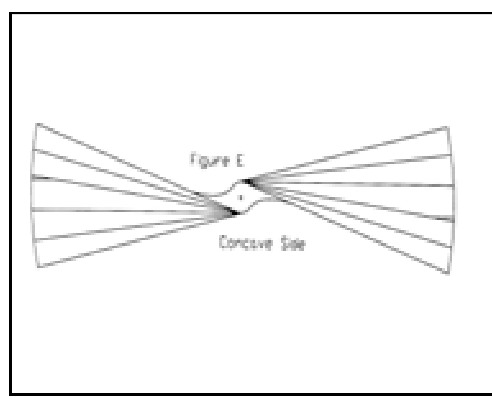
Catalyst

Journal of the Amateur Yacht Research Society

Number 24 April 2006

Features

Regulars



Ottilia - the first of James' Wharram & Hanneke Boon's Child of the Sea *catamarans.*

Catalyst

Journal of the
Amateur Yacht Research Society

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Contributions are welcome from all. Email them to **Catalyst@ayrs.org**, 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 in the mail.

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The new AYRS Committee

On page 31 of this issue you will find the draft minutes of the last AYRS Annual General Meeting. That meeting marked the retirement of Michael Ellison after some 35 years as an officer of AYRS - first Administrator, then Treasurer and finally Chairman. We owe him a great debt of thanks for keeping AYRS going for all those years. He is still on the Committee, so we don't lose his advice, but he now wishes to do less work and more sailing. And who will blame him?

Your current Committee consists of Fred Ball (Chairman - for the second time) Graeme Ward (Vice-Chairman), Sheila Fishwick (Secretary), Slade Penoyre (Treasurer), Simon Fishwick (Editor), and "ordinary" members Dave Culp, Robert Downhill, Michael Ellison, Charles Magnan, John Perry, Mark Tingley and Peter Westwood.

Catalyst

It is probably appropriate then that I apologise for the late publication of this *Catalyst*.

Your Editor has for the last year been negotiating to take over a new venture - a sailing school and adventure centre in the East of England - and it has this year taken more of my time to get it up and running than I had anticipated. So I have not been able to stick to the rigid timetable I had set myself for *Catalyst*.

However that should now be a thing of the past. With effect from the next issue, Peter "Percy" Westwood will take the lead in editing and producing Catalyst, leaving me freer to tackle through the winter some of the other editing jobs that have built up. I am very grateful to Percy for volunteering to take over this seat - it's time for new ideas, and I am sure he will fill the role admirably.

I'll leave it to him to introduce himself in the next edition, and although I don't expect these to be the last words I write for Catalyst, it remains for me only to write put down my pen.

Simon Fishwick
AYRS Editor

Down Wind Faster Than The Wind At Last!

I did try the DWFTTW car on a flat surface in a steady 6 knots of wind. It took about 20 feet to get to wind speed and the flag flew backwards for over 100 yards. I had to stop it before it got out of range. I will get some movies however I have to arrange steady wind, a chase car, 2 drivers, and a photographer.

Jack Goodman
Imaginationltd@aol.com

[Jack Goodman's article on his experiment should appear in the July edition of catalyst. In the meantime, you may like to watch the video on the AYRS website http://www.ayrs.org - Editor]

Call For Papers —

The 18th Chesapeake Sailing Yacht Symposium, March, 2007 in Annapolis Maryland USA

TOPICS OF INTEREST

Yacht Design and Analysis
Materials and Fabrication
Structural Mechanics
Failure Analysis and Repair
Modeling and Simulation
Software, Electronics and Systems
Racing Yacht Developments
Sails and Rigging
Lessons Learned from Volvo/IAC Racing
Human Factors in Sailing
Rating Rules
Regulatory Developments

DEADLINES

28 April 2006 Submission of abstracts,
27 October 2006 Submission of draft papers
29 December 2006 Submission of papers in final smooth form

Contact: Prof. Marc Zupan email: mzupan@umbc.edu website: www.csysonline.com

[If anyone is proposing to attend this conference, we would appreciate a report - Editor]

Classic boat building DVDs.

We thought you and your members would be keenly interested in these These two DVD titles are excellent for boatbuilders, boatbuilding schools and courses. They are great as an adjunct to classes and excellent as a reference in the library.

The Lines Plan With Arno Day

"The Lines Plan." is a classic. It is high quality transfer from a 1980s master and teaches all about understanding and creating lines plans for wooden boats. Lines plans can be used to take lines from classic boats to preserve their design as well as to create plans for building classic wooden boats.

This course gives designers and builders the confidence to create their own lines plans for designing, preserving and building their own boats. It is excellent for boatbuilders of all skill levels. Running time: Approx 2 hours (set of two 1 hour DVDs, (sold as set only) The DVDs play in the UK. The list price is $59.95 plus $4.00 shipping.

The Art of Lofting By Arno Day.

Lofting is the process by which a builder draws the design of a boat full size, correcting the errors and fairing the humps and hollows in the skin of the boat before he builds. Correct lofting makes the boat hydrodynamically sound.

Arno demonstrates clearly the types of problems that come up and how to solve them. According to Arno, "Lofting completely saves you a lot of time in the shop. You're more accurate and the boat goes together easier." These DVDs give you the confidence to know you can do it.

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[Similarly, if anyone has a copy of these DVDs and would like to review them for AYRS, it would be appreciated - Editor]

A Voyaging Canoe for Tikopia

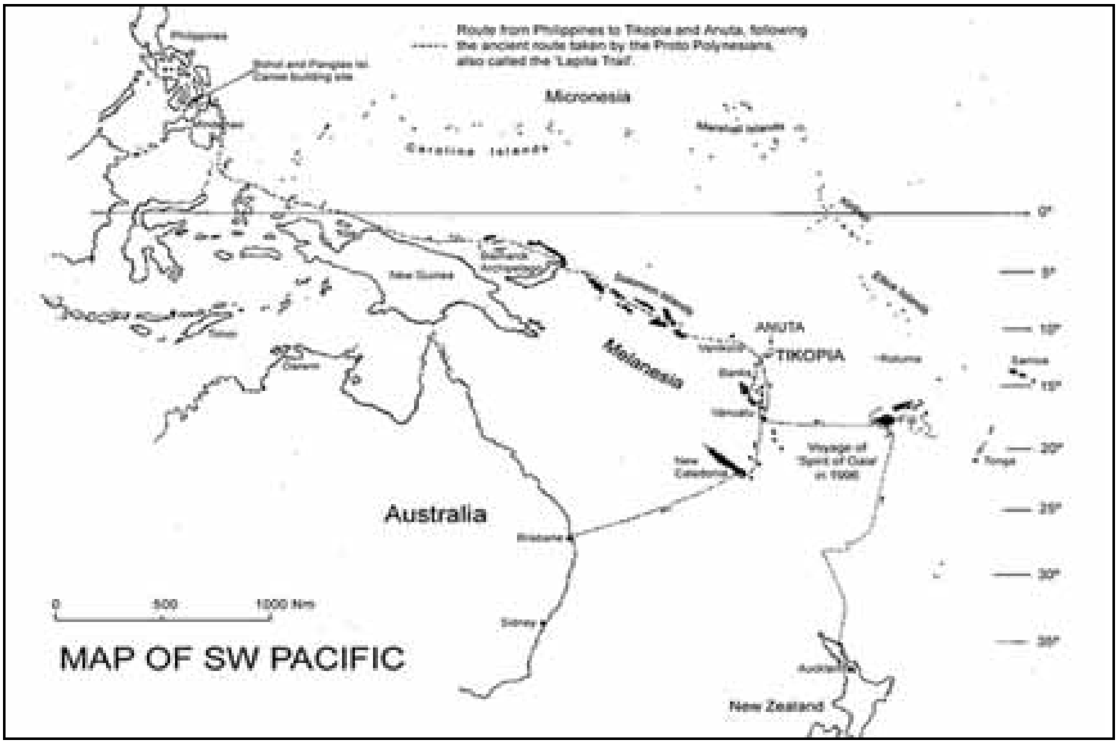
A proposal for a project to give the people of the tiny Pacific island of Tikopia back independent sea transport, in the form of a seagoing sailing double canoe.

James Wharram & Hanneke Boon

Tikopia

Inspiration for this project came when we read the chapter on Tikopia in a new book by Jared Diamond (author of 'Guns, Germs and Steel' and other books) called 'Collapse, How Societies choose to Fail or Survive' in which he describes how societies all round the world have either survived or collapsed and the reasons why. Reading about the society that survived for 3000 years on Tikopia, an island we visited in 1996, and realising how unique and important this tiny island is, gave me the inspiration for the project proposed here.

To sum up Jared Diamond's description of the uniqueness of the island of Tikopia: Tikopia is a tiny tropical island of just 1.8 square miles situated in the SW Pacific, at the Eastern end of the Solomon - Santa Cruz islands, supporting a population of approx. 1200 people of Polynesian descent. This island has been self supporting & self sufficient for the last 3000 years using stone age technology. The nearest island (85 miles distant) is the even tinier sister island of Anuta (population 170). Other slightly larger islands in Vanuatu and the Solomons are between 100 and 140 miles distant.



At present the only transport to and from the island of Tikopia is by an old Solomon Islands Government ship, which calls at the island about every three months. Islanders that leave the island on the ship have to wait for its return before being able to go home. Tikopians living on other islands have to take six months leave to visit their home island and family. The ship is also the only means of bringing in outside supplies. Occasionally the island is visited by passing yachts, through whom messages and letters can be sent.

The only craft on the island are small outrigger canoes, used for fishing, and too small for longer sea voyages. There are no other watercraft, no outboard motors and no fuel. There is no airstrip, and it is too far for a helicopter to reach.

A new seagoing canoe will give back to Tikopia the independence it had in its long past as a totally self-sufficient, self-sustaining island, with its own canoes fit for ocean travel. The Polynesian island of Tikopia has been unique in this way for 3000 years and needs to be able to continue to be so.

In the words of the anthropologist Raymond Firth, who lived on Tikopia for a year in 1928- 29 and returned for subsequent visits: "It's hard for anyone who has not actually lived on the island to realise its isolation from the rest of the world. It is so small that one is rarely out of sight or sound of the sea. [The maximum distance from the centre of the island to the coast is three-quarters of a mile.] The native concept of space bears a distinct relation to this. They find it almost impossible to conceive of any really large land mass… I was once asked seriously by a group of them, 'Friend, is there any land where the sound of the sea is not heard?"

Due to the impossibility to import foodstuffs of sufficient quantity by the only transport available to the people, i.e. their outrigger canoes, the question has always been how could a food supply sufficient for 1,200 people be produced reliably? And how could the population be prevented from increasing to a higher level that would be impossible to sustain?

These two problems were solved in Tikopia by:

1) Developing a form of agriculture that mimicked the natural growth of tropical jungle, but where every tree, bush and plant was of an edible nature, thereby optimising the productivity of every part of the island.

2) Following a policy of Zero Population Growth, which in the days before Christianity was achieved through birth control in the form of coitus interuptus, abortion and infanticide of newborn babies. Adults also would sometimes, in times of shortages, resort to suicide or to 'virtual suicide' in the form of going out to sea in a small

canoe on a dangerous voyage with the likely result of never returning.

There is only one period on record when the people resorted to warfare as a result of food shortages. About 300 years ago, one clan was exterminated and sometime later another clan was driven off the island on canoes, never to return.

The system of self-sufficiency on Tikopia has evolved over the 3000 years the island has been inhabited. The first people on Tikopia were part of the 'Lapita Migrations' of early Polynesians from the west. Their agricultural methods were based on the slash-and-burn techniques; they also made quite a heavy impact on the bird and sealife populations. This has been verified archaeologically. With time the food growing techniques seen today were evolved. Around 1200 AD a new influx of Polynesians came from islands to the East; these people are the ancestors of the present day population.

An important event happened around 1600 when the decision was made to kill every pig on the island, and from then on rely only on seafood for protein. It was judged that pigs were too destructive to the agriculture and that they were an inefficient source of protein. There are now four tribes on the island each with a hereditary chief (Ariki), though the chiefs do not have a very superior place in society and have to grow their own food same as anyone else. The chiefs are overlords of clan lands and canoes, and jointly make decisions for the island's welfare and distribution of resources.

Tikopia in the 20th Century

Since Raymond Firth's anthropological studies in Tikopia in 1928/9 the island has slowly been absorbing influences of the 20th century and the rest of the world. At the beginning of the 20th Century the islanders accepted the Christian religion; but when this decision was made, the chiefs decided that they would only welcome one sect of the Christian church. Their choice was the Anglican church – probably a very sensible choice as it hasn't been trying to dominate the island and wipe out all its traditions. We have heard that on the side of the island that receives least visitors (the side furthest from the anchorage), there are still older Polynesian beliefs and cultural traditions practised.

