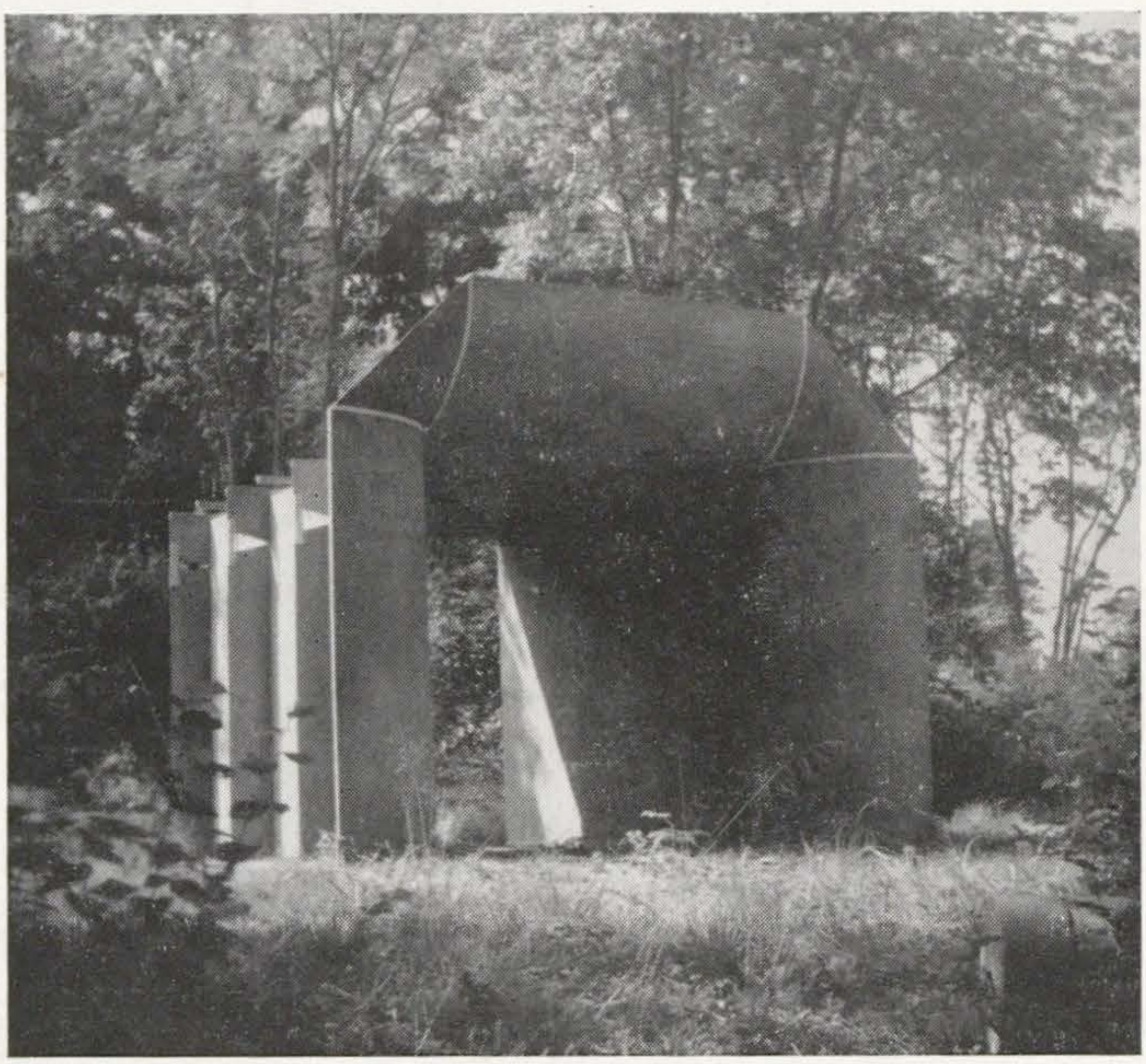
AERODYNAMICS I

A.Y.R.S. PUBLICATION No. 37



THE A.Y.R.S. YACHT WIND TUNNEL BEING ERECTED

CONTENTS

Price $1.00 Price 5/-

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(*Founded June*, 1955)

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October, 1961.

EDITORIAL

The ANNUAL SUBSCRIPTION to the A.Y.R.S. is now due, £1 or $3.50 as before. Please send it to the Secretary-Treasurers in the various groups. British members please send it to the " Membership Secretary."

Again, as usual, it is requested that, if anyone has had a misbound or faulty copy of a publication or has not had his full four, will he let me know.

It is regretted that not all the back publications have been kept in print. This has been due to increasing the size of the publications beyond the economic length to use the very interesting material which has been accumulated which has run down the publishing fund. It is to be hoped that this condition may soon be remedied but the size of some publications may have to be reduced.

Publications for the coming year will be *Multihulls* 1961 and one on *Aerodynamics*. *Boatbuilding* may be a third.

The Flying Kite. Progress in the development of new types of craft is continuous. Catamarans, trimarans, and hydrofoil craft seem to be developing fast. But surely, the ultimate in high speed sailing will be the hydrofoil craft pulled by the flying kite ; and this last has been utterly neglected since it was shown in publication No. 9 (at present out of print) that such a kite could pull a boat fairly efficiently to windward. Major General H. J. Parham has shown how a bent wing glider can give good lift to drag ratios at extreme light weight. If therefore seems a pity to me that the flying kite has had so little attention, especially when a trial can be made for a few shillings.

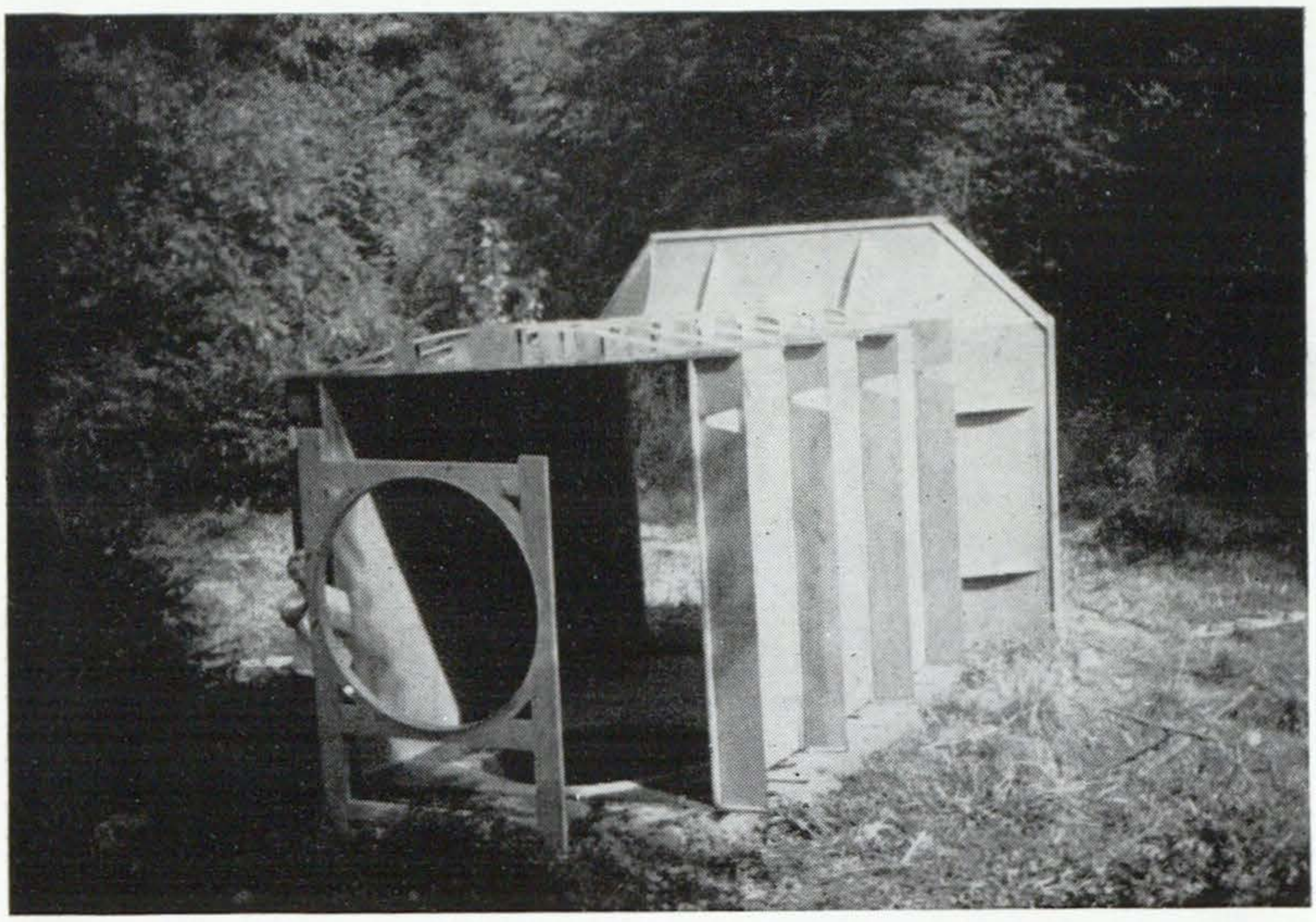
£10 Prize. A £10 prize will be offered to anyone who can build a flying kite which will sweep through an arc of 140° in the horizontal plane, i.e., will fly steadily at a horizontal angle of 70° from dead down wind. The general principles of design are given later in this publication, and I am willing to supply any further information wanted.

In this competition, we are willing to help anyone in any way we can. I have never heard of a competition where the promoters have done this before.

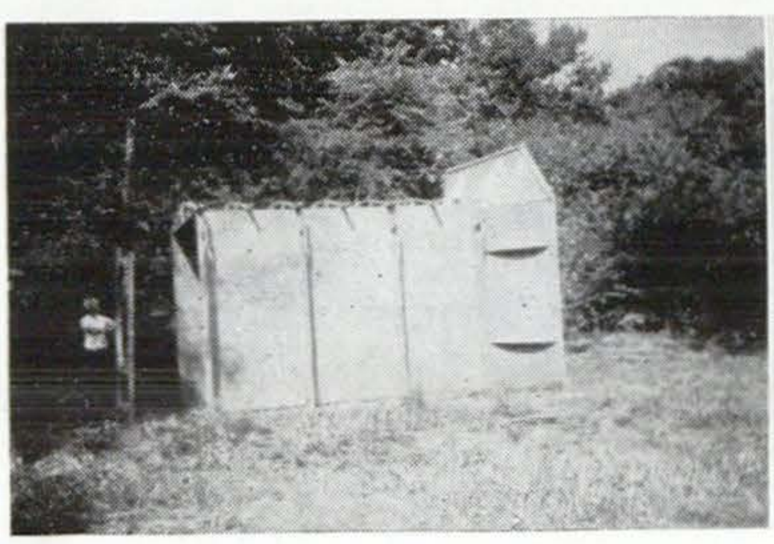
If any members would like to increase the value of this prize would they please let me know.

The A.Y.R.S. Yacht Wind Tunnel. Progress with our yacht wind tunnel has been slow. It really is amazing how difficult it is to erect a plywood box of the size we need. Many people have helped and the photographs show the stage we have reached at the time of writing. We hope to have the job completed when this publication is distributed. The full story of the erection of the tunnel will be given when results begin to come forth.

The Editorial Function. This has become somewhat easier this year due to the kind and efficient help given to me by Mrs. Tett who has not only taken most of the publishing work off my hands, this



A.Y.R.S. wind tunnel showing fan ring



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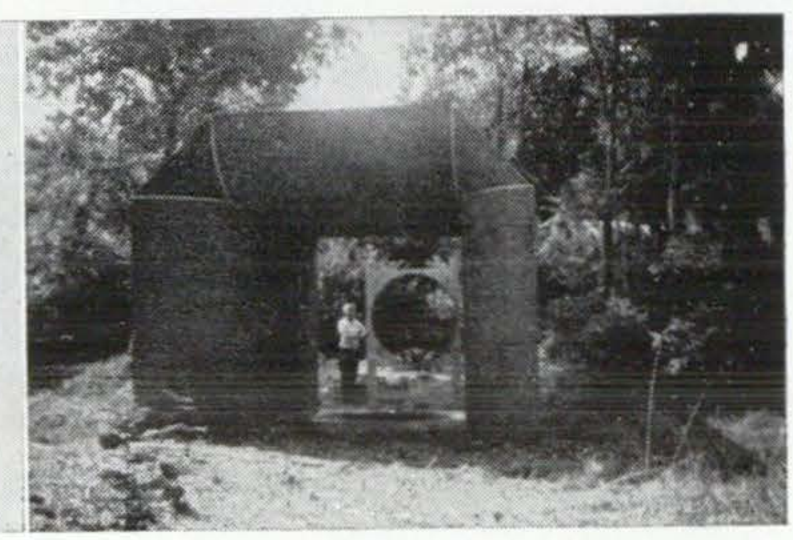


Entrance

alone enabling the construction of the wind tunnel to take place but she has also scrubbed and sandpapered the tunnel — a tedious task. She has been a tower of strength to the A.Y.R.S. and packs a power to weight ratio second to none.

The 1962 *Boat Show*. Will members with models or photographs for display at the next London Boat Show please contact A. J. Millard, 138, Fulham Road, Chelsea, London, S.W.10, who is organising it this year.

