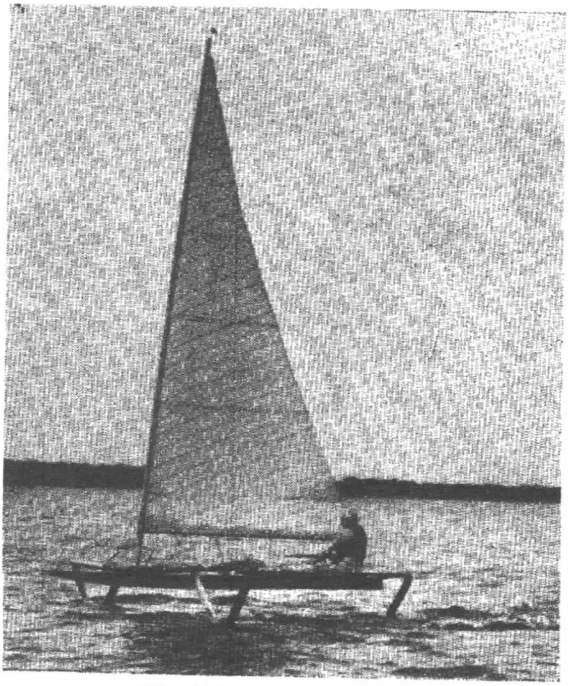
HYDROFOILS

A.Y.R.S. PUBLICATION

No. 2



The Baker Hydrofoil Craft.

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INTRODUCTION

I want to thank all the kind people who wrote saying how much they enjoyed the first A.Y.R.S. booklet on CATAMARANS. It is to be hoped that all the future publications will be found as interesting.

This one is on the much more fluid subject of HYDROFOILS where an old principle is being applied in new ways, so, as compared to the outrigger mechanism, the final applications still have to be worked out. In this way, it can give the inventive ability of the A.Y.R.S. members plenty of scope.

No apology need be given, I am sure, for the few devices which are described which might not be fully practical in their application such as the hydrofoils applied to the bottom of the keel. As shown, these would probably be useless, but they might be of value to keep in mind when designing a fin keel. The keel of the Flying Fifteen is a case in point where the upper surface of the " bulb " has some hydrofoil characteristics of the type shown.

In the closing pages, the first co-operative research project is envisaged which is wholly suited to the A.Y.R.S. This is on wind flows and could produce very useful results. If it does, other projects of a similar kind will be started.

The sailing season is now coming to an end. It would be surprising if every yachtsman had not learned something during this summer. I expect most will have tried out some new gadget or even invented something and it is these modifications and inventions which we want for these pages as well as the more startling craft with hydrofoils, outriggers or new rigs.

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HYDROFOILS

A hydrofoil is a thin sheet of material submerged in flowing water. It has all the main characteristics of an aerofoil working in air, but, because water is thicker stuff than air, the forces produced by a hydrofoil are very much greater than the forces produced by a foil of the same size and shape in air.

The value of a hydrofoil is essentially its ability to produce a force acting almost at right angles to the direction of the water flowing across it and this force is very much greater than the drag, or the resistance of the foil to the water flow. Thus, if we need a force to act on a boat which is travelling through the water, we can attach a hydrofoil to the boat and get it.

The main hydrofoils which are used by sailing boats are, of course, the fin keel, the centreboard, the leeboard and the rudder. The first three of these are used to produce forces acting to windward, preventing most of the leeway. The rudder, when it is slung separately from the keel, is a simple hydrofoil which is used to guide the boat. When it is slung on the after edge of a fin keel, however, complicated forces are brought into play which need separate consideration.

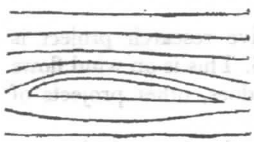


Fig. 1.

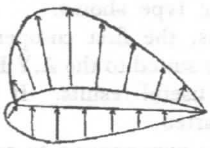


Fig. 2.

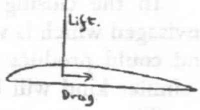


Fig. 3.

Fig. 1 is a diagram of a hydrofoil with the water flowing past it. The lines, called " Streamlines," are the directions in which particles of water travel. It will be seen that the water flowing past is turned from its course. Now, when a moving body is turned from its course, it means that a force is acting upon it, and in this case, it means that the foil is exerting a force on the water. Since action and reaction are equal and opposite, the water is exerting a force on the foil.

It will also be seen in Fig. 1 that above the foil, the streamlines are crowded closer together indicating that the water is flowing faster there and below the foil, they are more widely separated indicating that the water flow is slower. In the 18th century, a man called Bernouilli showed that when a fluid flowed along a pipe with a narrow part in it and, for this reason, had to accelerate, the pressure in the narrow part was less than in the rest of the pipe. Similarly, if the pipe had a wider part, the pressure there was increased. The streamlines around the foil can be thought of as indicating the boundaries of imaginary pipes because particles of water do not cross them as they move across the foil so that, where they are closer together above the foil, the pressure becomes less and, in the opposite way, the pressure below the foil increases. Fig. 2 shows how the forces at various parts of the foil act, each one at right angles to the tangent at that part.

The forces shown in Fig. 2 are far too complicated to study but they can all be combined into two forces namely 1, The " Lift " acting at right angles to the water flow and 2, the " Drag " acting along the direction of the water flow. The ratio of the lift to the drag can be as great as 20 : 1 for hydrofoils of certain shapes but, in actual practice, the usual hydrofoil with its connecting link to the parent structure cannot achieve a lift/drag ratio of that value.

At the free end or ends of hydrofoils large eddies form which result in the loss of power. It is for this reason that a high " Aspect ratio " or great length of span across the water flow compared to the " Chord " or distance along the water flow is of value because, if the aspect ratio is high, there is more foil for the same loss of power at the end or ends.

THE TRADITIONAL HYDROFOILS

The Centreboard. This type of mechanism for reducing leeway must be able to work equally well on either tack and thus it must be symmetrical about the midline plane of the boat. In the horizontal plane it must be the perfect streamlined shape. A flat plate with the front rounded off and the stern fined down to a point is not so good. It would appear from consulting aerofoil work which is thought to be as useful for hydrofoils as it is for aeroplanes that the greatest thickness of the centreboard should be 12.5% of the force and aft distance across it. However, this figure is not very critical and it can be up to 20% of the chord without losing any great amount of

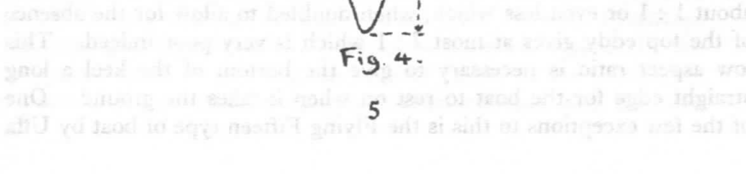


Fig. 4.

power. A thick centreboard might, however, cause surface waves and produce extra resistance in doing so.

