WINGSAILS

A.Y.R.S. PUBLICATION No. 14

Col. C. E. Bowden's "BIRDSWING RIG"

CONTENTS

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EDITORIAL

This is another publication on sails and aerofoils, called for the sake of convenience *Wingsails*. The rigs described here are, on the whole, arranged in an order varying from " harder " to " softer." What strikes me most about them all is the fact that it is the *Amateur* who makes the yachting advances at this level. This alone seems to be enough justification for the A.Y.R.S.

Yacht experiments are expensive. However, the cost of sail experiments can be greatly reduced by making one's own sails and to this end, Messrs. Bowker and Budd, of Bosham, Sussex, sell sail making kits with a copy of their book, *Make Your Own Sails*, which reduces the cost to about half the professionally made sail.

J. A. Lawrence of Wareham, Dorset, had several short bursts off the water sailing last summer on hydrofoils. This year, he is again putting a sailing craft on the water which is virtually " all hydrofoil " and weighing only 180 lbs. I feel that he will succeed this year in maintaining sustained flight. We all wish him the best of success.

In publication No. 9, it was mentioned that James Wharram was going to cross the Atlantic in a 20 foot catamaran. He has now arrived in the West Indies having had a pretty rough passage. The rudders broke many times and there was trouble with toredo worm causing serious leaking. In the ocean waves, the catamaran often nearly stood on end according to the report but a proper evaluation of the sea keeping properties of this catamaran by James Wharram will, it is hoped, be given in the course of time.

A CANOE WING SAIL

by P. V. MacKinnon

Very complete information on the lift and drag coefficients of aerofoils is available. Most of this is for Reynold's Numbers far above those experienced in connection with sails, but some allowance can be made for this. By contrast, very little information is available for sails but what there is leads me to the following conclusions which are purposely of a general nature only :—

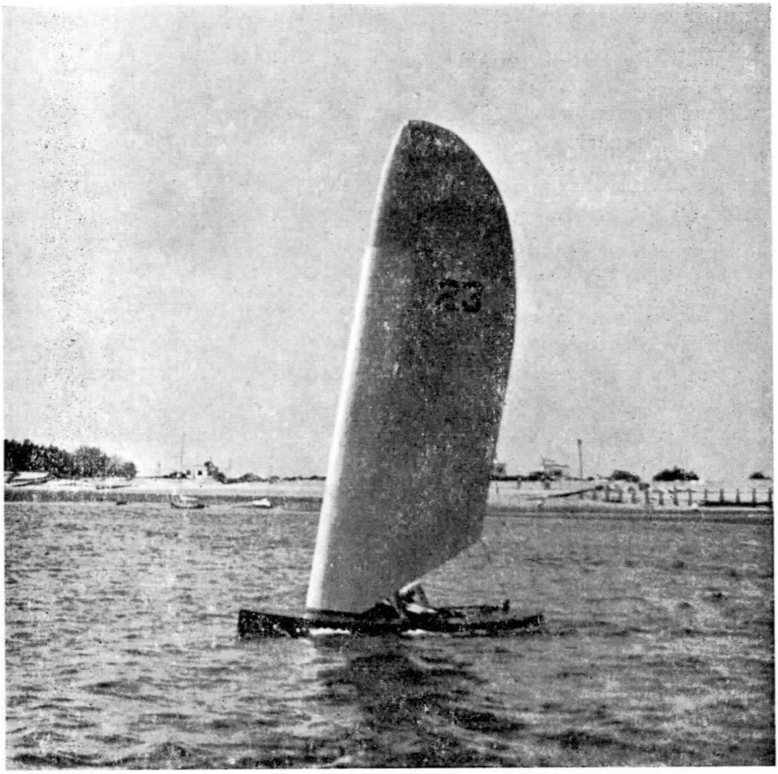
1. The lift coefficient of a good sail is about as good as that of a heavily cambered aerofoil.

2. The drag coefficient of the sail, even when not flapping, is very much higher than for an aerofoil and at low lift coefficients (which involve allowing the sail to flap) the comparison is all in favour of the aerofoil, especially if it is symmetrical.

This leads me to point out that the requirements of a sail for light winds are entirely different to those for strong winds. The average yacht or dinghy hull imposes an upper limit on the sideways force which can usefully be applied to it. Although the drag of the sail may contribute to this, most of it comes from the lift of the sail. (lift and drag are, of course, measured at right angles to and along the apparent wind). The result is that, at low wind speeds, the factor limiting performance is the maximum lift coefficient of the sail. At higher wind speeds, this lift coefficient cannot be used and the difference between one sail and another lies in the comparison of their drag coefficients at the maximum usable lift coefficient.

For sailing canoes closehauled, the change over from one condition to the other is at about 10 knots true wind speed. It follows that, up to this wind speed, the best that can be expected is that a cambered aerofoil will be about as good as a conventional sail. At higher windspeeds, the aerofoil should theoretically give much better performance than the sail, even if it is symmetrical, because high lift is not required and its drag is enormously less than that of the sail. In fact, the theoretically calculated speed made good to windward by a canoe in smooth water with a symmetrical aerofoil goes on rising as the wind increases up to a very high wind speed of the order of 30 to 40 knots, whereas, with a normal sail, the speed begins to fall off much earlier.

Against this theoretical background, my experiment with a symmetrical aerofoil of 18% thickness/chord ratio was a failure on a canoe. The chief reason was that with all the skill in the world, it



P. V. MacKinnon's Wingsail

is not possible to build the aerofoil light enough, although the Woolverstone Shipyard, Ipswich, England (from whom constructional details may be obtained), accomplished an extraordinary feat in keeping the weight down to under 40 lb. as compared with about 20 lb. for a normal canoe rig. The result was that in anything more than a light wind, the whole performance was too alarming and the experiment was abandoned because of the fear of wrecking the aerofoil.

Construction. The aerofoil was built with a ply leading edge and rib construction covered with doped fabric. The height above deck was 19 feet, with the top 5 feet detachable. The greatest chord was about $6\frac{1}{2}$ feet and the greatest thickness 18% of this, i.e., about 14 inches. The total area was 107.64 sq. ft. (10 sq. meters). The whole thing revolved through 360° on a tripod mast which went up inside it to a height of about 5 feet with a bolt and wing nut at the top to provide a bearing which was reached through access holes in the skin. The bottom of the tripod was fitted with 3 rollers which worked inside a circular hole in the bottom diaphragm of the wing.

Erection. Experience showed that the best method was to keep the tripod inside the wing and bring the wing and tripod to the boat which had previously been chocked up lying on its side. The 3 legs of the tripod were then bolted to the boat. With one cooperative helper, this was easily done in calm conditions.

The "Free" Aerofoil. In theory, the wing can be left up indefinitely with the boat at rest ; either chocked up ashore, or afloat. This is because the wing is free to weathercock and its drag is very low indeed. In practice, this was realised with one complication which I ought to have forseen. With the boat afloat and head to wind, there was a tendency to rhythmic rolling with oscillation of the wing from side to side. This effect, which seems analagous to aircraft wing flutter, is quite a serious problem as otherwise the wing could safely be left up when the boat is not being sailed. In theory, it is curable by mass balancing the wing so that, for example, if the boat is rolled a little to starboard, the trailing edge of the wing moves to starboard and not to port as is the natural tendency. This requires additional mass high up and far forward and to reduce its amount, it should presumably be on a long strut. The same rhythmic rolling was liable to happen on land if the boat was not securely chocked and on one occasion, it even happened to the front part of the boat when only the back part was chocked.

Conclusions. Results are inconclusive as the wing is expected to be of advantage in strong winds. Owing to the handling and weight difficulties these are just the conditions in which it has not been tried. The general ideas are as follows :—

1. The whole scheme is quite workable on a hull whose stability and structural strength are matched to the weight of, and loads imposed by, the wing. Some elasticity is needed in the attachments to deal with fore and aft pitching and the resulting inertia loads on the wing-hull junctions.

2. On the little sailing experience I have had, performance seems much as predicted by theory.

3. The experiment is worth pursuing, but not with a canoe. For the wing which I still have in store, a small light catamaran would be better than any normal hull. Catamarans such as *Shearwater III* would need wings of much larger area.