The Tikopian Canoes

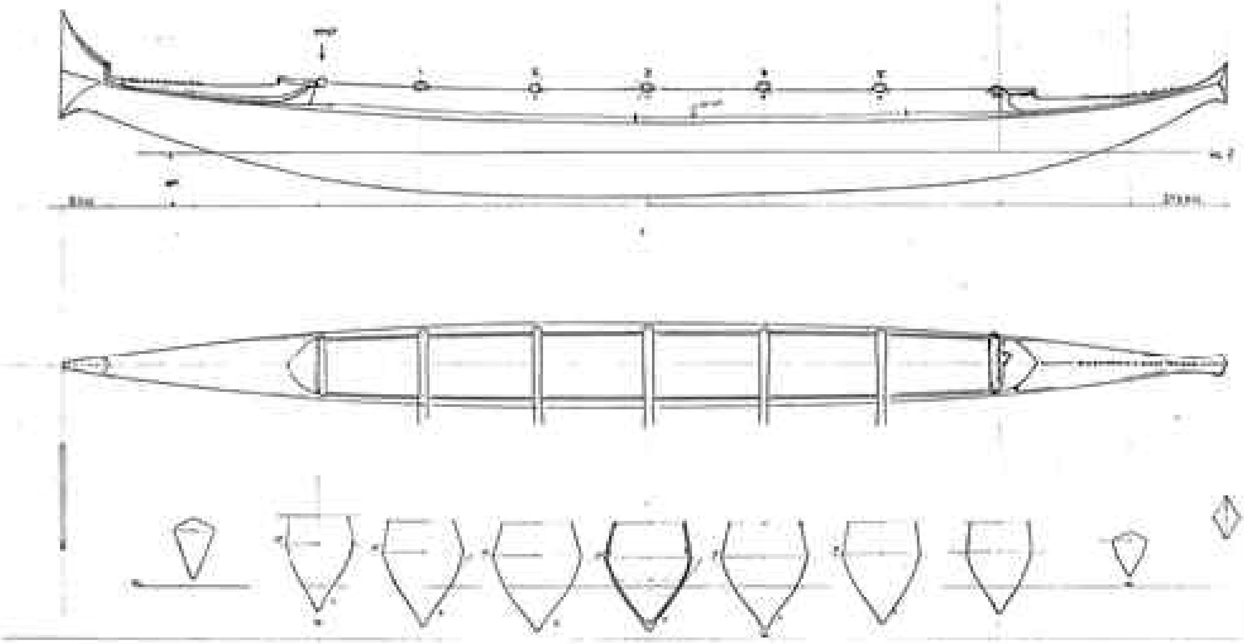
The people of Tikopia and her sister island Anuta have built canoes of a very distinctive design for hundreds of years. This canoe design is probably the only Polynesian ocean going sailing hull design to have survived the total destruction of the Polynesian ocean voyaging culture since the arrival of Western sailors and later missionaries in the Pacific.

Due to Tikopia's isolation and position surrounded by 100s of miles of open ocean, her canoes always had to be seaworthy, even the small ones. In 1828/9 Admiral Paris, an eminent and very knowledgeable French seaman, meticulously recorded some of the few surviving Polynesian canoe designs he found still in use in the Pacific. One of these was the voyaging double canoe of the Tuamotu islands, one of the few remaining places in the Pacific where at that time the population still had a tradition of making longer ocean voyages. A beautiful lines drawing and model of this type of boat is kept in the Louvre museum in Paris. The other canoe hull he recorded in writing was the Tikopian canoe shape. His description of this canoe closely matches the still existing Tikopian canoes built between approx. 1880 and the 1970s. (See Haddon & Hornell - Canoes of Oceania)

As Tikopia had hardly been touched by Western man by the 1820s, it can be true to say their canoe design was also untouched by Western influence and is therefore a unique example of a seagoing canoe hull design that has its origins maybe as far back as 1000 years or more.

The Tikopians and Anutans kept their canoe building tradition well into the 20th century, but by 1996, when we visited the island on our 63' double canoe '*Spirit of Gaia*', no one was building canoes on Tikopia. Some of the canoes they were using were built on Vanikoro, where Tikopian canoe builders still practised.

The canoe building tradition has lasted longer on Anuta. Richard Feinberg, Professor of Anthropology at Kent State University, made a study of canoe building and navigation on Anuta in 1972/3, which he describes in detail in his book 'Polynesian Seafaring and Navigation - Ocean Travel in Anutan Culture and Society '. Canoes are still being built on Anuta, but many canoes produced these days are small and lack some of the distinctive Tikopian hull features.



Tikopian Sacred Canoe ~ Vaka Tapu, donated by Ariki Taumako to Bishop Woods of Auckland in 1916. Now in Auckland Imperial Museum, New Zealand. Measured and drawn by Hanneke Boon, James Wharram Designs, June 1995. © Hanneke Boon

When Tikopia officially adopted the Christian religion, the island owned a 9m Sacred Canoe, a '*Vaka Tapu*'. At this point there was debate that this canoe should be destroyed as it represented the old religion, but fortunately the (great?) grandfather of Chief Taumako had the clever thought of donating the Sacred Canoe to Bishop Woods of Auckland. This means that now this beautiful canoe still exists and is displayed in the Auckland Imperial Museum remaining in perfect condition since its donation in 1916.

The Tikopian Canoe rediscovered

In 1995 we were sailing the Pacific on a round-the-world voyage on '*Spirit of Gaia*'. She is a 63' double canoe designed and built, in plywood/glass/epoxy by ourselves (James Wharram and Hanneke Boon) based on our studies of Pacific craft. She is our interpretation of what a true voyaging canoe would have been like, with only minimal Western adaptations.

When we arrived in Auckland in May 1995 we first saw a small Anutan canoe displayed in the Maritime Museum. This little craft intrigued us as it was the first vee'd Polynesian hull shape we had actually seen. This being a small paddling canoe the vee shape was fairly wide and therefore different from the vee'd hulls we had been designing for years. However when we visited the Imperial Museum and discovered the 'Sacred Canoe', we were bowled over, as here was a canoe hull that was so similar to the hull shapes we had been designing that it made the hair on our arms stand up. James first drew a vee'd hull shape like this in 1957, convinced that this was what a true voyaging double canoe should look like, even though all Western thought at that time was that the Polynesians did not use vee'd hulls and their boats could not sail properly to windward.

We were given permission to measure and photograph the Sacred Canoe. When we drew these lines to scale and superimposed them on the lines of Spirit of Gaia, the similarity was uncanny. What it did prove was that the Tikopian canoe was a very seaworthy hull shape, capable of sailing close to the wind. This we had proven with our sailing of *Spirit of Gaia*.

The following year (1996) we sailed Spirit of Gaia into Melanesia and from Espirito Santo in Northern Vanuatu we headed for Tikopia. We spent five days on the island, met the Chiefs and showed our large voyaging double canoe to Chief Tafua and his family. We also had discussions with Chief Taumako, whose ancestor had given the Sacred Canoe to the Bishop. We studied, measured and photographed all the canoes on the island and we realised that canoe building was no longer practised and the people were losing an affinity with seafaring. This visit made a deep impression on us.

Our studies of canoes in the Pacific and later in Indonesia and the Indian Ocean led us to get more and more involved with experimental Marine Archaeology. In 1997, inspired by the many small canoes we had studied in Melanesia, we designed and built a small and simple 16' outrigger canoe which could be built for under £200 from 2 sheets of plywood, and tested on her the Polynesian Crabclaw rig and steering paddle. Nearly 600 of these 'Melanesia' designs have now been sold all over the world and little outrigger canoes are now sailing in many remote parts of the world and people are rediscovering their sailing abilities. In 2000 we built a 21' version, which we sailed both as an Outrigger Canoe and a Double Canoe. This possibility to take two outrigger canoe hulls and turn them into a double canoe is something we think was done in many Pacific islands. We believe that the more economical to build (in materials and labour time) outrigger canoes were used for voyages of exploration and adventure, but that when a migration was planned the canoes were turned into double canoes with greater deck area and better stability.

A reborn Tikopian double canoe

In 2003 we were asked by an idealistic American, Glen Tieman, who in the early 80s had built one of our 26' Pahi designs and roamed all round the Pacific on her, to design a very simple Ethnic double canoe of around 35', with just enough room in the hulls for someone to sit, cook and sleep. A sort of stretched out version of his previous boat and even more truly Polynesian. This request led to the designing of the Child of the Sea - *Tama Moana*.

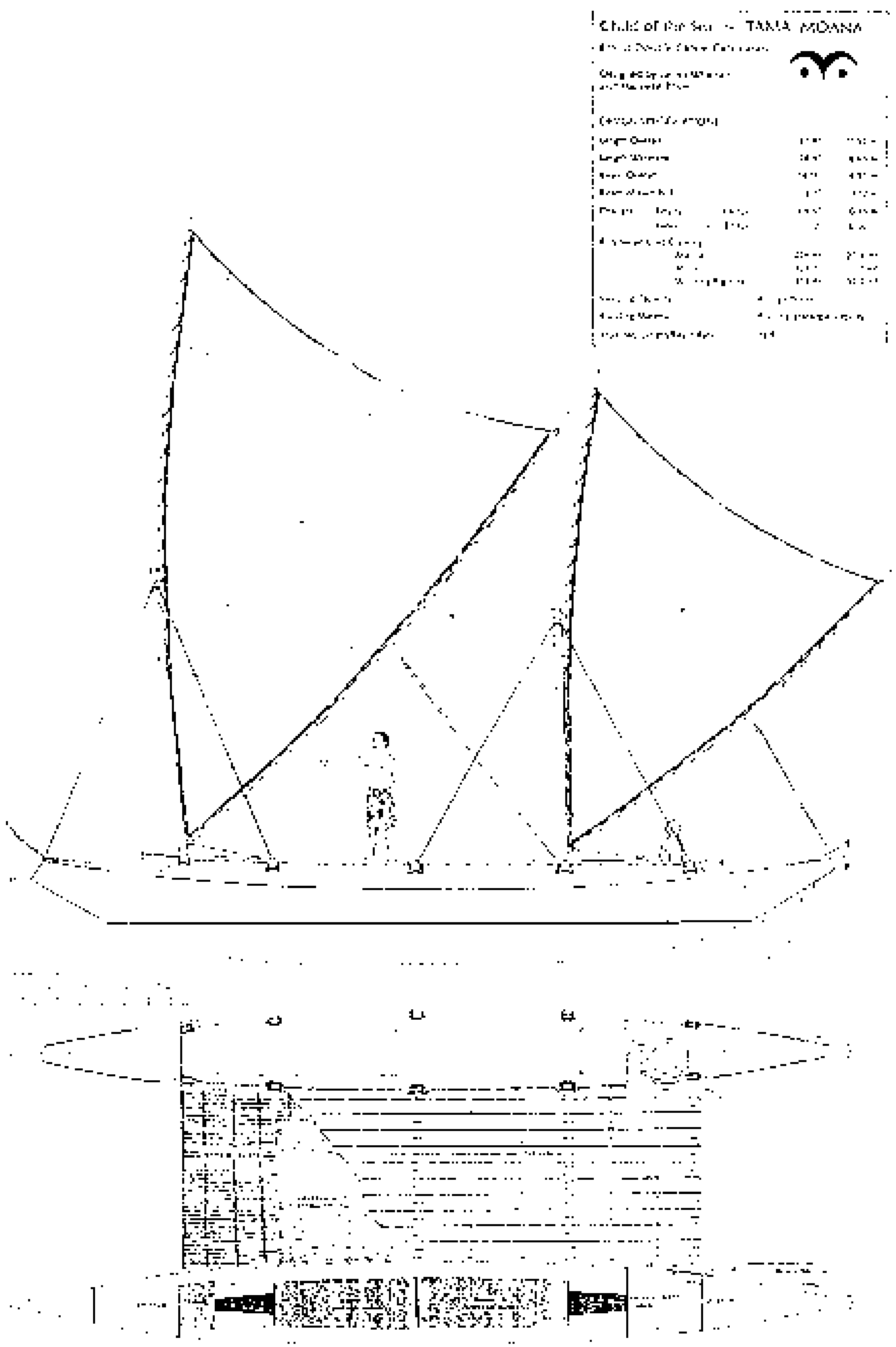
When drawing her we 'knew' we had to use the beautiful Tikopian hull shape, this being the only original Polynesian hull shape capable of efficiently sailing to windward, and tried to keep within the Tikopian proportions and design parameters. She turned out at nearly 38' long, with just sitting headroom in the hulls. The only change from the original design is that she is fully decked over the hulls, instead of just the bow and stern areas. This makes the boat a lot safer and dryer and we felt was a concession that could be made. Also she is a double canoe, though one of her hulls can be sailed as an outrigger. As a double canoe she is capable of making long ocean voyages. For full details of the design of *Tama Moana* see the Study plan (available from James Wharram Designs).