AERODYNAMICS I

With the A.Y.R.S. yacht wind tunnel nearing completion, we can now begin a series of publications dealing with sail research. For the present, we can have only one publication each year on the subject because our boat development studies must still be carried on and remarkably few people are interested in both aspects of sailing. However, by introducing the theoretical aspects gradually to our more practical members, we hope to carry them with us into the complete understanding of sails and hulls. It is hoped that our more astute and theoretical members will bear with some articles which may appear elementary to them, such as the first one of this publication.

The Editorial policy in the *Aerodynamics* series of publications will be to lay out the material so that it will accord with the findings of the wind tunnels where this is relevant but we will not be afraid of the occasional highly abstract article couched in general terms and mathematics. For the last few years, articles on sailing aerodynamics have tended to become complex calculations based on assumptions of probable sail forces. This is a natrual tendancy, in the absence of precise data but, if we can get good results from our wind tunnel, such articles need no longer appear.

The Resolution of the Sail and Hull Forces. For those people unversed in sailing aerodynamics, this may prove confusing even in this publication because it is possible to resolve the sail forces in two ways. 1. One can resolve the sail force along the fore and aft axis of the boat and athwartships giving " Thrust " and " Side force " or 2. One can resolve the sail force along the line of travel of the yacht and at right angles to this line. These lines will differ from those of No. 1 by the angle of leeway. Warner and Ober's paper and that of Professor Davidson use system 1 because they were trying to marry up wind tunnel results with full sized tests. More theoretical examinations tend to the system No. 2 because it is abstractly more satisfying. Both systems are correct and can be rightly used but it is essential that it is made quite clear which one is under discussion. Because it is impossible to give wind tunnel results with system No. 2 without assuming an angle of leeway, it is felt that system No. 1 will prove more useful.

THE THEORY OF SAILING

by

John Morwood

The theory of sailing is, oddly enough, self evident to anyone who knows the aerodynamics of the aeroplane. What is lacking, though, is a simple account of it which can be understood by everyone. In the notes below, I have given a simple explanation of the theory ; then gone on to explain the matter in greater detail.

Fig. 1 shows how the wind flows around the sails of a boat when it is close hauled. The lines around the sails represent the paths of individual particles of air and are the streamlines. This diagram

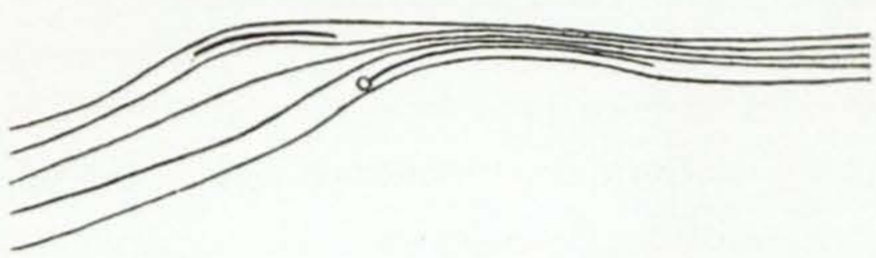


Fig. 1

is taken from Warner and Ober's pioneer study and these flows were discovered by putting model sails in a wind tunnel and allowing jets of smoke to flow in the artificial wind.

Fig. 2 shows the forces produced at various parts of both jib and mainsail by an airflow such as that shown in Fig. 1. Each force is at right angles to the sail at that point and is produced by the *local* speeding up or slowing down of the air. Speeding up the air *reduces*

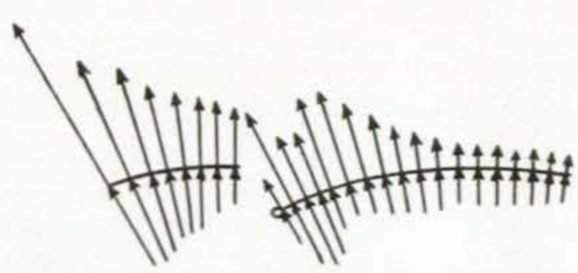


Fig. 2

the pressure below atmospheric and slowing it down *increases* it above atmospheric. If you refer again to Fig. 1, you will see that the streamlines crowd closer together over the lee side of the mainsail, indicating a faster airstream there.

This matter of the relationship of increased *local* windspeed and reduced pressure is made easier to understand by reference to Fig. 3 which shows a side view of a venturi tube. Wind flowing through such a tube is speeded up in the constricted part and its pressure falls as shown by the U-tube pressure gauges (manometers).

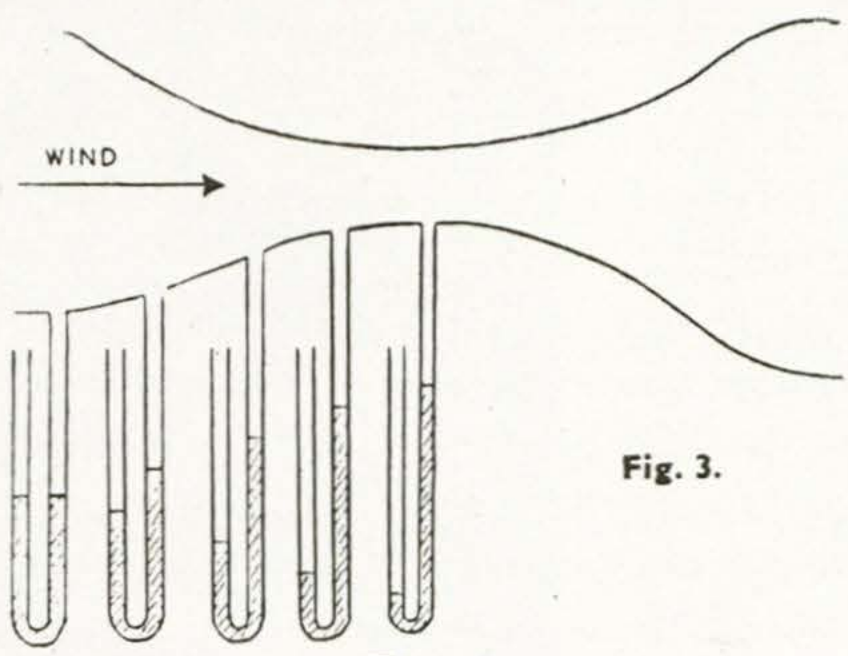


Fig. 3

Fig. 4 shows the result on the boat of all the little forces shown in Fig. 2. These small forces either pull or push the sails in about the same direction and they are equivalent to a single large force acting on the boat in about the direction shown. This can be expressed by saying that the sails in the wind act just as if someone had tied a rope to the centre of effort of the sails and was pulling the boat in the direction indicated.

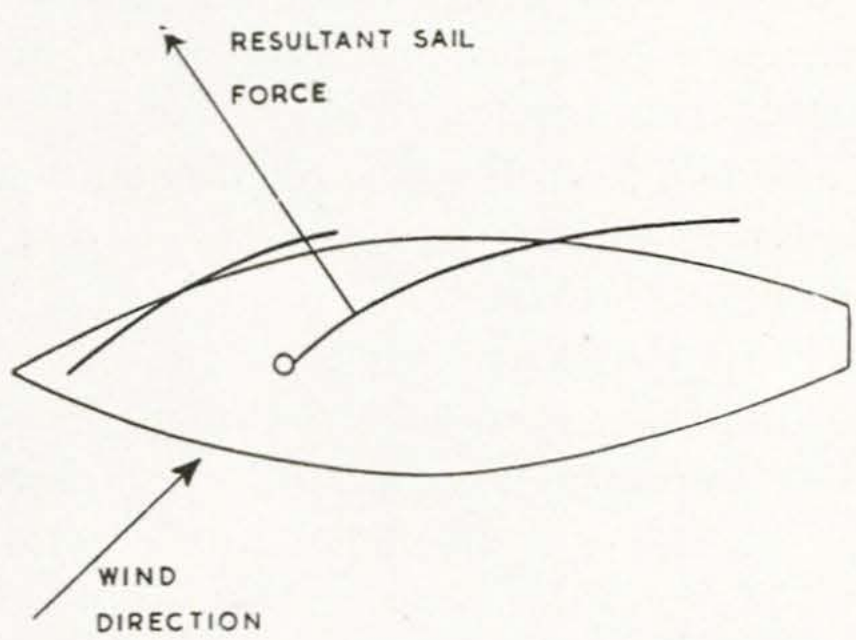


Fig. 4

The sails of a boat, therefore, act just like a tow rope pulling at the *real* centre of effort of the sails, trying to move her sideways but also a little forward of athwartships. This is the " Theory of Sailing " reduced to its simplest mechanics and is as correct for the practical sailor as it is for the most astute mathematician of sailing aerodynamics.

Finally, it is only necessary to show that a sailing boat with a centreboard or fin keel has a great resistance to going in the direction in which it is being pulled by our imaginary rope (the Resultant Sail Force). This is obvious because we know from experience that a flat plate is very much easier to pull through the water along the section of the blade than across it. Therefore, thanks to your centreboard or keel, your yacht will not go sideways, but, because the resultant sail force acts just a little bit forward of athwartships, it will go forward, close hauled.

That is the whole matter explained as simply as possible but it is not, of course, the whole picture. To get still more knowledge out of the theory of sailing, particularly if you wish to relate it to your own boat, we must go a little deeper into the matter. What follows, therefore, will enlarge the picture which has just been given.

As we saw above, a sailing boat being driven by the wind is subjected to two sets of forces :

1. Forces due to the wind flow.
2. Forces due to the water flow.

WIND FLOW FORCES

The wind itself is not a force. It is only when it strikes an object that a force is produced and this is the result of the fact that air has weight (mass). When striking an object, the speed of the wind (or its direction) is changed and this produces the force.

The force which the wind produces when it strikes an object may act directly downwind as, for example, when it flows around the stays of a boat, its crew and many things aboard her. But the wind force which interests us most is " the resultant sail force," which is the total force produced by the wind striking the whole boat, sails, hull, stays, etc. This force may not act directly downwind but may try to pull the boat sideways, Fig. 4. It must, however, always act in a direction *aft* of a line at right angles to the wind's direction. It cannot act upwind of this line because this would be equivalent to perpetual motion.

The nature of the resultant sail force can best be shown by the practical example of Fig. 5, which shows a model which was on the stand of the Amateur Yacht Research Society at the Boat Show in 1957. We had a fan which blew air on to the sails of a model yacht in a basin of water. The model was moored by two parallel threads of equal length at the bow and stern and attached at the edge of the basin. When the apparatus was set up as shown and the windflow started, the model forged ahead and the strings took up an angle such that the force was seen to act about 20° forward of athwartships and about 70° from the wind's direction. However, we usually think of the resultant sail force not as two forces as shown here but as a *single* force, acting at the real centre of effort of the sails.

The resultant sail force gets its name from the fact that it is composed of many little forces acting in different directions. The windage of the stays, crew and hull, for example, act downwind and cause the resultant sail force to lean more downwind. The sails,

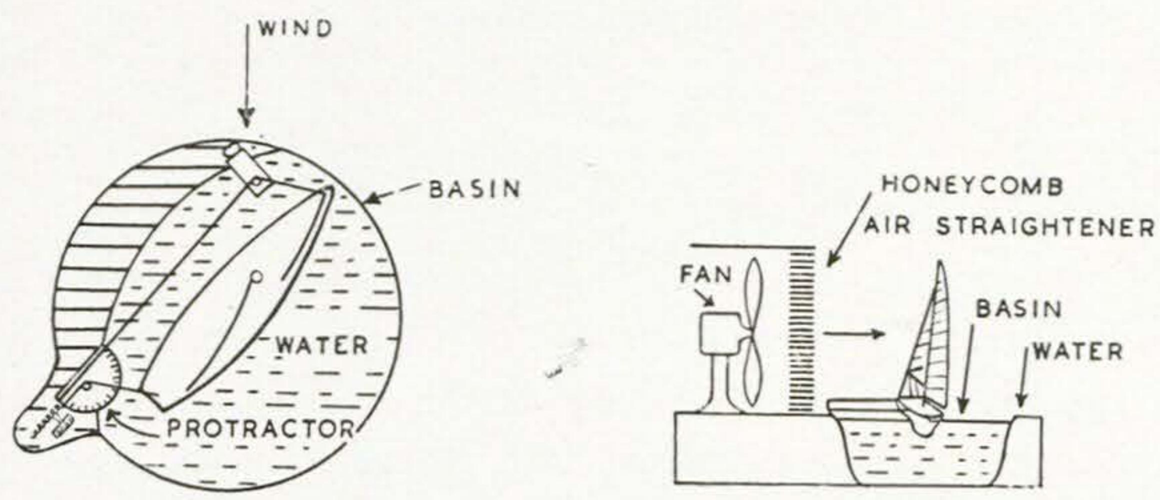


Fig. 5

however, act more upwind than the resultant sail force, and if made larger or better in shape, would cause it to lean more upwind. Even the sails, however, produce many different directions and sizes of force, all of which go to make up the resultant sail force. The " parasitic " wind resistance of stays, crew, etc., can be little altered by anything we do and out study must mainly concern the sails and how they contribute to the resultant sail force.