4. It seems worth considering an arrangement by which the wing is supported by rigging wires, either to a turntable on the catamaran, or to the two hulls in spite of the resulting restricted rotation.

5. It might be added that, once the idea of a catamaran is accepted, weight becomes less of a problem and it might be possible to build a wing sail with performance in light winds equal to that of a normal sail of the same area by the use of a simple trailing edge flap, to get the effect of a cambered aerofoil. In strong winds, the flap would be locked central, and the performance should be far better than that of a sail.

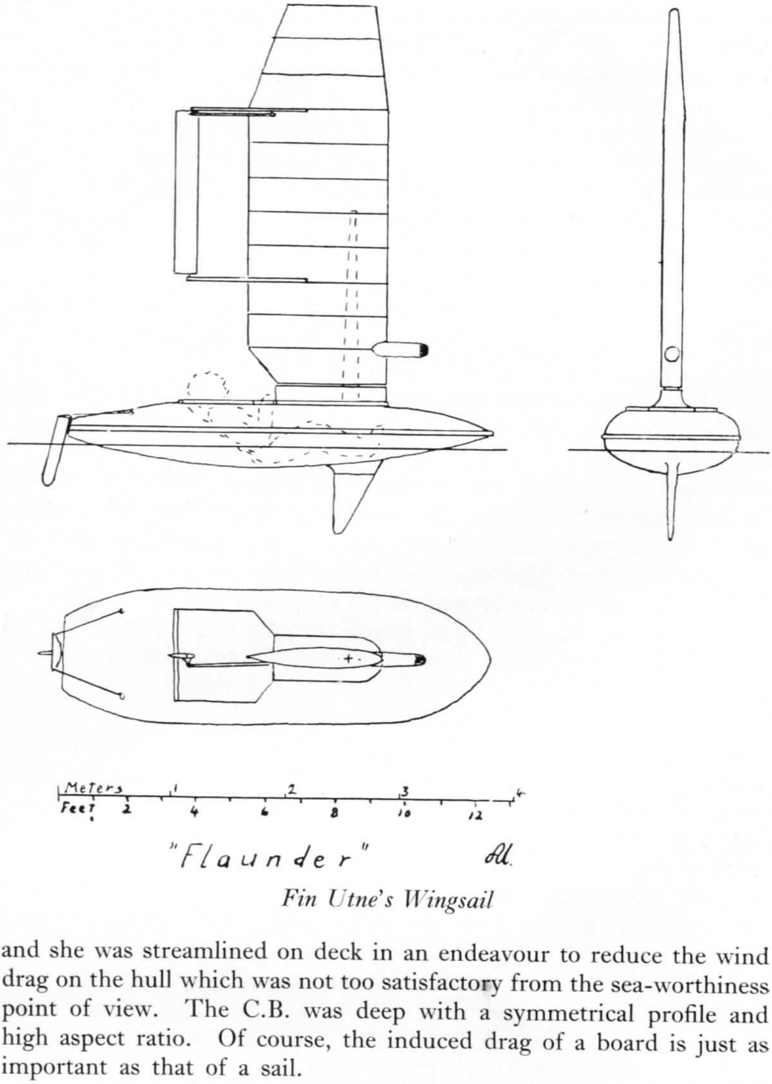
AEROFOIL INCIDENCE CONTROL

This ingenious and successful aerofoil was devised by Fin Utne, of Norway. As shown in the drawing and photograph, the main feature of it is an auxiliary aerofoil hanging on beams behind the main sail. This allows the sail to adjust itself automatically to changes in wind direction and keep the same angle of incidence to the wind at all times, once this has been set. With the help of levers and joints going inside the mast and aerofoil, the angle of the auxiliary sail can be adjusted in respect to the main sail *from the cockpit.* As the mainsail is hinged at the centre of pressure, the auxiliary sail can hold it at any desired angle of incidence over a wide range, up to about 30° from either side of the wind's direction.

In a letter to the Editor, Fin Utne writes : " I chose a symmetrical aerofoil for the sail (R.A.F. 30, somewhat modified). Firstly, because I needed a stable centre of pressure and secondly, because I felt that the aerodynamic advantages of an asymmetrical sail in no way counterbalanced the inconvenience of variable formers. The sail could turn on ball bearings with an axis 25% from the leading edge. The peculiar cigar-shaped body protruding from the leading edge, near the wing root, held a weight to balance out the sail so that its angle of incidence would not be affected by heeling or rolling. There was no gap between the sail and the deck when sailing close hauled, thus reducing induced drag.

" With an aspect ratio of around 6, the induced drag takes such a dominant part in the total drag of a sail that I find that any sacrifice to reduce the sail's profile drag is *not* justified. If the maximum lift co-efficient of a symmetrical sail is not large enough, then there is always the possibility of increasing the cord and thus achieving the same " lift " as with an asymmetrical sail.

"*Flaunder* was built under rather difficult conditions during the occupation and destroyed by act of war. Her hull was flat bottomed,

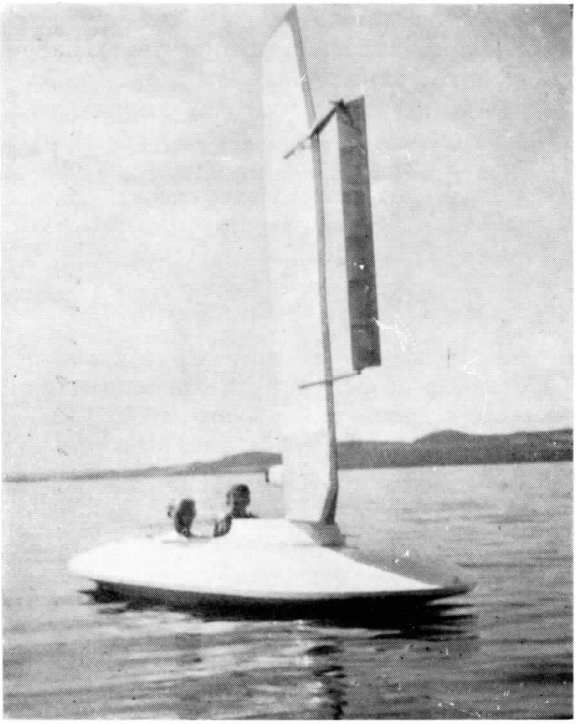


Fin Utne's Wingsail

and she was streamlined on deck in an endeavour to reduce the wind drag on the hull which was not too satisfactory from the sea-worthiness point of view. The C.B. was deep with a symmetrical profile and high aspect ratio. Of course, the induced drag of a board is just as important as that of a sail.

" I had a lot of fun sailing *Flaunder*. She behaved almost like a motor boat and could go backwards magnificently. She could also sail about 20° from the wind with adequate steering speed.

" I also made rather an important discovery : sudden gusts of wind which would heel a neighbouring sailing boat almost to the gunwale were in most cases no increase in wind speed but only changes



Flaunder *with wind astern*

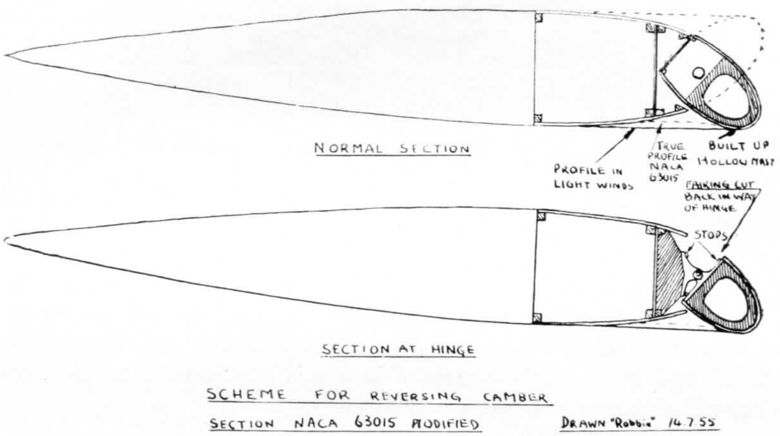
of wind direction. In such cases, the sail of *Flaunder* turned to a new position with hardly any change in the boat's heeling.

