Catalyst

Journal of the Amateur Yacht Research Society

Number 34 April 2009

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As examples, the polar diagram p16 of *Catalyst 28* was re-created from a second generation photocopy, photos of shunting in the Champion article in *Catalyst 27* (pp 19-21) were screen grabs from a video supplied on DVD. The rest of the images in that article were scanned from photographs, and the text was OCRed (Optical Character Recognition software) or keyboarded.

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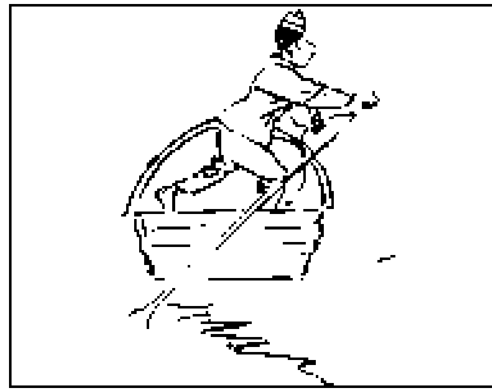
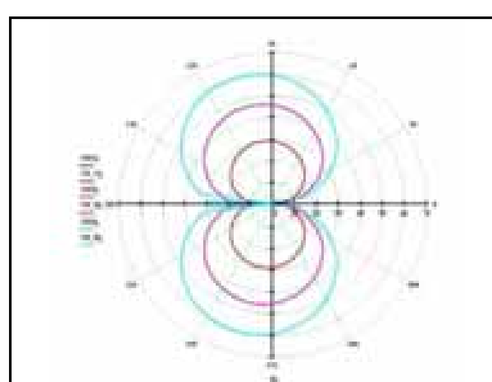
Model sampan with yuloh in the National Maritime Museum at Antwerp. Picture: Norbert Weismann by courtesy of Craig O'Donnell





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China is a very old civilisation, but also, over the centuries, a moderately secretive one. It's no surprise therefore for the Chinese to have developed their own solution to the problem of moving boats under human power. Equally, it is no surprise that we in what's often called the "western world" know little about the Yuloh (to give it it's most common English name).

We try to address that shortcoming a little in this issue of Catalyst. We have David Shannon's and Mike Bedwell's accounts of their experiments with Yulohs and related devices on an 11ft (3m) dinghy and a canal cruiser respectively. We also have Slieve McGalliard's analysis of the various variables in the design and handling of yulohs, ending with some suggestions for a design method for various sizes of boat.

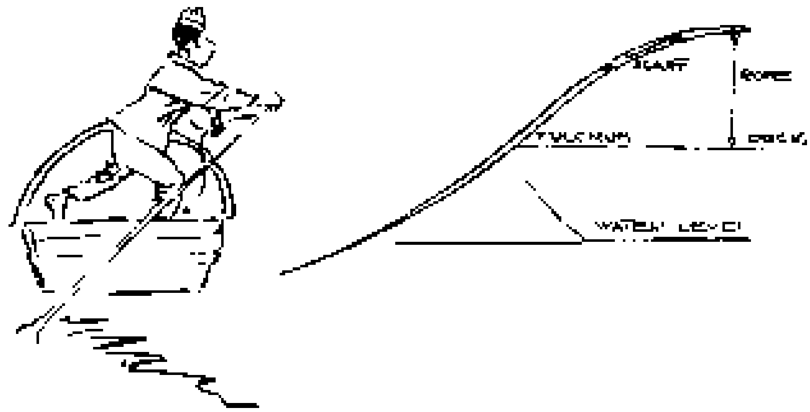
I wonder if we will see a rash of yulohs appearing now? After all, something that allows the mythical little old lady to move craft of several tons may well be something we can learn from.

Those who wish to invent an improved yuloh should first read Tim Glover's insight into the patent process. Although the article has a substantially UK bias, inevitable given Tim's personal career in the UK development department of a major international company, the process is similar in most other countries, and the major lesson - "Don't tell anybody about your invention without swearing them to secrecy" - is globally applicable.

The converse lesson - "If you want to stop *anybody* from patenting your invention then tell the world" - is also globally applicable, and an area where AYRS publications have played their part in ensuring that inventions e.g. sailboards, are available to anyone to exploit. Certainly anyone looking to patent a yachting invention should consult AYRS past publications first.

Finally, we should all read Yoav Raz' analysis of boat versus wind speed which gives us a useful tool for predicting speeds of fast craft given a little data. His accurate prediction of the recent sailing land speed record proves his point.

Simon Fishwick



"In theory, the most efficient form of marine drive is to be found in hydrofoil action which may be classified generically as "sculling." The two traditional sculling methods are 1, the simple sculling with an oar and 2, The Chinese "Yuloh" as drawn by G. R. G. Worcester (above), which is a large oar on a pivot, tied down by a long cord at its forward end. An angle in the oar and the skill of the manipulator give the angle of attack on each stroke. The large junks were driven by several of these yulohs, six or seven being often used." - *J Morwood, AYRS Pub No 36, 1961*

A Short Yuloh

David Shannon

Despite pleading for years with travellers to China to bring a yuloh back in their luggage I have yet to see one. So this year 2008 I at last got round to commissioning and trying out one of my own design.

It was built by Classic Sheds at Burnham Market in Norfolk, the first oar they had ever made. The stern saddle fitting for my Mirror dinghy Bod was made by the Burnham Deepdale blacksmith James Sedding. The accompanying photographs show the yuloh and the fittings.

Weight on the blade end

Key dimensions are: blade length 180 cm, handle length a further 54 cm, maximum handle offset from upper face of blade 20.5 cm, widest width of blade at tip 15 cm, greatest thickness of blade at tip 2 cm, thickness of blade at about water line 2.5 cm with the curved surface of the blade downwards of course, top surface of blade flat, fulcrum pin hole from blade tip 153 cm, lanyard line eye-bolt from end of handle 13 cm, handle section 4 x 4.5 cm. The saddle is of iron 15 cm long by 10 cm high and 3.5 cm outside dimension fore and aft, 2.7 cm internally. The angled offset pin is of 1 cm diameter rod tipped with a 2.5 cm ball. Overall height from top of saddle to top of ball is 7 cm. A hole has been drilled in the saddle to take a bolt through the transom.

A Mirror is 330 cm overall length, 140 cm beam and weighs about 62 kg.

I have carried out three trials, all at Burnham Overy Staithe. The first was without the transom saddle, the blade being simply lashed down on the transom. This clearly demonstrated the need for a pin and socket support and for weighing down of the blade.

The second trial used the new wrought iron transom saddle with a ball and pin recessing into a simple 2.5 cm deep hole drilled into the underside of the blade. Neap tides meant very shallow water, between 18 inches and 3 feet. Consequently the centre board could not be used and the yuloh touched the bottom on nearly every stroke clearly affecting performance. Wind was force 1 to 2, the stream was about 1 knot and manoeuvring room restricted by moored boats. I had hoisted the gunter sail out of the way, but it still caught the wind.

The transom saddle had to be offset from Bod's centreline because of interference with the rudder fittings. Despite this and using minimal skill in terms of oar twist, stroke length and lanyard use the Mirror moved forward against the wind or the tide. On the few occasions when the blade could angle down at about 45 degrees acceleration to 2 or 3 knots was rapidly achieved. However, despite obtaining a clear forward force with little effort, steering was a major problem, requiring the use of paddles and oars.

At the third trial we had deeper water and the saddle had been modified to fit centrally. Again the

Saddle before cutout adjustment

furled and hoisted Mirror sail and spars caught the wind and there was a significant tidal flow. Forward speed to 3 knots was readily obtained, the deeper water allowing for more continuous periods of sculling with the yuloh at the seemingly more effective angle of about 45 degrees.

Again steering proved difficult, despite trying varying the strokes. The simplest technique was trailing the yuloh at an angle near the surface of the water, this only working of course as long as one maintained one's way.

Lessons learned:

1. The blade and handle dimensions worked.
2. Weighing down the blade tip is essential.
3. The saddle needs to be fixed down to resist occasional upward forces from the yuloh.
4. The socket for the ball needs further refinement to reduce friction and to hold down the blade.
5. The handle section should be rounded for comfort.
6. The lanyard fixing to the handle seemed unnecessary.
7. The Mirror may prove too small and light a craft for a yuloh.
8. Windage on the boat can severely affect steering.
9. More practice required.

Overall this experiment was encouraging. The principle clearly works and little force was required. The blade proportions seemed about right, although I have since modified the section to increase the aerofoil effect further up the blade.

Possible further developments include lengthening and lightening the handle, modifying the dimensions so that the yuloh houses neatly on the deck of the Mirror inside the curved gunwales and improving the pin socket.

My experience does raise another issue. The blade clearly develops the intended water diverting effect. This requires an angled attack through the water, with the blade section encouraging linear flow. As speed increases so the angle of the blade relative to the boat surely needs to increase so as to maintain the required angle of attack through the water. This leads in turn to more demands on the sculler and on the fulcrum and to a greater difference between the angle of force from the blade and the direction of travel of the boat. Does this I wonder put an effective limit on the speed of yuloh sculling? What evidence is there of yulohs being adopted where tidal currents run at say over 3 knots?

If anyone else is interested in a refined version I could now supply one without the need to import from China.

An improved way of stern-sculling

Updated Oct 05

Mike Bedwell

The Practical Boat Owner of September 98 published, in their column "Waiting for the Tide" on p38, a description of the stern-sculling oar I have now been using for some six years in my 20ft (6m) boat Mercia Maid. Unfortunately, this is not available through the PBO's website, but the article contained the key technical specification of the blade as follows:

A standard, elongated rain-drop semi-symmetrical NASA15 section, about 13" (33cm) chord width and 17" (42cm) long, with the shaft centred about 25% of the chord width back from the leading edge. It was constructed from about sixteen 1" (25mm) thicknesses of softwood; these were individually shaped and drilled to accommodate the steel shaft before being glued together.

Conventional stern sculling is a well-established and centuries-old technique, perhaps best known in its Chinese version as "yullah".

Pro's & Cons of Stern-sculling

Compared to conventional rowing, the disadvantages of stern sculling in general are

1) In its most efficient form, it requires a special oar (in Yullah, a very long one) that can't readily be used for another purpose, e.g. as a bearing-out spar.
2) It requires skillful use of the wrists, which diverts some of the oarsman's energy from propelling the boat.
3) It generally requires the oarsman to stand, making the boat less stable.
4) It also offers less directional stability,

while the relative advantages are

1) Nothing projects beyond the beam of the boat, which thus can be maneuvered into locks, narrow channels & alongside without having to "ship oars"
2) The fact that the sculler stands means he can make use of more muscles than in a conventional boat not equipped with a sliding seat.
3) It is probably more efficient. This assertion is based both on experience, and on the theoretical considerations that there is (a) no recovery stroke and (b) no lifting the blade in and out of the water, all of which involve energy losses, and make for difficulties in heavy weather.
4) By suitable distribution of its mass, the unattended oar can be made to settle in a stable position convenient for the sculler to take in hand again, so he can readily change to any other task that takes priority, e.g. attending to the ropes. Stern-sculling is thus a natural "green" alternative to an auxiliary engine when sailing (See my article "Engineless on the Waterways, R.N. Sailing Journal, Spring 2003, pp. 47-8)
4) By standing on the other side of the oar, a second crewmember can more readily lend a hand in delivering power.
5) In a multihull boat, a second crewmember could also use a second paddle in the "well" between the hulls.
6) By putting a lanyard from the crutch round the loom, the paddle can be used to lose way and to go astern; for the same reasons as in (2), this is probably more efficient than in conventional rowing.
7) While it remains more effective for the sculler to face the stern, by using the muscles in his legs and trunk as well as in his arms, he can develop a rhythmic action where he naturally glances ahead at the end of each stroke.