We saw in Fig. 1 how the wind flows around the sails of the sloop rig. It will be noted that the wind, which was flowing in a constant direction is turned from its course by the sails and is made to flow in a different direction. Now, air is a moving body and it needs a force to alter the direction of a moving body (by the laws of Newton) so the sails exert a force on the wind. Because action and reaction are equal and opposite, the wind exerts a force on the sails. The angle between the direction of the wind and the direction of the air leaving the leech of the mainsail may be called the " weatherwash " and is a measure of the force produced by the sails.

An analogy which is partially true would be as in Fig. 6 where a series of balls being run down a board meet a curved piece of metal. The balls hit the metal and are pushed aside, if the metal is fixed. If, however, the metal is movable, the balls will not be pushed aside so much and the metal will be moved in the direction shown by the arrow.

The above explanation of the production of the resultant sail force is the practical explanation and suitable for the practical sailor.

However, it only partially explains the sail force and, to understand why there is a greater force on the *lee* side of the sail than on the weather side when close hauled, a more difficult explanation must be attempted.

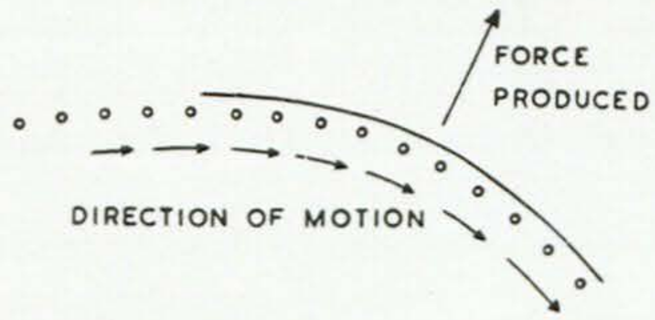


Fig. 6

Pressure Forces. When a current of air is blown through a venturi tube as in Fig. 3, it has to speed up in the narrow part, and as shown by the manometers, the pressure falls there. Now, the lee sides of the sails of our boats act just like the narrowing of the venturi tube and speed up the air which passes over them and this reduces the pressure of the air on them to less than atmospheric pressure, In a similar way, there is increased pressure on the weather sides of the sails. An analogy which holds here to some extent is to draw a teaspoon through a basin of either granulated sugar or salt. The grains speed up and form a hollow on the convex side and slow down and form a hump on the concave side.

Fig. 2 shows the pressures over the surface of a jib and mainsail similar to those measured by Warner and Ober in their classical experiments,* the forces being proportional to the lengths of the arrows. It will be seen that the *negative* pressure on the lee side of the sails is greater than the positive pressure on the weather side. Calling the pressure " negative " may be confusing. It is not a vacuum. Nor is it really even a lessening of the density of the air from normal though this, in fact, occurs. The " negative " pressure is an outwards acting force caused by the movement of the particles of the air, rather than any of those things.

Resultant Sail Force. We are now in a position to understand that the resultant sail force is composed of :

1. Negative pressure on the lee side of the sails amounting to about 75% of the total sail force when close hauled, as measured by Warner and Ober.

2. Positive pressure on the weather side of the sails amounting to about 25% of the sail force, when close hauled.

3. Parasitic and harmful forces from the stays, hull, crew, mast and all other exposed parts of the boat. These may give some slight

drive with the wind aft but they produce very serious losses with the wind ahead of the beam.

Integration. The little forces which go to make up the resultant sail force act in many different directions. All forces coming from the sail surfaces act at right angles to the tangent of the curve of the sail at that point. The parasitic forces act along the wind direction in which they are. Now, any two forces can be added together to make a third force which will act in exactly the same way as the two do. This is done by the principle of the parallelogram of forces as in Fig. 7 where the forces *A* and *B* can be added together to produce *C*

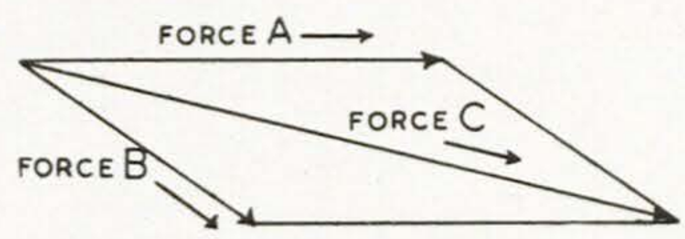


Fig. 7

which will produce exactly the same effect as *A* and *B*, together. In the same way, all the different forces which act on the sails and boat can be added together to produce *one force* acting in *one* direction and this is the direction and size of the resultant sail force. Our model at the 1957 Boat Show showed this force as two forces, parallel with each other in the threads mooring the model.

WATER FLOW FORCES

In exactly the same way as the Resultant Sail Force is composed of many different forces acting in many different directions, the hull and keel of a boat produce a Resultant Hull Force. This is composed of the following forces :

1. Skin friction which acts only as fore and aft drag.

2. Wave formation resistance which, though mainly fore and aft drag can also act out on the weather side when there is leeway, thus producing lateral resistance.

3. The forces produced by the keel or centreboard which are similar to those of Fig. 8 when there is leeway. If there is no leeway, the keel or centreboard only produces fore and aft drag.

The Resultant Hull Force. This differs from the Resultant Sail Force in that the direction in which it acts varies with the speed of the boat and the angle of leeway whereas the direction of the Resultant Sail Force does not alter with the speed of the wind. The head resistance of skin friction and wave formation cause the Resultant Hull

Force to act more from astern while extra leeway causes the force to act more from athwartships.

Now, the Resultant Sail Force must exactly be equal and opposite in direction and size to the Resultant Hull Force when the yacht is

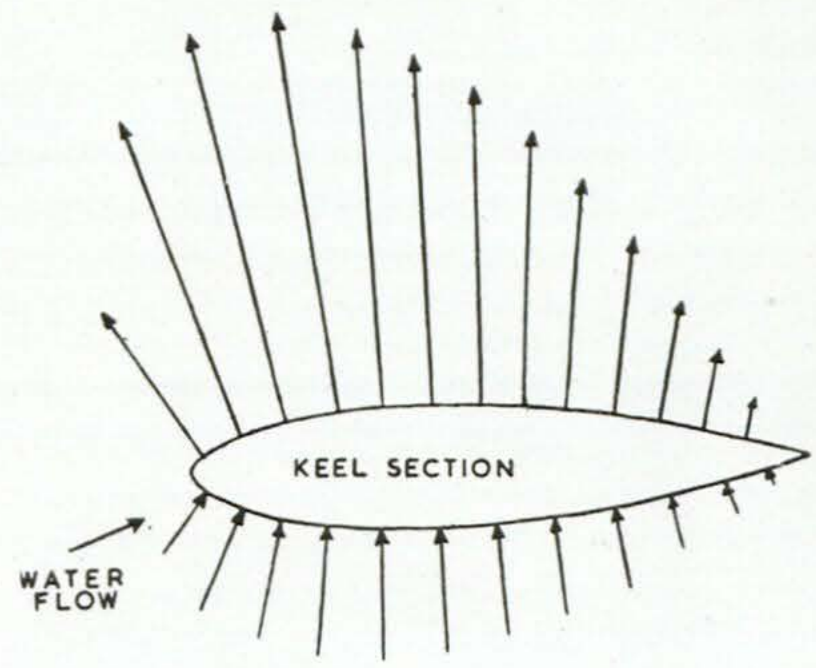


Fig. 8

at constant speed, as shown in Fig. 9. At a constant windspeed, the Resultant Sail Force will achieve a fixed value for its direction and size and the Resultant Hull Force will oppose this exactly by increase or decrease of speed and by adjusting the angle of leeway till this occurs.

Fig. 9 also shows the Resultant Hull Force resolved into two

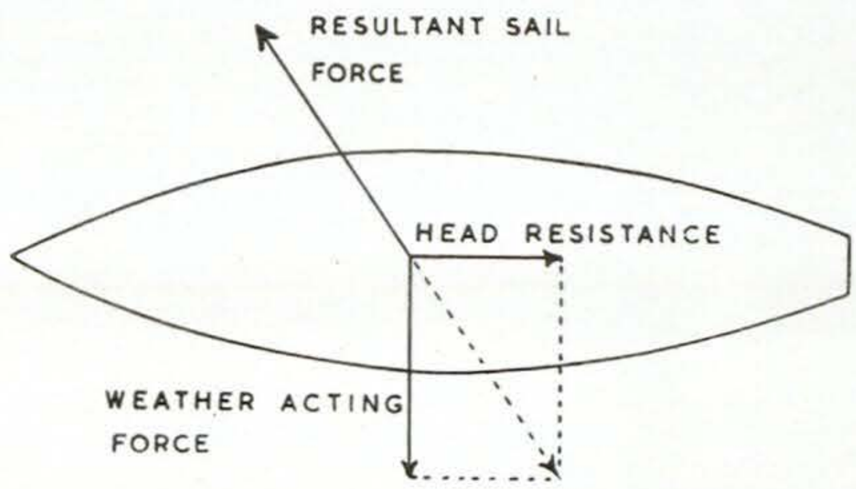


Fig. 9

forces " Head Resistance " and the " Weather Acting Force " which would be exactly antagonised by the " Thrust " and " Side force " respectively.

INTERACTION OF THE FORCES

We have now seen how all the forces which appear on a boat, which is sailing can be reduced to only two " resultant " forces :

1. Resultant sail force.

2. Resultant hull force.

Each of these must be equal in size to the other and act in exactly the opposite direction, if the boat is moving at a constant speed (by the laws of Newton). It will not be necessary to examine any other case than the close hauled course because what holds for that will hold for all other courses, the only difference being the amount by which the resultant forces lie off the fore and aft line.

Close Hauled Course. The wind flows over the sails, hull, crew, etc., and a resultant sail force is produced which acts about 20° forward of athwartships, the boat's head being about 30° from the direction of the apparent wind. While on this course and with the same sail trimming, the direction of the resultant sail force will remain constant, more or less, though its amount will vary according to the wind strength.

The boat will move forward as a result of the force acting on it and, when it settles down to a speed, the angle of leeway will be such that the resultant sail force will be exactly opposed by the resultant hull force, which is the result of the windward-acting force and the head resistance. Because the sail force will act at about 20° forward of athwartships and to leeward, the hull force will act at about 20° aft of athwartships and to weather. If there is not enough windward-acting force, more leeway will appear which will increase that force and, should there not be enough head resistance, the boat will speed up till there is.

As the wind gets stronger, the sail force increases and the boat goes faster, which increases the head resistance. The windward-acting force must also increase to balance the sail force and this is done by a combination of the extra speed and an increase in the leeway angle. The top speed close hauled is finally reached when the increase in leeway angle can no longer increase the windward-acting force to keep pace with the increase of the head resistance. It will therefore increase the top speed close hauled if the size of the fin keel or centre-board is increased, as long as there is enough stability to hold up the sail plan.

THE AERODYNAMIC FACTORS USING THE FINN SAIL AS AN EXAMPLE

by

G. H. GANDY

Aerodynamic Aspect Ratio or AR.

Yachtsmen frequently take the ratio of luff to foot of a Bermuda sail and call it the aspect ratio, but this is *not* the aerodynamic apsect ratio AR.

It is necessary to consider AR because it leads to a practicable ratio of comparison between different types of oil or sail or rig.

$$AR = \frac{\text{Span}^2}{\text{Area}}$$

Because our sails have no span in the horizontal plane like wings, we must consider sails in their vertical plane and so for ' span ' substitute ' height ' in the above formula.

AR of Finn triangular sail $= 3\frac{1}{2}$, (but for comparison with certain tunnel-tested foils, a Corrected AR is required).

Corrected AR (*applicable to yacht sail for comparison with certain tunnel-tested foils*).

Owing to the fact that the yacht's deck and the sea surface exercise a favourable effect in preventing eddy losses at the base of a yacht's sails, whereas the usual wind tunnel test on foils makes no provision for this effect, it is considered that the yacht's AR should have a percentage added in order to bring it to a Corrected AR more truly comparable with the AR of the usual tunnel-tested foil.

The amount of this percentage we can assume as 33%. Authorities differ over the exact figure, but 33% seems probable.

Thus the Finn Sail of AR $3\frac{1}{2}$ will have a Corrected AR nearly 5.

Tunnel tests results from suitable foils of AR nearly 5 should then be comparable to our Finn Sail ; so long as due allowance is made for the fact that the tested foil has no twist, whereas in the sail the twist is considerable.

Twist. Twist is an affliction suffered by all *soft* sails set in the conventional way, the head taking up a very much smaller incidence angle than the foot. Contrivences like kicking straps, etc., can reduce twist but do not eliminate it, unless the rig is Chinese, or, unless the thin sail material should be formed of some sort of plastic ply, fairly flexible in one direction yet stiffer in the other.

Practical sailors have found that it pays to have twist in their sail in very light weather. This is not because twist in itself makes for efficiency, but because allowing the sail to twist — not strapping it down tightly — is a quick way of putting more arch or camber into what is normally a sail too flat for these very light winds.

Suppose the twist in a Bermuda mainsail to be 15°, which I consider to be about the minimum, and occurring when the mainsheet exerts greatest downward pull in the closehauled position. Then, if the mainboom is set at 20° incidence to the wind, the top of the sail will lie at 20° minus twist 15° = 5° incidence.