" On one occasion, *Flaunder* was anchored without ballast in a storm and the auxiliary wing was set to hold the mainsail directly in line with the wind. She held splendidly and, in fact, the drag of the streamlined wing with no angle of incidence was much less than the drag of a conventional bare mast with stays."

In this account of Fin Utne's experience with his wing sail, the most striking thing is the paragraph concerning the changes of wind direction. We all know that these changes occur and that they lose us both efficiency and speed. What is useful about this account is that we now have been shown a method of using them to best advantage and also of appreciating them by the movement of the sail perhaps before we would have seen them by watching the racing flag. This particular ability of Fin's sail quite possibly more than makes up for any losses which he may have had through using a symmetrical section. In this connection, it is pointed out that a self steering gear of the Vane or Mill types also provides a constant angle of incidence to the wind. "Harriet," the Vane gear used by Michael Henderson on *Mick the Miller* produced a snaky course when steering. When left to steer the yacht all night in the company of other yachts of equivalent performance, on a close hauled course, "Harriet" would leave them in the morning about a mile to leeward.

AN ASYMMETRICAL AEROFOIL

A scheme for reversing the camber of a rigid aerofoil has been proposed by a member of the A.Y.R.S. The illustration shows this system applied to the aerofoil section known as N.A.C.A. 63015. In publication No. 9, *Sails and Aerofoils*, some ways of making up an aerofoil using this section were suggested, but none of them would be able to hold the shape of the aerofoil between the formers accurately. Also, the diameter of the mast with them could not be very great and stays would be necessary.



The essential conception here is that the main strength of the aerofoil would lie in a mast placed at the leading edge and this mast would be articulated to a symmetrical aerofoil in such a way that both would take up an asymmetrical shape of the required section on either tack. The drawings of the sections both between and at the hinges show the construction.

The symmetrical part of the aerofoil would be plywood covered at its fore part as far back as the position of maximum thickness, where inward acting forces can occur. Farther aft than that, only canvas covered ribs would be necessary as in the construction of the wings of gliders. This canvas and ribs would be attached to the trailing edge spar.

Erecting the Aerofoil

This aerofoil would not be of the collapsing kind and would be permanently stretched out. It would need to be kept in a shed near the boat and carried to it, when required. Below the aerofoil, the mast would project several feet, where it would have a round section. This round part could be fitted with two ball races, one to go at the deck when sailing and the other just above the keelson. When erecting the aerofoil, it would be placed flat on the boat in the fore and aft line, the foot being forwards. The upper ball race would then be put into a box which could rotate around an athwartships axis, the mast below it projecting forwards. The aerofoil would then be lifted up from the back so that the round part of the mast would go down and the lower ball race fit into another box on the keelson.

Advantages

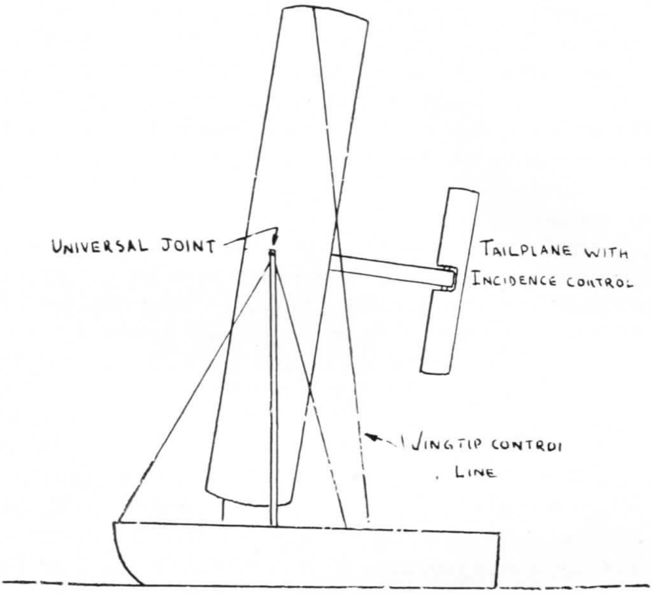
The advantages of this sail over the soft aerofoil sails with formers described in *Sails and Aerofoils* are, firstly, that it would take up a much truer shape. Secondly, the nose part would be plywood and thus not tend to fall in. The sharp angle on the weather side is not a great loss of efficiency. Thirdly, there would be no twist in such an aerofoil because of its rigidity and a single sheet would control it, as compared to the multiple sheet needed for the other type.

Disadvantages

The main disadvantage is the difficulty of erecting it. Most yachtsmen have neither the facilities nor the wish to go through such an exercise before sailing. However, if a yacht club were to sponsor such a rig, it could erect a wind shield so that putting up aerofoils could be done without difficulty. The other two disadvantages of this aerofoil are the weight and its vulnerability.

THE GLIDER RIG

This rig was, to my knowledge, first suggested by L. Francis Herreshoff in his book *The Commonsense of Yacht Design.* As shown in the drawing, it consists of a short mast which is streamlined ; to



The Glider Rig

the top of which is hoisted what is, in effect, a glider without room for a pilot. This is held in place by a universal joint at the top of the mast and running lines from the wingtips to each gunwale.

On putting about, the line from the lower wingtip is slackened off and that from the upper wingtip is taken in so as to draw what was the upper wingtip down to what will become the lee gunwale.

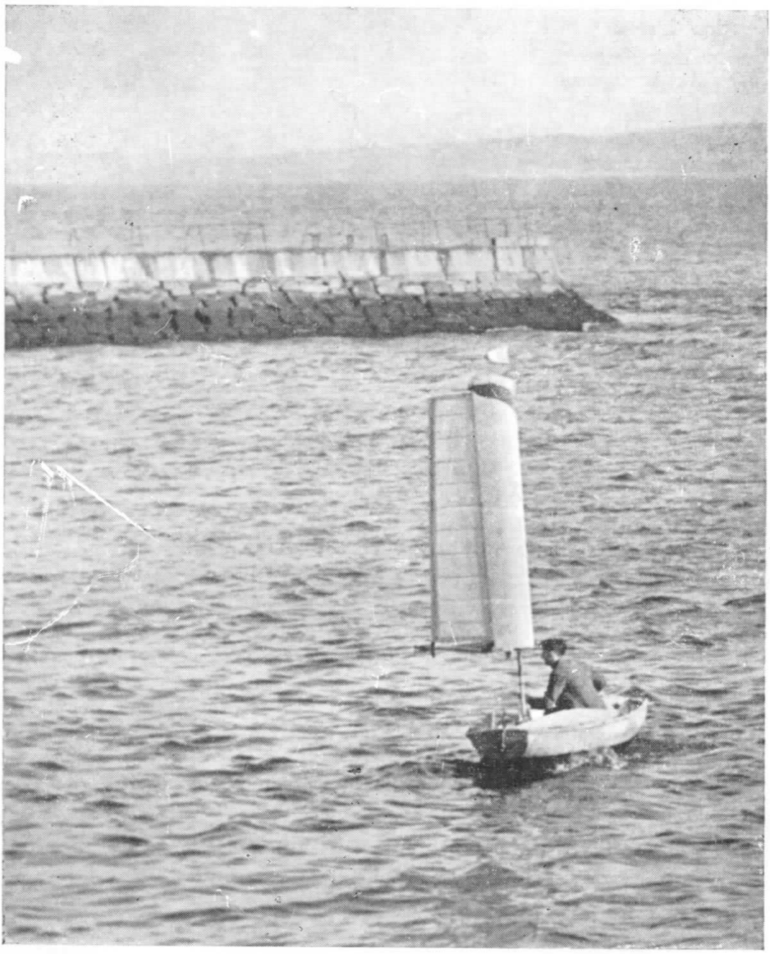
Because the weather side of the main wing is always the same, it can be an asymmetrical aerofoil of a high lift section and the tail plane would be adjustable so as to alter the angle of attack of the main aerofoil to the optimum at all times.