The claim for my oar in particular is that it offers all the above advantages, and is probably even more efficient, both because of its specific shape and because the blade is nearer the vertical than in yullah. Further, it counters the second disadvantage, because the blade "auto-rotates" to a suitable angle of attack so I can use both hands, and devote my mental and physical energies to propelling the boat. I demonstrate the auto-rotation to newcomers by ostentatiously keeping my palms well apart as I pull the loom towards and across my body, my fingers clasped together, but in contact with only about half of the shaft's circumference; the oar rotates in my hands as naturally as a log in a hammock.

Future Developments

More by luck than judgment, I feel I have built an oar that works well for a person of my particular physique in my particular boat. But I have little theoretical basis for recommending what dimensions should be used in other circumstances. In particular, the oar's performance is very sensitive to precisely where the shaft is centred. The 25% figure quoted above is commonly quoted in the literature on e.g. rudder design, but my own experience suggests a figure a little lower. Can anyone out there help me establish an optimum?

Several people have suggested I should patent the oar. But I doubt this would be possible, because descriptions of devices of the same principle have already been published, notably Dick Hazelwood's *Flowtiller* *. In any case my ambitions are less financial than self-fulfillment. My vision is to persuade youth groups near inland waterways that stern sculling offers a more challenging activity than sitting passively in a powered boat.

I would much appreciate hearing from individuals who could help promote this vision. The best way of reaching me is by Email:

michael_bedwell@hotmail.com

* AYRS Projects, pp19-23, Amateur Yacht Research Society, Publication No 112, London WC1N 3XX, 1993

Some thoughts on the Yuloh.

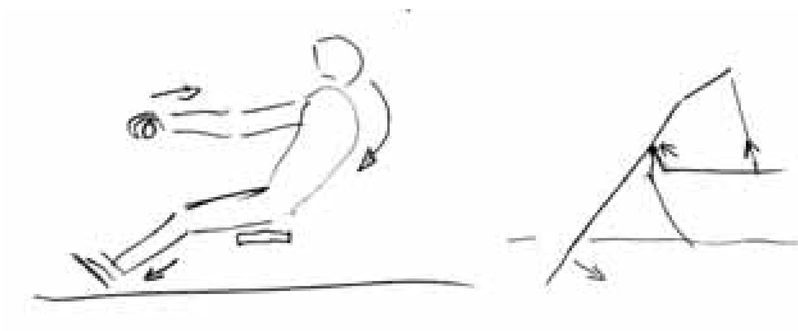
Slieve McGalliard.

From Audemard, Les Jonques Chinoises

Get a group of technically minded sailing enthusiasts together for an evening and the probability is that the Chinese Yuloh will get a mention. Where they all will be interested, probably none will have practical experience but will have heard that a Chinese lady with child or grandchild slung on her back can propel a 2 to 3 tonne sampan at up to 3 knots for prolonged periods. A quick search of the web will show that a few westerners have tried to use home made yulohs but have not achieved such significant performance, and have found it very tiring to use. The question is – could the quoted performance be realistic and if so, is it possible for a westerner to build and use a Yuloh and achieves this performance?

Many are aware that the Yuloh from China and the similar Ro from Japan have been used through out the south and eastern coasts of Asia as the basic form of manual propulsion for small to medium sized vessels. In its basic form the yuloh is an oar used for sculling over the stern of a vessel. By making a bend in the loom and attaching it to the boat with a lanyard from the end of the loom it seems to have developed into a remarkably efficient device.

The yuloh generates forward thrust by slicing through the water from side to side, like an oscillating propeller which changes pitch as it rotates each way. The operator only providing the energy to overcome the drag of the foil, the inertia of the yuloh and the effort required to twist the blade to the required angle. The thrust or lift produced by the blade is transferred to the boat through the fulcrum and the lanyard and does not stress the operator. Each stroke, left to right and right to left is a power stroke and no energy is wasted on a recovery stroke,



and therefore the thrust is effectively continuous.

On the other hand, in rowing the stroke is made by dragging the stalled blade through the water. The total force of the drag is supplied by the operator as he uses his lower arm muscles to grip the loom with his fingers, pulls with his arms, and using his back and legs the boat is propelled by the reaction at the rowlocks and the foot stretcher, with all the propulsive force going through the rower's body. The stroke is followed by lifting the blade out of the water for the recovery to the start position which although it requires less energy it imparts no drive to the boat, and may even suffer from air drag if the rower does not feather the blade.

Comparing the hydrodynamic performance of the oar to the yuloh is similar to comparing the paddle steamer to a propeller driven vessel, and it is well documented that the propeller is more efficient than the paddle wheel. This would suggest that the basic action of using the yuloh should require significantly less effort than using oars to produce the same work.

The yuloh seems to have other advantages, in that not only does the operator face forward but he can work in waters little wider than the beam of the vessel.

The photograph below shows a model displayed in the most interesting collection of 24 model junks in the Naval History Museum at the Arsenale in Venice. This would seem to be an extreme example of the use of the yuloh. The other photographs are also from the museum.

A search on the web on the subject shows one or two references to the writings of G.R.G. Worcester book, Junks and Sampans of the Yangtze, or drawings of the Japanese Ro, however the majority of the available information tends to be based on western sculling or attempts to make bent sculling oars which produce relatively low performance, and which tire the operator very quickly. None of the western experiments seem to be able to reproduce the performance reputed to be achieved in the eastern world.

So how can the mythical little old lady with the child on her back produce significant work output over long periods with a low calorie input? Having a child on her back may help with domestic responsibilities, but it may even be that the extra weight assists in the work of propelling the boat. It would seem that the yuloh is a very refined tool and the operating technique must make the most efficient use of its properties. It would seem that the reported western efforts have missed the finer points of design and operation.

Perhaps the best starting point to make an efficient yuloh would seem to be to go back to the original reports by G.R.G. Worcester. In his book he initially shows one yuloh in detail which has a downwards curve above the fulcrum and an upwards

curve below. (See page 3). This is the only drawing showing the upwards curve and at a guess this could be to allow it to be used in shallow water. The other yulohs he draws are either straight or with a bend/ angle positioned above the fulcrum, and these latter would appear to be the most likely to produce the efficiency which it is desirable to achieve.

To aim for maximum efficiency it would seem reasonable to tailor the physical properties (length, balance, bend position and angle and blade profile) to suit the vessel and the operator, and even consider adapting the vessel to assist the operator perform the work with the minimum of effort.

The bend.

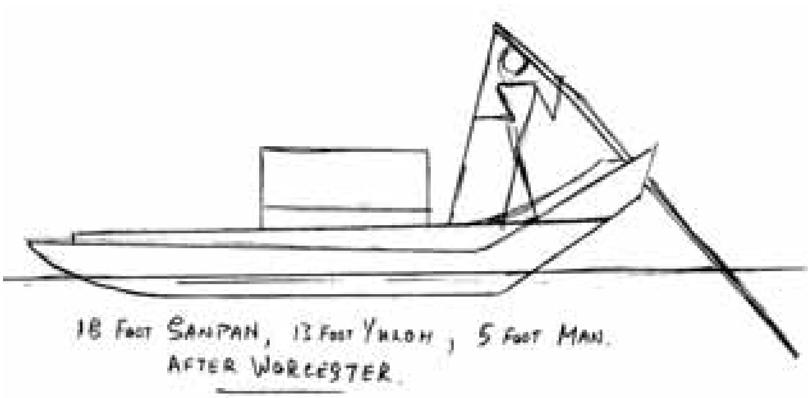
Although westerners have sculled with straight oars through out the ages, it is the bend that is unique to the eastern system. If there is no bend the operator will have to use his or her wrists to twist the blade to the desired angle for each stroke, reversing it at the end of each sweep. This will use the lower arm muscles which are not the most powerful in the body and which will tire the operator. By including a downwards bend the yuloh will automatically twist in the correct direction for the blade to produce drive. The position of the bend seems to have a big effect on the overall performance.

If the bend is centred on the fulcrum the tip of the loom will use a large proportion of the stroke while the blade swings round to change angle. This could waste up to half the stroke and produce negligible drive.

If the bend is placed just above the waterline less of the stroke will still be wasted in changing pitch. Although apparently more efficient than at the fulcrum, there is still waste effort, and the blade will always try to turn to the same angle on every stroke. The yuloher will have to use his grip and lower arm muscles to vary the pitch angle for differing conditions.

By placing the bend above the fulcrum and just below the hand on the loom the effort used to push the loom will all be used for drive, assuming the initial effort is with the hand on the lanyard is applied first to twist the blade. This position also allows the yuloher to control the pitch angle of the blade by varying the ratio and timing of effort with each arm. With a good technique and experience the yuloher can easily match the blade angle/ pitch to the requirements, eg. Light lanyard effort for fine pitch to acceleration from rest or into strong wind/ waves or by leading heavily with the lanyard, coarse pitch for cruise speed after the acceleration stage.

The actual position of the bend would seem to depend on the size of



vessel and the size of the yuloher. For a large vessel is appears that the yuloher has the aft hand just above the bend about shoulder height and aft of his/ her body with the forward hand on the lanyard across the chest and forward of the body. The tip of the loom will probably be level with the top of the head or slightly higher. With the bend just aft of the aft hand then by only using the aft hand the blade would receive a slight twist and give the minimum drive liable to be required, and to keep the blade pressing down into the water and unto the fulcrum.

The angle of the bend will depend on two features. The maximum speed will dictate the maximum blade angle, and the way the lanyard is attached to the loom combined with the bend will dictate the amount of twist imparted. If the lanyard is tied round the loom then the bend angle will control the twist, but if the lanyard is tied to an eye which is screwed into the underside of the loom then the effective angle will be from the bend to the eye where the lanyard is tied. This would suggest that to use an adjustable length eye under the loom would be a good way to experiment with or tune the yuloh for efficiency. Could it be that by using 3 pieces of wood lashed together to form the angle that the Chinese did adjust each yuloh to the usual yuloher on each vessel?

The lanyard would seem to be attached close to the tip of the loom, and to slope forward at an angle of about 14º to the vertical from top to bottom. The lower end seems to be attached to the vessel at about the level of the yuloher's feet.

The photographs of the harbour sampans show the elevated position of the yuloher and the raised transom to support the fulcrum. It is not a large heavy vessel, so the yuloh does not extend to above head height.

Length.

The overall length of each yuloh would seem to be tied to the length and design of the vessel. All indications seem to suggest the length of a traditional yuloh is normally over 50% of the length of the vessel, and as the vessel gets smaller the percentage increases to up to about 90% for vessels 3 metres long. Yuloh propelled harbour sampans seem to have a raised after deck for the yuloher to stand on and also a raised transom to mount the fulcrum on. Worcester suggests a stroke rate of about 41 per minute to be reasonable for a sampan, therefore to get effective drive the yuloh needs to be quite long with the yuloher raised above water level. We generally accept that a larger diameter slower revving propeller is more efficient than a smaller one.

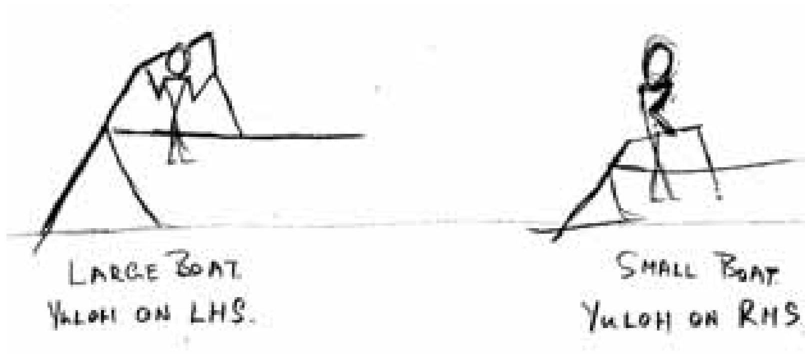
This would suggest that for efficiency a westerner should raise the operator and fulcrum to accommodate the desired length of yuloh, and not just accept the low level cockpit sole.