Now with only 5° incidence at the top, some shiver and shake in the wind will be on the point of developing up there. Thus with a 15° twist, the boom cannot be set at incidence much less than 20° for fear of shaking the wind out of the top. This is a pity because a 9° to 12° boom incidence together with a 9° to 12° incidence all the way up the sail — which is naturally obtainable if the sail is not twisted — can give much better closehauled results, both as regards increased forwards drive and decreased side force.

Thus twist is a handicap to closehauled performance ; it is not such a handicap when sailing free ; and this is just as well because the twist will increase to as much as 45° when the mainsheet is eased and boom squared off. (In parenthesis on the subject of boom incidence on the wind ; when boom incidence to the wind is small, the boom end lies off further from the boat's centre line than when the boom incidence is larger. Hauling in the sheet *without altering course* increases the incidence of the sail to the wind).

Twist also complicates the calculation of the force generated by a sail. For accuracy, the twisted sail should be considered as made up of a number of horizontal strips forming panels or elements, with each of these strips lying at different incidence to the wind owing to this unfortunate factor, twist. Thus a separate calculation for each panel is required, unless a short-cut approximate solution can be tolerated.

Wind Velocity Gradient. The wind velocity increases with height, (it is supposed to vary as the seventh root of the height), and this progressive increase in velocity is termed the wind velocity gradient. It is not worth bothering about with a low rig such as the Finn-type. For rigs which stretch far above Beaufort Height (33 feet), some allowance for the gradient may be advisable. In theory a really high sail should be allowed to twist a few degrees in order to suit the wind velocity gradient.

Arch or Camber. *Arch* is the amount of belly in the sail ; precisely defined by taking a horizontal section of the sail, drawing an imaginary chord across the arc of this section and measuring at right angles to the chord the maximum distance of the arc away from the chord. If the distance should be one foot and the chord ten feet, this particular part of the sail has arch 1/10.

It is regrettably impossible to give soft sails either a constant arch all the way up, or, possibly better still, more arch at the foot and less at the top. With our soft sails we have to accept less arch at the foot than higher up ; this is one of those things for which the cure might be a stiffer but still flexible material.

To simplify calculation we take the average or mean arch of the sail and assume that this average arch is maintained from top to bottom. This assumption is not strictly true, but it is not likely to make a great deal of difference to the total forwards and sideways thrusts so calculated. But if truly accurate heeling moments were to be aerodynamically computed, the assumption would be unjustified.

A generous sail arch produces more aerodynamic force, but at incidences somewhat larger than those at which a flatter sail gives its maximum ; so for pointing really close a full arch should be avoided. However, the real disadvantage of a full arch when closehauled — except in light weather — is that although it may deliver a creditable amount of forwards force, it gives at the same time far too much sideways force for the keel and hull to react against properly if pointing high ; however, for a keel-less boat, which never points high, the fuller arch sail is likely to be suitable. (Off the wind the full arch sail comes into its own, generally speaking. Aerodynamically a flattish sail with high AR is good for general windward work, whereas a fuller sail with lower AR is better off the wind).

The average or mean arch chosen for certain of my Finn-type sail calculations is 1/13.5 which I would describe as the mean arch of the normal general purpose sail — neither too flat nor too full for the average weather and courses expected. (Incidentally a large arch or full arch sail could have a mean arch approaching 1/7).

IMPROVING SAILING CRAFT PERFORMANCE

by

Edmond Bruce

In the past, several contributors to the A.Y.R.S. have indicated their belief that more can be accomplished in improving sailing-craft performance by concentrating on sails rather than hulls. I am writing to show how hull and sail efficiency, as indicated by their Lift to Drag

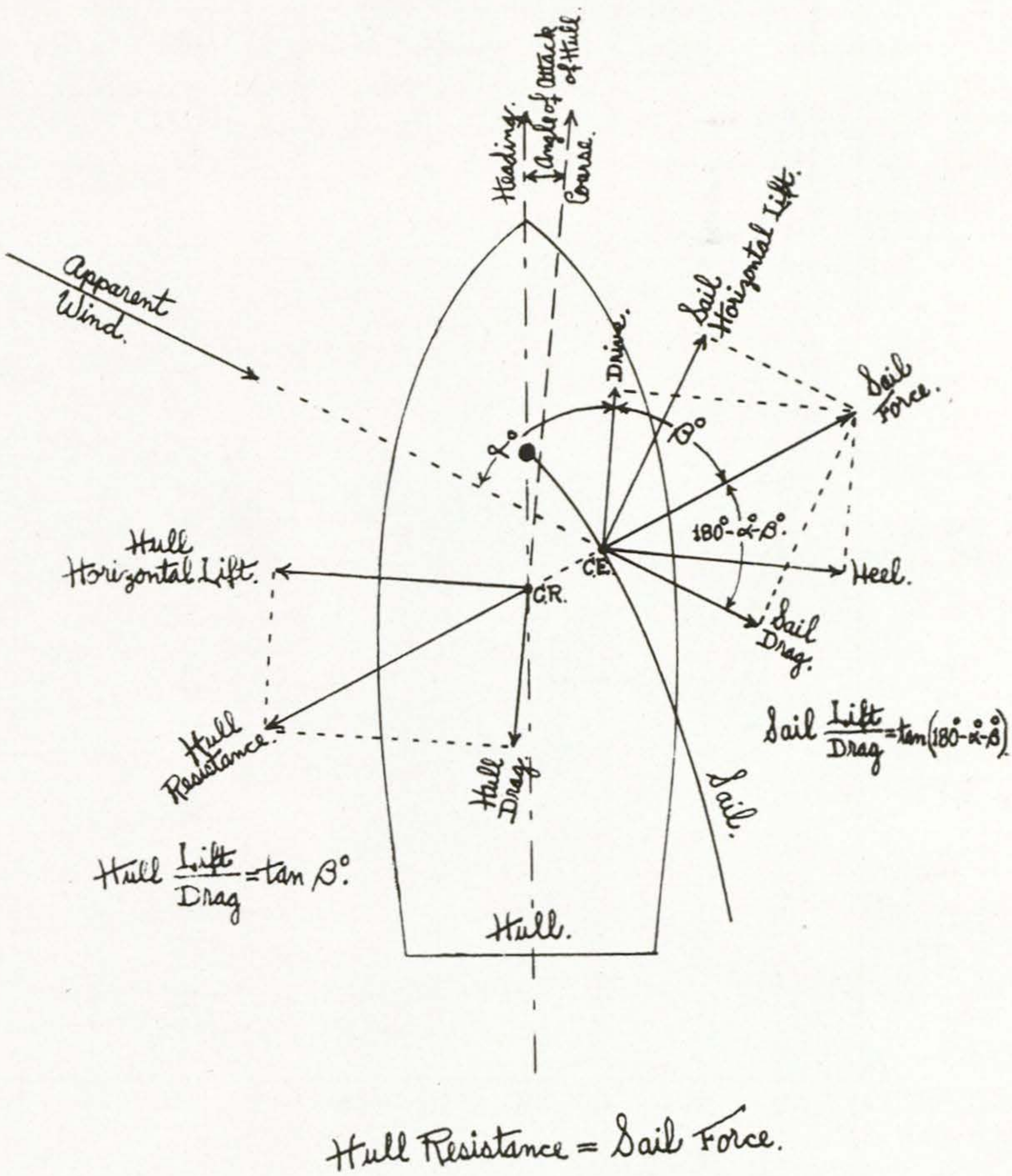


Fig. 10

ratios, are inter-related with the angle of the course from the apparent wind, thus giving a true picture of the situation.

Fig. 1 is the conventional windward diagram of horizontally

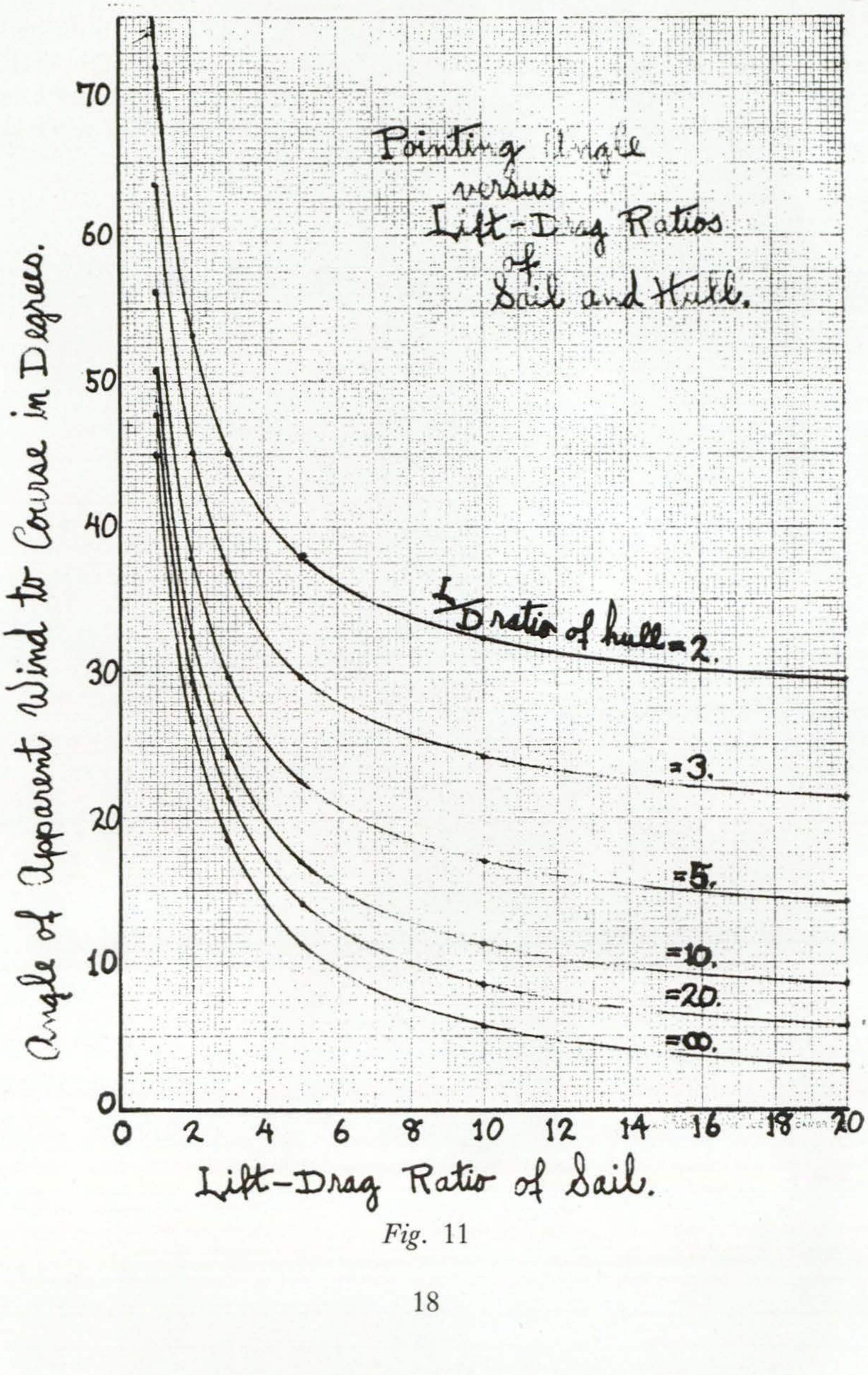


Fig. 11

balanced forces for sail versus hull. A cat-rigged sailing craft is drawn for simplicity. After acceleration has ceased, the total hull resistance must equal the total sail force in magnitude and must oppose it in direction as drawn. The usual horizontal Lift and Drag component forces for sail and hull are indicated. The total sail force is also resolved into the component which indicates, the useful drive along the achieved course and the heeling component horizontally perpendicular to that course. These components must equal and oppose the mentioned hull components.

α, in Fig. 1, represents the angle between the apparent wind and the achieved course. β is the angle between that course and the total sail force. The hull will seek a speed and angle of attack which will create balance with the demands of the sail. Thus, simultaneous equations can be written as :

(a) Hull $\dfrac{\text{Lift}}{\text{Drag}} = \tan \beta.$

(b) Sail $\dfrac{\text{Lift}}{\text{Drag}} = \tan (180^\circ\text{-}\alpha\text{-}\beta).$

Using these equations, for every value of hull lift-drag ratio (sample maximum values : 3 for cruising yacht, 4 for a catamaran, 20 for an ice yacht), we can find a value for β. From equation (b) we can now get a series of values for each value of β which relates sail lift-drag with the angle of the apparent wind from the achieved course. Fig. 2 is a plot of these results.

Each curve of Fig. 2 is for a different value of hull lift-drag ratio and shows how the course angle becomes greater as the sail lift-drag ratio gets less. The disposition of the curves show how the course angle becomes greater as the hull lift-drag ratio gets less.

The curves of Fig. 2 are applicable to all sailing craft and all courses in respect to the apparent wind. Note that they are independent of wind velocity and boat speed provided the lift-drag ratios are known for these conditions.