The plan shape of the centreboard or the shape when it is looked at from abeam is capable of a certain amount of argument. The facts, however, are these : (1) The hull of the boat prevents the formation of a wing tip eddy at the upper end of the board so the aspect ratio of the centreboard is twice that calculated (2) It is generally the case that an aspect ratio of 6 : 1 is as good as is needed for ordinary work for either an aerofoil or hydrofoil ; (3) The greater the aspect ratio, the lower will be the centre of pressure on the centreboard which will cause the boat to heel more. Therefore, it is advisable to keep the aspect ratio just on the lower side of efficiency ; (4) The ideal shape of the centreboard is half an ellipse but a triangular shape with the point downwards will have a higher centre of pressure and therefore will heel the boat less.

Taking all the above facts about centreboards into consideration, there is a good case to be made out for a centreboard being more or less a triangle with a vertical depth of $1\frac{1}{2}$ times the fore and aft length along the hull as in Fig. 4. This gives an aspect ratio of 6 : 1, using the formula $Span^2/Area$ and multiplying it by 2 because there is only one wing tip eddy. It might be worth while to round off the tip of the triangle to bring the aspect ratio to 5 : 1.

It is well worth remembering that the International Twelve Square Meter Sharpie class with a centreboard of about this shape is considered to be a " stiff " boat, though this is usually attributed to moderate sail area.

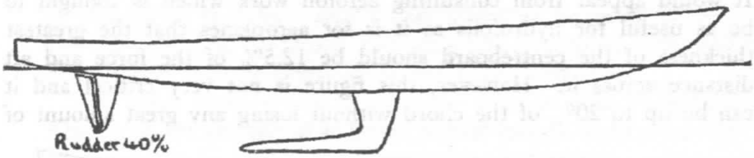


Fig. 5.

The Fin Keel. In this section we will deal with a fin from which the rudder is quite separate and is slung at a considerable distance aft. For this type of hydrofoil, everything which has been said of the centreboard is absolutely the same but, in practice, we find that the aspect ratio of fin keels is very much less than ideal, usually being about 1 : 1 or even less which, when doubled to allow for the absence of the top eddy gives at most 2 : 1 which is very poor indeed. This low aspect ratio is necessary to give the bottom of the keel a long straight edge for the boat to rest on when it takes the ground. One of the few exceptions to this is the Flying Fifteen type of boat by Uffa

Fox where the fin is actually longer at its lower edge than along the hull giving a reversal of the usual shape. This has the advantage of getting the main weight of the keel lower.

The problems which are posed by the fin keel are thus great and their solution by a shape of fin like Fig. 5 which, on the face of it seems to be the answer, is rather contradicted by some recent experiments at the Stevens Institute of Technology. It is, however, felt by the writer that it would be well worth the consideration of the A.Y.R.S. to investigate types of fin keel of approximately this shape.

The Fin Rudder Combination. When the rudder is slung on the after edge of the fin as in the conventional deep keeled sailing yacht, all the general rules of shape as already described still apply but two extra features appear. The first of these is a greatly increased force acting to windward when there is slight weather helm. This is, of course, due to the whole hydrofoil becoming asymmetrical in a way in which the " lift " force is increased. Tank tests at the Stevens Institute show that this effect is greatest when the angle of weather helm is about 5°. The second new feature is concerned with the turning power of the rudder. Here, the rudder alters the water flow along the main fin so as to produce a turning force in the main fin itself as well as a change in the real centre of lateral resistance. The exact changes are rather complex.

The Leeboard. This device achieved its greatest efficiency among the Dutch. On the shallow draught craft of Holland, it became an asymmetrical hydrofoil with the flat side to the outside and the curved side next to the hull and of occasionally quite high aspect ratio. As a hydrofoil, it differs from those which we have previously examined in cutting the surface of the water and because of this, it loses some power but, if the leeboard is designed to enter the water as a symmetrical foil at an angle of no force, the loss will be slight.

The Separate Rudder. A rudder slung on the transom of a boat such as is the normal practice among dinghys is a simple hydrofoil and is subject to all the forces already examined. However, like the leeboard, it cuts the surface of the water and thus makes surface waves *even though the tiller is in the centre line of the boat.* For this reason, Uffa Fox at one time slung the rudder below the hull of one of his dinghys and found that the steering had become so fierce that it was possible to capsize the craft at speed with the rudder action alone. This surely must have shown an increased efficiency.

In the J.O.G. of the R.O.R.C., the present trend is to have a rudder separate from the fin keel but, to steady the steering, it is slung on a variety of skeg. In my opinion, the rudder-skeg combination should be an approximate triangle of the ideal hydrofoil shape with a depth of $1\frac{1}{2}$ times the fore and aft length and the rudder should be approximately 40% of the chord for this is the proportion which has been shown in the case of aerofoils to increase the lift force by the greatest amount.

ASYMMETRICAL HYDROFOILS

Symmetrical hydrofoils produce very little in the way of lift for the drag they have at an angle of leeway of 5°. Asymmetrical hydrofoils, on the other hand, can produce as much as twice the lift for the same drag as a symmetrical foil. It would therefore be of great advantage if the fin keels of sailing boats could be asymmetrical with the lee side much flatter than the weather side because both the weight and wetted surface could be reduced and the sail area and heeling moment would become less with these.

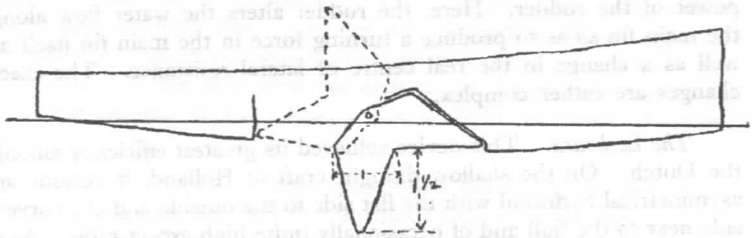


Fig 6.