Fulcrum.

As a fulcrum Worcester reported that the Chinese used an iron pin with a small ball end attached to the transom, and inlay a hardwood block with a cut out into the lower surface of the yuloh as a socket. When worn the hardwood block could be changed. On larger load carrying vessels the hardwood block can be quite long with a number of sockets distributed along the length. Worcester suggested that this would allow the yuloh to be adjusted for different heights of cargo and different waterline levels. This suggests that the trim of the vessel and the yuloh have to be right to gain best efficiency.

Many westerners seem to use a towing ball as a fulcrum, though the standard 50mm ball is quite large and a hole of that size would weaken the shaft significantly. It may be possible to find an adequately strong towing ball nearer 15mm diameter from a bicycle shop.

From Worcester's diagrams it seem that on large heavy vessels the fulcrum is placed to the left of the centre line, and on small punts on the right hand side



of the centreline. This may be that as the majority of Chinese are right handed they use the left hand on the loom and the right hand across the chest on the lanyard when propelling a heavy vessel, but for a small light one the yuloh is not high enough so they possibly only use one hand, the right hand, below waist level and move the hand fore or aft on the loom to vary the blade pitch from fine to coarse.

A couple of simple experiments to try now.

First, stand up, and imagine a line on the floor to be the centre line of your vessel. Place your feet on either side of the line just over shoulder width apart and with the right foot forward such that the line joining the feet is at 45 degrees to the centre line. (If you are left handed reverse all lefts and rights). Imagine the yuloh to be on your left hand side and raise your left hand to hook it over the yuloh at shoulder level. Raise your right hand to a high waist level and grasp the imaginary lanyard in front of you. Remember that the lanyard is tensioned between a point at your foot level and the tip of the loom above your head. Using a relaxed upright stance, start to sway from side to side across the centre line at a stroke rate of about 40 per minute, which is a sway from left to right and back again in 1.5 seconds. Lead the change of direction with the lanyard hand.

If you imagine you are trying to propel a heavy vessel, but trying to use minimum effort you should realise that you can effectively lean on the yuloh and use it as a support. Adjust your stance to get the most relaxed position. You should notice that you will be using the larger muscle groups in a fairly relaxed way, and that the main effort going into the stroke will be coming from your weight swaying from side to side. It should become evident that, once you are used to the action that it should be possible to continue for long periods without getting overly tired. It would seem ideal to place the bend about 30 cm behind your left hand.

Now repeat the experiment, but with the yuloh much lower, so that the left hand is at waist level and the lanyard hand lower. By not standing upright the action will become tiring very quickly. This seems to be the situation with most of the existing western experiments where the yuloh is shorter and does not extend above the yuloher's head.

As a second experiment, imagine you are in a 3 metre light weight punt. Stand astride with your feet at right angles to the centre line. Let your right arm hang down by your side, and start to swing it out and in to the side as if you are 'swinging' the yuloh from side to side. This should be the 'fine pitch' position, with the bend just a short distance behind the hand. As speed increased and you want more twist, move your hand forward and upward on your imaginary yuloh and continue to stroke from side to side. Again you should see that this is a simple relaxed way to propel your vessel.

These simple experiments should help to give an idea of how to use a well proportioned yuloh with minimum exertion.

Blade profile.

As the yuloher is pushing the blade from side to side he is only overcoming the drag of the blade. The lift, or forward thrust is generated by the shape of the blade. Therefore it is important to use a blade shape to which gives the best lift/ drag ratio.

Western attempts to make sculling oars seem to be based on the oars used in the Bahamas, where the

underside of the blade is generally flat and the top of the blade curved. With a straight oar this blade shape naturally wants to twist in the required direction for forward thrust, and reducing the wrist effort required from the oarsman. If cambered on the bottom and flat on top the blade will try to twist the wrong way, and will require additional effort from the oarsman.

As shown above, the bend in the yuloh takes care of the twisting of the blade for each stroke allowing the blade profile to be optimised for maximum forward thrust for minimum drag on the yuloher. For best lift/drag an asymmetric cross section with the camber on the lower/ forward face would seem best. A Lift/Drag ratio of 6:1 should have 50% more drive force than a L/D of 4:1 for the same effort, and although these figures are a pure guess they do show that getting the optimum section would seem to be the key to getting the remarkable performance mentioned earlier. The problem is that at the end of each stroke the trailing edge becomes the leading edge for the return stroke, so the section has to be symmetrical end to end.

The diagram above is simply the Clark Y section and mirror image superimposed in an effort to draw a two way section to give a downward force. (The only lifting foil that requires a leading edge at both ends that easily comes to mind is the Frisbee, which might be a good starting point). A compromise would have to be reached to combine hydrodynamic efficiency and mechanical strength. Ease of manufacture must also be considered.

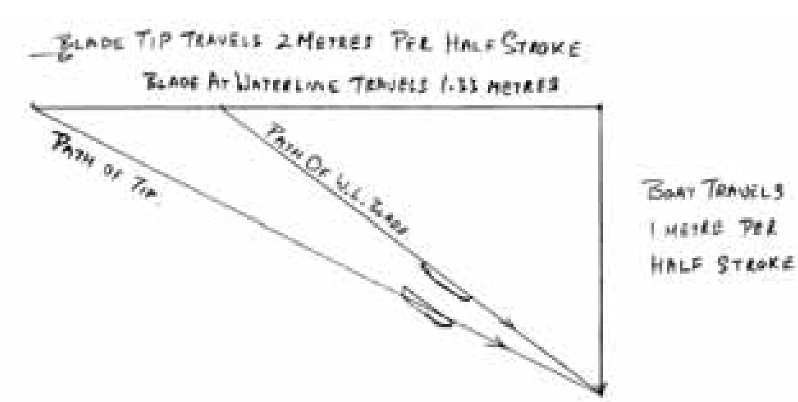
Clearly putting the camber on the top surface is similar to flying an aircraft with a Clark Y section inverted which is well known to be so inefficient that some such aircraft cannot maintain level flight when inverted.

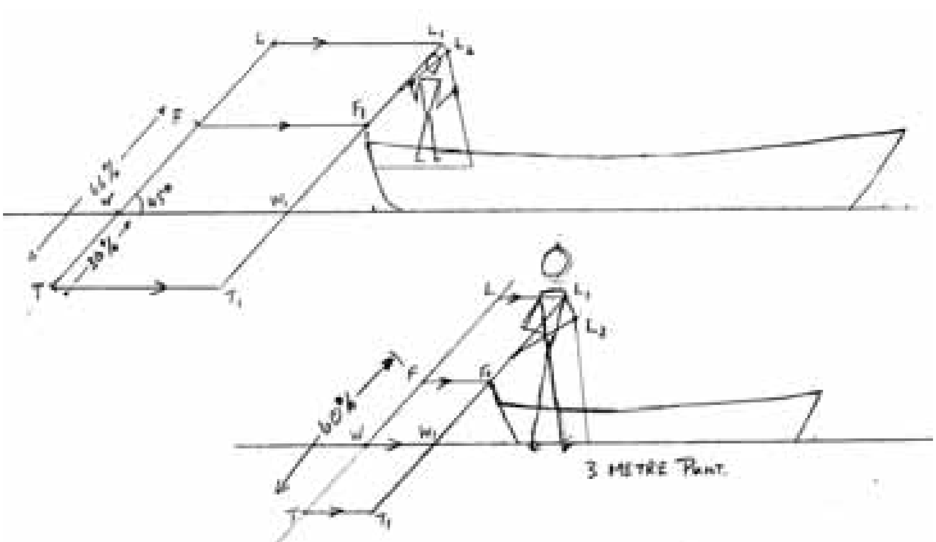
As the blade is operating as a foil and not as a stalled surface, it would seem that the blade could be quite wide near the tip, possibly at about 4 – 5% of the length, but the following paragraph may suggest a rethink of these figures.

A further ‘refinement’ which may be worth considering, and possibly improve the performance would be to vary the section along the length of the immersed blade. A propeller blade has a twist built in along its length to optimise the pitch angle. As the yuloh sweeps in both directions the blade cannot be twisted, but it may be possible to adjust the cross section along the length in an effort to optimise the angle of attack of the leading edge. The diagram below is based on best guess for a 5 metre yuloh at 41 strokes per minute (82 half strokes / min) (Worcester) and a vessel speed of 2.5 kts.

This would seem to suggest that the section near the tip could benefit from being flat closer to the leading edges (or even slightly under cambered on the top surface) than the section near the waterline. At the quoted speeds the angle of attack would seem to differ by about 12° over the length of the immersed blade. The section near the waterline would naturally tend to be thicker and possibly narrower for practical mechanical reasons. This is one area which would benefit from a more detailed study.

All the above would seem to suggest that with a well designed set up, as seems to have evolved in the eastern world, that the yuloh can be a very efficient device. The following is a suggested list of actions which should result in a well proportioned yuloh.





at the tip, tapering in a straight line to 3% of the length at the waterline, and 0.4% of the length thick at the tip increasing to about 0.8%L thick at the waterline.

11. Make sure the blade is cambered with well rounded edges on the lower surface, and flat on the top surface if not slightly concaved near the tip.

Recipe for a Yuloh for a large vessel.

The following is one suggested way to design a yuloh.

1. Make a scale drawing of the side elevation of the hull.
2. Draw a line at 45º clear astern of the hull. T – W – F – L.
3. Make the line 60% of the hull length, such that the bottom mark (T) is 30% of the length below the waterline, and L is 70% of the length above W.
4. Mark point F (fulcrum) 66% up from the bottom.
5. Transfer the line forward to the hull to position F_1 over the transom. This should be the desired position of the fulcrum.
6. Draw in the yuloher to scale, and adjust his/her position so that the tip of the loom (unbent) is above their head. This should indicate the level of the platform they should ideally stand on, and may be at cockpit seat level rather than at the cockpit sole level.
7. Mark the bend point a short distance below the yuloher's aft hand and just below the level of his shoulder, and draw in the upper section of the loom bent forward some 9 to 10º to get L_2.
8. Draw in the lanyard from the tip of the loom sloping forward some 14º to the level of the yuloher's feet.
9. You now have the general setup, and have to decide on the blade width and cross section which may vary from near the tip to near the waterline.
10. A reasonable starting width for the blade of a large vessel would be about 4% of the yuloh length

Recipe of a Yuloh for a small vessel.

Similarly draw a diagram for short light weight dinghies or punts, but this time draw in the yuloher using an under arm action, and adjust the proportions to a length of about 90% of the boat length, and place the fulcrum about 60% up from the tip. As you will not be using the lanyard, then it would seem advisable to increase the bend angle to almost 20º when drawing L_1 to L_2, so that you can control the twist simply by moving the hand forward or aft on the loom. You may find it desirable to raise the fulcrum slightly above the edge of the transom on a normal western dinghy/ punt.

Worcester reports that the Chinese sometimes strengthen the tip with an iron band, which also helps to keep the tip under water when not in use.

Conclusion.

It would appear that western attempts at making yulohs with the bend designed to stow neatly around the gunwale and not designed for easiest use are not ideal, and by not placing the camber on the lower surface cannot achieve high efficiency. They do not encourage good use of the lanyard and good technique. The length does not encourage a relaxed stance. If the design can be optimised and the technique learnt then it may be possible for a westerner to compete with the little lady with the (grand)child slung on her back to produce good performance for long periods.

The author would like to receive constructive comments on the above, and any reports of recent experience on the use of yulohs at slieve@onetel.com (but he does not want to receive any more junk e-mail).

A Rough Guide to Patenting.

or a personal view of the Patent Process.

Tim Glover

Important Notice.