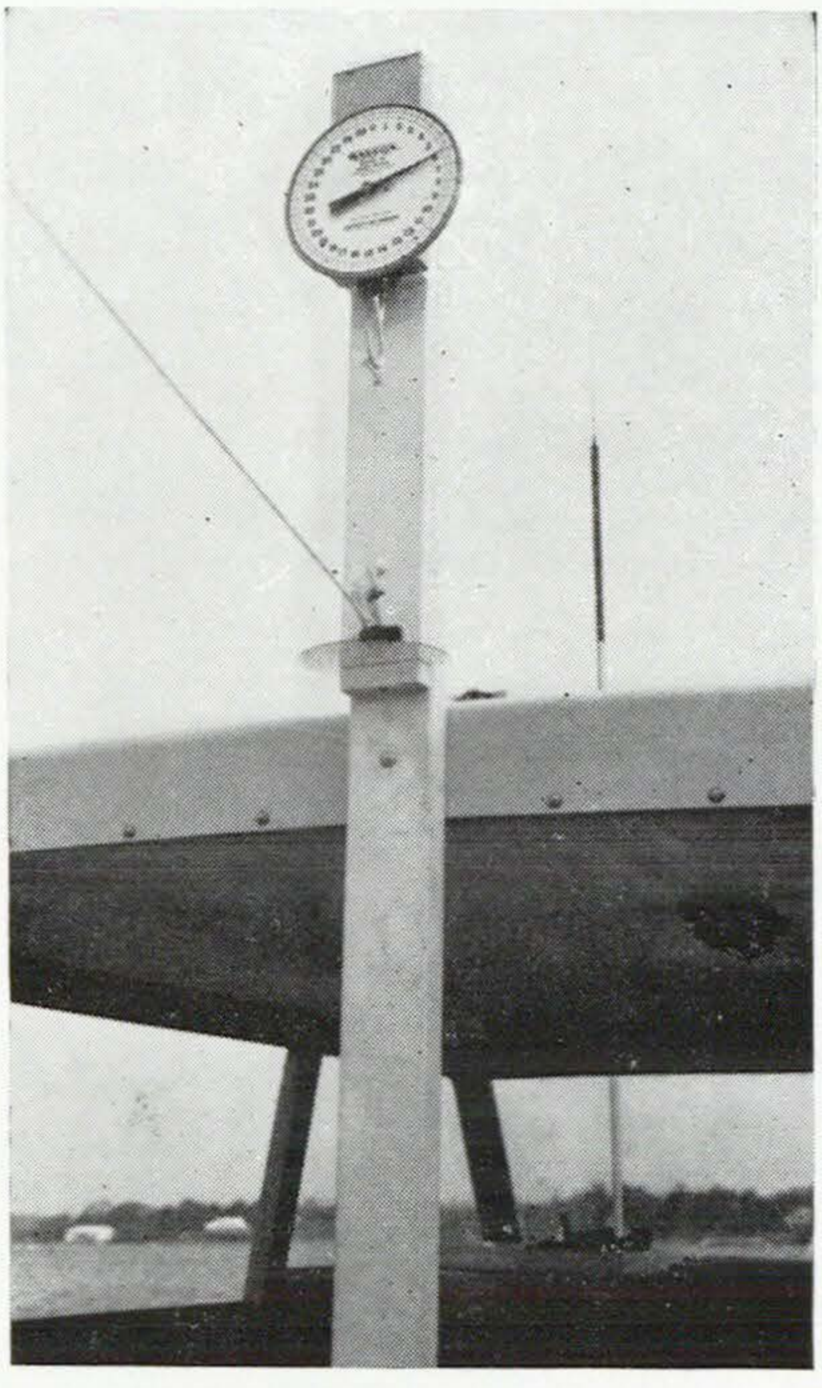
As an example, suppose a cruising boat, at some windward speed, has a maximum possible hull lift-drag ratio of 3. It has a sail which, at optimum adjustment for the course, produces a lift-drag ratio of 5. The curves show that the limiting angle α that can be sailed into the apparent wind is not less than 30°. If the boat speed were 35% of the apparent wind, the calculated angle of the course to the true wind will not be less than 45°.

Other examples are : An ice-boat with a chassis, measured lift-drag ratio of about 20, in a towing test, and a sail of about 8, in a tethered test, fitted the curve of Fig. 2 precisely at 10° from the apparent wind in pointing ability. All the sail boats which have been similarly measured have fitted the curves also.

Finally, let us examine the curves to see whether we should concentrate on sail or hull improvement for most benefit. We can see that improving the hull lift-drag ratio from 3 to 5 at a sail lift-drag ratio of 8 improves the course angle from $25\frac{1}{2}°$ to $18\frac{1}{2}°$, i.e., 7°, while improving the sail lift-drag ratio from 6 to 10 at a hull lift-drag ratio of 5 improves the course angle from $20\frac{1}{2}°$ to 17°, i.e. $3\frac{1}{2}°$.

Dear Sir,

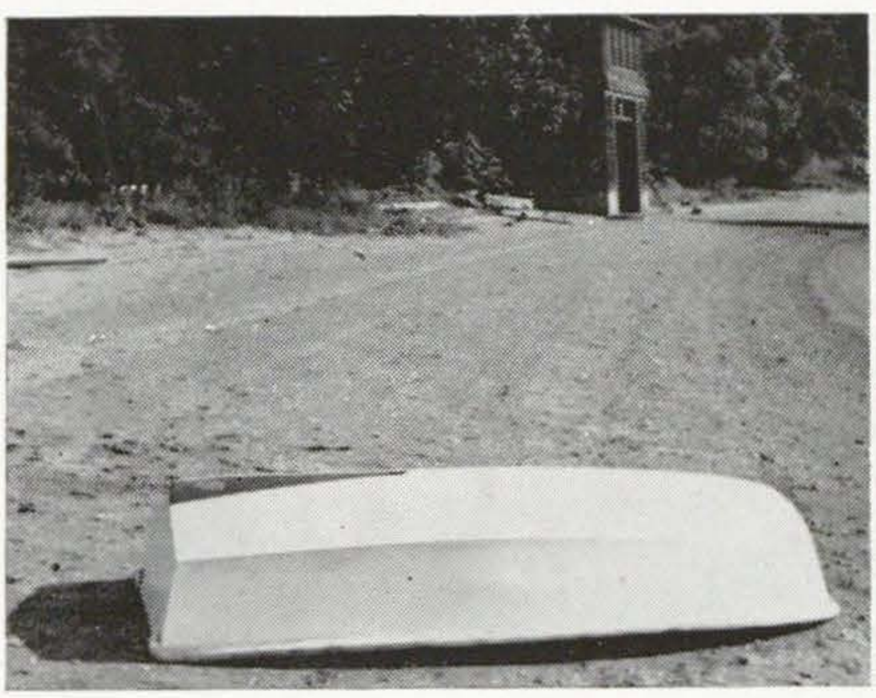
I have received letters from universities, designers, a boating magazine and amateurs regarding my towing-tank article in A.Y.R.S. No. 30. There have been no technical criticisms except the wish for details of full size confirmation.

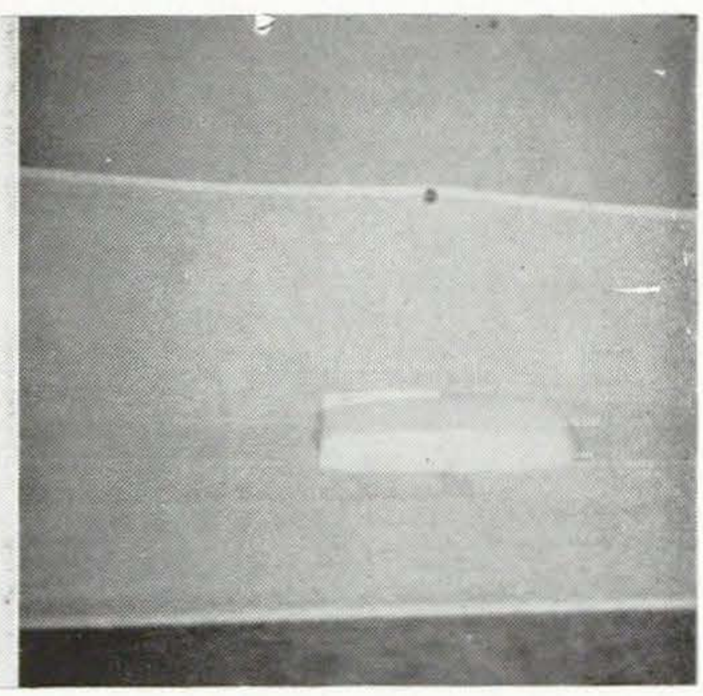


Towing attachment

Most of my full size confirmations have been in the field of fast power boats and in the form of predicted speeds for various horsepowers and propeller efficiencies. These agreements have been excellent but I considered them not quite appropriate in a discussion of sailing tests.

Some time back, I tried towing my dinghy, with one passenger, from my deep draft sailing auxiliary but found that the dinghy speed relative to the water was disturbed by the deep draft wake. A good check at a single speed was obtained by towing from the end of the main boom which was swung out abeam and supported by a topping lift. The turning moment on the towing boat was so great that a





Dyer Dhow *Model*

hard-over rudder compensation was necessary. The auxiliary's power was so low that only one speed was practical in this test.

I have now acquired a shallow draft body but amply keeled power boat which is equipped as a full size test vehicle as shown in an attached photograph. It measures towing force and horizontal angle, therefore windward tests of actual sailing craft, similar to the corresponding tank tests, are being accumulated. Using this equipment on the previously mentioned dinghy, measurements were obtained as indicated on the attached curves for the boat and it's model. Photographs of this dinghy and its plastic model are also attached.

To obtain sufficient accuracy in the speed determination, two-way towing and timing over a measured nautical mile was employed.

The results of these tests are in the curves shown of the Dyer Dhow. The upper dotted curve shows the total resistance of the model, as tested in a laminar flow tank, multiplied by 12^3. 12 is the scale factor of linear dimensions of boat to model. The water for this test was 50 degree F. and fresh. The speed in this curve is the tank speed multiplied by $\sqrt{12}$.

The lower dotted curve is of the same type but it is for tests of the skin alone when in the same water conditions as the model test.

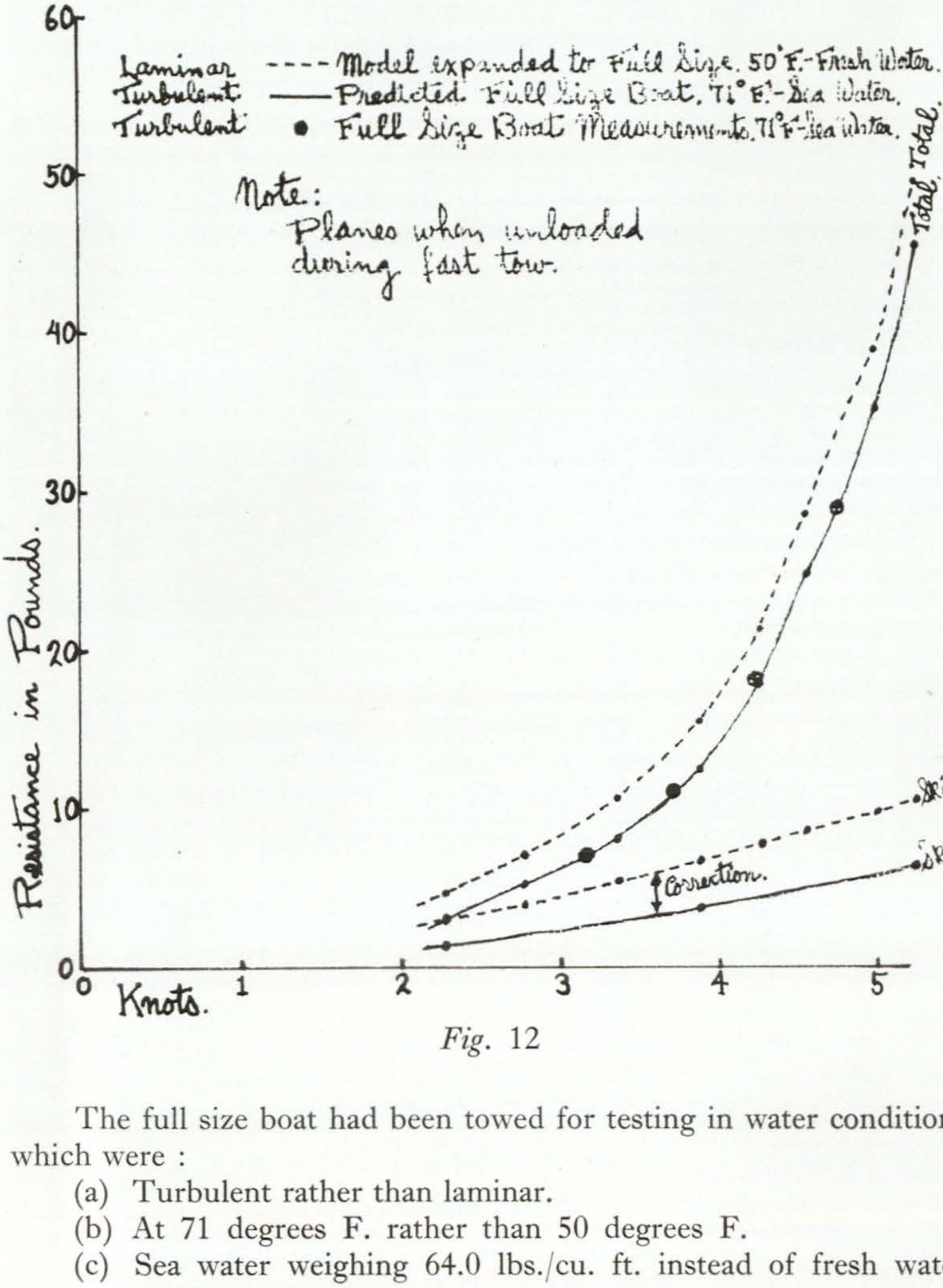


Fig. 12

The full size boat had been towed for testing in water conditions which were :

(a) Turbulent rather than laminar.