The first attempt known to me of the use of an asymmetrical fin other than the Dutch leeboards was by Manfred Curry who devised a mechanism for warping both his centreboard and rudder to give a hollow to leeward and a convexity to windward. It is not known what happened to the idea or what success he had with it.

The next attempt, which proved to be successful, was on the yacht Zeevalk. Here, the fin keel had the trailing edge hinged like the aileron of an aeroplane wing and, on each tack, the flap was turned to leeward by about 5° so as to increase the windward acting force of the fin. The rudder was, of course, slung separately.

There are four other ways, however, of achieving the same object which spring to the mind. These are :

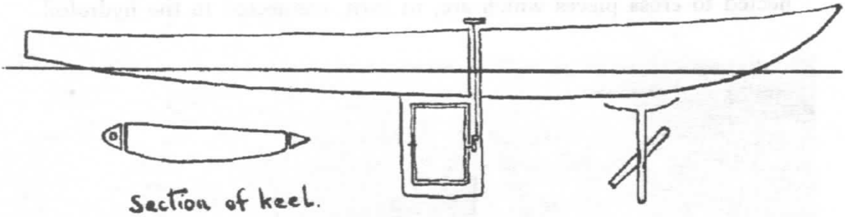
1. Having two centreboards in two cases or the same case either of which can be let down as appropriate.

2. Having an L shaped centreboard of wood worked by a handle at the side and kept in place by friction. One of the arms of the L

would be for one tack and the other for the other tack. Both arms of the L could be raised as in the position shown by the dotted lines of Fig. 6.

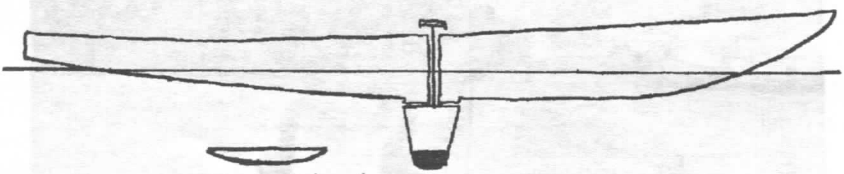
3. A "Turn over" keel which is shown in Fig. 7. The main part of the keel is here pivoted on a fore and aft horizontal axis so that it can be turned over on putting about so as to keep a flatter side always to leeward.

4. A "Turn around" keel as shown in Fig. 8 where the axle is vertical and the whole asymmetrical fin swings around a vertical axis on putting about.



Section of keel.

Fig. 7.



Section of keel.

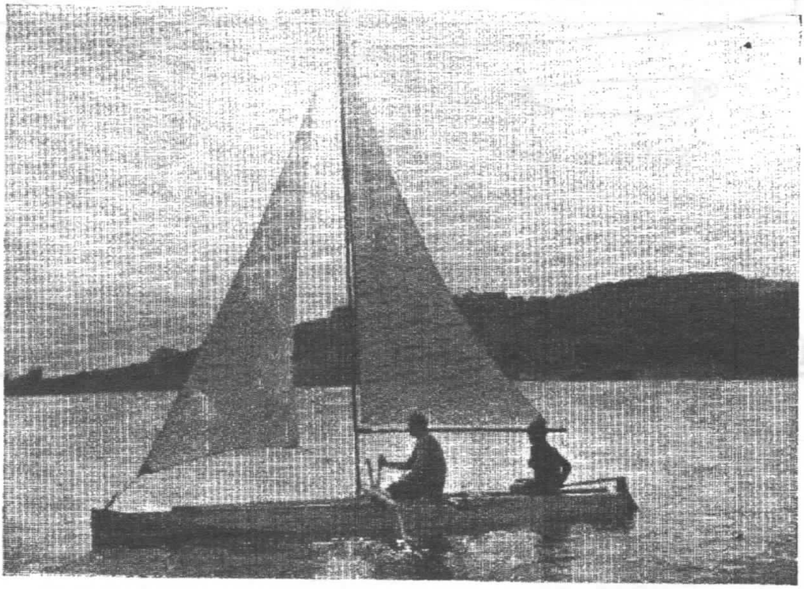
Fig. 8.

HYDROFOIL STABILISERS

Hydrofoils are used on many steamships to prevent them from rolling which they do very successfully. They consist of fins which can be run out from the sides of the ship, horizontally. Automatic devices alter their trim to the water flowing along the sides of the ship by twisting them about thwartships axes and the rolling can be reduced to about 5° on each side of the vertical.

It was thought that this same principle could be applied to a sailing boat, not only to prevent rolling but also to prevent heeling and, if the hydrofoils were to be given an angle of dihedral or slope from the horizontal so that the outside ends of the foils were higher than the inside ends, a keel or centreboard would not be necessary. A model was made and it worked perfectly, so last year (1954) a long hull, 19 feet in length and 2 feet 6 inches in beam was made by Sam Catt and myself and fitted with hydrofoils as shown in the photograph and Fig. 9.

In this craft of ours, the things like beer pump handles are connected to cross pieces which are, in turn, connected to the hydrofoil



stabilisers which run beneath the water. The cross pieces are connected to the boat by two hinges. When one of the handles is pulled back, the hydrofoil on the same side as the handle swings forwards, thus increasing its angle of incidence to the water flow. The water flowing over and under it then lifts it up. As we have it fixed, these planes are quite large enough to heel the boat to windward when sailing *even close hauled.* Not only do the planes keep the boat from heeling but they push it to windward so that there does not appear to be any leeway.

Another factor in favour of these planes is that the wind pressure tends to lift the hull of the boat out of the water when it is going at any speed and put the weight on to the hydrofoil. Fortunately, the foil does not hold the boat back when weight is put upon it as much as does the hull, so the effect is that greater speed is obtained. This effect is quite evident if, instead of the lift of the lee foil being used to keep the craft upright, the windward foil is used to pull down the weather side of the boat. There is a very distinct slowing up which is probably due to the increased displacement.