Before you have filed a Patent Application,
Do NOT tell anyone about your invention.
Do NOT show it in public.

Having got the important points of this article over, i.e. "Keep it quiet", here is some background information about this. You can tell people about your invention but the meeting must be 'in confidence'. There are a number of ways of doing this. Firstly you can get everyone to sign a N.D.A., (a non-disclosure agreement). An example of this document is given on page 26.

The second way is to have a third party, (i.e. have an other person as a witness.)

If you have a group of people at a meeting it must be made clear to them that "this meeting is in confidence and the meeting will be discussing your invention (of a new mouse trap for example) on this date". This is the minimum precaution that you should take to protect your invention. So that in future the witness can state in court, if required, that the people who were there and whom they represent, did agree to keep the information given by you about your invention and discussed at the meeting, secure.

The object of this article is to explain the UK patent system, as I understand it.

The idea is to give the reader some hints and tips on how to navigate though the system along with some common pit falls and also dispel some myths.

What is a Patent?

A granted patent gives the owner up to a 20-year period of ownership or monopoly over his or her invention. He/she can grant licences to other people either for a fee or free if they want to. The licence can be multiple or exclusive.

How to start the process

The first thing is to simply phone the UK Patent Office, now called the Intellectual Property Office (IPO) on 08459 500 505 (see the Notes for the address) and they will send you an excellent information pack. Read it!

Next thing to do is to check whether your invention is new, or whether there is an obscure patent lurking somewhere that covers it. Now you can do your own search at any time. Please be careful!! The I. P. O. may well include a search request form in with your application forms and reading matter. You do not have to get them to do a search for you at this stage. These searches cost a lot of money (£400). (You do need to pay them later for a search on your patent application but this later search is much less expensive - £130 at today's prices).

Patent Search.

Let me explain how you can do your own search on line for free. This is well worth doing right at the start. Even before you have written your patent application forms. Here is a 'Free Search System': -

Go on line and do the following:-

1. Go to Google
2. Search for "Esp@cenet quicksearch"
3. On the Espacenet Quick Search page, under (2) select "words in the title or abstract", and then enter in your key words at (3) and click on 'Search.'
4. An important point to note is that if you want to find patents on "plastic bicycles" then you have to type in "plastic AND bicycles", otherwise (without the "and") you will get all the patents on plastics plus all the patents on bicycles!.

There are a great number of other patent search engines, e.g.

USPTO.gov This is a good one but it does not handle request information in the same way as UKIPO; just write each bit in each box. This is a good site but one problem is the front page is in very high definition, so you only get about 1/10th of the image at one time.

Google Patent is also very good, but only put in the number not the US in front of it.. This seems to be only US patents. I am always being asked about good search engines so do let me know if you find any good ones.

Prior Art.

If someone has published your idea before your filing date, it becomes 'Prior Art'. This term describes 'what has gone before'. It can be a patent document or any other publication describing your idea.

It is a good idea to add some prior art to your patent application. This shows the examiner that you have done your research and hopefully it will save him time.

If you find that someone has patented your invention before you, you have saved yourself a lot of time and money. Do not be put off, the patent may not still be valid or the payments may not have been kept up.

The easiest way to tell if a UK Patent or a European Patent (UK) is in force is to go to the IPO web site. Click on "Patents", then "On Line Services", then "Search Patents" and finally "by patent number". Either application number or publication number can be used. The number should be prefaced by GB or EP according to whether it is a national or European Patent (UK). The result will show the status and when the next renewal fee is due.

Applying for a Patent

Back to the patent application itself. If you are going to do the patent application yourself I suggest you read "Ideas or Inventions Can Make Fortunes, How to make yours", by Harry Cole. (Details in the Notes) It is very thick, very good and very readable. (Please note the charges given in the book are now out of date.)

The strategy that I suggest is to first, do a free patent search on line for yourself, then having considered what it has produced, you can modify your patent application to avoid replicating anything that has already been patented before.

If there is a patent that is very like your idea do not panic. Get a complete specification and read the 'claims' very carefully. If you are not doing exactly what is stated in their Claim (1) you can still proceed. You may have to reduce the breadth of your Claim (1) to get outside their Claim (1) and do look at their other Claims as well.

When writing your specification, put all the details of your invention in. Do not put in any claims to start with, as they are very difficult to write, as they have to describe the whole invention in one sentence. My strategy is to put all the raw material for the claims in the application document, and then amend it later.

You can write your own patent application and send it in with the required diagrams. You will then receive a unique number from the IPO with your priority date or filing date; this date is very important as it establishes the starting date for the one years time that you are allowed before finalizing the patent application. Filing the patent application is completely free.

During this year you can find a manufacturer or a business that want to develop, make and sell your invention. You can talk openly in public and also demonstrate your invention.

Before the end of the first year see if you or anyone is interested in taking up the invention. If so get a patent agent to write the claims for you, but ask him how much he wants to write the claims. He may give you a hard time and want to write the whole patent application. If he does you can ask if he would like a percentage of the equity. Some will do this and then write the patent application for you free.

At this stage, if you have a company interested in the manufacture of your invention, you can assume that they would be willing to pay you a licence fee. You can ask for an advance of the first year's fee and pay the Patent Agent with that.

Paying for the Patent

In my experience in industry I have come across firms that will pay all the inventors patent expenses and consultancy fees while they were putting the invention into production. They have been known to pay the inventor £30,000 per year and that was twenty years ago. So everything is negotiable. You can also make it point of the licensing agreement that if they do not want to continue with the venture that all the patents, tools and other 'stuff' reverts to you the inventor without charge. This also has happened.

Beware of Patent Promoters.

Patent promoters are people who will take your invention and put it into production for you, for money. The best thing is to read the "Step-by-Step Guide to using Invention Promoters" document from the Intellectual Property Office itself. This is a very good document and it can be copied and reproduced without having to get their permission.

A further point of interest: If you Google 'Patent Office' you get a list of firms. Beware of the first two or three. Although it says 'Patent Office' they may be nothing to do with the old patent office or the new IPO. If you phone them your first question should be, "are you part of the Intellectual Property Office"? Then you will know whom you are dealing with. If they are a promoter, I would ask them for people whom they have helped in the past and ring them up to ask them if they would use that promoter again. If they refuse to give these details, try another firm.

Back to the patent process:

1. You have done a search on line for free.
2. You have written your application, plus or minus claims and submitted it.
3. You have got a number and a priority date. (Date of filing.)
4. You have 12 months to find a manufacturer
5. You also have 12 months to finalize the patent application on your own or with help from a patent agent.
6. Then at the end of the year, if you want to finalize the patent application you pay the IPO for a Preliminary Examination and a search of published patents and documents (cost £130) which checks your invention is new and inventive. They will also do a preliminary examination of your patent application with regard to the formal requirements. The search is not restricted to patent documents as any publication prior to the filing date is prior art. If you look at the list of citations among published UK patent applications you will find one case where The Dandy comic was cited and another where a video of a James Bond film was cited!
7. The IPO search will probably cite some prior art. You will have to satisfy them that these have nothing to do with your patent. (More later.)
8. Your Patent Application should then be published within 18 months from your filing date.
9. BUT YOU STILL DO NOT HAVE A PATENT!!!
10. Within 6 months of publication, you have to pay the IPO to do a Substantive Examination. (£70 fee) which checks whether:
    a) you have an invention for which they can grant a patent

b) it is new and not obvious

c) the description is full and clear enough for the invention to be made or carried out by someone with a good knowledge of the technical area that the application is about,

d) the claims are clear and agree with the description of the application.

If the IPO find things they don't like, they will ask you to change it.

10. When the IPO are happy (which could take until year 4) your patent will be GRANTED!!!(*Now* you have a patent).

11. Note if you want a quicker route you can file Forms 9 and 10 at the same time and ask for an 'Accelerated Prosecution' at the outset. They will then examine your patent application and search for prior art, quickly. The fee is the same, and you should get your patent granted within the first year.

12. After the end of year 4 you start to pay renewal fees to the IPO. These increase annually until year 20 is reached when the patent runs out. (Year five £50 – 20th year £400) ie it increases by £50 pa

Note: Renewal Fees. It might be useful to mention that if you endorse your patent "Licences of Right" the annual renewal fee is halved. To do this file Form 18; there is no fee. It means that a licence must be granted to anyone who asks provided reasonable terms can be agreed. The endorsement is reversible. The IPO does not advertise this provision but I have found it very popular with individual inventors.

IPO Searches and how to deal with them

The IPO will usually cite some patents for you to comment on and once again 'do not panic'.

Start with Claim (1) of the other patent. If your not doing exactly what that Claim (1) says you are not infringing that patent. Next if you *are* doing what Claim (1) says, stand back and consider other ways of doing the same task. Let me give you an example. I tried to patented an array of 49 lenses (7 x 7 in a square array.) The Patent Office came up with the same array in a previous patent. What to do? I changed the lenses for 49 'pin holes' in a sheet of thin black plastic. Not only did this get around the patent but also it made a much cheaper and simpler device. So if you get what seems a 'direct hit below the water line', stand back and have a rethink; you can usually get around it.

Note: if your patent is relevant to government servcies e.g. military, health service, the Crown has the right to use it subject to payment of a reasonable royalty.. (Note this is a UK statement.)

Public Disclosure

While patents are designed to give the inventor a monopoly of his invention for 20 years, the inventor may wish not to patent an idea but to give it away. This will mean that anyone can make and sell the invention. If the inventor wants to take this route he has to put the invention into the public domain by making a 'public disclosure'. Once this has been done no one else can patent the idea; so the outcome is that the idea is free for everyone to use.

The way this is done is to publish the idea in a recognised journal – *Catalyst* for example, or you could (for speed) use the AYRS mailing list on Yahoo. The advantage of a paper publication like Catalyst is that copies are filed in the various national libraries where anyone can consult them; the Internet may not be archived anywhere accessible, and may not be date-stamped. Make sure though that you get a committment from the editor to publish your idea, and also make sure you get a dated acknowledgement that he has your article. If someone claims you have infringed their (later) patent, you will need to be able to show when you "went public" with your idea.

One case is the people who invented the 'lap and diagonal seatbelt' for cars have given a Free Licence to anyone who wants to use the invention because they wanted to save lives.

Infringements.

If someone infringes your patent what can you do? You can sue him for infringement but this can be very expensive, so the route that is open to everyone is to find a lawyer that will take on your case on a 'no win, no fee' basis. I know one inventor who has taken this route; he found a lawyer in the USA who would do this for him and he won the case. When I asked how much the lawyer took the answer was 100%. When I asked him if he was happy with the outcome he said YES! All the inventor wanted was to stop the other person from manufacturing and selling his invention. After which he was able to offer the manufacturer a license to sell his invention.

Exploiting your Patent

So when you finally get your patent granted what can you do with it?

1. Get a manufacturer to make it and sell it for you. i.e. grant him a Licence. Anywhere from 2% to 10%

- usually 3% to 5% - of gross receipts. Do not base the figure on profit because he can always hide profit.
2. Make certain the licensing agreement has a minimum 'Royalty' clause and a minimum production run specified; otherwise he could just get a license from you and shelve it, or sit on it, selling his version and not yours. (For advise on Licensing –see Note 3 at the end)
3. Go into manufacturing business for yourself.

Conclusion.

So you can now see that you can get protection for an invention for up to a year with minimum cost, i.e. free. This means that you can protect your invention and show them in public and talk to possible buyers with out cost.

I hope this article has been helpful. If you have any questions do write to Catalyst and I will try my best to answer them. I am not qualified in any way as a Patent Attorney but I have had 69 patents granted during my working life in the Research Laboratories of a large firm.

Good Luck and I wait for any feed back with interest.

