to B= 3, 500, 333, 250, and 167 pounds each, for infinite boom lengths. Further, I have drawn on the plot the points where the angle of the rope makes angles of 55°, 45° and 30° with the boom. From the plot we can see that the line makes a 45° angle with the boom when L equals B.

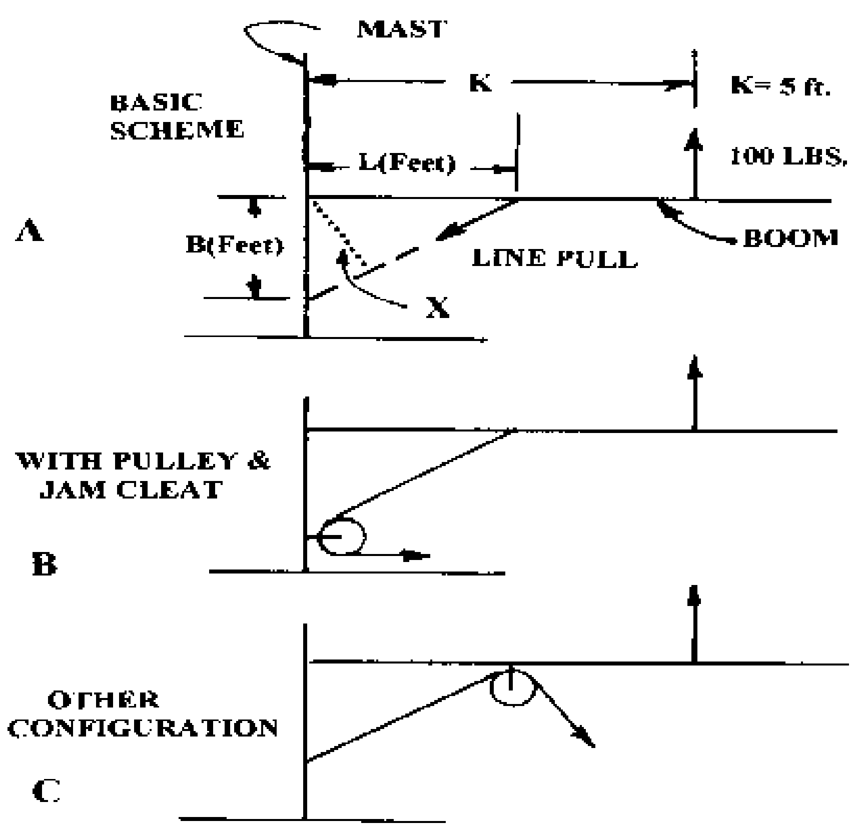
Now we have to make a decision as to how much we wish to tug on the vang line. When putting together our rigging the first thing to do of course is to mount the lower end of the vang as low as possible on the mast so the location of this point is easy to figure out. Your mast could also be of the swivelling type so the vang will swivel with the mast perhaps, maybe, etc. Then you can decide how much you wish to pull on the line. Normally, you might have at least a two to one mechanical advantage with your block so consider this. But of course the more mechanical advantage, the more line you will have to pull through your blocks. It also appears that placing the upper block anywhere that causes the angle between the boom and line to be 45° or greater has some advantage in reducing your line pull, which doesn't at first thought seem to make much sense. According to this analysis, it appears you could still mount the upper block at the outer end of the boom for something approaching minimum line pull.

There are a few more considerations before the big important conclusion to this article from The Toad Hill Boat Shop.

We have not considered any reaction forces between the boom foot and the mast. These change quite significantly in size and direction depending on the values of B and L but mostly L. However, for this analysis, I am assuming that the boom swivel, thingamajig or widget, is sufficiently designed so that it will not fail no matter what the loads. However, this area could be a fruitful area of analysis to save a few pounds of displacement here and there.

Referring to the Force Diagram, Sketch B, I have shown the normal, I hope, arrangement of where to apply the line pull. It is convenient here because it is always close to the same place for the times when you reach for it. If this position were on the upper end, it would quite frequently be a bit outboard and hard to reach as shown in Sketch C. Further, using Sketch C, the line pulls will be different from the above calculations depending upon what angles you pull from.

A final consideration is where to apply the upward load and how large is it. Any analysis of this sort