The first Child of the Sea has now been built and is undergoing sailing trials in the Philippines. [*see front cover - Ed*] The second one, being built by Glen Tieman, is nearing completion. A third one has started building in Australia.

The project

Having seen the beauty and sailing qualities of the first sailing Child of the Sea we strongly feel that this boat should now be returned to the people who inspired her, i.e. the Tikopians. This boat will make an ideal communication vessel between Tikopia, Anuta, Vanikoro, the Banks and the Solomon Islands, she can even be sailed to Fiji where many young Tikopians go to study. She is driven by sails and paddles (when necessary), requiring no fuel, though a small outboard motor could be fitted for emergencies. The rig is the traditional Tikopian/Polynesian 'Crabclaw' rig that can be hand stitched (from low cost fabric, as done in Indonesia) by the locals. Crossbeams, spars, centre decking and steering paddles can be made of locally grown timber.

The hulls are not made the traditional way out of a dugout log. Such logs are now very scarce and mostly not large enough to make a seagoing canoe. We therefore designed the hulls to be built out of strip planking over a plywood framework of backbone and bulkheads, which accurately determines the shape of the hull. All the wood is glued and sealed with epoxy resin and glass cloth, this makes the hulls very durable so that with some minor maintenance and painting they can last 25 years plus. Strip planking gives a result and shape closest to a dugout hull and we can replicate the subtle carving of the hull, bow and stern details accurately.


Child of the Sea — TAMA MOANA

The building of the Canoe for Tikopia

Building this boat in Tikopia or Anuta would not be practical, as all materials would have to be imported and the people at present lack skills in building with these type of modern materials. We therefore propose that the hulls be built by our professional builder in the Southern Philippines (near Bohol) and his team of Filipino workers, who have already built the first Child of the Sea sailing. We would like to have a few selected Tikopians/ Anutans participate in the building process, alongside the trained Filipino builders, if they can get permission from the Solomon Islands government to spend time in the Philippines. We would suggest some young enthusiasts, male and female, as well as one or two older men with knowledge of past canoe building or wood working/carving skills. They could bring some local timber with them to make the steering paddles, which they should carve themselves to give them Mana. They would also be responsible for sewing the sails and rigging her, with our help if necessary.

Participation by all the people on the islands of Tikopia and Anuta

It would be good if the people on the islands, particularly the schoolchildren, the new generation that will be sailing the boat, can be involved in the project. At its most basic there could be a regular radio broadcast from the Philippines. A satellite link with a computer on the island would be even more interesting, though we mustn't corrupt the sustainability of Tikopian society by bringing in high tech 21st Century equipment and all the paraphernalia needed to run it. Until now the most high tech piece of equipment on Tikopia is the battery powered transistor radio.

The voyage to Tikopia

Once the canoe is finished and had sailing trials she is ready to make the voyage to Tikopia. The route of this voyage is the same as the Polynesian ancestors made 3000 years ago and follows the 'Lapita Trail'. This sailing voyage in its own right is of enormous interest to experimental archaeology.

Arrival on the island and future care and use of the canoe

The islanders should prepare safe mooring for the boat. A permanent strong mooring block in the existing anchorage would be a good idea, as anchoring there in 20m depth is quite hazardous in the changing weather conditions and strong wind gusts that whip round the island. A sheltered place on the land (cave?) should also be prepared into which the boat can be carried during the cyclone season. The Anutans, according to Feinberg, had an elaborate way of protecting their precious canoe hulls when kept ashore, by parcelling them in several layers of palm leaves, so the wood would not dry out and split. The new boat should be similarly cared for, so she can last for as long as possible. All the loose parts, like crossbeams, centre decking, steering paddles, spars and sails, should also be stored safely. Over time these loose items can be replaced by new ones made on the island from locally grown trees.

Sailing this canoe will also require the people to relearn navigation and sailing skills. We hope there are still existing traditions that can be tapped into for this (they were still there on Anuta in 1972/3 according to Feinberg), otherwise new/old ways can be taught by either ourselves and/or by one of the rare remaining Pacific navigators.

Funding & Publicity

The project will be launched on our web site www.wharram.com, which receives nearly a million hits a month and is visited by all the type of sailors and enthusiasts that would like to see such a project happen. We think we can raise the required money (approx. $US 48.000 - £27,000 for one boat including sails, plus finance to bring several Tikopians to the Philippines) by appealing to these people, as well as through press releases to yacht magazines, Marine Archaeological Societies and private appeals to selected interested persons. The web site will maintain a continuous coverage of the progress of building and sailing and of how much money has been raised and is still needed. If a lot of money is donated, a second boat could be a possibility, which would mean that Anuta could also have its own canoe. The project should of course apply for some form of charitable status to avoid having to pay taxes and so all the money can be used to cover the expenses of the project.

Documenting the project

A sympathetic small film team/camera person should cover the building and sailing of the canoe, footage that can be made into a TV documentary. We feel this film making must at no time dictate the project or intrude into its natural progress.

Who is involved?

James Wharram Designs, as the designers of the canoe are the initiators of the project, but a number of people with connections to and an interest in the welfare of Tikopia are also keen to be involved. The first of these is Klaus Hympendahl, who has visited and lived on the island of Tikopia on a number of occasions. His first visit was on a round-the-world sailing voyage in 1989, when he spent several weeks anchored off Tikopia and got to know the island's people and customs. He was responsible for setting up an appeal for donations after the January 2003 cyclone 'Zoe' devastated the islands of Tikopia and Anuta. These donations have paid for a cyclone proof medical centre on Tikopia. Two years after this cyclone, the islands are still in the process of recovering from its disastrous destruction. The prospect of having their own seagoing canoe will hopefully give them renewed energy to get their island functioning self sufficiently again. Without such a boost the island could slip into becoming a society permanently dependent on outside help. When the idea of building this canoe for the Island of Tikopia was recently presented to the Chiefs, they responded with great enthusiasm, so we must make the project a reality.

Full Circle in 50 years

50 years ago, when James Wharram sailed across the Atlantic in a tiny 23'6" double canoe he designed and built himself, no scholars in the Western world at this time believed that the Polynesians had boats capable of directed ocean voyages. James believed otherwise and set out to prove it by doing it himself.

The building and sailing of a voyaging double canoe for Tikopia and to reintroduce seafaring to the islands of Tikopia and Anuta would be the best possible way to celebrate the 50th anniversary of James' first Atlantic crossing by double canoe and his lifelong devotion to the Polynesian double canoe concept.

Contacts

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[The Current Position

The current position of this Project is that money is starting to be collected, although the Project has yet to complete registration as a Charity due to pressures of the day job. If someone would like to volunteer to help set it up and administer it, please contact Hanneke at James Wharram Designs (see above).

The Project is getting a lot of support from Tikopians, both those resident on the island, and those who have left albeit temporarily to pursue higher education elsewhere, and although Tikopia has no sea transport of its own, it now has email, so Wharrams are in regulatr contact with those there.

Multihull sailors the world over owe a great debt to the islanders of the Pacific for showing that light fast sailing craft can indeed cross coeans safely. Supporting this Project is one way we can repay that debt.

- Editor]

A Different Approach to Sail Design and Constuction

Ken Coles.

Sail Shape

The purpose in writing this article was to present a simple aerofoil section that could be mathematically adjusted for a given sail width so that the inlet angle was tangential to the apparent wind and the exit angle pointed aft - a condition proven by the tell-tales currently used on sailing boats to give maximum power. However to obtain a more accurate estimate of the apparent wind angle other influences needed to be considered such as wind gradient and up wash as well as the effects of mast deflection and distortion of the sail material. The article is not intended to discuss the various controls that modem yachts use to modify the design sail shape. It should also be remembered that while an analytical approach can help in sail shape and settings there is a vast area where judgement and experience is the only solution

Sail Material

The following procedure of designing the sailshape and subsequent manufacture of the sail has been developed from making model boat sails using polyester film (50 micron thickness) which produces a superb sail surface, in general polyester films have the same strength and elongation in all directions and so cannot relax to accept minor errors made when cutting or making the seams, and any errors introduced are obvious and distortion of the sail curvature is inevitable. Whereas with woven sails the weave allows the material to relax and tolerate minor defects in cutting and sewing, as the amount of stretch in the direction of weave is larger than that across the weave.

Sail Plan

The driving force for developing the most efficient sailshape comes from the various yacht racing classes where the sail area is constrained by class rules, which normally specify the major dimensions of each sail. The most obvious difference between various sailmakers is a variation in the cross seam angles used to join the panels. Normally this seam angle is at 90 deg to the head/clew diagonal. However the seam angle can affect the sail shape especially when using polyester film with glued seams.

In general the panels used to construct a sail are formed by the sloping surface of a truncated cone and if each seam passes through its related leech cross measurement point, then the seam angle between adjacent panels that gives the least distortion can be found using a construction given in Appendix I and also maximizes the sail area allowed by the class rules.

Sail Design

Traditionally the course a yacht sailed was determined by sheeting in the sails and repeatedly pointing the boat gently up until the sail luff shook, then bearing away until the sail luff settled down.

The introduction of “tell-tales” in the 1960’s radically changed the understanding of the airflow over sails, as when using “tell-tales” there is no longer any need to point up until the luff shakes, and as the amount that the boat bears away can also be controlled, the sail operates closer to its optimum setting for longer periods. Additionally the “tell-tales”

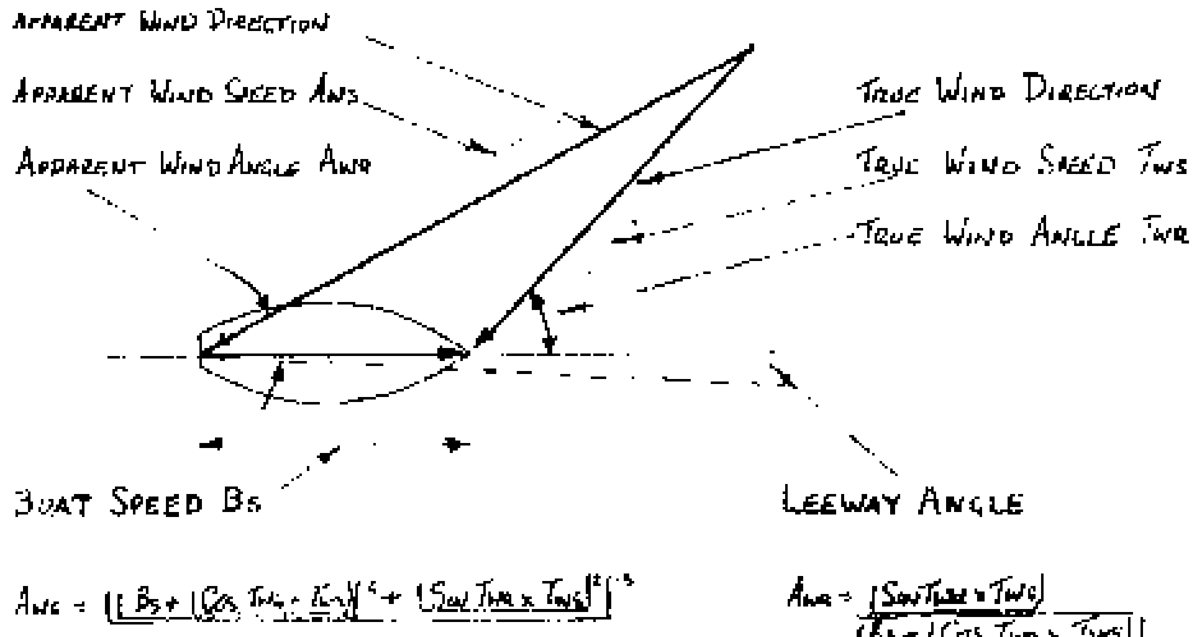


Fig 1. Vector Diagram Wind Speed/Boat Speed

show that to get the most power from a sail the inlet angle must be in line with the apparent wind and the trailing edge must be in line with the exit angle airflow. If the sail inlet angle is correct both windward and leeward luff tell-tales stream aft, if the sail is too close to the wind the windward tell-tale twirls, similarly if the sail is too far off the wind the leeward tell-tale twirls. Single Leech tell-tales, may also be fixed to the trailing edge of a sail if the exit angle is correct this tell-tale streams aft. If the sail exit setting is incorrect, the tell-tale disappears behind the sail as the leach is too tight.