Notes

1. IPO (UK Patent Office) Address

UK Intellectual Property Office
Concept House
Cardiff Road
Newport NP10 8QQ
Tel: 08459 500 505
Website: http://www.ipo.gov.uk

2. Step-by-Step Guide to Using Invention Promoters.

Available from the IPO website at http://smtp1.patent.gov.uk/usingpromoters.pdf

3. Advice on licensing patents.

British Library web site link http://www.bl.uk/bipc/msheahan.html

4. "Ideas or Inventions can make Fortunes, how to make yours " by Harry Cole

ISBN0951809016 paper back, ISBN0951809008 hard back, Owl Publishers (Jersey) (Mar 1992)

5. Non Disclosure Agreement

The agreement overleaf was drafted by Croydon Round Table of Inventors for use at their meeings, but the text is generally applicable. It can also be downloaded from the AYRS website.

Acknowledgments: Many thanks to Mr. Guy Selby-Lowndes and Simon Fishwick for all their help and advice. And also a lady from NZ who put me onto the quick patent search method

History of Patents in UK

Initially the sovereign would give out 'Letters Patent' to people who gave him money. This gave the owner of the 'Letters Patent' a monopoly to sell things. i.e. salt and playing cards for example. The practice ended in 1624 from when monopolies could be granted only for new methods of manufacture and the present patent system was born. The Patent Office was started in 1843. Things improved in 1850 with the 'The Commissioners of Patents'

Later in 1852, the actual numbering system was introduced. The system started with a four digit number followed by the last two digits of the year.ie 1234 52. In 1916 a new system was started with the number 100,001. Then in 1949 another system was started with 2,000,001. Since in any patent the inventor had to divulge his secrets; Society gained this knowledge and in return the inventor was granted a patent. This stops the knowledge of how something is done dying with the inventor. One example of this is the knowledge of how to make exact replicas of flowers in glass. There are fine examples of this invention in the Peabody museum in Boston Mass. USA. but no-one knows how they were made.

The UK Patent Office is now known as the Intellectual Property Office.

Other countries have their own systems but the laws are similar. The Paris Convention of 1883 created mulual recognition between signatory countries with regard to filing dates for patent applications. The most significant international agreement on basic patent law was the Patent Cooperation Treaty 1970 which has been ratified by over 100 countries, and is administered by the World IPO in Geneva.

Non-Disclosure Agreement (NDA)

The Inventor should complete 2 copies of this NDA and keep one copy for future reference, the other copy should be filed by the other parties.

This agreement is made on…………… ……………………...... between

(1) The Inventor : and (2) Name
Address

Background

The Parties wish to discuss investment and collaboration opportunities relating to business models and/or the technical and commercial capabilities of various technologies and projects ("Opportunities and Technologies") developed by one or more of the Parties. The Parties wish to mutually disclose certain confidential information to enable each of them to fully assess the Opportunities and Technologies.

It is agreed that:

In consideration for the mutual disclosures, the Parties agree to the terms of this Non-Disclosure Agreement.

1. "Information" means all information, data, ideas, innovations or material disclosed by any of the Parties relating to the Opportunities and Technologies, whether or not marked or designated as confidential, including, but not limited to business plans, business proposals, projects, financial information, customer lists, prospective customers, technical proposals, product descriptions, hardware specifications, software in both source and object code, computer outputs, computer interfaces, application programme interfaces, computer calls, flow charts, data, drawings and know-how.

Each Party's Obligations

2. Each Party will:
   a. keep the Information disclosed to it by any disclosing Party confidential and secure, and in addition apply the same degree of care and the same controls which that Party applies to his or its own trade secrets.
   b. use or make copies of the Information disclosed to it solely to assess the Opportunities and Technologies. Any such copies shall remain the property of the disclosing Party and be distributed or otherwise be made available internally within the receiving Parties on a need to know basis.
   c. give immediate notice to the disclosing Party if a receiving Party knows of or suspects that there has been any unauthorised use or disclosure of Information arising through a failure by a Party to keep the Information confidential.

Publicity

3. No receiving Party will without the prior consent in writing of the disclosing Party either release any press statement or issue any other publicity regarding the existence, scope, objective, conduct, performance or results of any proposed or actual contract between any of the Parties.

Exclusions

4. The provisions of this Agreement shall not apply to Information:
   a. which a receiving Party can prove to the reasonable satisfaction of the disclosing Party was lawfully in his or its possession at the time of disclosure and was not acquired either directly or indirectly from the disclosing Party; or
   b. which is lawfully generally known (other than due to the negligent act or omission of Parties or his breach of this Agreement); or
   c. which the receiving Party obtains from a third party which was entitled to disclose that Information to the receiving Party without any restriction.

Various Obligations

5. Each receiving Party agree that he or it shall not acquire any right in or title to or licence in respect of the Information disclosed to it or any intellectual property rights embodied in the Information. The rights provided to the Parties under this Agreement are personal to the Parties and shall not be assigned or transferred to any other party whatsoever.
6. The obligations under this Agreement shall continue as regards any item of Information until it is lawfully generally known or is otherwise not subject to the provisions of this Agreement, to a maximum term of five years from the date of this Agreement.
7. On the written request of a disclosing Party at any time, each receiving Party agrees to
   (a) promptly return or procure the return of or destroy (at the disclosing Party's option) all or some (as the disclosing Party may direct) of the originals and copies of the Information under his or its care or control and
   (b) confirm in writing that this has been done and that no Information or copies exist under the receiving Party's care or control and
   (c) not use the Information for any other purpose whatsoever.
8. Nothing in this Agreement prevents disclosure of the Information to any persons or bodies having a legal right or duty to have access to or knowledge of the Information.
9. This Agreement constitutes the entire agreement and understanding between the parties with respect to its subject matter and replaces all previous agreements between, or undertakings by the parties with regard to such subject matter. This Agreement cannot be changed except by written agreement between the parties.
10. This Agreement is governed by English law and the parties submit to the jurisdiction of the English Courts.

Signed for and on behalf of:
…………………………………………………..
Date:

Signed for and on behalf of:
…………………………………………………………..
Date:
.

Sailboat speed vs. Wind speed

Predicting sailboat's speed at a given wind

Yoav Raz

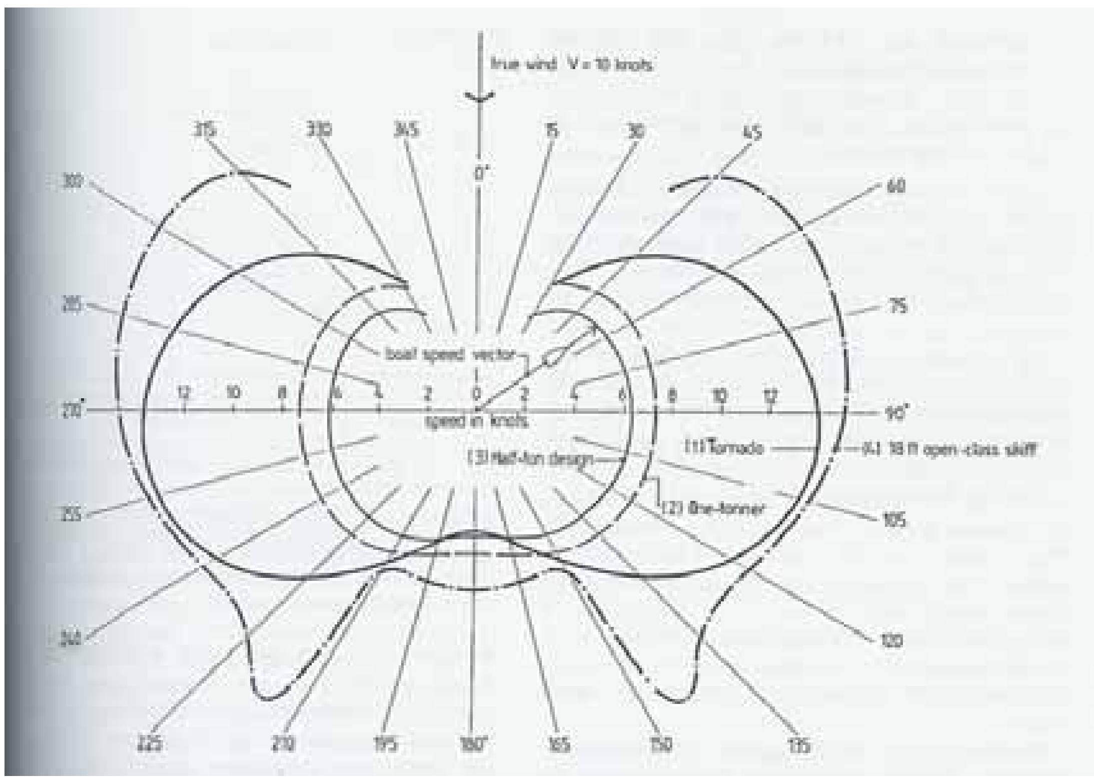


Figure 1: Polar diagrams: Sailing boat speeds for several water boat types at wind speed of 10 knots.
From the book The symmetry of sailing *by Ross Garrett, Sheridan House Inc., 1996.*

Sailboat speed predictions based on geometry and physics are complicated and pose a substantial challenge. The simple approximation method presented here allows very accurate predictions for all boat situations based on several measurements. It also allows quick, approximate, predictions based on a single measurement set consisting of boat speed, wind speed, wind direction, and possibly other relevant parameters. In such a case error may increase the more the variables deviate from the measured point. Several sets of such measurements across the boat's variable space allow accurate predictions for the boat's speeds across the entire variable space, comparable with complete polar diagrams for sailboat speed. The method is much simpler, with less needed measurements than direct speed interpolations. While the method bypasses most of the sailboat's specific details, it is based on approximating the two major factors that determine sailboat behaviour: Lift and Drag. By this it defines and utilizes mathematical functions that are very close in shape to typical speed polar diagrams, and are natural for describing sailboat performance. Basically, the method provides a transform (and its inverse) from sailboat speed to a quite flat, slowly changing, easy to approximate function, which transforms back to very accurate speeds.

The mathematical relationship

Several years ago I sent friends an article about attempts to reach speed of 200 mph with an *Ice Yacht*, at wind speed of ~60 mph. They wondered how it was possible, and I applied the qualitative explanation I got as a kid about sailing boat speed, and later taught, together with a little more Physics, and reached the following equation for relatively fast sailing boats (on water, ice, or land; with water turbulence for water, and air turbulence for water planing, land and ice, i.e., with relatively high Reynolds numbers[1], virtually for any contemporary sailing boat at its normal conditions; the general scope and validity of the equation is due to the fact that the wind force extracted by any sails can be expressed as an integral on their surfaces, over the wind laminar flow regions, and a theoretical equivalent planar sail exists, which is used to develop the formula):

At steady state ***Sails forward force = Drag force*** implies the following equation (at approximated optimal sails' setting)

$$\sin(\gamma)\cdot\sin(\beta)\cdot\left(\frac{\sin\left(\beta/2\right)}{\sin(\gamma-\beta}\right)^2 = V_T\cdot\eta \quad (1)$$

Where

γ = real wind direction relatively to boat (0 when wind from front)

β = apparent wind direction relatively to boat

V_T = real wind velocity

η = sailing boat's slowly changing function of many parameters (1/velocity units), which incorporates most of the boat's and rigging's specific Physics.

η is a measure of the overall boat's resistance to increased speed, and in correlation with the (overall) drag coefficient. The smaller η is, the faster the boat at a given wind velocity. It depends on many changing parameters like heeling angle, flows turbulence levels, sea waves conditions, etc., and even may depend on γ and β, depending on boat architecture. It may have relatively large jumps when parameters change abruptly, like when moving to planing mode, or lifting a spinnaker, but usually not in order of magnitude. An accurate η function, which is quite difficult to determine by the boat's physics alone, but can be determined quite accurately by few measurements across the parameters space, makes the above formula very accurate.