FORCE DIAGRAM

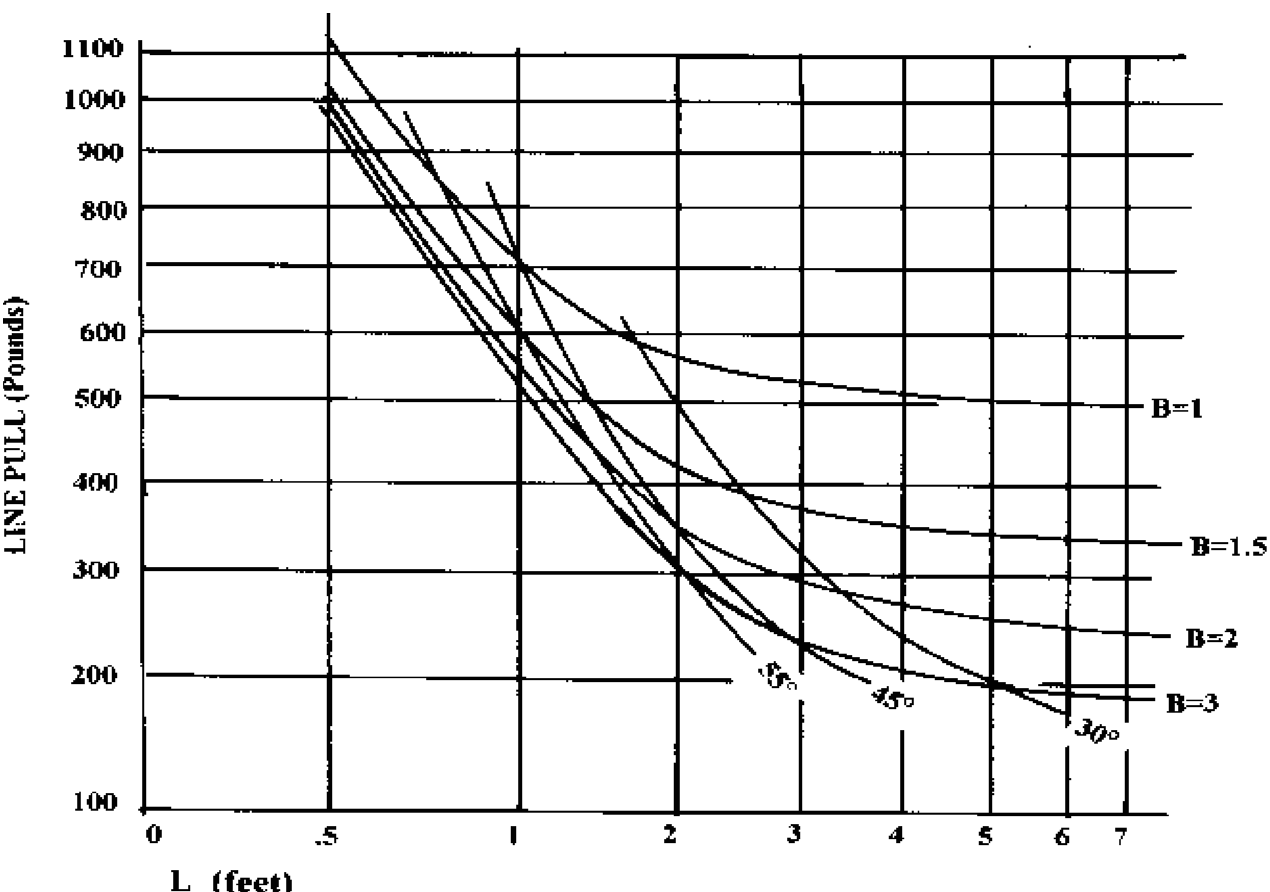
is as good as the original assumptions. I have just taken a stab at this. Why don't you go out in your boat with a spring scale and take some readings as our dear departed Edmund Bruce used to do? Some of you purists might draw up a triangular sail of sorts and place the center of effort in its appropriate position and tell me I have applied my 100 pounds in the wrong place, and I agree — but it was so convenient to just use 5 feet. However, it is easy to make the change, as the value is a constant in the formula.

And now for the big conclusion.

I remember a few years ago, I attended a meeting of the now sadly defunct New England Group near Newport, RI. A very astute young gentleman whose name I of course forget, showed us around his tri or cat, I forget that also. He, as I recall, showed us each fitting on his boat and explained the how, where, and why, each fitting was placed and the advantages and disadvantages of the same. In other words, he paid attention to all of the minute details of outfitting the rigging on his boat. Someone has said that genius is 95% paying attention to details and we should be doing the same when we throw a boat together if we want to win races or get the most out of our racing machines. I can rephrase this in the following words: If something was done one way once, there must be a better way to do it now. (By the way, I ought to get paid by the line for this stuff. Just kidding!)

A Correction and a Thank You. In a previous diatribe of mine, A Solar Panel Experiment, I had a decimal error. The cost per square foot of the panel was stated to be £8.13 but the correct figure is £81.25. I regret any inconvenience this might have caused. This error was pointed out by member John Ponsonby whom I thank for bringing this to my attention. Further, John has had considerable experience with solar panels (which I have not), and he pointed out to me that any kind of slight shadow on even one of the panel segments reduces significantly the output of the panel. I attempted to examine this phenomenon but gave up because I did not have sufficient time or method to develop any reasonable shade output curves. This paragraph only proves that just because you read a printed article in the Catalyst does not mean that the author is the most suited to write the article. There is a lot of talent "out there" to be tapped for the benefit of the Society.