Good sources of information on tell-tales can be found on “www.wb-sails.fi/news/95”, together with earlier explanations in “The Best of Sail Trim” (chaps 4 & 7) by Arvil Gentry. On full size yachts the luff tell-tales are generally positioned some 100-250mm behind the luff.

The art of a sailmaker is to provide that amount of curvature in each section of the sail which will extract the most energy from the wind. Obviously to get this maximum power we must produce a sail shape with minimum drag and that will change the direction of the apparent wind through the maximum permissible angle - which means that the inlet must be inline with the apparent wind direction and the exit must point directly aft or, when more than one sail is involved the exit angle for the leading sail must be adjusted for the downwind sail, (which itself may need to have its entry conditions adjusted) so that the sail combination produces the maximum power

There is no advantage in producing an optimum sail shape when the boat is about to be overpowered, and the true windspeed used to design the sail shape should only be some 80-90% of the maximum windspeed (60-80% power).

The angle between the true wind direction and that in which the boat is travelling is called the True wind angle (TWA) – in practice this angle needs to be corrected for the leeway (generally between 2-4 deg). The vector diagram in Fig l shows that provided the Boat Speed (S), the True wind speed (TWS), and the True wind angle (TWA) are known, then the Apparent wind speed (AWS), and the Apparent wind angle (AWA) can be found. However instead of drawing a diagram each time, the values for the apparent wind speed and angle can be calculated using the equations as shown.

It will be apparent from the vector diagram that the apparent wind angle depends on the wind speed to boat speed relationship. This relationship is not a

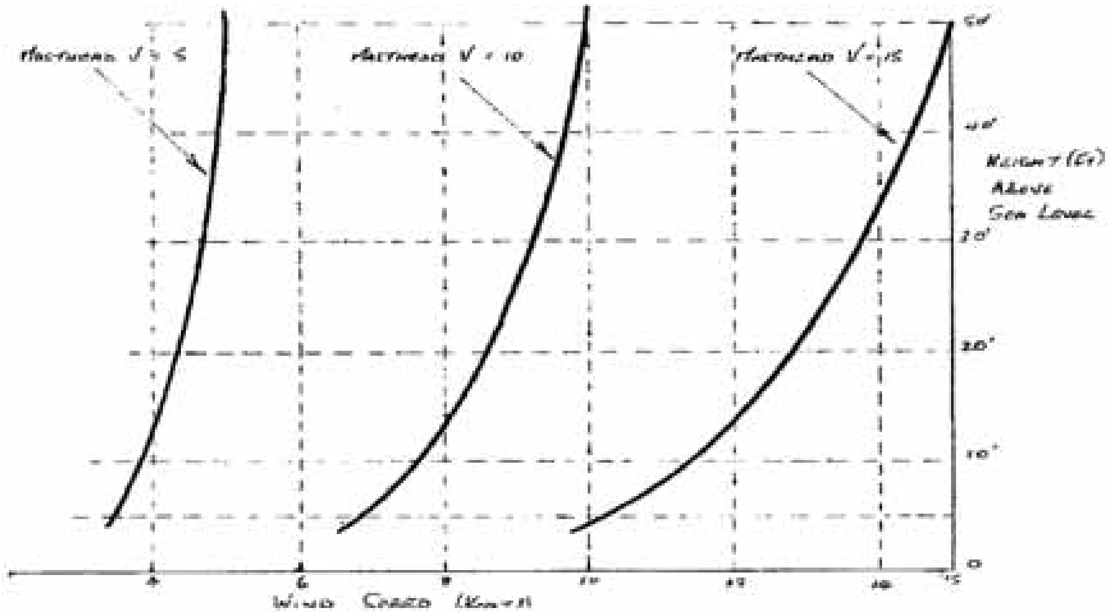


Fig 2: Wind gradient at different windspeeds

fixed value for a given windspeed as the hull resistance increases both in waves and when the underwater surface of the boat deteriorates which causes the speed to drop. This explains the often-repeated comment that the sail should be fuller when sailing in waves.

Wind Gradient

Wind speed increases with height generally as shown in Fig 2; the calculations as given in Fig 1 must be repeated for each particular sail height chosen. Several equations exist to calculate wind speed at different heights. One equation derived from measurements taken during the Gimcrack tests gives the equation: -

$V_H = 0.464 * V * h^{0.167}$

where h = selected height (ft),

V_H = wind speed at height h,

V = wind speed at 100 ft.

However these wind speed values require to be further adjusted, as the wind gradient is increased in calm (overcast or misty) conditions and reduces in gusty conditions (Cumulus clouds). Obviously the degree of twist required in the mainsail leech must vary with the different wind gradients and this twist is controlled by a combination of the kicking strap and mainsheet, and is monitored by the use of a number of leech tell-tales (usually 3).

Similar conditions apply to the headsail which is provided with tell-tales both at the luff and the leech. In practice the luff tell tales are used to control the angle that the boat is sailed to the wind and the leech tell tales control the sail trim.

Upwash

A further factor that requires to be considered is the amount of "Upwash" experienced by the sail. The term upwash is used to describe the angle that the airflow at the leading edge of a sail is deflected, and

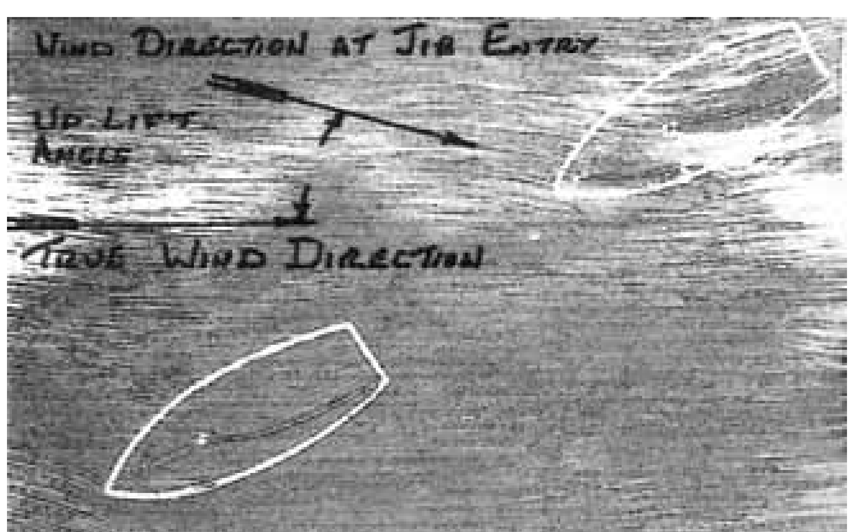
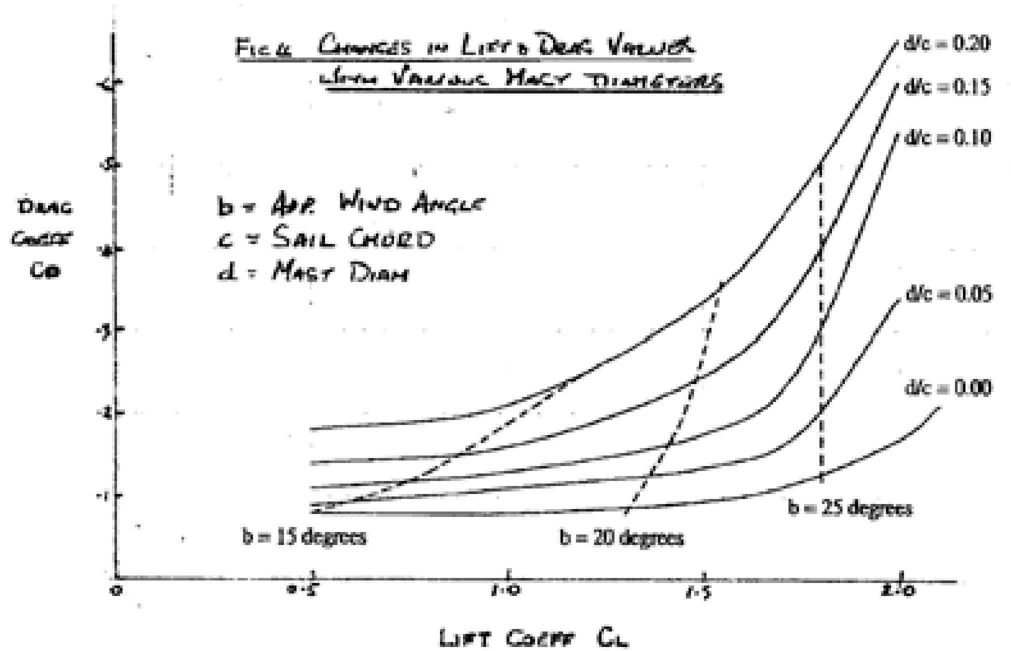


Fig 3: "Upwash" at jib entry



which effectively increases the angle of attack of the sail as shown by the flowlines in Fig 3.

A similar lift effect is found when sailing close to a lee shore; and this is also the reason that, when setting a boat up in its basic trim with a main boom angle of 5-7 deg, the jib boom angle should be in the order of 10-15 deg.

The problem with upwash is that there appears to be no data on the angle that the air is deflected as :-

(a) The upwash angle increases between the foot and the head of the sail.

(b) The maximum upwash angle is dependent on the angle of attack.

Some sources estimate that the airflow over the leading edge may be deflected as much as 30 - 40 deg at masthead. In this article the maximum angle of deflection at the masthead has been estimated as 14 deg for the mainsail and24 deg for the headsail, the effects of height have been adjusted by multiplying this max value by the ratio of (Seam height / Masthead height $)^2$ - all heights being measured from the waterline. Therefore:

The Correct Apparent Wind Angle AWC =
the Calculated Apparent wind Angle AWA *
the Upwash Angle UWA.

Clearly the amount of upwash must be influenced by the amount of air that passes under the foot of the sail, and it is advantageous if the boom height is kept to a minimum

Sail Camber.

The amount of camber introduced into the sail to provide the optimum inlet and exit conditions can be made by either, or a combination of two methods:-

a) The first method to shape a sail is to cut each seam with a degree of curvature, the amount of curvature being varied in each seam to produce the required shape, the amount and distribution of camber is more controllable using this approach.

Precise measurements are necessary with an accuracy in the order of plus or minus 0.5mm when producing the seam curvature. This degree of accuracy is more easily obtained using a jig or mould - details of which are given in Section C

b) The other method is to cut the luff of the sail with an amount of curvature which when hoisted on a mast will introduce the required camber into the sail, Traditionally masts were used with little mast deflection, which meant using a heavier mast with a thicker wall section or a larger diameter with the associated adverse effects on the stability of the boat or the aerodynamics of the sail

Modern practice is to use much lighter and thinner masts which bend under the sail loadings and these deflections are amplified by the combined vertical loads from the shrouds, backstay and forestay

Mast Bend

Before designing one must select the final sail shape and the initial amount of mast bend (or forestay sag) for the design windspeed.

There are several ways to introduce more bend into the mast :-

(a) One is to reduce the mast diameter. which makes the mast weaker as the slenderness ratio is increased and the section modulus is reduced. This method has the advantage that the rig is more efficient, as shown in Fig 4.

(b) Another is to reduce the mast wall thickness - which reduces the mast strength and weight, with beneficial effects on stability.

(c) The compressive loading on the mast can be increased by reducing the shroud base width.

(d) A further approach is to use a material that is more flexible, i.e. that has a lower Modulus of Elasticity (E) (such as carbon fibres).

When setting a mast up the rigging is adjusted to produce a forward prebend in the lower mast that is compatible with the sail luff. This has the effect that as the loads increase the mast bends in the forward direction that has the effect of flattening the sail profile by pulling the luff forward while at the same time freeing the leech as the masthead moves downward. Additionally these deflections have the effect of freeing the leech as it moves to leeward which essentially luffs the sail and reduce the sail power..

Currently, with modern rigs the mast flexure is made so that it automatically adjusts to depower the rig as the windspeed increases and repower as the windspeed drops.

Sail Distortion

The sail shape is also affected by the varying wind loadings, as the sail luff is supported by either the mast or the forestay, the forces induced in it are lower than those found in the sail leech. The effect of the higher loading in the leech means that it stretches more than the luff and allows the sail to free, therefore the design sail entry and exit angles require to be corrected. The easiest solution is to design the sail with slightly more mast bend at the design windspeed which then allows the sail to take up the correct shape.