(b) At 71 degrees F. rather than 50 degrees F.

(c) Sea water weighing 64.0 lbs./cu. ft. instead of fresh water at 62.4 lbs./cu. ft.

To enable comparison, these same values were used for determining the predicted full size curve.

All three of these corrections must be applied to the frictional resistance. Temperature and density are taken care of in the standard tables of kinematic viscosity. This kinematic viscosity is used in the determination of the Reynold's Number. Using this, the frictional coefficient is determined from the Schoenherr curve for turbulent flow. The predicted full size skin resistance can now be calculated for various speeds since we know the Schoenherr coefficient, density of sea water and the full size wetted area as per equation in A.Y.R.S. No. 30. The lower solid curve is a plot of these calculated skin frictions versus speed for the full size boat.

The differences between the two model dotted curves at each speed are the expanded model resistances in fresh water. When these are multiplied by 64.0/62.4, which is the weight ratio of sea water to fresh water, we get the final full size pressure resistances. Adding these to the corresponding full size skin resistances give the upper solid curve which is the predicted full size, turbulent, total resistance in 71° sea water. The four circled dots are measurements made on the full size boat when towed in these water conditions.

Sincerely,

EDMOND BRUCE.

Lewis Cove, Hance Road, Fair Haven, New Jersey, U.S.A.

A YACHT WIND TUNNEL

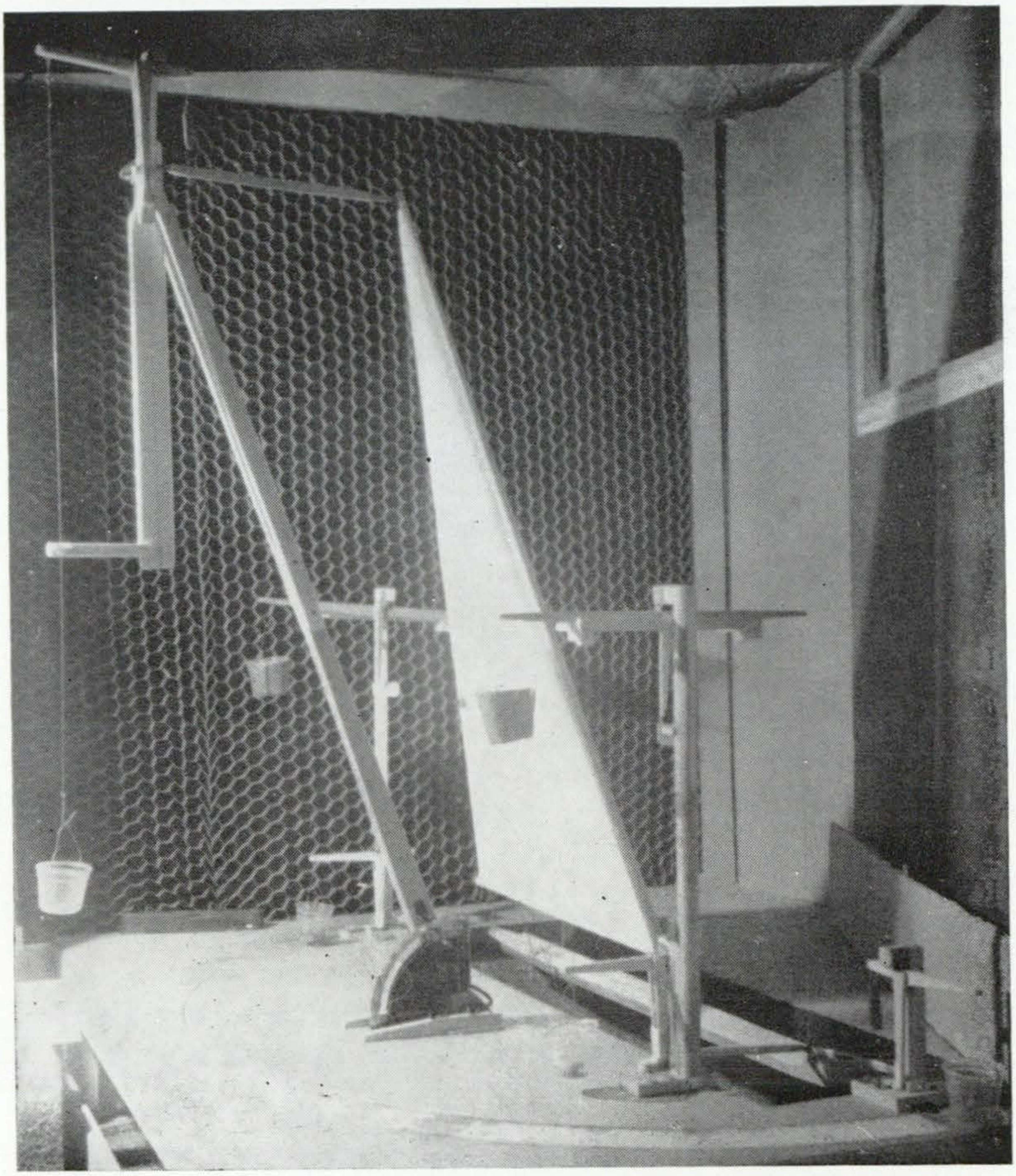
by

R. J. HARRINGTON HUDSON, M.ENG., A.R.I.N.A., Rosemary Cottage, Galmpton, Brixham, South Devon

In view of the proposal to construct a wind tunnel, mentioned in A.Y.R.S. Publication No. 24, I thought it might interest members to hear what I have been doing in a small way since that date in my spare time, unfortunately rather limited.

At first, I built a " blower-type " wind tunnel about 9 feet long with a 24″ diameter fan, discharging air through a Dufaylite honeycomb 3 feet square and arranged a test platform, with rotating turn-table and trough outside the honeycomb. Gauges were mounted on the turn-table, all well clear of the trough on the lee side, to measure forces on the model floating in the trough and its sails. An exact scale model of a Dragon was used.

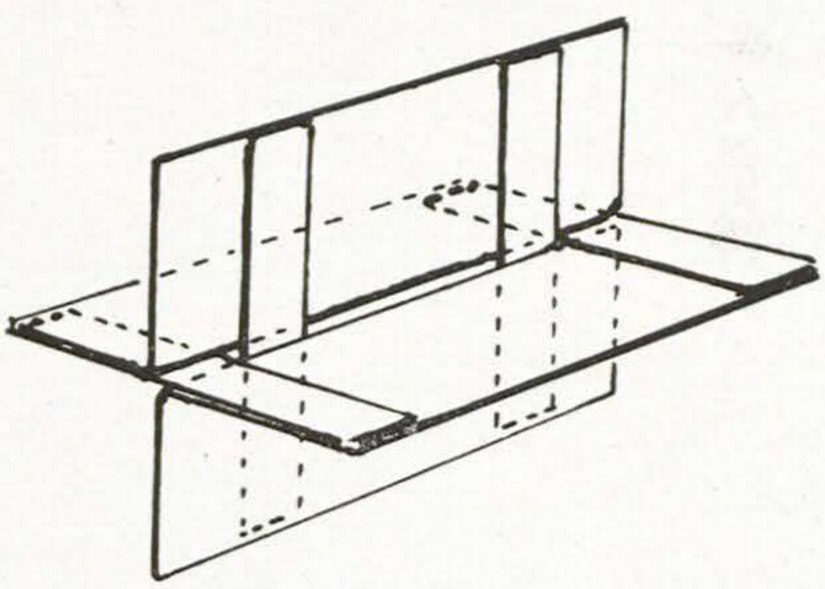
The construction of the fan, four blades, aerofoil section made of hardwood with a metal hub, and the tunnel presented no difficulty and the flow of air at the honey comb was steady and easily controlled, but a foot outside the honeycomb, quite impossible eddies occurred which weeks of work with screens and other devices failed to eliminate



Inside the tunnel

and eventually I had to abandon the blower-type, reverse the fan and adapt the tunnel to a pull-through type. A working chamber 5 feet long was made to enclose the turn-table platform, retaining the same section 3 feet square and a honeycomb and bell mouth were fitted at the intake. This arrangement has proved successful and provides a steady air stream in the working chamber.

Gauges for measuring the thrusts on the model and sails presented difficulties. Flexible metallic bellows connected with manometers were tried but the most sensitive obtainable were nothing like sensitive enough. I then tried threads, (trout line), carried over small pulleys to weighing pans, but found that friction of the most carefully made pulleys upset the readings. I then tried light bell-cranks but again the friction at the hinge pivots ruled out this arrangement. I finally fitted these light (balsa wood), bell-crank levers with hinges of the " crossed spring " type familiar to instrument makers. For these I used pieces of light watch spring arranged as shown in the sketch.



The bell-crank levers fitted with these hinges have proved completely successful. The scale I am working to is necessarily small, limited by the 3 feet square section of the working chamber and to obtain the degree of accuracy necessary, I found the gauges had to respond to loads of the order of 0.01 ounce. With these light balsa wood bell-crank levers, mounted on the watch spring hinges I have mentioned, accurate measurements of the order of about 0.009 ounce can be taken. In fact, I regard these hinges as an essential part of the gear. Without them I should have got no results worth recording.

I soon found that the floating model was unsatisfactory. The forces I wanted to measure were :

(a) At the bow, Lateral thrust,
Longitudinal thrust, (on centre line)
Vertical (depression of bow).

(b) At stern, Lateral thrust,
Vertical, (lift or depression).

(c) At masthead, Lateral thrust.

To measure accurately the vertical lift or depression at (a) and (b) was impossible, so I abandoned the floating hull and substituted a simple piece of wood to carry the mast and sails and supported this by suspending it from the ends of balances at bow and stern. These balances, or scales, are supported at their centres by watch springs as I found these more convenient and quite as sensitive as knife edges. The balances are counter-weighted to exactly " float " the sail assembly and readily respond to vertical forces, plus or minus, of the order of 0.01 oz. Their fulcrums are adjustable laterally to compensate for the slight movement of the c.g. of the sail assembly when heeled.

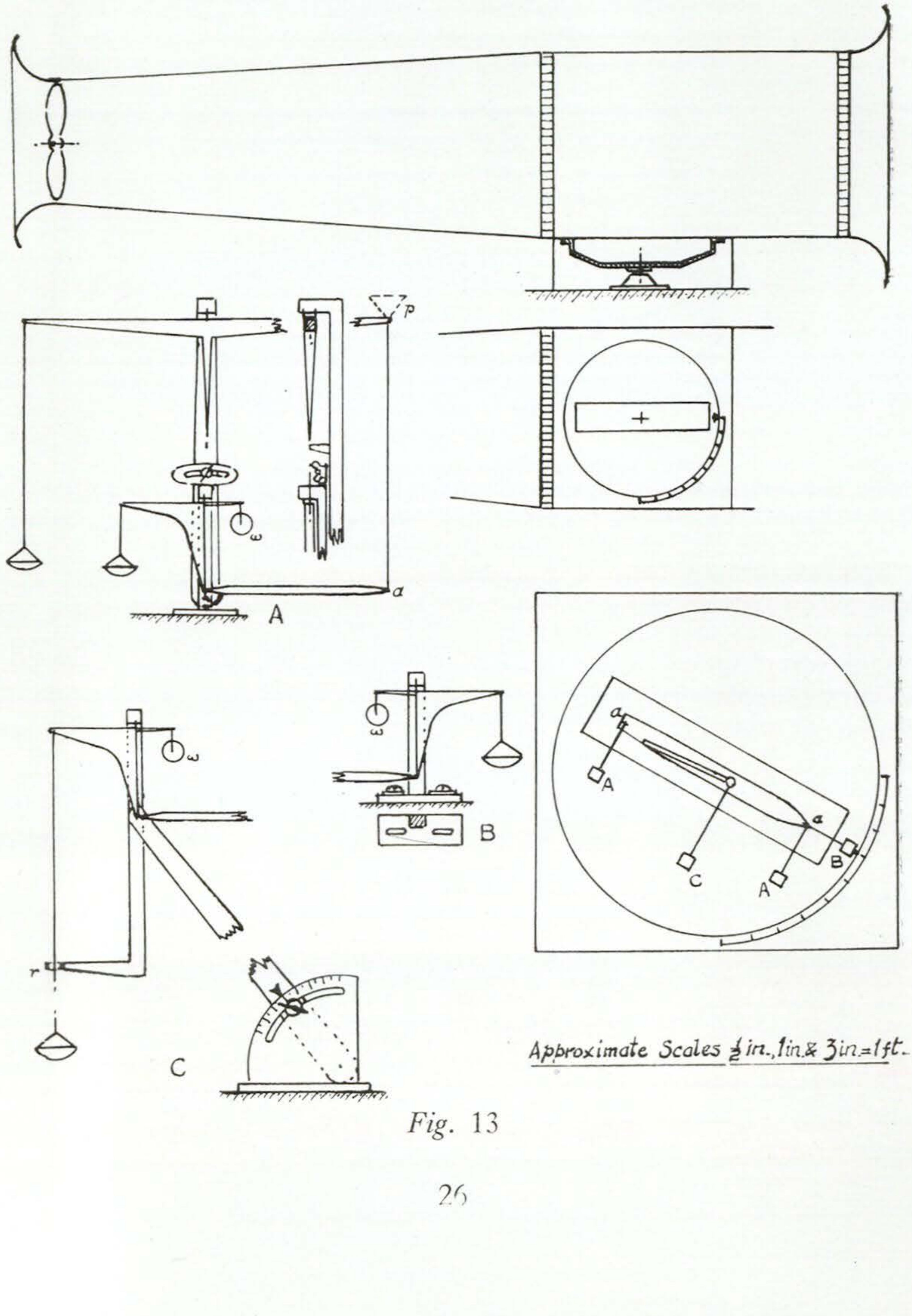


Fig. 13

There are four bell-crank lever gauges, all similar to record all four horizontal thrusts noted above in (a), (b) and (c), the mast head gauge, (c) being adjustably mounted on an arm the same height as the mast, and itself adjustable to the angle of heel. Light balsa wood struts connect the sail assembly with the four bell-crank gauges.