One would be very tempted to want to have the mast of a cup shaped section so that the leading edge of the main aerofoil would fit into it on either tack and give perfect streamlining. In this case, a balance weight could be attached to the mast to prevent heel and roll from waving the aerofoil about. The similarity between such a rig and a Hawaiian rig with tail plane, which would be easier to handle, should be noted. The Hawaiian rig will be described later.

A SEMI RIGID WINGSAIL

by MAJOR GENERAL H. J. PARHAM

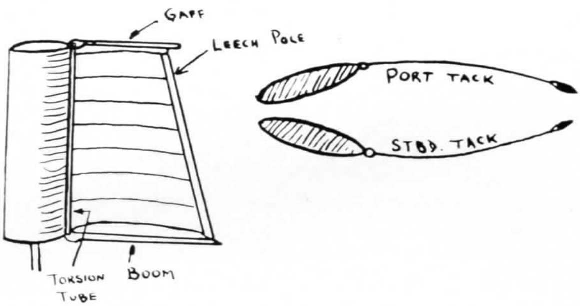
The rig shown in the photograph was fitted to a very small pram dinghy. The total area was only 27 square feet and thus it was almost on a " model " scale. Nevertheless, it was the best thing I have ever sailed with, being quite superb in really high dangerous



General Parham's Wingsail

winds and I had quite a lot of such winds because I was then sailing in a harbour which gave smooth water despite the wind. As with all wing sails, the difficulties arise when the size is stepped up.

In my view, it is out of the question to have an all-rigid sail as, if one makes it light enough, it is then far too frail to stand the inevitable biffs it will get. If only the first third is solid, this can be adequately robust and able to take all the normal mast stresses. To my mind, it is also pointless to go to all the trouble of making a wingsail, if it cannot take a positive camber on either tack since a bi-convex symmetrical section has a fairly low " lift," much lower than cambered ones. For this reason, the wingsail illustrated changed its camber automatically as the wind came onto it from a different side.



Mechanism of Gen. Parham's Sail

The sail consisted of a " lobster claw " of a symmetrical section made from very light plywood glued onto ribs and an after part of canvas of two thirds of the total area. A steel tube was built into the lower end of the symmetrical part to fit into bearings in the hull.

Gaff and boom were used for the canvas part of the sail and these were coupled to each other by a torsion tube at their fore ends running up just aft of the plywood. This torsion tube transmitted the movement of the boom to the gaff and avoided using a vang. At the leech, there was a trailing edge slat which served to keep the canvas part of the sail spread and also gave some vertical support to the gaff. There was an "outhaul" arrangement on both gaff and boom so that the flow of the canvas could be adjusted.

Once set, the rig was entirely automatic and needed no attention, both gaff and boom swinging over on change of tack.

Disadvantages

The troubles which were met on larger sizes but which did not occur on this small rig were :—

(a) Difficulty in erecting the " lobster claw " unless some hinging arrangements were made. The " lobster claw " was liable to oscillate, if left up at moorings.

(b) Bending and weakness in the trailing edge slat. There are several ways by which the use of a trailing edge slat could be avoided (as I think it must be) but none which I can think of are very neat. light or practicable. If anyone *can* get a good answer to this one problem, it might well produce a very good wingsail. But it *is* important that the curve of the " lobster claw's " lee side should fair smoothly into that of the canvas part.

Summary

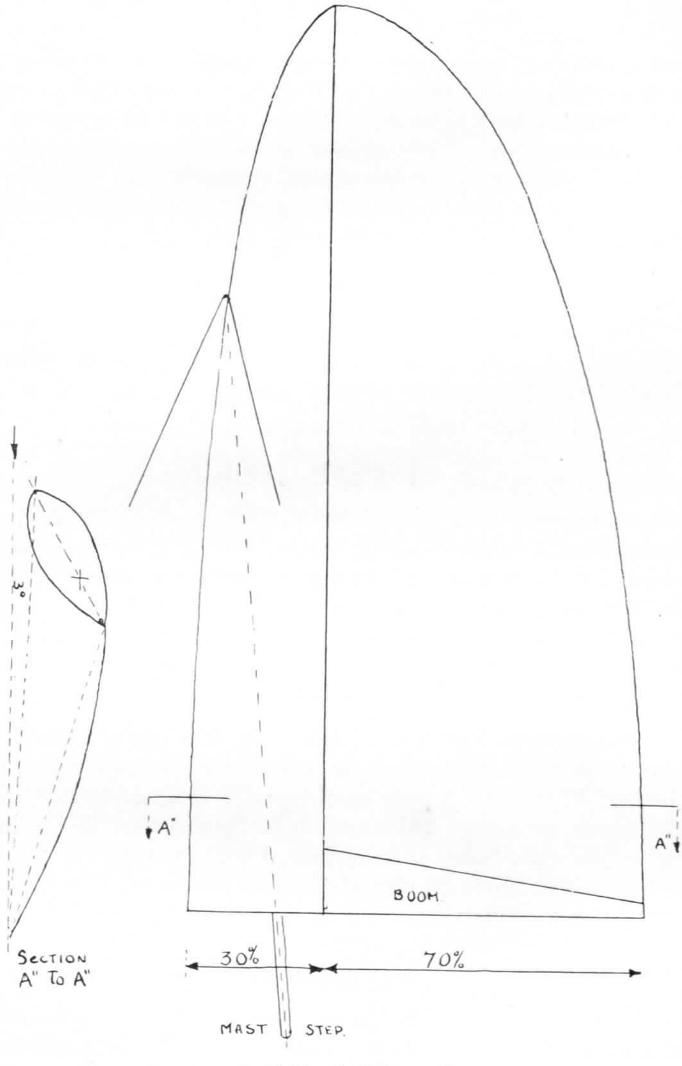
There are difficulties in using this rig in the bigger sizes but, in this small size, it certainly was lovely to handle and pushed the little pram dinghy along remarkably fast.

A WINGSAIL DESIGN

This wingsail was devised by A. Jeffrey about 1942. It is a semi-rigid sail with the fore 30% of the chord made from plywood and the after 70% of canvas. These are the same proportions as those of Maj. Gen. Parham's sail but this sail is a Bermudian rather than a gaff sail, thus avoiding the weight of the gaff and the trailing edge spar. It will be seen from the section that there is much more camber here so it would be better in light winds.

The symmetrical plywood " mast " as Mr. Jeffrey calls it, has a groove at its trailing edge for the luff rope of the sail which would be hoisted normally. A very deep boom is attached to it by hinges rather than a gooseneck and stops would be necessary to prevent the angle between the boom and the mast from becoming too big. The stub mast below the main plywood mast is placed rather far back and might not give enough revolving force to turn it far enough on each tack. If this were the case, some coupling would be necessary such as was suggested for the Prout wingsail described in *Sails and Aerofoils*.