Mast Deflections

It is important that the shape and amount of mast bend is known before designing a sail as it has a major effect on sail curvature. The measurement of mast deflections is much easier with models than in the case of full size yachts. With the boat fully rigged and the mast marked at the points as shown in Fig 5, a line attached to a rubber band is now looped

FIG 5 MAST DEFLECTION MEASURMENT

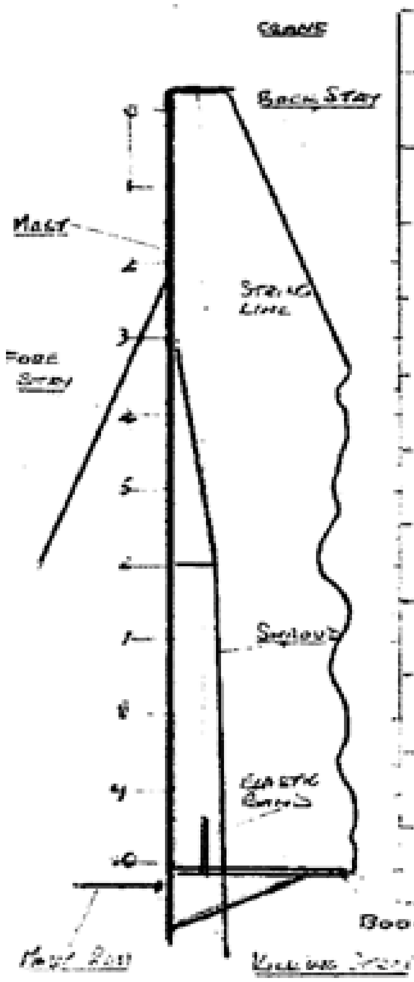


TABLE (1)

STN	DEFL	CONSTANT
0	0	0
1	4.5	.455
2	7.8	.788
3	9.62	.972
4	9.90	1.00
5	8.72	.851
6	7.24	.751
7	5.65	.571
8	3.92	.396
9	2.15	.217
10	0	0

Fig 6 Jib Luff Curvature

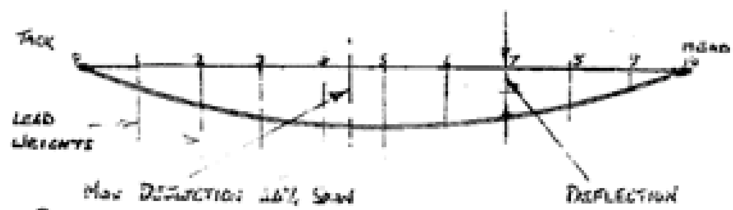


Table 2.

Station	0	1	2	3	4	5	6	7	8	9	10
Deflection	0	2.2	3.9	5.0	5.6	5.5	5.0	4.1	3.0	1.6	0
Constant	0	.393	.696	.893	1.0	.982	.893	.732	.536	.286	0

around the masthead backstay crane and the other end tensioned and tied around the boom.

The "No Load" deflections are taken at each point with everything slack. The rig is now set up to normal sailing trim and the deflections again measured. If the No Load deflections are subtracted from the Set Up deflections, then the true Mast Deflection values will be obtained and show the magnitude and pattern of mast bend for that particular rig. The deflection values obtained for the mast are dependent on the shroud, spreader, forestay attachment point, kicking strap, main sheet, and backstay tension and these factors are unique to your boat - further tests could be carried out to show the effect each control can have on both the mast and the sail settings. Table I shows typical values for a model boat.

These deflection values can be further manipulated to show the various mast deflections when using different amounts of mast bend as follows:- If each of the True mast deflection values at each point are divided by the Maximum True mast deflection a factor is found for each point. If a different maximum mast deflection is selected then the associated deflection at each point can be found by multiplying the selected maximum deflection by its appropriate factor.

Jib Luff Curvature

Headsail luff curvature (hollow) is complicated as it is a catenary which is subjected to variable loading as determined by the sail chord and windspeed at each height. To simplify matters a test rig as shown in Fig 6 was used to represent the sail luff.

The apparent windspeed AWS at each height was calculated as previously, and the sail chord W at each height was also found.

The load at each point is proportional to AWS^2 x W - and this was replicated by cutting pieces of 1/8" plumbers solder to the appropriate length and hanging them over the luff cord at that position.

The deflections obtained indicate that the point of maximum deflection is some 44% above the tack. The associated deflection factors are given in Table 2 which can also be manipulated as above.

The maximum amount of curvature for any headsail is in the order of 0.1 to 0.3 % of luff length depending on the mast stiffness and backstay tension.

Sail Making

The problem is to find out what sail section will produce the required inlet and exit conditions in order that a jig for each seam can be made. From the tell-tales we know that the sail must be in line with the corrected apparent wind direction. Further for a mainsail to obtain the maximum power the sail must deflect the wind so that its direction when leaving the sail must be directly aft (or to suit any down wind sail), to achieve this the wind needs to be deflected at an angle that is equal to the Corrected Apparent wind angle Awc as given in Fig 1.

The shape presented in Fig 7 has been derived from practicalities, and makes no pretence to being an exotic aerofoil shape, neither is it based on any aerodynamic theory. It does however have several useful features as it allows an aerofoil shape to be calculated using a construction as follows:-

If at each seam height an arc Ra is drawn tangentially to the Corrected Apparent Wind , and from the same tangent point a Sail Chord is drawn such that it makes an angle of $^2/_3$ angle AWC to the apparent wind direction.From the other end ofthe sail chord (trailing edge) a further line is drawn such that it makes an angle of $^1/_3$ angle AWC to the sail chord and at the same time is tangential to the arc produced by radius Ra.

As the sail entry is tangential to the curve produced by radius Ra the sail entry must be inline with the Corrected Apparent wind Awc. Similarly as the exit surface is also tangential to the radius Ra and as it makes an angle of $^1/_3$ Awc with the sail chord it must point directly aft. Since the Sail Seam length Sl and Angle Awc are known then the radius Ra can be regulated by repeated substitution (or in computer language iteration). Once Ra is known the values for the sail chord and the maximum camber height and position can be found which complies closely with current sail design practice (Max camber at approx 45% of the chord with a 1/7 ratio).

Obviously the effects of drag and sail loading would affect the above shape but it is considered that the degree of accuracy required to produce this shape is unobtainable in small sails.

Although this article is based on using the above sail section there is no reason why the following method of sailmaking should not be used with other sail sections.

A jig section as shown in Fig 8 is now cut out (with the station pitches increased to allow for the seam angle) for each seam including the sail foot. Each jig should have its base some 25mm below the chord line to allow the jig to be fitted to the sailboard. The base of each jig can if desired be cut at an angle to the chord line to simulate twist when building the sail . The marking out of each jig can be simplified if the camber height is calculated for a number of equally spaced sections each with a pitch of $^1/_5$ x(Distance the Leading edge - maximum camber point), the jig shape from the aft tangent point to the trailing edge being a straight line. Datum points at the luff point (Station 0) and the max camber point (Station 5) should be positively marked .

Note:- The upper surface of the jig cannot be true to each panel and the amount of distortion introduced into the sail can be minimised by making the jig as thin as possible and also fairing the upper surface as appropiate. (After use the seams may yield and further accommodate any misalignment - similar to stretching of sails in the age of cotton.)

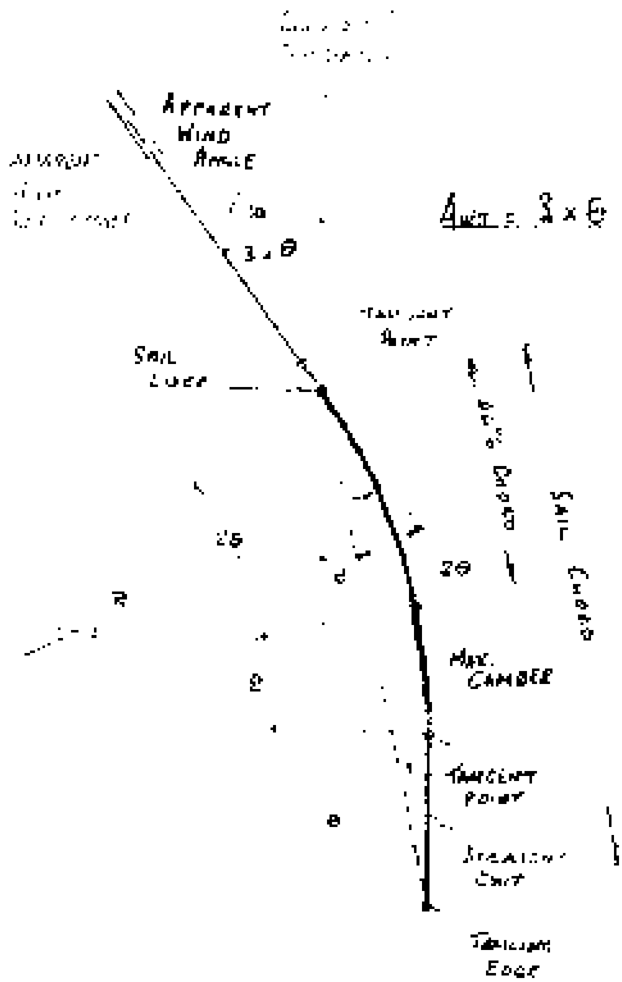


Fig 7 Development of Sail Sectional Shape

A full size drawing or layout of the sail should now be made which allows both the final sail shape to be checked and the shape of each panel template to be obtained.. The panels can now be marked out, solid cutting lines are now marked 10mm outside of these corner points. The luff point being the datum on each seam .

A sailmaking board must be made as shown in Fig 9 (Photo) and a full size layout of the sail marked out showing the luff as a curved line as produced from the mast bend values previously obtained.

The seam lines are now drawn at the correct angle from each of the intersection points, and the sail section jigs are now attached to the sail board at and below the associated seam line as shown in Fig 9 .

The process of making the sail is carried out in several stages as follows:-

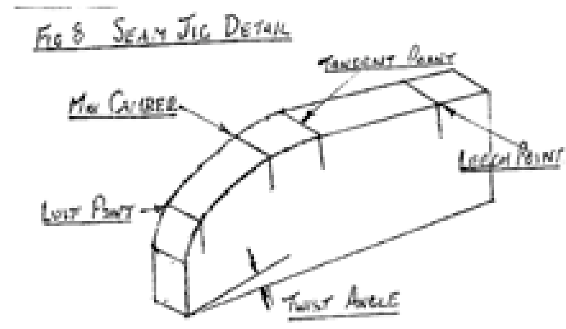
l) The sail panels are now cut out and sailmaking can begin

2) The profiled surface of each jig is coated with a repositionable adhesive.

3) The separate panels are now fixed to the jigs starting with the lower panel, the panels are positioned so that the upper and lower luff points previously marked on the panels are aligned with the respective points on their jigs, and in addition the upper seam points of the panel must be aligned with the top face of the upper jig. The panel is now adjusted on each jig until a fair shape is obtained. New reference points are now marked on each seam both at the luff and the leech and the point of Max. camber from the cut marks previously made on the jig. Finally the surplus film above the top jig upper edge is cut off - which produces the correct curve line for this edge. The panel is removed from the jig, the process being repeated for the remaining panels with exception of the head panel.

4) The upper panel with reinforcement and eyelet fitted (as this takes some loading when building the sail), is anchored to a datum block and is adjusted so that the head position is at the correct distance from the upper jig. The head panel lower edge is now joined to the upper jig and positioned until a fair shape is obtained. When this fit is satisfactory the surplus film below the jig lower edge is cut off which again produces the correct curve line.

Notes :- a) In the case of sails that have relatively large head cross measurements it is preferable to fit two small eyelets as



this allows better control of luff and leach tensions, and allows the sail to take up the required camber.

b) While the initial fitting of the sail panels can be carried out with the sailboard horizontal, it is recommended that the final building of the sail is carried out in the vertical position - this eliminates any tendency for the sail material to droop between jigs.

5) Double sided adhesive tape is now fitted on the upper panel in way of the lower edge seam and the next panel is fitted at this position so that the reference points made in para. 3 above coincide with their respective jig marks, and the trimmed upper edge of the panel is in line with the upper edge of the jig. A reasonably fair sail shape should be found but again this can be further adjusted until the optimum shape is found. The bottom edge of the sail is now trimmed to the lower jig edge which again produces the correct curve line. This process is then repeated for the remaining seams.

6) When the sail has been completed it can be removed from the jig , but some care is required when detaching the seams from the jigs and removal should always carried out from the top panel downwards. In this way any load is taken by the sail and not by the seam.