We have found this boat nearly normal to sail. It is not necessary to counterbalance the wind pressure by sitting out to windward so the attention which the hydrofoil handles need is no hardship and they

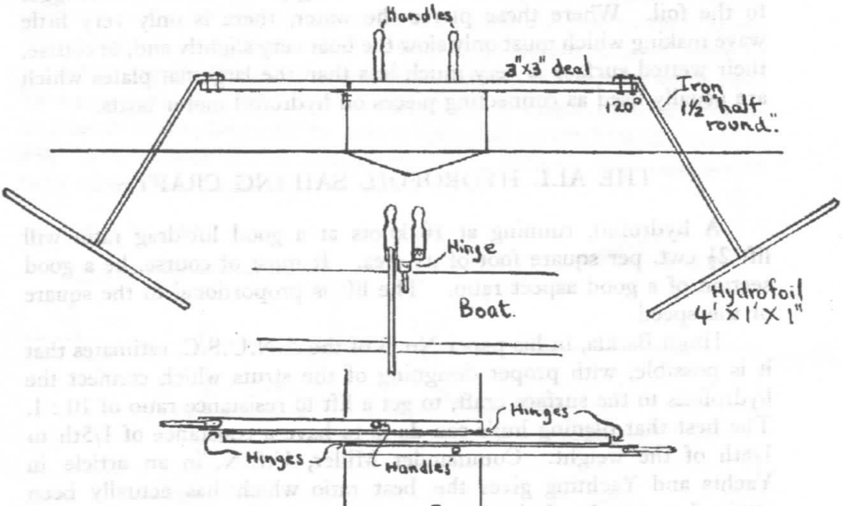


Fig. 9.

need very much less effort than " over the side athletics." There is only one thing which has caused any difference in handling to a normal dinghy. That is a tendency for the hydrofoil to " Stall " when a strong puff of wind hits the boat when it is stopped. A slight easing of the sheets till the boat gathers way is then needed.

This hydrofoil craft of ours was a complete success, The hull we used was very heavy and the hydrofoils were, on the whole, much too big so we did not get any very great speeds from it but if any A.Y.R.S. member wishes to carry on with this type of mechanism, he will undoubtedly travel at much greater speeds in much greater comfort than are possible with the ordinary dinghy now in use. The mechanism is fully capable of being used with any sailing craft with a great chance that speeds will be increased in stronger winds. Speeds will be less in light winds because there is extra wetted surface to be pulled through the water.

Though the full sized craft we made used hydrofoils which were operated by hand, the model which I had previously made had foils which worked automatically from the difference in pressure on the two foils as a result of the sideways pressure of the sails. No attempt has so far been made to try this out full scale.

It is felt that at least some of the success of these hydrofoils is due to the smallness of the iron connecting pieces from the outrigger to the foil. Where these pierce the water, there is only very little wave making which must only slow the boat very slightly and, of course, their wetted surface is very much less than the large flat plates which are usually used as connecting pieces on hydrofoil motor boats.

THE ALL HYDROFOIL SAILING CRAFT

A hydrofoil, running at 10 knots at a good lift/drag ratio will lift $2\frac{1}{2}$ cwt. per square foot of its area. It must of course, be a good section of a good aspect ratio. The lift is proportional to the square of the speed.

Hugh Barkla, in his paper No. 3 of the A.N.U.S.C. estimates that it is possible, with proper designing of the struts which connect the hydrofoils to the surface craft, to get a lift to resistance ratio of 10 : 1. The best that planing hulls can do is to have a resistance of 1/5th to 1/8th of the weight. Commander Miller, U.S.N. in an article in Yachts and Yachting gives the best ratio which has actually been attained as 15 : 1. It is therefore, quite possible that the answer to really high sailing speeds is to be found in hydrofoils running below the surface of the water.

Fig. 10 shows 14 ways in which hydrofoils can be arranged. There are three main ways only, the other eleven being combinations of these. 10a is the most simple and efficient. It is the method used for my boat's stabilisers and it has two faults. The first is that its angle of incidence to the water flow must be constantly changing as the speed rises and falls. The second is that its area is fixed so that, if it is running efficiently at 20 knots, it is four times too big at 40 knots. The constant changing of the angle of incidence can be automatically operated in several ways, however, for example by the " Jockey " floats of the " Hook Hydrofin."

10b. is a step ladder arrangement shown totally submerged but this state would only occur at low speeds. When travelling fast, one or two of the " rungs " would be out of the water but would fall down into it as the speed fell.

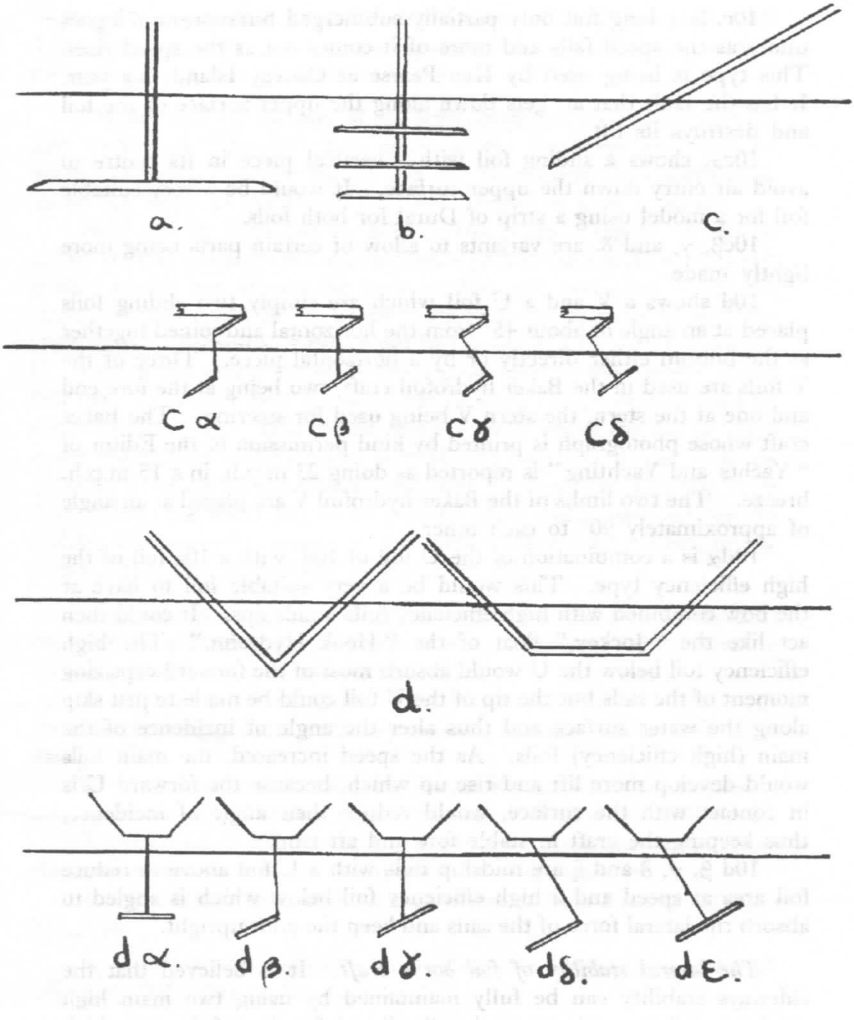


Fig. 10.