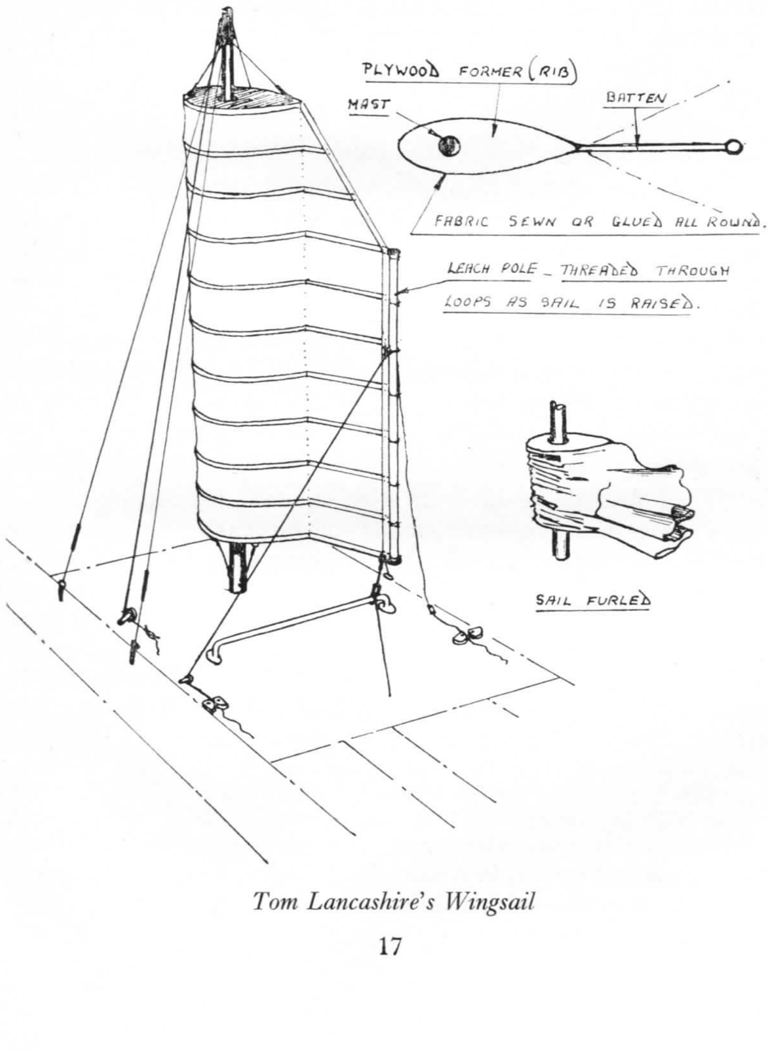
Mr. Jeffrey suggests in his drawing that stays be used but the section is very thick and these may be dispensed with if the construction were to be made strong enough. Such a large size of mast would cause a good deal of windage if left up at all times, unless it were allowed to weathercock and it would be a tricky matter to raise and lower it. The deep boom would act as a kind of tail to keep the mast end on to the wind.



A. Jeffrey's Wingsail

A FURLABLE WINGSAIL

This wingsail was devised by Tom Lancashire before publication No. 9, *Sails and Aerofoils* came out. A model of it, made by him, was on the A.Y.R.S. stand at the 1957 London Boat Show. The sail consists of canvas attached to plywood formers, at the aft end of which there is a batten on a hinge which allows side to side movement. The whole sail collapses down to the foot of the mast when the halliard is let go and the leech pole is undone. It can then be taken off the mast by slackening the stays, lifting the foot of the mast and slipping the sail and formers off the bottom of the mast. As with all aerofoil



Tom Lancashire's Wingsail

sails, no reefing should be necessary. In the drawing, the top former is the same size as the rest, but, in practice, it could be smaller so as not to foul the stays.

The Leech Pole

The leech pole is to prevent twist in the sail and appears to be the only reasonable way to accomplish this. It is shown threaded through loops but a pocket in the sail would be more convenient. About one quarter of its length from the top, there would then be a rope grommet around the leech pole pocket, and vangs would be attached to this and sheeted to weather. The use of this sail with a catamaran would be simplest because the vang could be brought out at a better angle.

THE BOWDEN "BIRDSWING" RIG

This sail, which is shown in the cover photograph, appears to me to be the last in a long line of sails which started, in my opinion, with the first primitive spritsail off the China coast. All the faults of the fore and aft mainsail which were given in No. 9 publication, *Sails and Aerofoils* have been conquered here, except the arch enemy, twist, and even that has been brought down to a minimum by a low aspect ratio and a rigid kicking strap, though this last does not seem to be used in the photograph.

Immediate Ancestry

Lord Brabazon used a sail with an elongated rotating mast in his *Redwing* in the twenties but the weight of the mast in the bows made her bury her nose. We hope to have more details of this sail in a later publication on the *Redwing Class*. It is likely that General Parham's sail and the other sails produced by amateur experimenters also contributed to the general idea. It is, however, Col. Bowden's special genius that he makes things work and he does that by the painstaking means of gradually enlarging his ideas from the model stage.

Starting from a radio controlled model and passing through stages with the rig applied to a planing dinghy and a *Flying Fifteen*, Col. Bowden has now had two seasons experience with his sail on a 6-ton cruiser *Tentative*, in cooperation with Dr. Lamont, of America. It will be that rig which will now be described.

The Rig

The sail can be described as a fully battened Bermudian or jib-headed mainsail of low aspect ratio on a cantilever, elongated, streamlined and rotating mast, with a rigid though adjustable kicking strap. Stays can be and are used in strong winds, and to set a foresail and Genoa in light airs.

The Battens

Col. Bowden writes : " The full length battens certainly increase efficiency and close windedness. Also, and more important, they make it possible with the aerofoil mast to weathercock the whole " wingsail " absolutely inert with no flogging whatsoever in any strength of wind we have encountered up to 30 m.p.h. All drive then ceases and, on hauling in the sheet, drive can be taken up at very low angles of attack in strong winds with no trace of flogging — a thing that can never be done with any soft sail. It is therefore virtually unnecessary to reef in any normal winds and the throttle can be shut or opened as desired. It is possible to stop the boat, or sail very slowly or at the maximum speed with this rig.

Low Aspect Ratio

" It is a low aspect ratio and therefore anti-stall at large angles of attack. I do not agree with the statement made in publication No. 9 that a low rig causes greater heeling than a tall one. With this type of low drag and stiffened rig, it has been found in practical studies that heeling is completely controllable " by closing down the throttle," as already described, to a low angle of attack. In really strong winds, we have sailed as upright as we have desired on *Tentative* as on the *Flying Fifteen*, also fitted with this rig. Possibly, a higher aspect ratio would make a more efficient rig but it would cause greater heeling and therefore a less effective hydrofoil action of the keel for its work to windward and, of course, a high rig stalls earlier when at big angles of attack off the wind."

The Mast

The mast is quite exceptional. It has been built by Col. Bowden of fibreglass and is an aerofoil in its own right being of 20 inch chord at the foot. It is thus a rigid cantilever, fully rotating through 360° in roller bearings in a stiffened hull. However, two preventer stays are usually used so the full rotation does not occur. For 1957, an external contracting band brake is fitted at the foot of the steel rotating stub tube. This is controlled by cable and a brake lever situated in the cockpit for easy operation by the helmsman. Thus, at moorings, the mast is kept locked fore and aft by the brake. In a heavy seaway, if the mast tends to rotate too freely on change of tack, the brake gear acts as a damper.

The Boom

The boom is pivoted on the mast by a gooseneck and changes the camber over quite automatically on changing tacks by the pressure of the air. The lowest batten lies just above the boom when it is amidships and head to wind but lies to lee and slightly above when sailing. Between it and the boom is an " end plate " of canvas to prevent losses and regulate the flow. The camber can also be adjusted by the helmsman by a simple adjustment so the flow in the sail can be varied at will. For 1957, a large " endplate " T-shaped boom has been fitted to prevent end flow losses and to act as a table to collect the battened sail onto at moorings. Smoke candle tests have shown that this endplate is very effective as compared with the original round boom.

Sailing with the Birdswing

Again to quote Col. Bowden : " I find the cruiser sails closer to a smart wind without a foresail and, except for very light airs, when obviously surface counts, I never sail with any sail other than the single main wingsail. I have both a foresail and Genoa which I use in light winds and I find I can use the Genoa for running because the stiffened main, like a wing, works very effectively the reverse way round and can spill air onto the goosewinged Genoa to form an excellent funnel effect and a balanced rig downwind.

" When sailing close hauled, the foresail or Genoa can be sheeted farther in than usual when the airflow from the sail is purposely directed onto the rigid battened mainsail to produce an improved " Slot effect " with increased airflow between the sails and increased drive, taking care, of course, not to overdo this in the case of the overlapping Genoa, which can cause " trapped air," if in too close.

" It has been suggested in the past that full length battens on a cruiser would be easily broken, unhandy and too heavy. In actual fact, none of these troubles have occurred, the battens on the cruiser have proved even more anti-flog than on smaller craft because the slight extra weight and length controls the air better. For 1957, the wooden battens have been shaved down and covered with thin fibre-glass cloth, making them very strong, flexible where desired and waterproof. The fabric of the sail batten pockets further protects the battens.

Summary

Col. Bowden has spent some six years in developing a sail which is very near perfection from a theoretical point of view. It is the work of an amateur and springs from the work of other amateurs, though it needed Col. Bowden's practical skill to get it sailing. One wonders how much the sail of the *Finn* class dinghy and the Prout wingsail owe to the train of thought which led up to Col. Bowden's wingsail.