Frank Bailey



LINE PULL VS. B(Feet) & L(Feet)

Call For Papers

THE CHESAPEAKE SAILING YACHT SYMPOSIUM

To be held March 2003 in Annapolis, Maryland

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TOPICS OF INTEREST

Yacht Design and Analysis	Sails and Rigging
Materials and Construction	Racing Yacht Developments
Software and Electronics Technology	Human Factors and Practical Sailing Experience

DEADLINES

15 MAY 2002	Submission of abstracts, (400 to 500 words)
15 JULY 2002	Authors informed of acceptance
NOVEMBER 2002	Submission of draft papers
JANUARY 2003	Submission of papers in final smooth form

SUBMIT ABSTRACTS TO

Stephen R. Judson,
Papers Committee Chairman
1731 Thistle Court, Gambrills,
MD 21054 USA

E-mail: CSYSPapers@hotmail.com
Phone: (410) 721-6889
Internet:
http://wseweb.ew.usna.edu/nahl/csys

High Performance Yacht Design 2002

Auckland, New Zealand, December 2002 - First Notice

An international technical conference on yacht design is to be held in Auckland, 'City of Sails'. Scheduled for the middle of the Louis Vuitton Cup and shortly after the finish of the Volvo Ocean Race, the conference will be a venue where naval architects, engineers, designers and researchers can present papers on the current state of yacht and power craft technology.

Conference Outline

The Conference will focus on power as well as sailing yachts. With evolving rating and class rules allowing ever more exotic materials and advanced construction techniques the need for testing and performance prediction has never been greater. The design of a high performance yacht has to encompass all these issues to be successful.

The ongoing success of events such as the America's Cup and the Volvo Ocean Race are driving the development of ever more improved performance analysis and design tools. More and more time is being spent developing soils and rigs using sophisticated techniques and wind tunnel testing.

Conference Dates and Venue

The conference will be held in Auckland, New Zealand, on the 4th - 6th December 2002.

The venue is The University of Auckland, School of Engineering, 20 Symonds St.

The welcoming evening function is at the New Zealand Notional Maritime Museum, Cnr. Quay St. & Hobson Wharf, Auckland.

The Dinner is at the Royal New Zealand Yacht Squadron (Hosts to the America's Cup) at Westhaven, Auckland.

Early registration is recommended because of the proximity to the Louis Vuitton and America's Cups.

Guideline Themes and possible subjects for papers

Delegates are invited to submit technical papers, which will be of a high standard, on the following topics:

Rules & regulations - Testing & performance prediction - Propulsion systems - Construction & materials - Design

Timeline for Submission of Papers

1st March 2002 - Abstracts due

31st July 2002 - Completed papers due

A two-page abstract should be submitted for selection by an international panel of referees.

The conference will take place over three days and there will also be an opportunity to visit local testing facilities and places of interest.

Registering for the conference

There are three options for registration

1) Use our secure registration form on our website to register online.
2) Download and print out the application form (Adobe Acrobat format), simply fill in your details and payment information and post it to this address -
3) Contact for forms and all enquiries:
   RINA "High Performance Yacht Design Conference 2002", Private Bag 102904, NSMC Auckland, New Zealand.
   Telephone: +64-9-4439799 Ext:9560
   Facsimile: +64-9-414081

Information on technical papers:
email: p.jackson@auckland.ac.nz

General conference enquiries:
email: B.Woods@massey.ac.nz

http://www.hpyacht.org.nz

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**

April 2002

2nd **AYRS London meeting** on ***Hydrofoils***. 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

13th-14th **Multihull Symposium** Mount Batten Sailing & Watersports Centre Plymouth, organised by *themultihull.com*. £30.00 attendance fee includes lunch on 14th. Programme and further details from http://themultihull.com/symposium

August

September

28th (to 4th October) **Weymouth Speed Week** Portland Harbour, UK. For entry details etc contact: Nick Povey tel:+44 (1342) 825292; email: nick@speedsailing.com

October

2nd **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

November

5th **AYRS London meeting** on ***Windmills and Gyroboats*** 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

December

3rd **AYRS London meeting** on ***Landsailing*** 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

4th-6th **High Performance Yacht Design 2002** - Conference at the University of Auckland School of Engineering, Auckland, New Zealand. hosted by the University of Aucjland, Massey University and the Royal Institution of Naval Architects. Details from RINA High Performance Yacht Design 2002, Private Bag 102904, NSMC Auckland, New Zealand; Tel: +64-9-4439799 ext: 9560; Fax: +64-9-414081; http://www.hpyacht.org.nz

January 2003

2nd - 12th **London International Boat Show** Earls Court Exhibition Hall. 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

11th **AYRS Annual General Meeting** 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

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

On the Horizon . . .

River Power Generator - *Ken Upton*

Ergonomic Oar Blades - *Robert Fraser*

Hydrofoil sailing - *Michael Ellison*

....

More sources and resources: reviews, publications and Internet sites

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

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