10c. is a long foil only partially submerged but more or of it goes under as the speed falls and more of it comes out as the speed rises. This type is being used by Ken Pearse at Canvey Island this year. It has the fault that air gets down along the upper surface of the foil and destroys its lift.

10cα. shows a sliding foil with a vertical piece in its centre to avoid air entry down the upper surface. It would be a very suitable foil for a model using a strip of Dural for both foils.

10cβ, γ, and δ. are variants to allow of certain parts being more lightly made.

10d shows a V and a U foil which are simply two sliding foils placed at an angle of about 45° from the horizontal and joined together at the bottom either directly or by a horizontal piece. Three of the V foils are used in the Baker hydrofoil craft, two being at the fore end and one at the stern, the stern V being used for steering. The Baker craft whose photograph is printed by kind permission of the Editor of "Yachts and Yachting" is reported as doing 23 m.p.h. in a 15 m.p.h. breeze. The two limbs of the Baker hydrofoil V are placed at an angle of approximately 90° to each other.

10dα is a combination of the U foil of 10d. with a 10a foil of the high efficiency type. This would be a very suitable foil to have at the bow combined with high efficiency foils amidships. It could then act like the "Jockey," float of the "Hook Hydrofin." The high efficiency foil below the U would absorb most of the forward capsizing moment of the sails but the tip of the U foil could be made to just skip along the water surface and thus alter the angle of incidence of the main (high efficiency) foils. As the speed increased, the main foils would develop more lift and rise up which, because the forward U is in contact with the surface, would reduce their angle of incidence, thus keeping the craft in stable fore and aft trim.

10d β, γ, δ and ξ are midship foils with a U foil above to reduce foil area at speed and a high efficiency foil below which is angled to absorb the lateral force of the sails and keep the craft upright.

The lateral stability of foil borne craft. It is believed that the sideways stability can be fully maintained by using two main high efficiency foils in such a way that the lines of action of the lift which they create meet the midline of the craft above the centre of effort of the sails. If this is done, a foil borne craft cannot be capsized sideways. This is because, at a side force of the sails greater than a critical amount, the weather foil starts to exert a downwards force. This effect can be made greater by making the main foils so that their angles of incidence can be altered as with my hydrofoil stabilizers. It is reduced by such things as centreboards (which should not be necessary anyway) and large flat connectives. The Baker craft with three V foils could, of course, be capsized not only sideways but also stern over bows, though both are extremely unlikely.

The fore and aft stability of foil borne craft. The forward capsize may seem very hypothetical to some people but these craft can be made extremely light in weight and the sails exert their force high above the water so the possibility must always be kept in mind.

Fore and aft trim can be held in two ways. Firstly, it can be got by the use of a stern foil which carries part of the weight of the craft at slow speeds but, should the force on the sails ever start to lift the stern, this foil could be set at an angle downwards so as to pull the stern down. Secondly, it can be got by the use of a forward foil which, like a stern foil doing the same job, carries part of the weight, but in this case, no matter how the wind blows, only extra weight would be thrown on the foil. This means that the work which the foil is doing never changes its direction and so it should be easier to use. In my opinion, it is a better mechanical principle. It has, however, the faults that, firstly, the water has to be pierced in an extra place aft for the rudder and secondly, owing to the extra strut running down to the forward foil, the craft would be harder to steer.

The disposition of foils. The disposition of the foils to support the boat is still very much a matter of conjecture. The following methods have been or could be used :-

1. Ken Pearse is using four foils, two forward and two aft — the most stable arrangement and very suitable for the sliding foils he is using.

2. J. A. Lawrence is using an oblique V main foil with a manually controlled aft foil. He may expect his craft to heel while on the foils.

3. A broad U foil with the straight piece stretching right across the craft would be a useful main foil of the heeling type.

4. The Baker hydrofoil craft uses two V foils forward and one V foil aft.

5. John Westell suggests two sliding foils forward and one high efficiency foil (10a) on the rudder.

6. The Grunberg method consists of two high efficiency foils amidships with two " skis " running along the surface of the water forward. The forward " skis " automatically adjust the angle of incidence of the main foils so that the hull " flies " at the correct height above the water.

7. This same principle could be employed slightly differently by using two foils of type 10dξ amidships combined with a type 10dα forward. At low speeds, such a craft would be using the U foils but

at high speeds the main foils would become of the highest efficiency and the forward horizontal foil would prevent the forward U foil from disturbing the water as much as it otherwise would. (For a model, I would use main foils of type 10cα of Dural).

8. The " Hook Hydrofin " has automatically controlled main foils and a fixed, high efficiency stern foil.

All these eight methods are fully automatic (so far as is known) and do not need any attention from the crew when sailing. The ability of some types to capsize either forward or sideways would have to be investigated. The following method is not automatically controlled :-

9. Three high efficiency foils could be worked by a " joy stick." The rudder could be worked by the feet, leaving the crew of one with his other hand free to manage the sheets. In this case, the main foils would act as stabilizers at very low speeds and the sheets could be held by jamb cleats. It is not known whether it would be best to have the single foil forward to absorb the forward capsizing moment of the sails or aft on the rudder where at really high speeds it might have to exert a downwards acting force, thus holding the craft back.

The efficiency of foils. THE SLIDING FOIL. The main virtue of this type of foil is that its angle of incidence to the water flow can stay the same at all speeds. It will naturally be set to give the greatest lift/drag ratio. Both the lift and drag of foils increase with the square of the speed, if they are totally immersed. This means that, if we ignore the inefficiencies of this foil, it will have a constant drag quite irrespective of the speed. This can best be understood if we take the example of a doubling of the speed when the lift of the submerged part will increase fourfold resulting in only one quarter of the foil remaining in the water. The drag of this quarter will be four times as great as it was, so the total drag will be the same as at half the speed. The upper surface air entry, the decrease in aspect ratio and the surface waves keep this from occurring, however, the resistance in practice being approximately proportional to the speed up to the point where the tip of the foil only is submerged when it increases greatly due to the high loading.