The Future

The cover photograph of A.Y.R.S. publication No. 12, *Amateur Research*, shows a radio controlled 9 foot model fitted with two of these Bowden sails in schooner fashion. Trials with this model proved that excellent balance on the wind, reaching and running goosewinged can be obtained with a most manoeuverable boat having low heeling characteristics. As a result, a 60 foot boat will probably be built in America on these lines for Dr. Lamont.

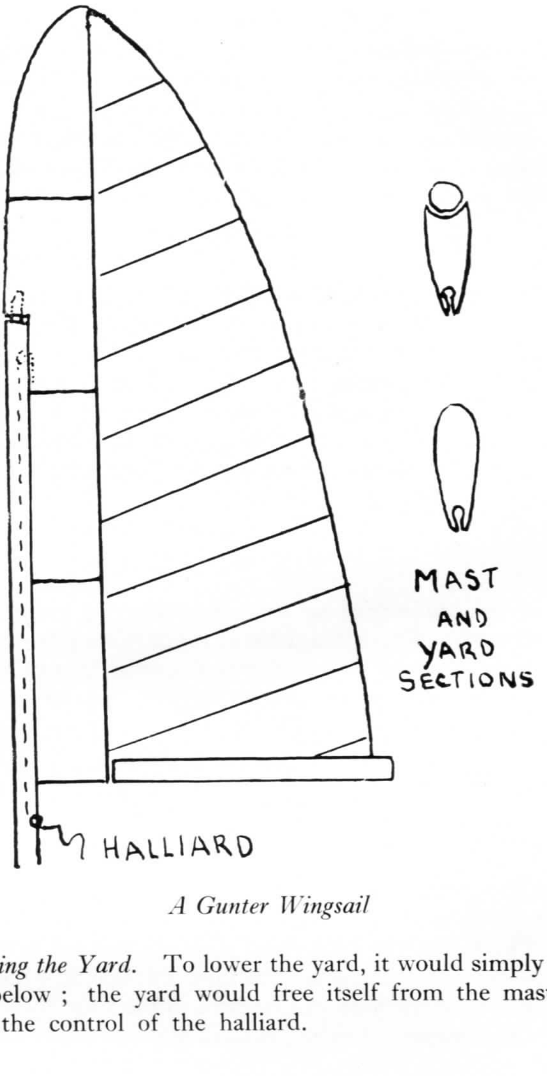
A GUNTER WINGSAIL

One of the difficulties of semi-rigid aerofoil sails is that the elongated streamlined mast has a lot of windage, unless it can revolve freely. A boat will then be unstable at moorings in a gale. Another difficulty lies in erecting the mast. Both of these troubles can be removed by using the system shown in the sketch.

The Mast. The mast is shorter than normal, has a circular cross section and is held up by stays. Light alloy would be the best material.

The Yard. The yard is fully streamlined above the mast but streamlines the mast where it comes behind it as shown in the two small figures. It could be made of several lengths to allow of easy stowage. The top of the mast has a short metal plug which fits into a corresponding socket in the yard to form the axle on which the yard turns. The foot of the yard can be held to the mast by a parrel line or some similar system. The sail runs in a groove in the trailing edge of the yard.

Hoisting the Yard. The halliard would pass through a block a few inches below the top of the mast and be attached to the yard below the position which would arrive at the block, when hoisted. The yard would then be hoisted and, when the halliard was fully in, the yard would be vertical but with the socket over the plug at the mast head. On easing the halliard, the socket would drop onto the plug.



A Gunter Wingsail

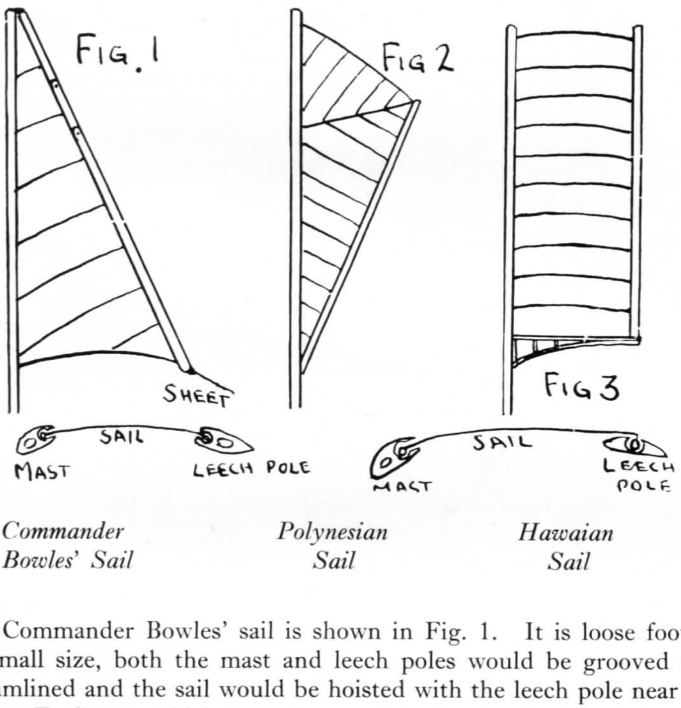
Lowering the Yard. To lower the yard, it would simply be pulled up from below ; the yard would free itself from the mast and fall aft under the control of the halliard.

LEECH POLE SAILS

Neither General Parham nor Tom Lancashire like the leech poles they have put in their aerofoil sails. However, there is nothing unseamanlike about leech poles and they have been used since the beginning of sails themselves as seen in No. 3, *Sail Evolution*.

Leech poles prevent twist in sails or, if placed parallel to the mast as in the Hawaian sail, they make the twist controllable. They therefore will greatly increase the efficiency of a sail.

Commander Bowles is the first person in modern times who has advocated a leech pole for a sail and for the reason that it would make a sail easy to furl for use in a commercial sailing vessel. The leech pole can be easily brailed into the mast and give the sail a better stow than with a loose leech as in the Thames barge. Commander Bowles' commercial sailing ship will be described in a future publication but it is of interest here to study leech pole applications.



Commander Bowles' Sail

Polynesian Sail

Hawaian Sail

Commander Bowles' sail is shown in Fig. 1. It is loose footed. In small size, both the mast and leech poles would be grooved and streamlined and the sail would be hoisted with the leech pole near the mast. Furling would be easy but reefing could only be done at the foot, without lowering the peak and this would make its application to small craft difficult. However, articulations in the leech pole as shown might allow reefing in the normal manner to be done and still preserve the usefulness of the pole.

Fig. 2 shows the Polynesian sail. It is in the proportions of Frederic Fenger's Main Trysail or Wishbonesail and the leech pole could be used instead of a wishbone. Fritz Fenger thinks that it might be useful and is considering trying it, though the Fenger wishbone sail has practically no twist as it is. However, it seems to be the custom in some yachts to do away with the wishbone and sheet the main trysail inefficiently amidships as in *Creole* and such a spar would improve such a sail enormously.

Fig. 3 shows the Hawaian sail (modernised). Twist could only be abolished in such a sail by the use of vangs but reefing would be simplified and full length battens could be used.

The Leech Pole

The leech pole would be grooved at its leading edge which would be rounded. Alternatively, it could be grooved on its side and be twisted to weather on each tack to give a smooth airflow on the lee side of the sail. This latter system was first suggested and used by General Parham on his wingsail described in publication No. 3, but as a mast.

Two Wingsails

Figs. 4 and 5 show two wingsails which use full length battens, streamlined luff and leech poles and an auxiliary aerofoil. There would be no mast interference, no flogging, no twist, little boom loss, and the plan form is superior to a triangle. The auxiliary aerofoil allows instantaneous use to be made of wind shifts.