However, even an average η, a constant, usually provides a rough approximation for a given boat for a wide range of conditions (η function parameters) and wind velocities, since η typically does not change very much - for some water boats a change factor of up to 4 over the entire applicable wind velocity range has been observed - and typically not in order of magnitude. Thus, such average η is a good characterization of the overall sailboat's performance, and helpful in rough comparison of different boat designs. Hence, even a coarse approximation of the η function (with very few constants) for a given boat, using measurements based polar diagrams (but typically accuracy and exact external conditions/parameters of such is unknown), provides very good predictions with the formula above.

After solving the equation above for β, the boat velocity, $\mathbf{V_B}$, is given by

$$V_B := V_T\cdot\frac{\sin(\gamma-\beta)}{\sin(\beta)} \quad \ldots (2)$$

Comments:

1. When solving iteratively for β, a good initial value for β, to converge to the right solution, is slightly below γ. This emulates starting with low boat speed and converging to the final speed.

2. Alternatively, η can be determined by the equations from $\mathbf{V_B}$, $\mathbf{V_T}$, and γ (or, on board, from measured $\mathbf{V_B}$, $\mathbf{V_A}$ = Apparent_wind_speed, and β, where now γ is solved from the equation above, and $\mathbf{V_T}$ is calculated by

V_T := SQRT(V_A*V_A + V_B*V_B - 2*V_A*V_B*cos(β))

Figure 3 is an example of resulting $\mathbf{V_B}$ vs γ plot for η = 0.001 at wind speeds of 10, 20, and 30 mph, characterizing a very fast water sailboat (η is close to that of the water speed record holder; see below).

This solution is a good approximation for polar diagrams given in the picture above at the top and alike, where every boat type with a given setting is fitted with a specific η. It is applicable equally to traditional flexible sails, to rigid sails, and to vertical wings. This solution together with rough η approximations also provides a compact implementation for accurate *Velocity Prediction Programs* (VPPs) which are becoming more and more common for boat design and on board sailing boats for tactical planning (e.g., for

[1] Reynolds numbers: see http://en.wikipedia.org/wiki/Reynolds_number

calculating the fastest path to destination given wind geographical distribution. The simplest well known calculation that uses polar diagrams is choosing an optimal γ (fastest VMG) and gybing/tacking for a destination down-wind/up-wind in a wind with constant velocity along the path). For boats with a relatively heavy keel (e.g., yachts) V_B is quite uniquely determined by V_T and γ in typical sea conditions and optimal tuning, since any deviations from the assumed averages of mechanical forces and moments effects created by the crew are typically negligible. Thus a single polar chart for multiple V_T values provides a good description of such boat's behaviour. See a detailed example of a *polar diagram* (or polar chart) at <http://yoavraz.googlepages.com/polardiagramforboatspeed3>.

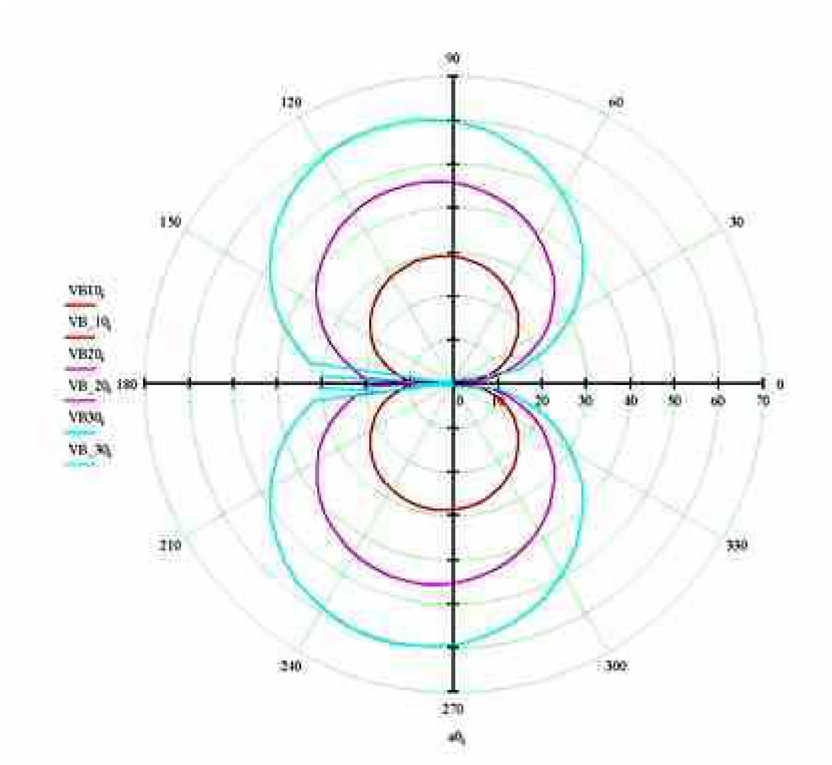


Figure 3: An example of V_B vs. γ polar diagrams resulting from the formula above, where η = 0.001 (a land or very fast water sailboat) at 10, 20, and 30 mph winds. (Note lack of numerical convergence at 180 degrees.)

Conclusions

Due to its slow and relatively small change, η can be approximated for a given sailing boat compactly (with few constants) and accurately across the entire parameter space by few measurements of V_T, VB, and either γ or β.

After calculating η for each measurement, η can be approximated accurately across the parameter space from the accurate tuples [γ,V_T,η,any_desired_parameters]. In this form it is an explicit function η(V_T,γ,any_desired_parameters) where $V_{Tmin}<V_T<V_{Tmax}$, and $0<\gamma<180$. Then V_B(V_T,γ,any_desired_parameters) is calculated across the parameter space using the formulas above. **This results in a considerably better compact approximation of V_B, with fewer measurements needed than for approximating V_B directly at the same quality**.

These formulas also provide simple good predictions of sailing boat's behavior change from existing current behavior when wind speed and direction change. From measured V_B, and V_T (or apparent wind speed on board) and γ (or β on board) the current η is calculated. Then this η is used with the expected new V_T and γ to calculate the new V_B.

Note: I first circulated the formulas above by email in November 2004. They were posted on my website on August 1, 2008. I have not seen the main equation above anywhere else. Please let me know if you have seen any independent publication of it, or equivalent, or very similar.

For V_T = 10 mph, and γ = 1 radian ~= 57 degrees, the following results are calculated using the formulas above to demonstrate how η affects the relationship between wind speed and boat speed:

η	.1	.01	.001	.0001	.00001
V_B	4.01	10.28	24.21	54.31	119.15
V_B/V_T (boat/wind)	0.4	1.0	2.4	5.4	11.9

Ranges of η for various sailing boat types seem to be as follows:

	Water boats	**Land boats**	**Ice boats**
η	.5 - .0005	.005 - .0001	.0005 - .00005 mph^{-1}

Using the method - A detailed example

A detailed example of how the method presented above can be used is demonstrated with the *Aerodyne 43* yacht class at <http://yoavraz.googlepages.com/polardiagramforboatspeed3>.

Best VMG - Zigzag both upwind and downwind

(See equations at <http://yoavraz.googlepages.com/sailing-bestvmg>)

An exact formula for optimal VMGs, up and down wind, has been derived from the formulas above. It is assumed that η is a constant, or at most very little changing in and around these points. The optimal VMGs are calculated by finding the points in the polar diagrams above at the top where the tangent line is horizontal. If V_B is described in a Cartesian system of coordinates where **x** is the horizontal axis, then $dV_B/dx = 0$ exists at these points (the quite involved resulting equation that should be solved simultaneously together with the equation at the top (for both unknowns γ and β) is given at <http://yoavraz.googlepages.com/sailing-bestvmg>). The solutions provide numerical results as follows:

$V_T*\eta$	.1	.01	.001	.0001
VMG upwind γ	43.8	41.9	40.6	39.9
β	23.7	13.7	7.1	3.5
V_B/V_T	0.85	2.00	4.49	9.85
Best_VMG/V_T	0.61	1.49	3.41	7.56
VMG downwind γ	153.5	145.1	142.5	141.5
β	60.8	21.1	8.6	3.8
V_B/V_T	1.14	2.31	4.80	10.16
Best_VMG/V_T	1.02	1.89	3.81	7.95

Thus for best VMG, picking γ=~44-45 degrees upwind, and γ=153-155 downwind seem to be the best choices for most keelboats in all their applicable winds (and knowing accurate values of η in these directions determines γ very accurately). These results are very close to values found on polar diagrams of yachts. For land and ice boats the γ values for best VMG are a little smaller (~40 and ~143). Very fast water boats are in-between (~41-43 and ~144-153).

Water sailboats

The following calculations (using the formulas above and constant η) roughly emulate a Tornado (η = 0.008)

When V_T=10 mph and η = 0.008 (Tornado)

γ (degrees)	30	60	90	120	150	180
V_B (mph)	6.98	11.54	14.11	14.49	12.46	9.31

When γ = 60 and η = 0.008

V_T	10	20	30	40	50	60	70
V_B	11.54	17.64	22.52	26.74	30.51	33.96	37.15

and an 18ft Skiff (η = 0.003):

When V_T = 20 mph and η = 0.003 (~ 18ft Skiff)

γ (degrees)	30	60	90	120	150	180
V_B (mph)	15.71	25.74	31.24	31.76	26.78	18.93

When γ = 60 and η = 0.003

V_T	10	20	30	40	50	60	70
V_B	16.67	25.74	33.09	39.48	45.23	50.52	55.44

Note that for Tornados and Skiffs V_T > 35 is quite impractical; it is shown for the formula's demonstration.

At higher wind speeds the speed amplification (boat/wind speeds ratio) reduces due to increased drag.

For boats with a jib, η typically increases slightly with γ (speed decreases) for stern winds, due to reduced jib efficiency and contributing interaction with the mainsail. Also wind turbulence initiation and increase, as β is getting relatively large, increases η (When γ is getting closer to 180 degrees, this turbulence can be observed with tell-tales on the main's leech). Thus by picking an average η, the above results become slightly overoptimistic for stern winds.

In October 1993 the speed record for water was broken by Yellow Pages Endeavour (YPE) which reached ~52 mph at wind of ~21 mph (resulting η ~= 0.0008 at optimal wind direction and sail setting). Since then the record has been broken in 2004 by a windsurfer and in October 2008 by a kitesurfer who at winds of ~45 mph reached speeds of ~56 mph.

Figure 4: Aerodyne 43

Figure 5: Record holder Yellow Pages Endeavour *(YPE).*
Subsequent contenders include Macquarie Innovation

(evolved from YPE; **η***~=.00065 ?; thus expected by me to pass the ~56 mph record at wind above ~21.5 mph),*

and Sailrocket
(Reached ~52 mph at ~21 wind ? so far; η *~= .00083 ?)*

Ice and land sailboats

Ice and land sailboats/vehicles typically operate at higher speeds than water sailboat, and the aerodynamic drag becomes the bigger factor. Also typically the travel medium (ice or land) drag is much smaller than that of water (and the typical hull-length effect does not exist). A slightly different speed formula that considers this is more accurate (see http://yoavraz.googlepages.com/sailboatspeedvs.windspeed), but also the original formula above can be used as an approximation.

Modern iceboats are documented to reach maximum amplification of wind speed of factor 8-10 at light winds. At 15-20 mph winds they reach their top reasonably measured and documented speeds of 80-90 mph. Based on these data iceboats have very low drag coefficient and **η** (< 0.0001), so theoretically (by the above formulas) they can pass the 200 mph barrier in 40-60 mph winds. Though I have no detailed ice yachts speed data, **η** seems to hardly change near the optimal true-wind direction for such yachts (85 < **γ** < 115) with a single-sail (or a single vertical wing), with good aerodynamics (of both body and sail/vertical wing; low drag and turbulence at high-speed apparent winds are crucial at such speeds) and proper blades on a uniform ice surface at a range of temperatures. In this case, with a properly measured **η**, the above formulas predictions are expected to be quite accurate.