THE HIGH EFFICIENCY FOIL. As compared with the sliding foil, this type will usually meet the water flow at varying angles of incidence For this reason, it need be only half the area of the sliding foil to lift the hull out of the water because it can use a greater angle of incidence. The drag of each would be about the same, however, if the inefficiencies of both are ignored. However, it would appear from the aerofoil graphs at my disposal that, as the speed increases, the angle of incidence would become less and this would have such a marked effect on the drag that it would actually be less at twice the speed at which the hull lifted clear than it was at that moment. There comes a point, however, when this effect no longer appears and the drag once more increases in proportion to the square of the speed.

MISCELLANEOUS USES FOR HYDROFOILS

A Hydrofoil to reduce displacement. It has been shown that the majority of the stability of normal keeled yachts is due to their shape rather than to the weight of the keel. The weight is used more to prevent a capsize than to increase sail carrying power, though it does have a marked beneficial effect on the latter. It might, in some circumstances therefore, be useful to have a hydrofoil on the keel as shown in Fig. 11 to reduce the displacement. It is unlikely that this would help when close hauled.

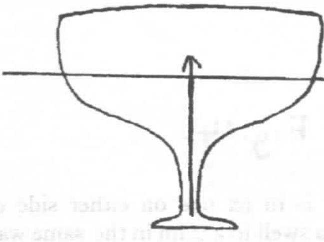


Fig. 11.

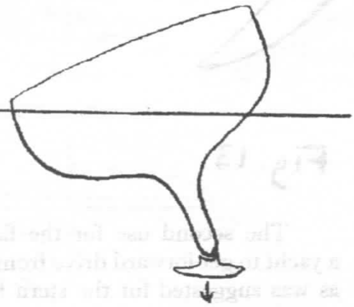


Fig. 12.

A Hydrofoil instead of ballast. As compared with the last possible use, a hydrofoil which was hinged to the bottom of the keel in the fore and aft axis and acted vertically downwards could replace the ballast weight altogether. This arrangement is shown in Fig. 12.

The Flap Foil. Fig. 13 shows a diagram of what may be called a " Flap foil." The essential nature of this is a hydrofoil hinged at its forward edge so that the trailing edge can move freely up and down through an arc of a circle. Though the hinge allows this movement, the foil is fixed by it at right angles to the supporting bar.

Though it is quite possible that the flap foil may prove to have hidden possibilities, only three are at present seen where it might be of value. The first of these is shown in Fig. 14 where it is fixed over the tail end of a yacht and by the up and down movement of the handle, a driving force is created of the nature of up and down sculling. This could be considered to be a refined version of the Chinese " Uloh " or large sculling oar, though this was worked from side to side more like the method used to scull small boats. This device could, of course, be made fully efficient and has the added advantage that, if the handle were to be fixed so that it could not move up or down, the lop of either a following or head sea would drive the boat along in a calm.

Fig. 13.

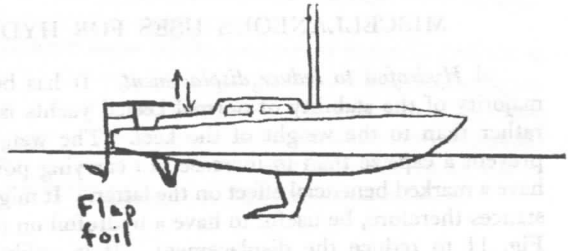


Fig. 14.

The second use for the flap foil is to fix one on either side of a yacht to get forward drive from a *beam* swell in a calm in the same way as was suggested for the stern flap foil. Flap foils of this kind could not only be used for this purpose but they could probably also be used as stabilizers. Thus, they could be left as fixtures on the yacht except at moorings or against a harbour wall.

Water Stilts. The third use for flap foils is shown in Fig. 15 though it is not anticipated that, when the wind fails, some member of the crew will be really sent over the side with one of these queer things to give the parent yacht a tow back home. Here, the arc of flap of the foils will be arranged to give only a very fine angle of glide on the downstroke. The manipulator (or should I say pedipulator ?) of this amazing vehicle stands on one side till it almost sinks to the water and then transfers his weight to the other side. One side must be rising as the other side is going down and this can be arranged by having a streamlined float attached to the foil in such a way that the centre of its buoyancy is in front of the pivot. The float will then pull upwards, twisting the foil downwards when no weight is upon it. There is a stern foil with a small vertical fin to give directional stability. It should be possible to steer by giving one or two extra strokes on one side or the other.

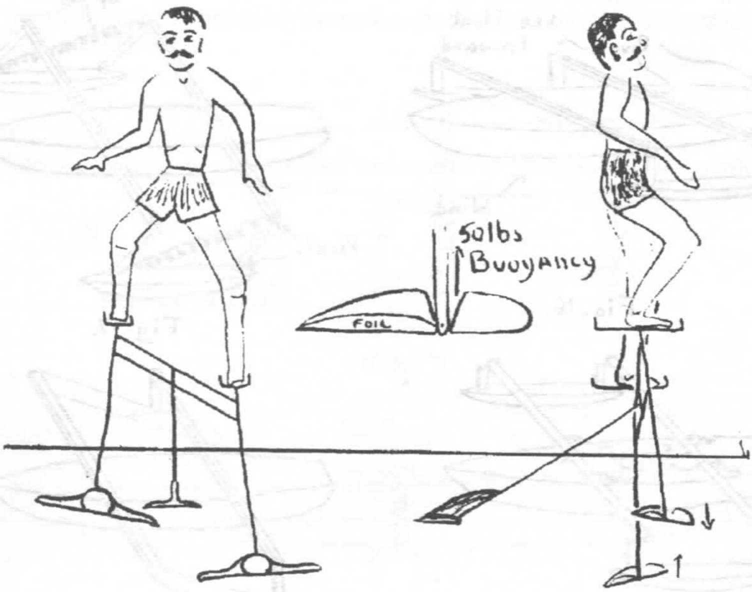


Fig. 15.

MORE ABOUT CATAMARANS

In the first A.Y.R.S. booklet, which was on the subject of Catamarans, the idea of using buoyancy from the lee float for stability was not seriously considered, largely because it was not used in any native type of craft. It is still not considered to be a very good type of stability but several methods of using the lee buoyancy have come to light which resolve the inherent difficulty of the backward movement of the centre of lateral resistance when the craft heels. There is only a theoretical objection to the use of lee buoyancy and in practice it may not be a matter of importance. Definite information on the point has still to come my way.

The first method about which I know was invented by Commander Fawcett and the craft whose photograph was in the first booklet was, in fact, built with the ability to use lee bouyancy without upsetting the sail balance though the mechanism was never used. The principle is shown in Fig. 16. On each tack, the lee float is moved forward and the weather float is moved backward by a simple parallel coupling.