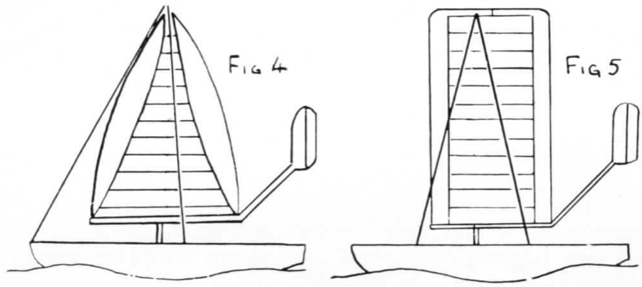


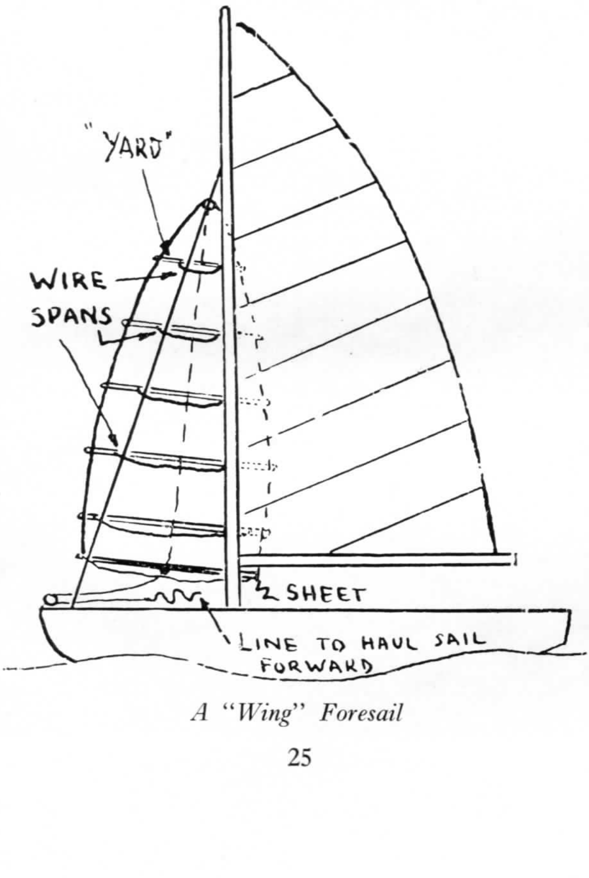
Fig. 4. *Two Wingsails.* Fig. 5.

Fig. 4 shows an aerofoil of nearly elliptical plan form with luff and leech poles placed on a boom supported on a stub mast about 25% of its length from the fore end. Both luff and leech poles are larger in their middles than their ends both to give the plan shape to the sail and to allow of the flow being varied by hoisting the sail up and down in the grooves. The centre of pressure travel of this sail at different angles of attack will be greater than that used by Fin Utne and a larger auxiliary aerofoil might be necessary. It would need some development to allow the sail to be easily hoisted and lowered.

Fig. 5 shows much the same sail with a rectangular plan form. As compared with the sail of Fig. 4, this sail would be easier to make practical, because the sail with its full length battens would be easier to hoist.

A "WING" FORESAIL

A jib has many of the faults of the Bermudian or jib-headed mainsail. It is twisted ; often has a straight foot and has a triangular plan form, instead of the perfect semi-ellipse. Perhaps also, it could have greater flow if fully battened. Of all these faults, perhaps the greatest is the shape of the leading edge which so often sags off to leeward. Even when set on an extremely taut forestay, however, the jib is not set to its best and many forestays have been set up so



A "Wing" Foresail

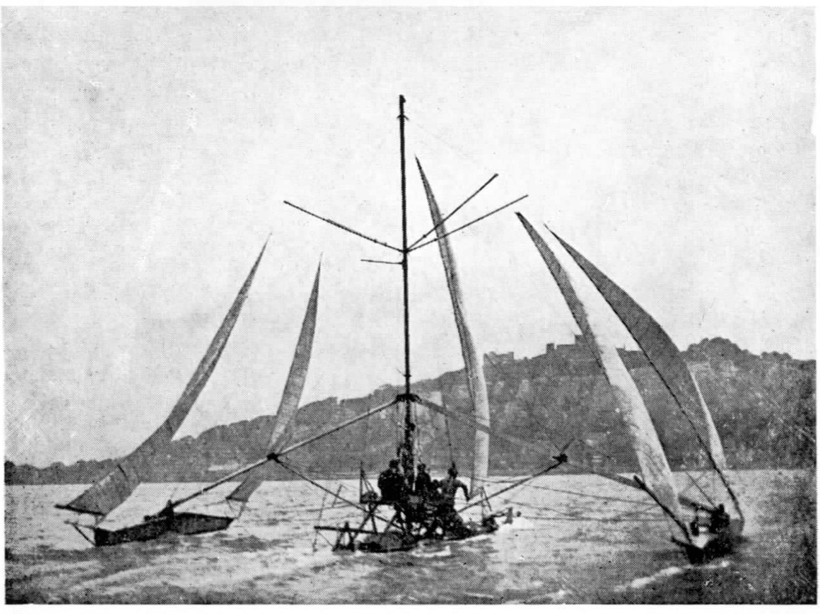
hard as to distort the shape of the dinghy. The luff of the jib should be *convex*, not merely straight.

As shown in the sketch, this sail is a rigidly battened lugsail of semi-elliptical plan form. The battens are rigid, bent poles of wood or light alloy held to the forestay by wire spans. On putting about the sail is pulled forward when the boat is head to wind, " gybes itself " onto the other tack and is allowed to slide backward once again to become a lugsail. Its similarity to the semi-elliptical squaresails described in publication No. 9 will be noted.

When used with a normal Bermudian or jib-headed mainsail, this sail should be allowed a slight twist to lead the air onto the twisted mainsail so it is thought that a single sheet from the clew would be proper to control the sail. Two sheets would, of course, be necessary for use on both tacks. One or more downhauls might be necessary with a line running from the middle of the bottom batten forward to put the sail onto a new tack.

Summary. A " wing foresail " is described which might have greater efficiency than a normal one on any boat but might be vastly superior in a catamaran where there is difficulty in getting the forestay taut and unusual close windedness is required.

THE FALLACY OF SLOPING SAILS



Commander Fawcett's Sloping Sails

THE FALLACY OF SLOPING SAILS

Various yacht experimenters, including myself, have often used sloping sails to avoid having any heeling moment or at least to reduce it greatly. This looks very fine in theory because, by having a sail to leeward and sloping it out from the top of the mast, the line of action of its sail force can be brought down till its heeling moment is negligible. Often, there is another sail or sails to weather as in Commander Fawcett's craft, shown in the photograph, or as in Tom Lancashire's drawing. These sloping sails appear to work on a model scale, too, which is indeed misleading.

Sloping Sails by Tom Lancashire.

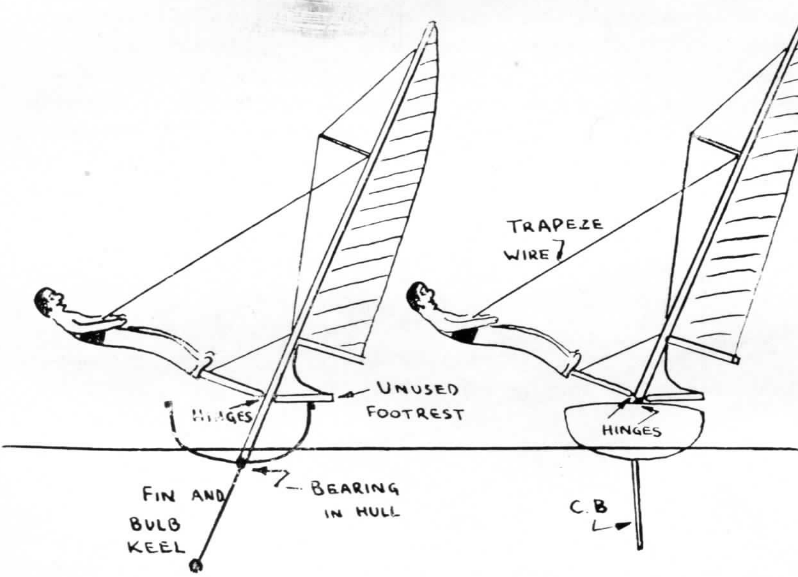
The fallacy in using a rig such as this is that, when the sails are sloped to 30° from the vertical, they lose half of their force, as shown by the *Gimcrack* experiments. Also, there are interference effects all of which result in a great lowering of the Thrust to Side force (or lift to drag) ratio. The weight of such sails must be very much greater than with a simple rig.