The following calculations (using the formulas above) approximately emulate an Ice yacht (**η** = 0.00005):

When $\mathbf{V_T}$ = 30 mph and **η** = 0.00005 (~ Ice yacht)

γ (degrees)	30	60	90	120	150	180
$\mathbf{V_B}$ (mph)	95.90	144.84	164.64	154.75	113.17	29.96

When **γ** = 90 and **η** = 0.00005

$\mathbf{V_T}$	10	20	30	40	50	60	70
$\mathbf{V_B}$	79.27	125.73	164.64	199.34	231.19	260.94	289.05

The range 0.00005 < **η** < 0.00010, which imply reduced speeds, but at the same range of magnitude, seem to be more realistic values of **η** for ice yachts.

When **g** = 90 and $\mathbf{V_T}$ = 50 mph

η	0.00005	0.00006	0.00007	0.00008	0.00009	0.00010
$\mathbf{V_B}$	231	217	206	197	190	183

Thus, at this parameter range any drag coefficient (and h) reduction is critical to breaking the 200 mph barrier. Wind-tunnel experiments with a scaled down model and turbulence visualization at ~200 mph equivalent and respective apparent wind flow directions (**β** = ~ 15 degrees) are desired for designing a proper vehicle.

The above also suggests that at these speeds when the real wind direction is **γ** = ~90 degrees, and apparent wind = ~15 degrees, if the blades' direction is 0, then the aerodynamic fuselage should point to ~15 degrees (against apparent wind for minimum fuselage drag), and the aerodynamic vertical wing direction (of a certain well defined average plane in the wing) should be set to ~7.5 degrees from the blades' direction for maximal drive in the blades' direction. At this positioning the total force measured on a successful vehicle (including a correction for the blades' drag/friction), in the direction of the blades, should be 0.

Some examples -

Debutante

"John D. Buckstaff, … in 1938, apparently clocked 143 mph (230 km/h), in a 72 mph wind on Lake Winnebago in Wisconsin (USA). His craft was a stern steerer *Debutante*, [pictured right]. Little is known about how it was timed or who witnessed it. The consensus amongst most modern ice sailors is that this sort of speed would have been impossible in such a craft." (From http://www.windjet.co.uk)

Comment: Resulting η ~=0.00045 at optimal setting looks reasonable for such a vehicle

Figure 6: The Debutante

Windjet (now called *Greenbird*)

The *Greenbird* team reported that attempts to break the world record for land vehicle were underway at the salty Lake Lefroy in West Australia in August 2008. However, in September, the attempt was stopped (never really started) due to surface flooding by rains and lack of proper winds.

Published data, 90 mph at 20 - 25 mph wind for the land craft, imply (at optimum) a range of .00015 < η < .0002.

If η does not change much (e.g., due to travel surface moisture and texture change, increased turbulence and friction coefficients due to increased speed) expected speeds (optimal γ ~=98; β ~=16) are:

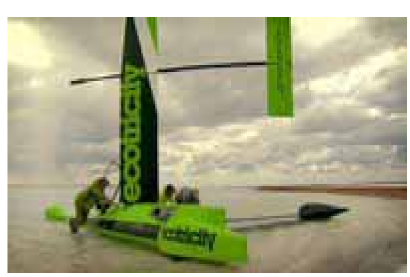
30 mph wind 104 - 115 mph.
40 mph wind 125 - 140 mph.
50 mph wind 140 - 160 mph.

To break the current record of 116.7 mph set by *Iron Duck* on March 20, 1999 (at probable 25 - 30 mph wind implying .0001 < η < .00014 at optimal setting) the expected wind needed for such *Greenbird's* η (.00015 to .00020) is above 31 - 36 mph.

Yoav Raz
Chestnut Hill, Mass.
yoavraz@rcn.com

Figures 7: The latest Windjet *land craft. Looks like a proa?*

Windjet *ice craft*



Figures 8: Greenbird *craft.*

Figure 9 Iron Duck

Footnote: On the morning of March 26th 2009, on the 'dry' Lake Ivanpah, the Ecotricity 'Greenbird', driven by British engineer, Richard Jenkins smashed the world land speed record for wind powered vehicles. The Greenbird clocked 126.1 mph (202.9 km/h) in a north westerly wind of around 30-35 mph, eclipsing the old record of 116 mph, set by Bob Schumacher in the Iron Duck in March 1999 at the same location. (Ed)

AYRS Meeting at Thorpe, Sunday 25th January 2009

For the several years, Fred Ball has arranged a couple of AYRS meetings each winter, these having been held in Thorpe village hall which is to the south west of London, not far outside the M25 ring road. These meetings start about 10am and end about 4:30pm, with a break for lunch, so allowing for most people having to do some travelling they are all day events. I think they do offer an excellent opportunity for a mid winter day off to think and talk about boats and sailing. The format is for members to give short presentations on their current, future or past projects and these presentations generally prompt quite enough group discussion to fill the time available.

Here is my summary of proceedings from the most recent of these meetings, held earlier this year.

The main presentation, which took most of the morning session, was by guest speaker Andrew Hall, who is a member of the Stirling Engine Society and who is particularly interested in the application of Stirling engines to leisure craft.

Andrew started with an explanation of how a Stirling engine functions and gave a brief history. For the benefit of those who are too busy to click the appropriate buttons on 'Wikipedia', a Stirling engine works by alternately heating and cooling a closed volume of gas and utilising the expansion and contraction of this gas to produce mechanical power. In practice, the heating and cooling of the gas is achieved by moving the gas to and fro between heated and cooled spaces. Efficiency can be improved by placing a 'regenerator', typically consisting of a mesh of copper wires, into the transfer passage between the heated and cooled spaces. The temperature of the regenerator will settle at about the mean of the hot and cold space temperatures so that gas leaving the hot space is partially cooled before entering the cold space and gas leaving the cold space is partially heated before reaching the hot space. The two most popular basic arrangements of Stirling engine are known as the Beta type and the Gamma type. In the Beta type, an oscillating 'displacer' shifts the gas to and fro between heated and cooled ends of a single cylinder. The displacer is like a piston which is a loose fit in the cylinder so that the gas can flow past it. Power is taken from the expansion and contraction of the total gas volume by means of a close fitting piston at one end of the same cylinder that contains the displacer. The Gamma type engine has no displacer but rather has two inter-connected cylinders, one heated and one cooled, and each cylinder has a piston. The movement of the two pistons is contrived such as to both transfer gas to and fro between the cylinders and to take mechanical power from the expansion and contraction of the total gas volume. The first Stirling engines to be developed (by the Reverend Stirling working in Scotland) were Alpha engines, more modern variants are usually of the gamma type.

Some years after the Stirling engine was first demonstrated, Eriksson, an inventor and entrpreneur working in Sweden then the UK and then the USA, took up the idea of the Stirling

AYRS Chairman - preparing the hall

engine and developed it with some commercial success. Eriksson built a huge Stirling engine to power a 2000 tonne paddle steamer, which at that time was one of the largest ships afloat. Sorry, I should not have called it a paddle steamer, there was no steam involved, Eriksson referred to it as a 'caloric ship'. It was not a great success, perhaps because the engine was much larger than a contemporary marine steam engine of the same power. The ship sank, was salvaged, was then fitted with a steam engine, was later converted into a sailing ship, before finally being wrecked. Although the caloric ship was an experiment that was not repeated, Eriksson did also mass produce thousands of small Stirling engines which were used across the USA for purposes such as domestic and agricultural water pumping.

Having explained the principle and given a run down of the history Andrew then proceeded to demonstrate the operation of two small Stirling engines fired from a portable propane bottle. One of these was an Alpha type and was an accurate reconstruction of one of Eriksson's original engines, the other was a gamma type which Andrew had made in his own workshop, starting with the crankcase, crank shaft and flywheel taken from a small Vee twin air compressor.

So how does a Stirling engine compare with an internal combustion engine such as a diesel or petrol engine? Well, the most technically advanced Stirling engines can more or less match the thermal efficiency of a modern diesel engine, so there is not a lot in it from that point of view. The main disadvantage of the Stirling engine is that it tends to be less 'power dense' than a modern internal combustion engine, that is it is larger and heavier for the same power output. However, the Stirling engine does have some advantages on its side. Stirling engines tend to be quieter than internal combustion engines since they do not burn the fuel explosively. Stirling engines produce fairly harmless exhaust gas since full combustion can usually be achieved, avoiding the production of poisonous carbon monoxide. Stirling engines can be designed to run on a wide range of fuels, e.g. petrol, diesel, LPG, wood chips. Indeed, a combustible fuel may not be required, waste heat from industrial processes may be utilised, solar heat can be focussed using a mirror(s) and a nuclear Stirling engine is not an impossibility.

There have been various efforts to develop advanced Stirling engines to compete with internal combustion engines. For example, during the 1950s, the Phillips company developed efficient small

Andrew Hall (right) demonstrates the operation of Stirling engines

Stirling engines for use as portable electricity generators and in recent years the 'Whispergen' Stirling engine generator has been introduced as a combined central heating and electricity generating unit. Stirling engines have also been developed for submarines. If a Stirling engine is fired from oxygen and hydrogen stored in tanks on board a submarine, the exhaust consists only of steam which can be condensed and expelled from the submarine leaving no trace. The Stirling engines so far developed for submarines are not powerful enough to provide main propulsion, rather they are used as a secondary power unit when quiet underwater travel is essential.

Advanced Stirling engines use gas under high pressure as the working fluid, rather than gas at atmospheric pressure. Pressurising the gas within the engine increases the power density of the engine. Another improvement is to use helium or sometimes hydrogen as the working fluid, these gasses having higher thermal conductivity and higher specific heat than air. A major difficulty with using high pressure helium or hydrogen is sealing the engine against leakage. The Wispergen unit avoids this problem by having the engine and the electricity generator both enclosed in an all welded pressure tight vessel which is not penetrated by any rotating shaft. The gas fired WishperGen unit produces about the same heat output that you would get from a central heating boiler of the same gas consumption, but with the bonus of producing some electricity as well. Of course, you can achieve much the same result with a diesel generator if you use the exhaust and water jacket heat for central heating, but the Wispergen is quieter and having fewer moving parts may well be more reliable. WisperGen units were originally marketed for leasure craft, but significant numbers have recently been sold for installation in houses.

Most of the Stirling engines that are home built by members of the Stirling Engine Society use air at about atmospheric pressure as a working fluid, so they are not particularly efficient engines, but the society members seem to have a lot of fun building and running them. A number of Stirling Engine Society members have fitted Stirling engines into boats, mostly small boats ranging from canoes to small launches, so there is a cross-over of interest with AYRS.

After Andrew had finished his presentation, we had a group discussion to consider what would be the ideal roof-rack-transportable craft that could carry two persons on inland waters and which could be powered at about 3 to 4 mph by a Stirling engine. This did generate quite a lot of discussion and the consensus seemed to favour a catamaran with the engine and propeller between the hulls. My own thought is that at this low speed a slim monohull can have no more resistance than a similar length and weight catamaran, so the main advantage of a catamaran would be better stability, but if you only operate on inland waters that may be of lesser importance. I would suggest a slim monohull, something like a typical lightweight narrow beam row boat.

Following our lunch break, we continued with a series of presentations of individual members projects. There were quite a few of these so apologies for only including in my summaries below a selection of those presentations that I can best remember.

Charles Sutherland showed us a small model of his sailing proa canoe together with some photos of the full size boat which he has been improving bit by bit over recent years. This proa has a single sail in the shape of an equilateral triangle with a yard along one side of the triangle. A rope span, connected to the yard at two points, runs over a pulley at the top of the mast when 'shunting' the proa, so keeping the yard at the leading edge of the sail. The yard is a streamlined section with the sail faired into it. A picture would be worth a thousand yards, but I haven't got one. This looks to be a meticulously executed project which has produced a neat little boat for day sailing on sheltered waters and perhaps even for camping trips. Charles now feels that he has taken this project about as far as he can and he is looking for someone who would

be able to put the boat to good use and possibly to develop his ideas further.