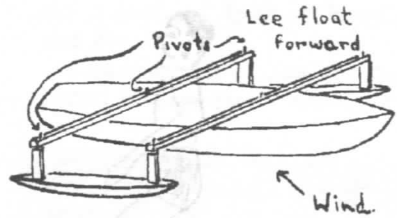


Fig. 16.

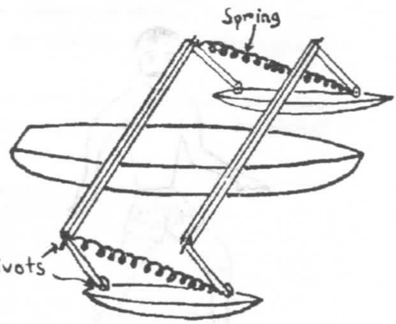


Fig. 17.

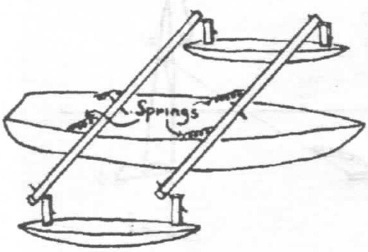


Fig. 18.

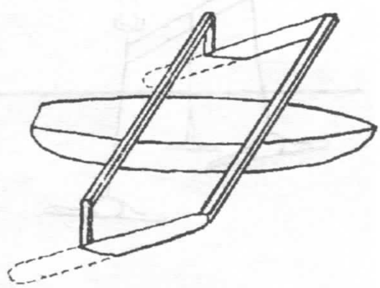


Fig. 19.

Now, on heeling, the craft can make full use of the lee buoyancy and, when putting about, the lee float can be put just a little further forward to help the manoeuvre.

Figures 17 and 18 show two ways of fitting up a craft with double outriggers which could heel in about the way of ordinary yachts, be able to carry sail and be stable. Here, as in Commander Fawcett's mechanism, the lee float moves forward when it is pressed into the water but in this case, the movement is actuated by the hull heeling in relation to the floats and is not worked by the crew. That shown in Fig. 18 would be self righting after a " knockdown " depending on the integrity of the springs. All this could be achieved without ballast. Because the safety of the craft depends on a mechanism, these systems present rather large hostages to fortune. It is pointed out that it is folly and bad seamanship to leave the most sheltered waters with the safety of a vessel depending on any moving part unless it is very much over strength or duplicated several times.

Fig. 19 on the other hand, shows yet another way of getting buoyancy from the lee float, still maintaining the sail balance and moreover doing it without the use of any moving part whatever. The floats are of a rather thick hydrofoil shape supported at their fore ends and middles. When the craft is upright, only the aft halves of each float hydrofoil are in the water but, when the craft heels, the float on the weather side comes out of the water either partially or completely and thus its centre of lateral resistance moves aft. The float on the lee side submerges more in the water on heeling which causes the lateral resistance on the lee side to move farther forward. Because there are no moving parts with this system, it is thought that it is the most seaworthy of all these methods of using the lee float buoyancy for stability.

FUTURE RESEARCH

1. *Wind Research.* This line of research is very suited to the A.Y.R.S. Everyone of us knows of some little patch of wind in his own sailing waters which appears under certain conditions. Perhaps it is where a little dip in a cliff allows an off shore wind to be stronger at that point or where a group of trees on the shore causes the wind to alter its direction. These alterations in the wind could, if we knew where to find them, be of great benefit to us in sailing races or even in sailing from one place to another along the coast.

One of the ultimate objectives of this research would be to produce a series of little manuals for all the shores of Britain so that if, for example, a south coast yachtsman were to decide to race his yacht on the Medway, he could study the winds which he would be likely to find there and thus be able to sail with the yachtsmen of that river on more equal terms than he does at present. The local knowledge of a region would still give a great advantage to the yachtsmen who keep their yachts there but such a manual would greatly encourage visitors and, in this way, add to the pleasures of everyone.

The other ultimate objective is to find out the general principles of the inshore windflows such as those mentioned in the first paragraph. These principles would be distinct from the general meteorological windflows which can be studied in weather manuals such as have been so excellently produced by the Admiralty and Air Ministry. The windflows we want to know about are the local deviations from place to place along the coast where the wind does not flow in the direction which would be expected from a study of the synoptic chart. The meteorological pundits call it " Local weather."

The method of research is simple. Next time you sail your boat into that calm patch, or meet that altered wind, just send a few words about it to the Editor on a separate piece of paper from the rest of your letter but with your name and address on it. Part of future A.Y.R.S. publications will be reserved for these observations and correspondence about them. It is too early as yet to say if these wind variations will be named, but perhaps there might be a " Smith's Smooth " a " Brown's Blow," a " Green's Grass Wind" or even an " A.Y.R.S. Air."

Two main types of results would be expected to appear. The first of these would be the variations in the wind along the coastline for all natural wind directions. The second would be the wind variations along rivers in all wind directions. Precise wind speeds would not ordinarily be of interest though at least one exact study should be made of a river area with the precise wind speeds and directions being measured as exactly as possible. For this particular study, one of our members, Alan Cole, has been good enough to design apparatus to measure wind speeds across a river or over a strip of ground.

It is felt that this wind research would be of great use to the yachting community and immense fun to do for everyone taking part in it.

2. *Self Steering*. Many yachtsmen like to steer their boats. They like to have the feel of the tiller in their hands and enjoy the impression which the sailing boat gives of shouldering its way through the waves almost as if it were alive. Some others like to put their boats on a course, balance them so they sail on their own and then merely maintain a watchful attitude, adjusting here and there as necessary. But the short handed off-shore cruising yachtsman has little or no choice. Fatigue is his greatest enemy and many a " Round-the-World " voyage has ended in France for that very reason. The cruising yacht must have some form of self steering.

Many, if not most, yachts will keep a course when the wind is before the beam because, if they come up into the wind, a tightened headsail will pull the head off again against a mainsail which has lost part of its driving force from the closer course. The main difficulty lies when the wind is on the quarter or dead aft because the mainsail will stay full of wind and be trying to turn the boat's head up to windward right up until the wind is abeam or even a little forward of this.

The principle on which all the self steering mechanisms work is that the more nearly the wind strikes a sail at right angles, the greater the force on the sail which it produces. The exception to this is the vane which acts as an aerofoil and thus in the neutral position the wind flows along it and produces no force at all, but the wind striking one or other side pushes it over and this turns the rudder to bring the yacht back to course. Here, the negative pressure on the lee side of the vane is of value in the force production.