All in all, sloping sails can only mean that, by using more than twice the sail area with nearly three times the weight and cost, one can almost achieve a stability which is equivalent to the weight of a crew on a sliding seat or hiking board. Outrigged stability, such as one gets with a catamaran, an outrigger or hydrofoils can be achieved at a fraction of the weight, cost and resistance to motion.

THE UPRIGHT BOAT RIG

All men should be upright and righteous, but few of us are. Boats which sail should also be kept as upright as possible and this is a fact which has now been proved beyond all question.

In 1955, as I was standing on the quay looking at the two outrigged craft which we then had in the Wellington dock at Dover, a man came up to me. We chatted about outriggers and catamarans and he



Upright Boat Rig

then asked me what I thought about the mechanism to be described now. Unfortunately, I did not get his name but he said that I could publish the idea.

Essentially, the idea is to have a watertight fore and aft bearing in the bottom of the boat so that the mast can heel without heeling the boat. Also attached to the bearing on the underside is a fin keel with a weight at the bottom. When sailing, the rig heels to leeward, though the crew could place themselves on either a sliding seat or a trapeze fixed to the mast but not to the hull to lessen this. The keel heels to windward.

Probably it would be better to have the bearing just below the gooseneck and use a normal centreboard. I should think that the weight of the helmsman would be enough to keep the hull on an even keel against the heeling force of the centreboard.

The rig for this system is difficult. The Bermudian rig would be difficult to arrange and probably one of the lugsail rigs which were described in *Sails and Aerofoils* No. 9 would be best. With these, no sprit would be necessary to take the tack of the jib and the sail forces come on the mast itself.

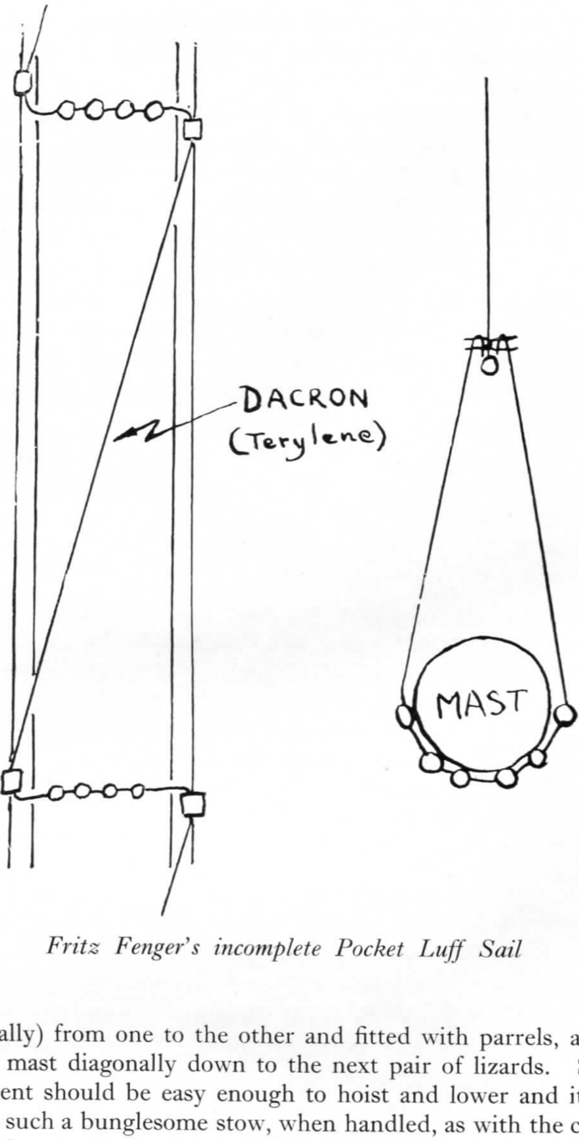
As opposed to the above suggestion, L. Francis Herreshoff, in his book, *The Commonsense of Yacht Design*, describes using a normal rig on a boat but having the fin keel on a fore and aft bearing in the bottom in the same way as that shown. The angle at which the keel is set from the line of the mast is controlled by a handle and worm gear. When beating to windward, the keel is swung to windward so that it balances the heeling force of the sails. The boat itself sails more or less upright. Herreshoff reported very favourably on this system, but, like so many yachting inventions it has gained no acceptance.

LETTERS

Dear Sir,

In regard to " The Pocket Luff Mainsail," described in publication No. 9, the matter of handling the pocket together with the fact that all stays must run to the masthead seem to be the only faults with the rig. Now, in regard to the pocket, one way of solving this would be not to have the pocket go all the way around the mast, but to bring the two side pieces only half way around and then to have lacings to pass around the forward side.

The luff edges of the pocket would be fitted with small lignum vitae lizards, paired so that the lace line would pass directly across



Fritz Fenger's incomplete Pocket Luff Sail

(horizontally) from one to the other and fitted with parrels, and then cross the mast diagonally down to the next pair of lizards. Such an arrangement should be easy enough to hoist and lower and it should not make such a bunglesome stow, when handled, as with the complete pocket. One problem might be that of determining as to just where to attach the halliard.

For the mast without shrouds, I should like to try my cored " made-up " mast. With this mast, one would have uniform bending to leeward. As you know, when a bending mast is used and the sail hoisted with a lace line, the luff of the sail remains straight, despite the fact that the mast has bent somewhat to leeward. With the pockets rigged with lines, as above, one might obtain the same effect.

When the mast is fitted with masthead shrouds — which have no great stretch factor — the mast will bow out to leeward and the draft in the middle third of the sail will be appreciably reduced. Were I to use masthead shrouds, they would have such diameters and stretch factors that the mast would simply bend to leeward from the deck, but not as much as were the mast left shroudless.

The temptation for me would be to try the pocket luff sails on the main and mizzen masts of my Main-trysail (Wishbone) rig. But there are several practical considerations which might cancel out the notion.

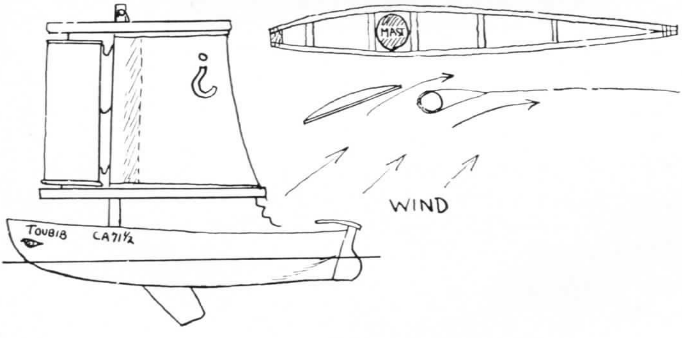
FREDERIC A. FENGER.

Norwell, Mass., U.S.A.

Dear Sir,

I have had some experience with aerofoil sails, but inconclusive, as it was war time aboard a fast moving cruiser. An abandoned 16 foot rowing boat was fitted with centreboard. Limited in spars to 16 foot, I then designed an unusual rig which I hoped would give lots of sail area for a low mast, be efficient and streamlined, be simple to handle and use the slot effect to best advantage.

The drawing shows the rig. The jib pivots $\frac{1}{3}$ of the way from the leading edge to the limits of the sheets which are fastened to the leading



Captain Sunderland's Sail

edge of the main, thus automatically setting a slot effect on each tack. I told the sailmaker I wanted the device of a large red question mark on the sail. He got it upside down but my shipmates insisted he was right. The eye on the bow is borrowed from the Chinese sampan and invokes divine guidance in times of peril, urgently needed by all experimenters in sail. I was serving on CA 71 (Cruiser armoured 71) so it seemed only right to name my splinter CA 71½. Pocket luff mainsail was used and the halliard tension held the sails fairly flat.

Yours sincerely,

M. SUNDERLAND, Captain, U.S. Navy.

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