Fig 9: Photo of jig board

7) The seam can now be sewn, the main difficulties found when making the seam is that the double sided tape grabs the film and prevents accurate alignment, and while the use of a hair drier allows the seam to be released, minor stretches introduced in releasing the panels remain , and that pristine seam aimed for has been lost. Another disadvantage of double sided tape is that if it is stretched when taking it off the roll it produces rucking in the

polyester film. A further problem found when sewing is that the glue on the tape gums up the needle and causes dropped stitches - this can be alleviated to some extent by lubricating the needle

8) The completed sail is now aligned with the full size drawing and held in place with masking tape tabs. The luff line is now marked to correspond with the mast bend figures previously obtained less some 2.0mm to allow for fitting a luff tape. When marking the luff offsets a further mark should be made on the sail some 8.0mm from the first mark to provide a guide when fitting the luff tape. Straight guidelines for fitting the luff tape can be drawn between the marks (it is better to have precise straight lines rather than an inaccurate curve), the sail can be released and the luff shape cut.

9) Separate sections of luff tape (using a suitable material) are fitted to one side of the sail, with an overlap between each luff offset mark and following the above guide line. With mainsails this overlap provides the reinforcement for the luff tie cringle.

10) The sail can now be turned over and the luff wire fitted along the sail edge. The luff tape can now be folded section by section to complete the seam before sewing.

11) The corner reinforcement patches (see above notes) are now fitted together with their associated eyelets. The current practice of using woven materials to provide the head and corner reinforcement on Polyester sails is questionable since when loaded the woven material distorts more easily than the polyester - surely the best reinforcement is provided by using the same material as the sail and ideally patching each side of the sail to prevent distortion

12) The luff eyelets can now be fitted at each luff tape overlap which provides the reinforcement. When securing the sail to the mast care should be taken that each tie is exactly the same length otherwise distortion of the sail will be introduced. Obviously the calculations required to produce the seam jig shape are manually quite lengthy but a computer programme has been written with outputs that can be run on simple computers.

Ken Coles

Appendix I

No precise method exists to join two cones at an angle, but a method developed by sheet-metal workers shows that the angle which produces the least distortion, is the mean of their base angles.

To simplify finding the best seam angle the following shortcuts have been made which should not affect the result :-

a) The jig profile as shown in Fig 8 is assumed to be a full arc.

b) The apex angle is the same for both the sail panel and the cone it develops - the difference in chord length to arc length with a 10% camber is about 2.5%

c) the sail luff is formed by a straight vertical line.

The vertical height from the head to each sail cross measurement point is obtained from ,the full scale drawing required in Section 5.

If each sail panel is considered to be part of an isosceles triangle as in Fig l0 below, then for each Panel :-

Apex angle Aa = Atn [(Wb – Wt)/(Hb-Ht)]

Note: The values Hb & Wb for the upper panel also provide Ht & Wt for the lower. As the sum of the angles of any triangle equals 180 degrees, and also as each side of the generating triangle are equal, then the angles that the base makes with both the luff and the leech are equal. Therefore :-

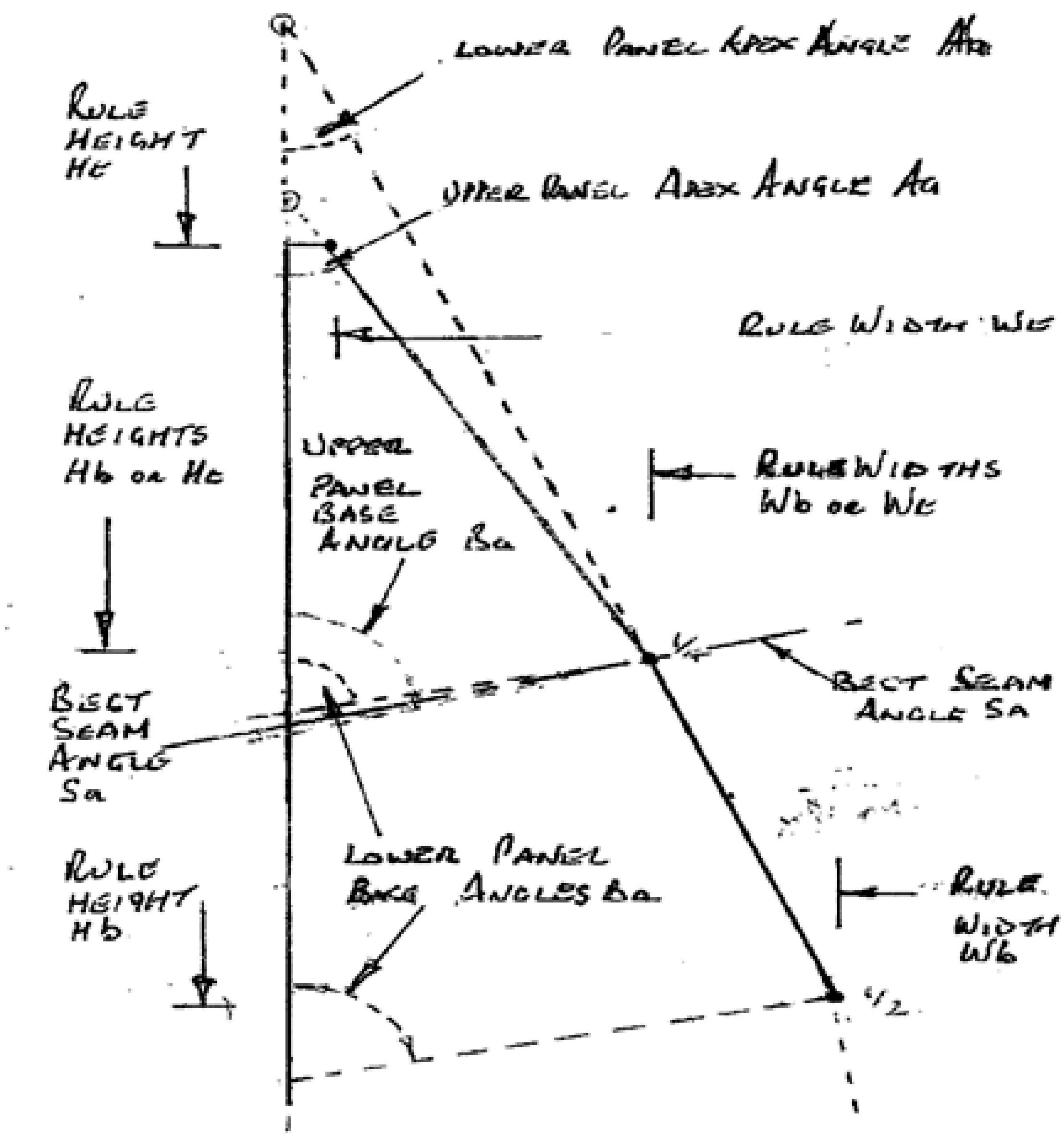
Base angle Ba = [(180 - Aa)/2]

Since the base and the top of the panel are parallel, the angle Ba also applies to the top of the sail. Therefore for any two adjacent panels the seam angle giving the least distortion is :-

Best Seam angle Sm =

[Ba upper panel + Ba lower panel] /2 .

FIG 10. CONSTRUCTION FOR BEST SEAM ANGLE.



Stingray

Patrick Tuesday Wheeler

My entry to the John Hogg Prize is a boat inspired by the natural form of the stingray. Highly original, this stingray design is closer to and more in harmony with its surroundings than typical vessels.

The craft expresses the characteristics of:

- an ability to explore in shallow waters
- a facility of resting on dry land for long periods of time which reduces the expense of mooring
- during movement in water, the ability to move from semi-displacement towards planing
- an all-weather design

The vessel blurs the edges between boat and plane, and is amphibious. Highly novel and unlike other craft, it has similarities to the catamaran but has the advantages of a monohull. It has been described as a steerable interactive kinetic sculpture – a refuge, safe from the sea.

The stingray-style boat would function for weekend or longer breaks with basic provision of living accommodation. Mod-cons would include berths for 3 or 4 persons, heating, and limited freshwater storage. Propulsion is via a large propeller at the front which is raised well above the water line. This is powered by a 100hp diesel engine. In addition, there is a slower diesel hydraulic propeller at the rear. There would be one or two masts to hoist sails in order to save fuel or drift along.

The fully-fuelled, ready-to-go weight would be approximately 3.5 tons including 3 or 4 persons.

If I won the £1000 prize I would spend it on materials for a new 8 foot version. These materials would include plywood, polyester resin, a second-hand diesel engine and some hydraulic components.

The final construction cost is expected to be in the region of £40,000.

I have always been interested in aircraft as well as boats and some of the construction techniques in this stingray craft have been borrowed from aircraft.

I have constructed a 1/9th scale model, which including the motor weighs 14 kg. I have conducted buoyancy tests using this model at Milford Haven in Pembrokeshire.

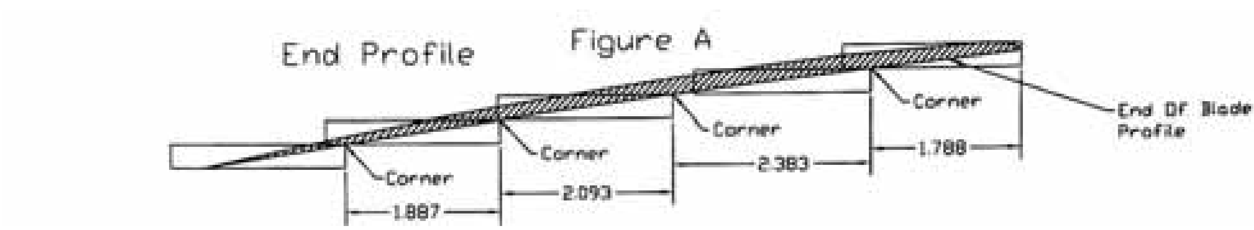
CREATING AN EFFICIENT PROPELLER

Jack Goodman

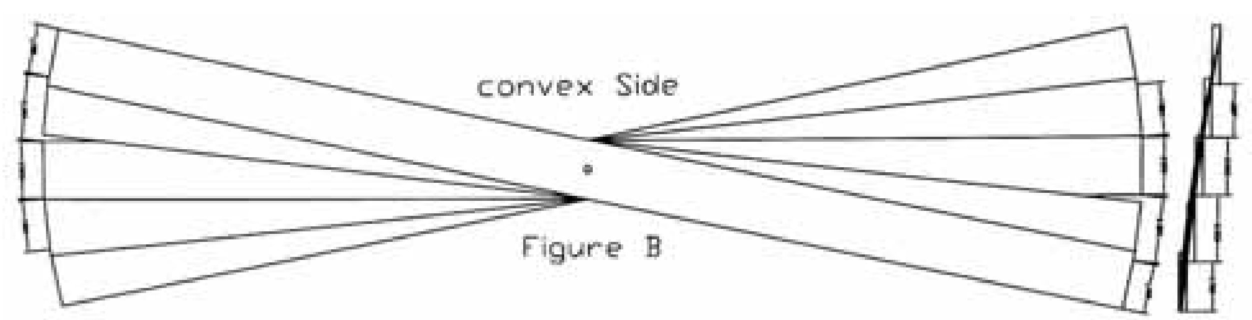
I recently needed an efficient propeller to make a down wind faster than the wind model. Looking through the catalogues turned up a good selection of fans, but nothing with a good lift to drag ratio at a price I could afford. Since I already knew the approximate diameter, pitch and profile, I decided to make one myself. It turned out so well I decided to share the procedure. When making a wooden propeller, getting the perfect twist and making both ends the same is not as difficult as it first seems. If you follow a few simple steps, you will end up with a propeller that looks suprisingly like the ones the Wright Brothers made in 1903, and they were only a few percent less efficient than modern propellers.

Six Steps

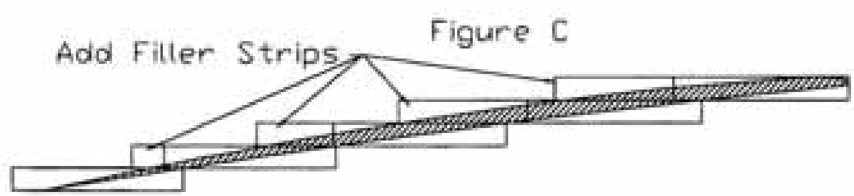
Step one. Draw the end profile with the pitch and thickness that you desire.