Joshua Slocum developed self steering in SPRAY by sheeting his headsails in flat when running down wind. He even put on a flying jib to help. Captain Otway Waller invented the twin staysail rig. Le Toumelin used the staysail sheet to control the rudder against a spring with the jib hauled flat. Sopranino at one time tried out the Brain steering which used to be used on model yachts. A recent yacht projected the use of a vane steering mechanism which is now almost universally used on model yachts but did not, apparently, actually try it out.

The Vane Gear. It is not difficult to rig this on any sailing craft. The differential gear of a small car could be mounted on the top of the rudder of many boats by one of the half shafts cut off short. The other half shaft, also cut off short, could support the balanced vane and a wheel could be fitted on the stub end of the cardinal shaft. The whole alteration could be done quickly and cheaply. The wheel would be able to control the boat at a moment's notice as necessary and the slight backwinding of the vane to maintain the lee pressure on the rudder would be more than offset by the accuracy of the vane in keeping the craft on an exact close hauled course. An objection to the vane gear is the sweep of the vane around the stern which would interfere with the boom or backstay in most yachts. In model yachts, the aspect ratio of the mainsail is very great and the boom is short so that there is room for the vane to swing.

The Mill Gear. This mechanism is that employed by windmills. It differs from the vane gear and the other types which have already been described in that the power of the wind is used to turn the rudder rather than its force. A small windmill could be mounted on the top of the rudder and geared to it so that, should the wind strike one side of it, the rudder would be turned in one way, and vice versa, when the wind blew on the other side of the wheel, the rudder would be turned in the opposite way. The direction of the axis of the fan would be controllable from a wheel in the boat. This system has the advantage over the vane gear that, because the power of the wind is used, the fan can be geared down to give a great turning power to the rudder for a small size of rotor. Also, there is no real interference with the deck space.

3. *Research into the possibilities of commercially successful sail.* There has been a considerable improvement on the efficiency of yachts in the last thirty years. Their windward ability has improved by the use of the modern Bermudian rig by as much as 100%, though this is not completely separated from improvement in hull design. While this change has been taking place, there has been some improvement in the efficiency of motors but the fuel costs of engines have been steadily rising all the time. It is worth while, therefore, occasionally to go into the economics of cargo carrying by sailing vessels in case it should happen that these should once more prove profitable for commercial firms.

It is true that a few Thames barges trading only or largely by sail are still paying their way and it is thought that they may even be improving their position slightly as regards the motor barges but, even so, it is extremely unlikely that any more purely sailing barges will ever be built. This, to the slightly romantic mind of the average yachtsman, is a pity because we like to see them.

A quick check was made a few days ago into the cost of road transport to see what were the costs and how they were likely to compare with sail transport. The results are as follows :-

A large and efficient road haulage company gave me a price for a twenty mile haul of 10 tons of cargo of £7-10-0. Now, I believe a sailing craft to carry 10 tons of cargo would be about 35 feet long and, with an efficient Bermudian rig, could be easily handled by a man and a boy. Its speed would average out at 4 to 5 knots without using the tides and it could easily do the haul in question in half a day. Allowing for lower freight rates because of the nature of the transport and the urgency with which many traders want their goods, such a craft could thus earn about £10 a day if fully employed. It is within the bounds of possibility, therefore, that a fleet of sailing boats could earn their crews a very good livelihood and bring pleasure to us as we saw them going about their business along our coasts and rivers.

A small sailing cargo boat might thus be able to pay its way. Also, it is not unlikely that larger coastal and even deep water sailing vessels might be able to show similar profit earnings. In the case of the deep sea trading craft, the mechanism which was shown in the earlier pages of this booklet to drive a boat along in a calm might hurry them over the calm belts of the world in a voyage to Australia where so much time used to be lost in the days of sail.

4. *Self Acting Jibs.* There is no doubt that the self acting jib is a great convenience. The present types need no description to readers. It is a pity that none of them is as good as the normal kind. There is a field for invention here which can be heartily recommended.

Only one mechanism is known to me which could solve this difficulty and that is the boom which has been developed by Major General Parham for a twistless mainsail. It is hoped that this boom and sail will be described in the next booklet.

CURRENT YACHTING EXPERIMENTS

Full Size :-

1. Hugh Barkla — Triscarf planing hulls, "TRION."
2. Col. C. E. Bowden — (a) Cantilever battened rig.
   (b) Hydrofoil stabilizers.
3. Commander Fawcett — Outrigged sailing craft.
4. Lt. P. C. P. Johnson — Self steering.
5. J. A. Lawrence — An all-hydrofoil craft.
6. F. W. M. Lee — Double hulled catamaran with five aerofoils.
7. Bill O'Brien — An all-hydrofoil sailing craft.
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Models.

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2. Owen Dumpleton — Catamarans.
3. J. L. Smith — Catamarans.
4. W. J. Watts — Catamarans.
5. E. Wotton — Putting the jib to leeward of the midline of the boat.

The ideal hydrofoil section has not been discovered. Clark Y is much favoured because it has a flat lower surface. Bill O'Brien is using 4 A.D.1 whose ordinates follow :-

% Chord	0	3.16	6.33	12.65	19.00	25.4	31.7	38.0	46.9	55.7	64.5	73.5	82.3	91.2/0
Upper	0	1.93	3.15	4.75	5.63	6.15	6.38	6.45	6.28	5.78	5.03	4.18	3.22	2.03/0
Lower	0	1.13	1.27	1.43	1.52	1.60	1.65	1.65	1.63	1.55	1.38	1.18	0.82	0.7/0

A.Y.R.S. PUBLICATIONS

No. 1 CATAMARANS

Contents

1. The Objectives of the Amateur Yacht Research Society.
2. The A.Y.R.S. Two-hour Yacht Designing Method.
3. The Double Hulled Catamaran.
4. The Polynesian Canoe.
5. The Indonesian Canoe.
6. The Micronesian Canoe.
7. The Balance Board Sailing Craft.

No. 2. HYDROFOILS.

No. 3. SAIL EXPERIMENTS. To come out in November, 1955.

Contents.

1. The Evolution of sails.
2. Captain Illingworth's development of the fore triangle.
3. Major General Parham's Twistless Mainsail.
4. Peter Johnson's Self Steering Device.
5. The Perfect Sail.

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