For recording wind velocity I use Short and Mason's anemometer D.3132, and a stop watch. After many attempts I found this instrument to be the best, in fact, the only one that would meet the case.

For applying loads to the gauges and balances I use shot as it is convenient, and a chemical balance to check the weights of shot from the pans.

Much time has been spent in preliminary work and testing for accuracy, but I have now made a start with a mainsail only in the first place, to determine the exact movement of the C.E. with varying angles of apparent wind and heel. The results are interesting and, I think, prove that even on a small scale useful information may be obtained provided the readings are of sufficient accuracy. I should, perhaps, mention that all the gauges were wired to make electrical contact and light a small lamp when the correct loading was reached, but I found that visual observation was more satisfactory and also more accurate so I scrapped the electrical systems.

I have held up the completion of this letter to enable the enclosed rough sketch to be included as it may help to explain the layout and gear. Unit A comprises two gauges a bell-crank lever to determine lateral thrust and a balance arm to record vertical forces. You will notice that the vertical member which carries the fulcrum of this balance arm is pivoted at its lower end and can be swung laterally through a small arc and clamped with a thumb-screw. It is, of course, essential that for all angles of heel the bell-crank lever gauge for recording lateral thrust lies at its zero position before the fan is switched on, but heeling moves the c.g. of the sail assembly slightly so the above mentioned adjustment is necessary to bring the bell-crank gauge back to zero. Small counterweights *w* exactly balance the weight of the bell crank levers and empty pans. Two complete units *A* are located at *A*, *A* on the plan of the turn-table and connected at *a*, *a*, to the sail assembly. The small weighing pan *p*, (shown in broken lines), is only required over the stern to measure " lift." The balance arms are, of course, loaded to exactly " float " the sail assembly by suspension fore and aft before any readings are taken. Unit *B*, located at *B* on the plan to record foreward drive of the sail, requires no comments except that the base is slotted for the holding down screws to enable adjustment to be made to its zero position. Unit *C* to record lateral thrust at the mast head also requires very little comment. The long arm on which the gauge is mounted is the same length as the mast and remains parallel to the mast at all angles of heel. The pan suspension passes through ring *r*, mounted on an extension of the member which carries the gauge, for two reasons, the ring steadies the long pan suspension and also acts as a plummet for setting the gauge correctly when the angle of heel is altered.

As I mentioned above, to enable vertical forces (a) and (b) to be measured, the floating hull was abandoned and a *simple piece of wood* substituted to carry mast and sails, but I found later that the hull, (especially when heeled), has a slight but significant effect on wind on the lower part of the sail, so that *simple piece of wood* was replaced by a very light unballasted hull. Wind was prevented from passing under this hull by sheets of rubber cut and laid at waterline level on the windward side.

THE STAYSAIL RIG

by

C. O. Walker, Rancho Panico, 1887 Jonive Road, Sebastopol, California

Marara : a 42 foot catamaran previously described in A.Y.R.S. Publication No. 27 : Cruising Catamarans, and in No. 33 : Sails.

Marara was designed by the writer, primarily for cruising, thus is heavier than most for her length, as speed, if any, was to be a by-product.

Marara was originally cutter-rigged. Because of her weight and small sail area, she sailed very poorly except in gale winds. In a light breeze the sails seemed to be stalled most of the time. When we tried using a very large masthead Genoa, we succeeded in topping our mast.

Of course, the designer was disappointed ; but one thing could be said, she was undoubtedly the *slowest* boat on the San Francisco Bay. However, it was felt that there was a missing link, so the designer got out the drawing board once more, and dreamed up this " monster " (as it was dubbed by others).

The bipod mast was constructed and stepped, which brought about comments from the local yachtsmen that we had " really lost

Marama

our marbles," and the only cure was to give it the deep six. (The rig, not the designer).

The very first sail we took with her new rig was with only the two jib sails of her former rig, and to our surprise, she sailed better than before, with only half the sail area. This was a very great improvement, and with her new balanced staysail, she would rarely take a back seat.

With the staysail rig *Marara* puts about easily, and can be handled completely by one person. Reaching in strong winds, the sails can be eased off without losing shape, which creates lift to her thin bows. There is no chafe with this rig.

It was said that the balanced staysail would thrash about while in stays ; this we found to be no more than with a sloop mainsail if the balanced sail is not overbalanced : i.e., The pivot at 25% of boom length.

Since the last series of picture were taken, we have tried the " Back Rig " described A.Y.R.S. Sail Rigs No. 26.

The back rig is very good with the wind abaft the beam, but does not seem to have the drive to windward or close reaching that the staysail rig has. Of course, we traded two high aspect ratio sails for one low aspect ratio sail ; and that, too, would make a difference.

From these experiments, the writer feels that the back rig should have a very tall, but narrow, jib mounted on the balanced boom to act as a leading edge slat. This should produce greatest thrust to windward area for area. This would make a very interesting wind tunnel test, at least.

PINTAIL

by

W. Garnett, Hilton Hall, Hilton, Huntingdon

L.O.A.	12′ 7″	Mast	20′ 3″
Beam O.A.	8′ 2″	Sail Area	125′ sq.

Weight fully rigged : 262 lbs.

This is basically a pair of Hurricane (A.Y.R.S. No. 28 p. 45) hulls joined together with light alloy angle and tubular beams and a canvas deck. The wide beam is designed to give a lateral stability equal to the fore and aft stability. She is mastaft or, more correctly, stern-rigged, the mast being stepped on a beam across the transoms and supported from forward by a strut on each side. The two struts cross and extend abaft the mast to locate the spreader which carries the braces, and there are also two short stays between the ends of the struts and the ends of the stern crossbeam. The sail is of the now familiar balanced type, with slightly less than a quarter of the area forward of the pivot line.

The dagger boards are sloped inboard and used as alternate leeboards, and the sail is flown out to lee on each tack. The idea behind this is to obtain vertical lift from sail and board area in such a way as also to minimize the capsizing moments.

Special Features

(1) A half-wishbone spar of unusual design which is free to rotate through a half circle inside a pocket in the sail enlarged at the top for this purpose. This is simply a light alloy tube bent in a nice curve and reinforced with fibreglass ; the clew end carries a sheet

to which is attached a cord tied to an eyebolt projecting on the weather side (see diagram). It allows a limited camber to the sail, helps control twist, gives a smoother flow than a Fenger type wishbone and is stronger than an articulated sprit. On putting about a tug on the sheet turns the sail neatly inside out.

(2) A "tack-line," sheaved at the ends of the fore crossbeam, which controls the lateral position of the boom fastening on its horse. This enables the pivot of the sail to be cleated amidships or to weather, when running. When tacking the sail just blows across to lee, where it provides mild weather helm on a reach, but none at all if cleated amidships.

(3) A double Ackerman tiller linkage. This is a simple type which gives accurate alignment on sharp turns and slight turns, but is 6°