Mark Tingley brought us up to date on his project to design his idea of the ultimate small trimaran for day sailing and camping trips. Over the past few years he has worked with a couple of professional yacht designers to produce some fairly detailed concept drawings, he is now thinking about finding a draughtsman with an understanding of boats who could produce detailed construction drawings. Meanwhile, he has built a balsa wood model of part of the main hull and we discussed various features of this model. It occurs to me that if he were to make a suitably detailed model of the whole craft then perhaps he would not need so much in the way of detail drawings. Personally, I would prefer to make a 'virtual' model using software such as SolidWorks, but I realise that many people would prefer to work with a model that you can actually hold in your hands.

Slade Penoyre continues to work to promote his concept for producing renewable energy from large numbers of fairly small windmills mounted on moored rafts. He mentioned a rival project by a Norwegian company which intends to place a 2.3megawatt windmill on top of a huge spar bouy moored in deep water, a spar bouy being a verticaly orientated floating tube, heavily ballasted at the lower end. From top to bottom this structure is something like the size of the Eiffel tower. Slade's concept is to have much smaller windmills, but a lot more of them, so benefiting from economies of mass production and ease of deployment and retrieval of the individual units. He makes the point that the power output of a windmill increases with the square of the linear dimensions whereas the cost of construction increases with the cube of linear dimensions, so favoring large numbers of small devices. Neither of the statements leading to this conclusion is exactly true, but I think there must be some logic in the argument. Slade is considering exhibiting a prototype raft and windmill at the commercial marine exhibition 'SeaWork' held in Southampton and he would be pleased to hear from any members who might be prepared to help with manning his exhibition stand.

Charles Magnan showed us CAD drawings of a couple of sailing multihulls that he has designed as course work for a yacht design correspondence course that he will soon have completed. Perhaps the most interesting of these is a circa 6m trimaran (same size as Mark Tingley's one) utilising a Tornado catamaran rig and designed for use by a disabled helmsman, with or without an able bodied crew member. There is wheelchair

John Perry's sailing dinghy with tent rigged from the boom for overnight accommodation.

access to the main hull via an open transom stern and the craft is equiped with a retractable undercarriage' with electrically powered wheels, so allowing a disabled sailor more independence than would be possible if relying on able bodied manpower for launching and recovery.

Jonathan Barton showed us some of the parts that he has made for his speed sailing proa. This shares some of the features of past record holder 'Yellow Pages' in that it has two small planing skids on the lee side and a single planing hull which carries the crew on a beam extending to windward. Unlike Yellow Pages, the sail is a relatively low aspect ratio rectangular sail with end fences and has variable chord to reduce area as apparent wind increases. Also, rather than varying angle of attack of the sail by rotating the sail relative to the frame of the craft, the sail remains at a fixed angle to the frame and the angle of attack of the sail is to be varied by rotating the three small hulls relative to the frame. Steering is by relative rotation of one hull relative to the other two.

Towards the end of the meeting, the chairman suggested that I might show some pictures from my holidays spent sailing an open boat fitted with a tent cover for overnight accommodation. I did briefly explain how my 4.5m open boat is arranged for living on board. This triggered some discussion on how to construct a tent to fit on a boat, with some highly ingenious suggestions. There was also a question as to how one deals with sanitation with this type of sailing and I failed to provide a very satisfactory answer to that one. I can only say that most small cabin craft in the UK are still not provided with proper sewage holding tanks, so open boat sailors are not the only ones with this problem.

Thanks are due to AYRS Chairman Fred Ball for organising and chairing this excellent meeting. I look forward to the next Thorpe meeting which is planned for 14th November of this year.

John

Report of AYRS Devon meeting held 7th March 2009

For the second year running, we held a get together of AYRS members at our house in Wembury in South Devon. We had 9 members present, including a few new from last year, but also one or two from last year were unable to make it (busy boat building or judging sailing speed records). We were again joined by AYRS Chairman Fred Ball and Slade Penoyre from Surrey and Mark Tingley from Hertfordshire who stayed the weekend with us in Devon. As we did last year, we started our meeting with an afternoon walk along the coast path from Wembury, then returned to our house for tea and chat before starting our slightly more formal meeting in which several members gave presentations and answered questions.

Joddy Chapman started our presentations by showing us some pictures he had obtained from Australian dinghy designer Frank Bethwaite, these showing some prototypes that Frank has been testing to develop a hydrofoil version of the 49er Olympic class skiff. Joddy had only limited information about these developments taking place on the other side of the globe, but from what we could make out from the pictures Frank is experimenting with a canard concept having a lightly loaded surface following hydrofoil at the bow, this setting the angle of attack for a fully immersed stern hydrofoil. This is the arrangement I used when I built and tested a couple of 'bi-foiler' sailing hydrofoils which preceded those developed within the Moth dinghy class. I noted that at least one of Frank's prototypes appeared to be steered by turning the bow foil, which is something I have thought about to improve the poor maneuverability of my hydrofoil boats when not foilborne. With a canard foil arrangement, you are probably going to want the centre of gravity of the craft to be well aft, so when not foiling you have a lot of hull in the water at the aft end. With stern steering, you need to push the heavy end of the hull sideways through the water when turning at low speed, for example when tacking. It should be much easier to push the bows sideways using a bow steering design. Of course, if you could keep on the foils through a tack, as do the modern Moth boats, you would avoid the problem, but that takes practice!

I then gave a presentation which looked at the fundamental principles of sailing and how these have lead to a variety of different configurations being adopted in the search for performance. I began with a diagram of a most elementary sailing craft, just a keel above the water and a sail above. It is surprising, just how high is the predicted speed for this imaginary craft, Taking a very modest lift to drag ratio of 5:1 for both the keel and sail and with 20 knots of true wind just abaft the beam, you have 52 knots boat speed, enough for Weymouth! Of course, it doesn't work like that in practice. This elementary craft lacks any provision for resisting heeling moment or for support of its weight and it is these two requirements that makes the problem so much more difficult. I showed how the plethora of different types of sailing boat types which are either in use today, or which have been built as experiments and then largely forgotten, can all be classified according to how provision is made for resistance to heeling moment and support of weight. All this is fairly basic, but when thinking about an engineering problem, it helps to occasionally go right back to the start and think about the fundamental requirements before adding all the little details that are needed to make a fully practical solution.

At our Devon meeting last year, Simon Tytherleigh told us about his project to build a fast cruising catamaran to what is basically a Kurt Hughes design, but which incorporates many of his own features including a redesigned bridge deck. Simon was unable to come to our meeting this year but Andy Bartram, who has been helping Simon, updated us on progress. Andy described how he and Simon made the wing mast for the boat using thin plywood. A plywood sheer web runs the length of the mast and a plywood skin is bent around and glued to the edges of this sheer web to form the streamlined cross section. Unidirectional carbon fibre then laid on the outside to give bending strength and stiffness. The project is making good progress and may well be afloat some time in 2010. Simon has been considering how he is going to transport it to the water. With a twenty foot beam it may be too wide for road transport with hulls side by side. It may be possible to turn it 90 degrees to stand on a lorry with one hull high in the air.

There followed a discussion of the risks of multihull capsize and this prompted Slade to recall his memory from the 1970's of the capsize of a 28 foot proa several hundred miles west of Lands End. The boat was drifting downwind under bare poles in rough weather but all seemed well so Slade was down below making a coffee when it went over. He cut a hole in the foam sandwich hull to get out. Slade thinks the wind direction had changed causing breaking waves, one of which tipped the boat over. Slade was rescued by a ship which was bound for Panama and dropped him off there. Slade later heard that the boat had been salvaged but it turned out that it was so badly damaged to be not worth repairing. There followed some discussion on methods to right a capsized multihull, including Slade's proposal which involves swinging the mast sideways by adjusting shroud lengths and pulling up the masthead using an inflated float.

We continued with a discussion of Slade's work to promote the idea of large scale electricity generation using very large numbers of relatively small windmills mounted on moored pontoons in an area such as the north sea. Slade's trials to verify the survivability of prototype floating windmill units have been described previously in Catalyst, so I will not repeat this here.

Our final presentation was by Mark Tingley who showed us pictures of concept models he has made for a proposed 20 foot trimaran. I have mentioned this project in my report of the AYRS winter meeting in January of this year, so to avoid repetition I will just say that the numerous novel features of Mark's design initiated a group discussion that easily filled the remainder of our evening.

John Perry
J_perry@btinternet.com
(Note underscore in email)

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**

October 2009

10th – 16th **Weymouth Speedweek**
Portland Sailing Academy, Portland Harbour, Dorset UK. See www.speedsailing.com.

14th **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

November 2009

14th **Sailing Developments**
9.30am to 5pm, Thorpe Village Hall, Coldharbour Lane, Thorpe, near Staines & Chertsey. Bring your lunch - tea and coffee available. Donations invited to pay for the hall. Details from Fred Ball, tel: +44 1344 843690; email frederick.ball@mypostoffice.co.uk

January 2010

8th - 17th **London International Boat Show**
EXCEL Exhibition Centre, London Docklands. AYRS will be there, in the North Hall. Helpers are wanted to staff the stand, sell publications and recruit new members. If you would like to help (reward: free ticket!) please contact the Hon Secretary on 01727 862268 or email office@ayrs.org

30th **All-Day AYRS Meeting**
9.30am-4pm, Thorpe Village Hall, Coldharbour Lane, Thorpe, Surrey (off A320 between Staines and Chertsey – follow signs to Thorpe Park, then to the village). Details from Fred Ball, tel: +44 1344 843690; email frederick.ball@mypostoffice.co.uk

30th **AYRS Annual General Meeting**
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

Note: Items to be considered by the AGM, including nominations for the Committee MUST be received by the AYRS Secretary before 22nd December 2009 (post to AYRS, BCM AYRS, London WC1N 3XX, UK, or email: secretary@ayrs.org)

February 2010

27th **AYRS Southwest UK Area Meeting**
4pm 7 Cross Park Road, Wembury, PL9 0EU near Plymouth. As we did last year, we plan to hold a get-together of people interested in technical developments in sailing or boatbuilding. Wembury is a coastal village a few miles SE from Plymouth. We offer light refreshments at about 16:00, followed by presentations and discussions from about 17:00. We are reliant on at least one or two members coming prepared with some kind of presentation and maybe a few others bringing a few pictures to share, so do bring your pictures as prints or in a PC format such as CD, USB storage device etc. If you have a longer presentation in mind, it might be worth contacting me first so that we can fit it in.
As before, we propose an afternoon stroll for those who would like to join us prior to the evening meeting. This will start at 14:00 but we will try to think of a different route from last year and that may mean a different start point, so phone or email for details to John Perry, 01752 863730 j_perry@btinternet.com (note the underscore in that email address).

April 2010

25th **Beaulieu Boat Jumble**
The National Motor Museum, BEAULIEU, Hampshire, UK. AYRS will be there!

May 2010

Either 1st – 3rd
OR 28th – 31st (watch www.ayrs.org for confirmation)
***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!

28th –31st **UK Home Boat Builders Rally – Norfolk Broads**
Barton Turf Adventure Centre, Norfolk UK NR12 8AZ. For details see http://uk.groups.yahoo.com/group/uk-hbbr/

How to find Thorpe Village Hall

http://www.multimap.com/maps/?lat=51.40823&lon=-0.5285&redCircle=on

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

On the Horizon . . .

Split junk sails
Howard Fund applications
Experimental platforms
More sources and resources: reviews, publications and Internet sites

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

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