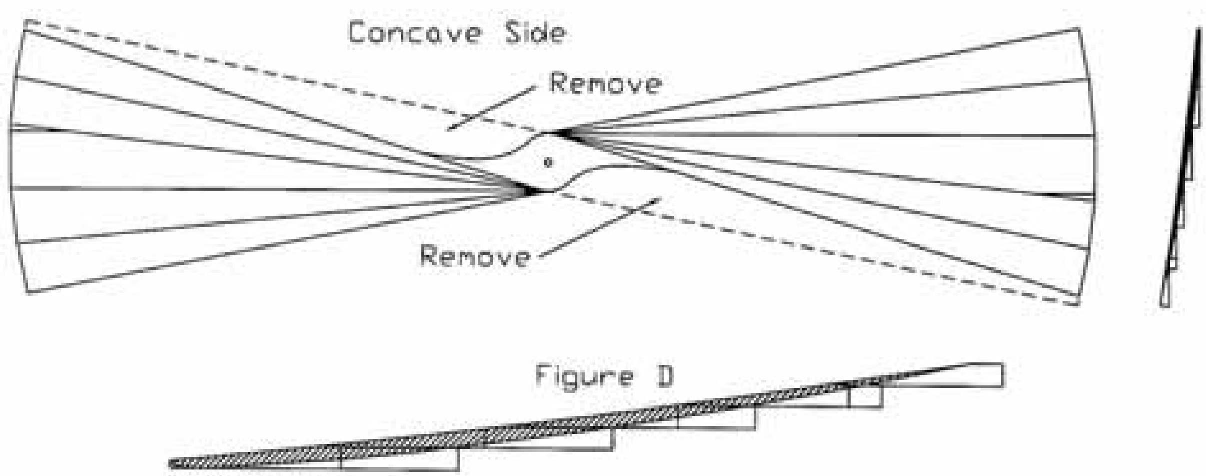
Step two. Find straight-grained wood strips of the width and thickness to fit the profile drawing, and of the length of the finished propeller. Since they are going to be your final pattern, you must have a minimum of 5 pieces. Draw the ends of wood strips exactly to scale, and arrange them as in Figure A. The inside corners must exactly intersect the bottom of the propeller profile. Measure the distance between the inside corners of the wood strips carefully, as this determines the final shape. It is easier to keep the dimensions accurate if the drawing is done with a CAD program.



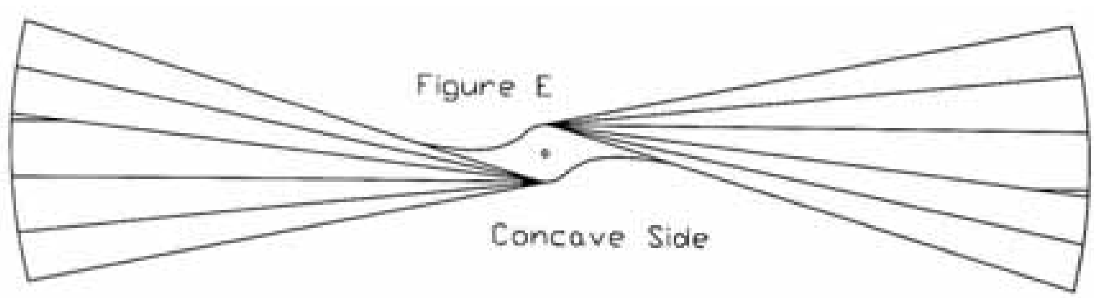
Step three. Drill a hole in the center of each strip of wood and arrange them on a flat board with a pin in the hole, as shown in Figure B. The concave side of the propeller should be down, and the spacing of the strips measured on the bottom side. It is critical that each strip be rotated by the exact amount measured in the drawing. Check both ends and mark the strips. To be certain the ends don't droop and alter the pitch, cut short pieces from a spare strip of wood, and stack them up to support the ends before clamping. Use thin polyethylene sheeting as a mold release to keep the supports from sticking to the propeller. You will also need some filler strips on the convex side, see Figure C. They do not need to be accurately cut. If there are still small gaps, more pieces can be added later. After you are satisfied with the arrangement, take the pieces apart and glue them all together.



Step four. After the glue has hardened, flip the assembly over and sand the outside corners off as in Figure D. If you sand exactly to the inside corners and use them as a guide, this side of the propeller will exactly match the profile, with the twist accurate all the way to the center.



Step five. Cut off the surplus wood at the edges. The propeller should now look like Figure E.



Step six. Turn the assembly over again, and sand the convex profile. This is not as hard as it might seem. Even though this part is free hand, if you use the pattern of the wood as well as the balance of the blades, both sides will be the same. Note; painting the sides of the wood strips a contrasting color will make the pattern more visible. If all goes well you will end up with a work of art as well as a very efficient propeller.

Jack Goodman
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Rotorboat

Stephen Thorpe

Fig 1. The completed boat.
From any distance you can't see the rotor spinning.

I have written this article to introduce my rotor boat, which has sailed a score of times over the last two summers off Seaford in Sussex. I hope you'll look at my very basic website, www.rotorboat.com , which is designed for the uninitiated reader but which will provide a more graphic sense of what follows.

I should point out three things immediately: one is that I cannot yet provide the scientific data that many readers will crave - graphs of lift against wind speed, L/D ratio at different rotor speeds, etc. I hope these will follow, of course, and I'm working on the means of providing them. Another thing is that the rotor uses an electric motor to spin it. Readers for whom such a revelation is anathema should fling the paper down right now. A third point to make right away is that a rotor boat is built for comfort not for speed. In other words, this project is not aimed towards developing fast boats, but bigger boats for unskilled, lazy and impecunious people like me.

I suspect most readers of this article will already be familiar with the Flettner rotor in theory. A spinning cylinder entrains air to create a vortex. If that air has a flow relative to the rotor, the vortex will interact with that flow to speed it up on one side of the rotor and decelerate it on the other. The faster-moving side experiences a lower static pressure, the slower side a higher static pressure. In cross-section, the theoretical points at the cylinder surface that separate low and high static pressure regions - points at which the pressure remains at its freestream value, are called stagnation points. The rotor and whatever is attached to it will move from the higher pressure towards the lower. The phenomenon is generally referred to as the Robins effect or the Magnus effect. Simple to grasp in essence, the fluid dynamics involved are in fact extremely complex, such that this is still a large area of study with new research appearing continually. I am no academic, and the selection of papers I set myself to read in an attempt to bolster my instinctive confidence in the idea were so involved, equivocal, tentative, and for want of a better term, 'virtual' (they nearly all rely on pre-existing fluid dynamics software to create computer simulations) that I rather gave up looking at them. Not that their subject matter is not pertinent: the thickness of the vortical layer with different Reynold's numbers; the reduction in vortex shedding at different rotational ratios; re-circulation in the vortex detaching the stagnation point: these subjects define the problem, but for me it was quicker (and more fun) to do the real world experiment than to grapple with the theory.

Flettner gave his name to the rotor after a ship converted to his design was a success. Since then various patents relating to the idea have been filed - mostly elaborations without much stress on practicality, and since lapsed.

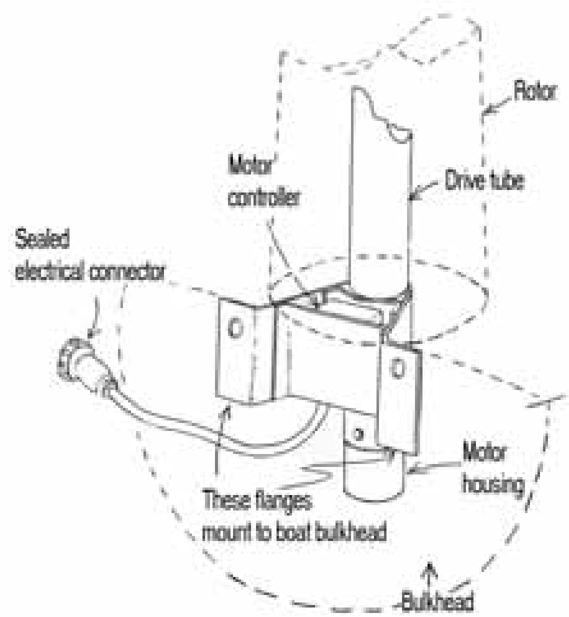
I became interested in the idea in blissful ignorance of this history. I expect readers will be able to point out rotor trials and projects I'm unaware of. I came to it from the perspective of flying rather than sailing. I felt that my idea merited investigation - even after learning that I was not the first but about the ten-millionth person to have that particular eureka moment - because I thought it would be more efficient than the Flettner rotor, which was short relative to its diameter and spun slowly. I saw a very strong, cantilever, tapering, high aspect ratio rotor, of a length less than the hull length, that spun fast.

Before moving on let me argue the advantages of my form. I always saw my rotor as a glider's wing, which is long and thin because high aspect ratio means less induced drag. The longer span you've got, the less tip loss can erode the lift which that span delivers. This is equally true of the rotor. Then, the longer the rotor the more it projects into faster moving air higher in the atmosphere's boundary layer. The smaller the diameter the less deck space is used. For any given rotor surface area, a smaller diameter means a smaller moment of inertia, and this is critical in minimising the power needed to run the system. The inertia and the induced drag arguments reinforced each other and made me set on a high aspect ratio. In practice, my doubts as to whether I could build the thing in the first place led to my initial effort being just 2.4 metres long, and the current rotor, that I consider the true prototype, being 3 metres long.

I produced a very conservative design for the dinghy so that if the rotor didn't work I'd have a nice rowing boat. . . Newhaven and Seaford Sailing Club's safety boats are a reassuring sight when setting sail.

The hull is a homemade and regrettably crude glassfibre sandwich, made using a vacuum-bagging technique I'm still rather coy about, which I dreamed up to suit the purpose. I think the technique could be practised to turn out fine and economic results, but you wouldn't think so looking at my boat. It's 3.6 metres long and weighs about 40kg without the rig. Due to the core density of 80kg per cubic metre, the dinghy wouldn't sink even if full of holes. It also has a large sealed bow compartment and a stern seat of large volume to make the thing determined to float even if full of holes and people. It features a very strong ply bulkhead to provide a rigid mounting for the rotor drive assembly. That's all you need to know about the dinghy, which after all is neither here nor there in regards to the rotor concept. Oh, except that I built the centreboard trunk to allow the board to be slid back and forth to establish the best CLR in relation to CLE. This point is important to the rotor concept as a whole, and will be revisited.

The rotor itself is 3 metres long, with a root diameter of 300mm and a tip diameter of 150mm, giving an aspect ratio of 13.3. In essence it's just a sheath: a single-skinned carbon fibre sheath connected to a drive shaft by two carbon/foam sandwich discs, the lower of which incorporates an aluminium brake disc. A couple of extra carbon tow stiffeners and a thin plastic cap complete the rotor. The drive shaft is carbon. Excluding the rotating bearing elements and rotor element of the motor, the whole rotating mass is about 3kg, and the all important peripheral mass - the rotor sheath itself - is 2kg. The upper half of the rotor is watertight.



Rotor drive assembly

To turn this 2kg weight, on average 112.5mm from the axis of rotation, at over 500rpm, with the drag that entails on a 2 square metre surface area, I use a 12 volt electric motor 72mm long, diameter 63mm - smaller than a tin of beans or a coffee mug. This if nothing else should illustrate why this rotor is something to consider. By the way, the motor's not having to work hard to do this. The system as I've built it has the motor encased very tightly, with no assisted cooling, and it starts to struggle with high temperatures somewhere above a continuous 1,000 rpm. The motor is coupled directly to the drive shaft, and the whole sits in a rigid 2024T alloy tube with two hugely overspecified bearings keeping the lot where it should be. There is a sadly ineffective brake at the head of this tube. An aluminium frame clamps the tube and allows the whole rig to be mounted or demounted very quickly to the dinghy. The weight of this drive system, less the battery, is less than 10kg.

From the motor's controller a tough, watertight cable assembly is connected to the bulkhead, where two leads go to a 10kg battery in the watertight bow compartment, and other signal leads are passed via a conduit to the stern seat, to which the control box can be connected. Thus, I sit at the tiller with a small buoyant and watertight box that allows me to brake the rotor, control its speed and direction of rotation, and monitor battery voltage. It should allow me to read the rotor rpm too but I've never yet managed to make the gizmo work.

Launching from Seaford beach is a struggle. My sailing experience was nil before I made this boat, and often I haven't launched when the braver and very experienced folk of the sailing club have. The shingle is like ultra-coarse-grit sandpaper to the fully loaded hull; the wind most often close to directly onshore. Often help is required, and the people at the sailing club are very helpful at all times, even though I think some see the rotor as the devil's work. An advantage the rotor has over conventional rigs in this situation is that you have the rotor running before you leap aboard, so you should sail out of the danger zone instantly if your alacrity in getting the board down, and the beach break, allows.

I started sailing, in July 2004, with the board almost directly under the rotor. This put it very well forward, damping the steering. I have since sailed with it significantly further aft and the boat feels better. Unlike a conventional rig, one can determine the centre of effort, CE, of this rig with absolute accuracy at all times. On the face of it, sailing with the board where I had it this summer places the centre of lateral resistance, CLR, aft of the CE. This is traditionally bad news, but all I can say is that it certainly doesn't feel that way. I suspect that more things determine the CLR, including influences above water, than geometric considerations allow for.

As the reader knows, one reason that tradition requires a CLR forward of CE is so that a boat will round into wind if set free. If it broaches crosswind when sheeted hard it could blow over: at this angle of attack the sails are producing pretty much no lift and huge drag. Sea state aside, the rotor boat may well benefit from a fixed trim that brings it off the wind if the tiller is freed, because the rotor produces the same lift and drag vectors regardless of the track of the hull underneath it: a rotor boat tending out of wind will simply heel less and speed up, as the lift vector comes home. The greater danger for the rotor boat is inadvertently rounding into wind under full power, when the rotor will try to capsize the boat. However, the relationship of CLR to CE can be more accurately determined than that of a conventional sailing boat, so the designer can ensure that the boat will tend to do the docile thing. You would end up with a boat needing lee helm not weather helm in this case, with a consequent penalty in trim drag, but again I invoke the predictability of trim that can be designed into the vessel in comparison to the conventional sailboat whose helm changes with each point of sail. The trim could conveniently approach neutral, minimising trim drag. More than one rotor on a ship would allow accurate aerodynamic trimming.

What of performance? As I said, I would like to present polar curves and performance figures, but can't yet. Young people examining the boat on the beach have almost invariably labelled it "cool", but I always have to answer the inevitable young person's question, "is it fast?" in the negative. There is a clear and strong relationship between rotor speed and boat speed in any given wind, but the subtler question of which rotor speed is most efficient in terms of speed for power consumption in any given wind, is beyond me as yet.

I run the rotor at about twenty five watts most of the time because that's a realistic figure for a reasonably sized solar panel to provide, and it seems to be a sweet spot in terms of system vibration (the rather badly-balanced, homemade rotor hums at certain frequencies, and generates just a hiss from the bearings at others. In general terms it's very quiet). Twenty five watts equates to about 800rpm, and intriguingly, I've measured the power required for any given rpm decreasing in wind as opposed to still air. If this effect is felt over a large wind range it could be important. An unpleasant truth to face though is that the power requirement rises enormously relative to rotor speed. 2 amps provide about 800 rpm in still air, but 7amps are needed to deliver 1400 rpm. If this is a consequence of electric motor behaviour or bearing friction it may be mitigated, but if it's due to aerodynamic drag it could signal an inherent limit to the efficiency of the system on any scale.

If there is just one useful statistic, I suppose it would be, 'what wind is required at x watts to get hull speed' or a variation of the same equation. I cannot even answer this as yet. At about 25 watts the boat will achieve hull speed in a wind I now believe to be in the middle part of force 4. Clearly this is spectacularly unimpressive compared to the Lasers, Darts, etc which whizz around my little prototype: I can only reiterate that we're not after the same things.

Furthermore, at this point vagueness possibly serves, because remember that the rotor I've made is a very rough prototype, which I was able to construct by gift of what was possible, not what was best. Given resource, I feel that a somewhat longer, much stiffer and better-balanced rotor could be made, of the same weight. A better-matched motor could be found to operate at its peak efficiency around the pertinent speed range. Importantly, more suitable bearings could make a big difference to power consumption: I've learned that bearing drag is the greatest power drain of the system, at least in the speed range I adhere to, and the bearings I'm using could carry a truck. I envisage an optimal performance significantly better than I am able to show currently. Even then however, what about scale effects? Greater Reynold's numbers, thinner vortical regions, more angular difference in flow direction from root to tip, different bearing losses and motor efficiencies - these and twenty other issues make predictions of a yacht's performance based on a dinghy's, less than clear to put it mildly.

A couple of final points to address are those of gyroscopic forces and windage. People often asked me before the boat sailed, 'won't the boat spin round the rotor?' Well it does, of course, but bearing in mind that the rotating mass is some 3kg, 0.113m from the axis, and this is opposed by a couple of hundred kilos maybe 2m from the axis, then you can see that the answer is "not much". Interestingly, what gyroscopic force there is on the hull (believe me, it's far too small to detect on the sea, even in no wind) acts towards the wind - in other words if it exists at any meaningful level it would reduce the lee helm required to keep the boat true if CLR is behind CE. Windage is a more serious concern, but my feeling is that the problem is not as bad as people tend to think. It sometimes seems to me that the rotor has hardly greater cross-sectional area than the aerofoil masts that modern racing yachts use: more importantly, it has nothing else. No boom,

The rotor started off as an expanded polystyrene mandrel, made with great accuracy.

The carbon fibre sheath on the mandrel before epoxy application and vacuum bagging.

The whole project was literally homebuilt. Here's the rotor drive.

The first runs of the complete rotor drive.

spreaders, shrouds and stays that make up the average rig and must contribute plenty of windage. If the rotor is stationary a von Karman vortex street may develop in its lee. Although the device should at minimum be strong enough to laugh off any shaking this implies, it certainly wouldn't make for a comfortable motion at harbour. A couple of studies I've scanned seem to suggest that spinning the rotor at a speed too low to generate problematic lift would give enough energy to the boundary layer to reduce the wake significantly, and disrupt formation of organised vortex shedding. I look forward to being able to test this. If it's true, a band of flapping plates slung round the rotor to make it a kind of surrogate Savonius may suffice to create this low-rpm spin for free, and perhaps generate a trickle of charge current too - but then the windage increases and. . . . The initial design thoughts I've given to a yacht or workboat-sized project assume a rotor that can be lowered in extreme circumstances and for maintenance (although once you've solved the problem of reliable bearing lubrication the system's virtually maintenance free). This feature would be much harder to incorporate at the scale of commercial shipping though.

I hope this brief introduction does not lead too many readers with a long perspective on alternative sail types to cry "oh no, not that again." Having said this, any comment would please me, and I'll do my best to answer any enquiries, via mail@rotorboat.com

AYRS 2006 Annual General Meeting – Draft Minutes

The 42nd Annual General Meeting of AYRS was convened at the Village Hall, Thorpe, Surrey, UK at about 16.00 hrs on 22nd January 2006.

1. Those Present & Apologies for Absence

Present were the following Officers and Committee members: Michael Ellison (Chairman of Committee), Fred Ball (Vice Chairman), Sheila Fishwick (Hon. Secretary), Simon Fishwick (Hon Editor), Slade Penoyre (Treasurer) Graeme Ward, C R Magnan, Mark Tingley, and 10 other members of the Society.

Apologies for absence were received from Dave Culp and Kim Fisher.

2. Minutes of the 41st Meeting held on Saturday 23rd January 2005.

The minutes of the 41st AGM were approved. There were no comments, and the Chairman signed a copy.

Last year, the Committee were asked to examine the use of credit cards for payments to the Society. The cost (including terminal rental) was found to be about £500 a year, and probably more than we would take. The Society already accepts PayPal across the Internet.

3. Chairman's Report

The Chairman's Report, which had previously been published in the January Catalyst, is summarised as follows.

· While survival is necessary it is the quality of our activity and what we achieve which is important. Far too many people have never heard of AYRS.

- The annual plea remains the same but is now more urgent: we need help with publishing, and people to run local and regional meetings. Could you do anything?
- AYRS has had a stand from the very first London boat show at Earls Court. The publicity has been considered vital to our survival but now the cost is rising and perhaps the money could be better spent in other ways.
- There is a vast amount that could be done in the future, we could squander our resources on a hundred worthwhile projects and achieve nothing. We could save our reserves and silently vanish into the unknown. Hopefully we can continue to publish and encourage people with ideas to put pen to paper, saw to wood and resin to fibreglass.

There were no questions or matters arising from this Report, and it was accepted, nem con.

4. Treasurer's Report and Accounts

The Accounts and the Treasurers Report had also been previously published. In summary, the Treasurer reported as follows.

- The Society's reserves remain in a more-or-less satisfactory position. At the end of 2004, the assets, including a nominal £1013 of publication and other stock, amounted to 85% of the current year's expenditure.
- From the Income and Expenditure account, last year the Society made a surplus of £2154. This is not a large amount , however it should not be allowed to grow (see below).
- In detail, comparing 2004-5 against 2003-4, income is down, and expenditure is well down.
- Last year, we said we would review both the subscription rate in US Dollars, and the Retired members rate, with a view to increase. As the Dollar exchange rate appears to have stabilised, and the costs contained, our current proposal is that the concessionary rate for retired members be increased to £12.50, Eur20 and, provisionally, US$20 but only from October 2006. We will review this again later in 2006.

In response to questions it was noted that Boat Show income has not this year been analysed into subscriptions etc, but was about 4% up on 2003-4.

Adoption of the Accounts was proposed by Roger Glencross, seconded by Jasper Graham-Jones, and carried nem con.

5. Confirmation of President and Vice-Presidents, Election of Officers and Committee Members

By universal acclamation of those present HRH Prince Philip, Duke of Edinburgh, was confirmed as President of the Amateur Yacht Research Society. The Vice-President, Dick Newick, was similarly confirmed.

The Chairman, Michael Ellison, having announced his wish to retire, the Vice-Chairman, Fred Ball, was elected into his position. Graeme Ward was elected Vice-Chairman (prop: Fred Ball, 2nd: Slieve McGalliard), and the Treasurer, Slade Penoyre, was re-elected. Committee members Dave Culp and Robert Downhill had completed their current terms of office, and were willing to stand again, and the Committee proposed also the election of Peter Westwood. The election was proposed by Michael Ellison and carried nem con.

6. To appoint a Reporting Accountant for the year

The Committee proposed that Robin Fautley be re-appointed. This was carried unanimously.

7. Any Other Business

No other business had been formally notified.

8. Vote of thanks to the helpers of the society

This was proposed by Fred Ball and carried unanimously. The meeting closed at about 16.45.

Sheila Fishwick
Hon Secretary

Catalyst Calendar

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

April

5th AYRS London meeting
19.30 for 20.00hrs at the London Corinthian Sailing Club, Upper Mall, London W6. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX; email: office@ayrs.org

7th-9th *Broad Horizons* – AYRS Sailing Meeting
Barton Turf Adventure Centre, Norfolk UK, NR12 8AZ. Contact AYRS Secretary AYRS Secretary, BCM AYRS, London WC1N 3XX, UK; email: office@ayrs.org. Note: All boats limited to 1.2 metre max draft!

23rd Beaulieu Boat Jumble
AYRS will be there !

October

2nd – 8th Weymouth Speedweek
Portland Sailing Academy, Portland Harbour, Dorset UK. Note – change of date!

4th AYRS Weymouth meeting
Speedsailing. 19.30 for 20.00hrs at the Royal Dorset Yacht Club, 11 Custom House Quay, Weymouth. Location Map: www.rdyc.freeuk.com. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX; email: office@ayrs.org Note – change of date!

November

1st AYRS London meeting
Subject to be confirmed. 19.30 for 20.00hrs at the London Corinthian Sailing Club, Upper Mall, London W6 9TA. Location Map: www.linden-house.org. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX; email: office@ayrs.org

December

6th AYRS London meeting
Subject to be confirmed. 19.30 for 20.00hrs at the London Corinthian Sailing Club, Upper Mall, London W6 9TA. Location Map: www.linden-house.org. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX; email: office@ayrs.org

January 2007

5th - 14th London International Boat Show
EXCEL Exhibition Centre, London Docklands

21st All-Day AYRS Meeting (Date to be confirmed)
9.30am-4pm, Thorpe Village Hall, Coldharbour Lane, Thorpe, Surrey (off A320 between Staines and Chertsey – follow signs to Thorpe Park, then to the village). Details from Fred Ball, tel: +44 1344 843690; email frederick.ball@tesco.net

21st AYRS Annual General Meeting (Date to be confirmed)
4pm, Thorpe Village Hall, Coldharbour Lane, Thorpe, Surrey (as above). Details from the AYRS Hon. Secretary tel: +44 (1727) 862 268; email: secretary@ayrs.org

February

7th AYRS London meeting
Subject to be confirmed. 19.30 for 20.00hrs at the London Corinthian Sailing Club, Upper Mall, London W6 9TA. Location Map: www.linden-house.org. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX, UK; tel: +44 (1727) 862 268; email: office@ayrs.org

March

7th AYRS London meeting
Subject to be confirmed. 19.30 for 20.00hrs at the London Corinthian Sailing Club, Upper Mall, London W6 9TA. Location Map: www.linden-house.org. Contact: AYRS Secretary, BCM AYRS, London WC1N 3XX, UK; email: office@ayrs.org

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

On the Horizon . . .

Tri-foiler project update — Peter Jefferson
Downwind Faster Than The Wind At Last! — Jack Goodman
Just Champion — Denys Teare
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More sources and resources: reviews, publications and Internet sites

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