Pintail

Fig. 14. The bent batten

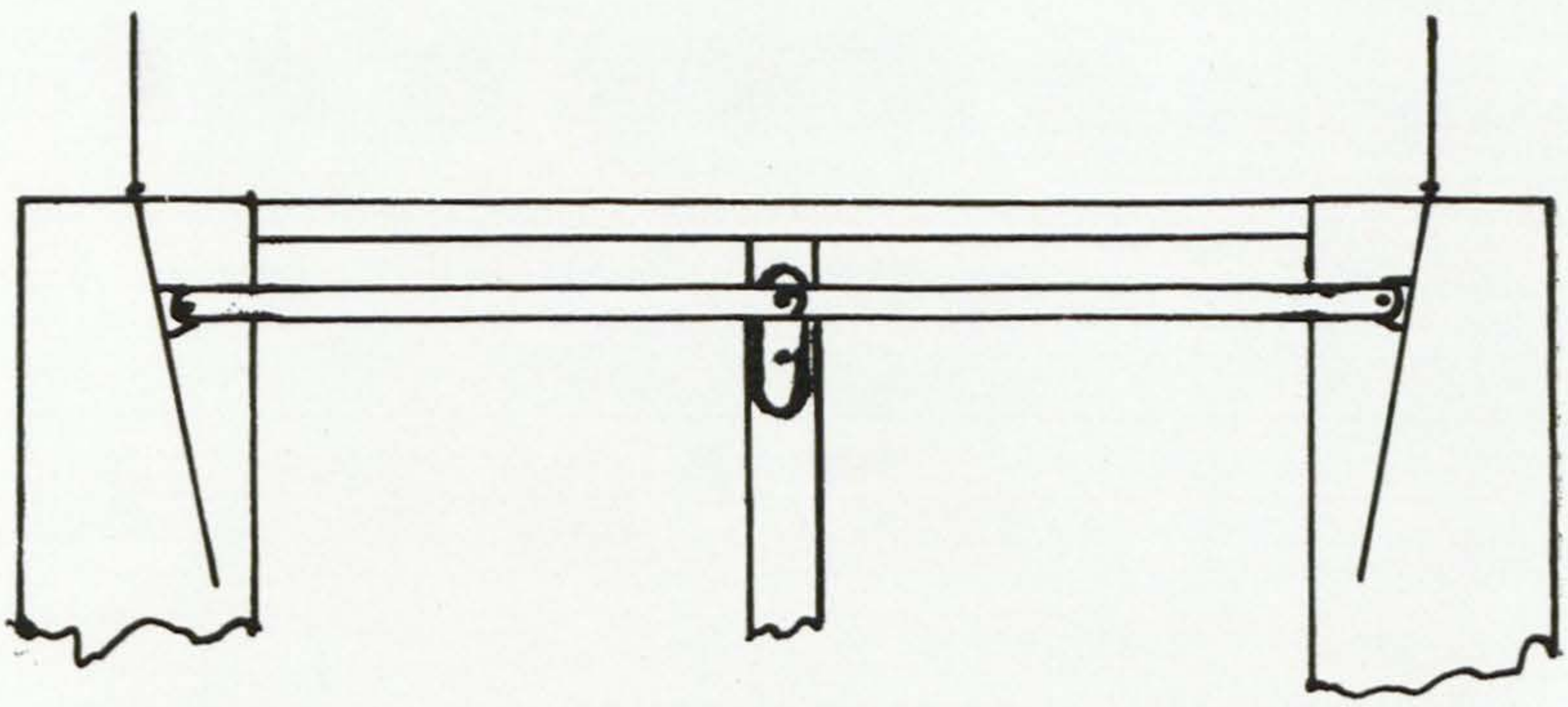


Fig. 15

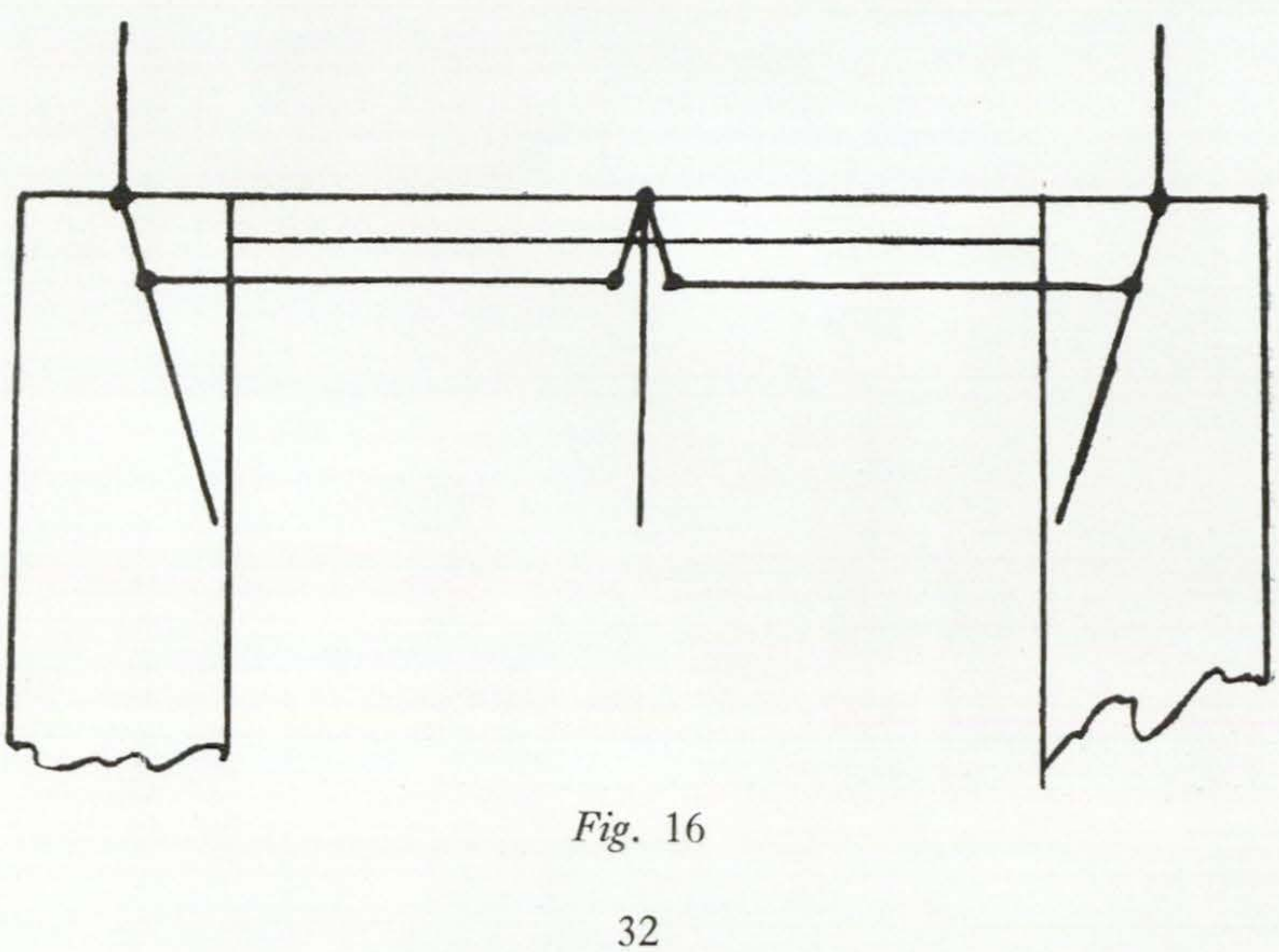


Fig. 16

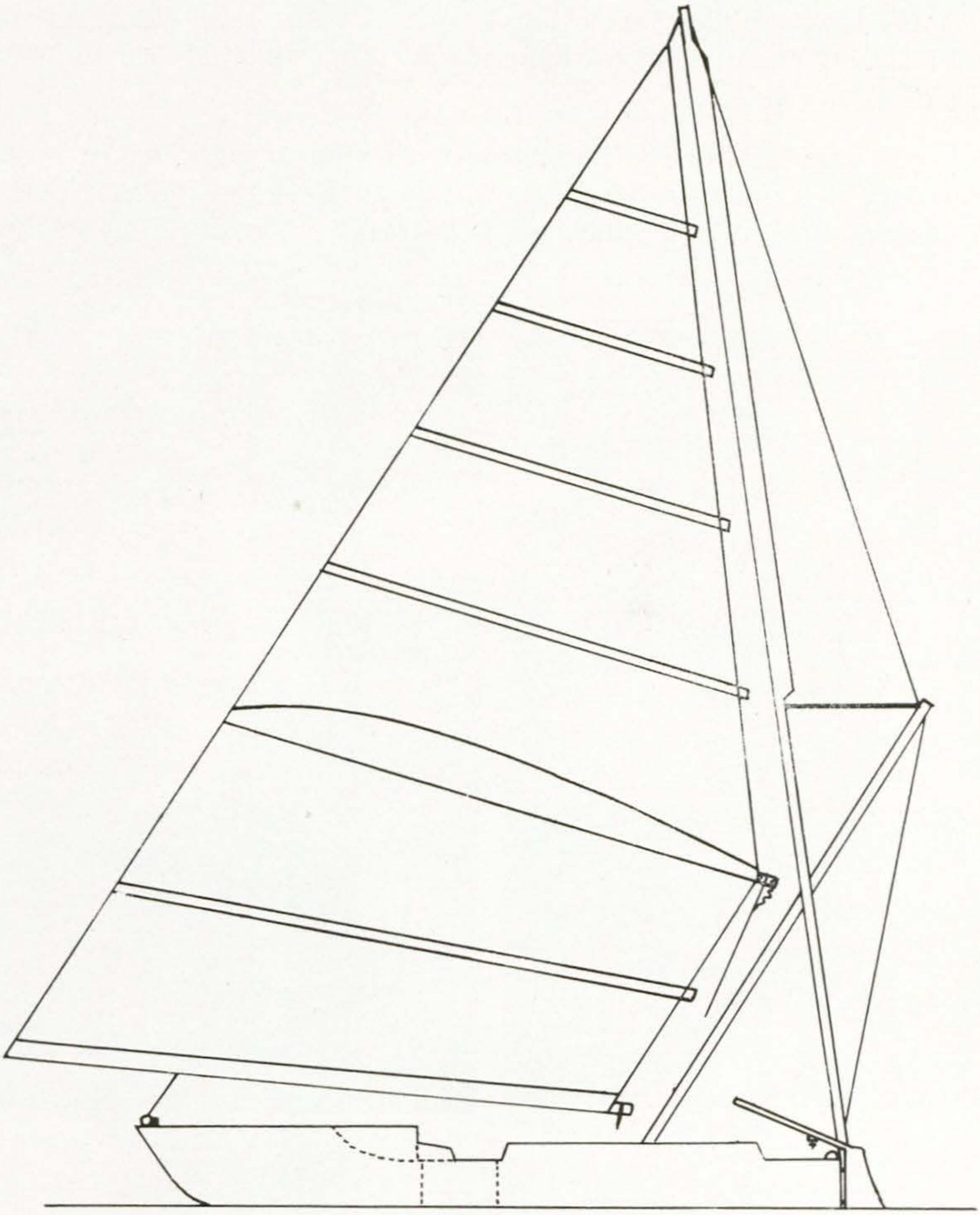
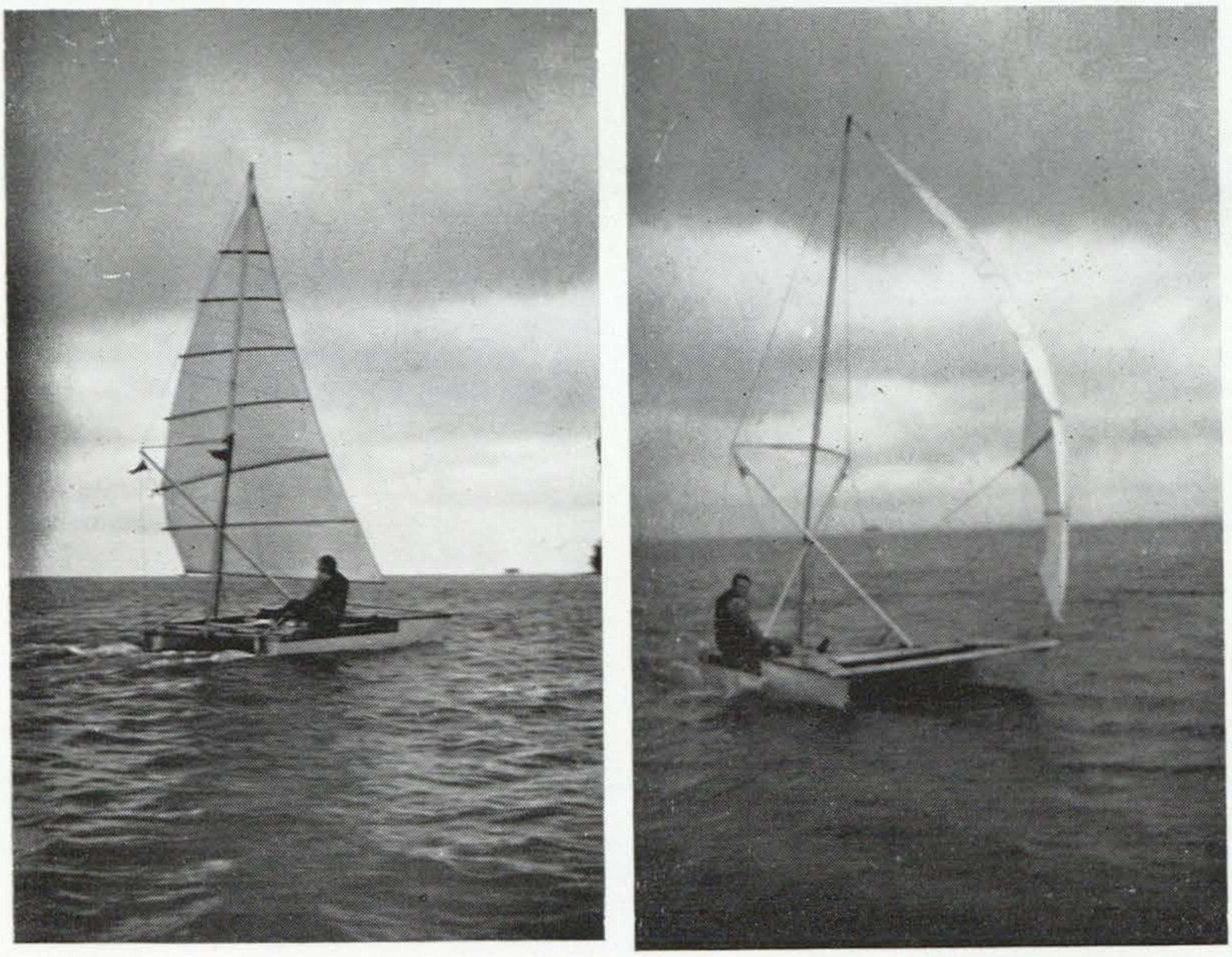


Fig. 17

out at about 30° turn of the inner rudder. I intend to convert to the type used by short-wheelbase vehicles which is consistently accurate up to about 60° turn of the inner rudder and which will provide a centre tiller acting in sympathy with the side tillers. Where deck space is at a premium I prefer a centre tiller to having the link(s) within easy reach ; but a centre tiller which acts in looking-glass fashion is just a nuisance. In the second diagram the track is 6′ 10″, the radii are 7″ and the angles 17°.

(4) Drop rudders each fitted with a ball-catch which resists normal drag but trips on encountering anything solid. Fixed rudders are death to pintles.

(5) A streamlined fairing fitted to the upper part of the mast on which it is free to revolve. This reduces the drag from bare poles and seems to improve windward performance.



Pintail

(6) A sail of unorthodox trapezium shape, which is virtually a triangle of 132′ sq. minus the least efficient part — the clew corner. It is interesting to note that other mastaft rigs, which may weigh less, would require a considerably taller mast to set the same effective area.

Performance

She is a boat of two very different moods. She lags behind all the single-hulled boats in light winds, and outstrips them all with ease in stronger winds. In this she appears both to pay the price of static weight and reap the advantages of her combination of stability and aerodynamic lift. In ideal conditions she performs well on all courses with no perceptible burying of the lee hull except in response to gusts, but when driven hard into head seas takes aboard huge slices of green water. When she accelerates on the reach there is no energy wasted in heeling — the wind is safely trapped between sea and sail — she just accelerates.

I have not tried her with a sloop rig, nor raced her against other cats, but evidence that the rig is a step in the direction of higher maximum speeds was provided by two incidents at Bembridge recently. On one occasion the leeward end of the fore crossbeam broke away so that the boom flew up held only by a wire from the windward end and the sail approximated to a kite rig : a searing burst of speed sent me weaving madly between the crowded moorings for a few moments before I could beach her safely. On another occasion the tack-line jammed with the boom runner to weather of centre in which position the wind was now getting on top of the sail : her progress was noticeably more laboured and although not slow, much less lively than it had been on the previous tack.

Handling

Her gear needs a little refinement here and there, but she will never be an easy boat to sail single handed. The chief drawback with this type of sail is the problem of hoisting and lowering, when it is apt to bang about and bend the mast unless the sheets are well held. The two sheets are docile enough except in strong winds ; the upper sheet takes the bigger strain and should be hauled down to eliminate twist.

Conclusion

First impressions are that the theory is sound, but that this rig does not go quite far enough in translating it into practice. The rig is definitely workable provided sufficient hands work it, but for best results a twelve foot cat has to be a one man boat. For this reason I think it would be very well worth while adapting a larger, two-man cat, which would also be less wave-prone, to this system. The flexibility of the rig could then be exploited to the full, with better manoeuvreability and seaworthiness and of course an even livelier performance.

SAND YACHTS

by

IAN DIBDIN, 217 St. Annes Road, Blackpool

Sand Yachting is a sport which I think will in the future become very popular. Sand Yachts are very fast, the official speed record for an average over a mile is over 45 m.p.h. The yachts vary in design, some with a single wheel at the front which steers and a wide axle at the rear. Others are just the opposite, with the single rear wheel steering. The main point against this design, with the rear wheel steering, is that with the mast being in front of the axle the forward thrust of the sail tends to make the rear wheel " light " and sometimes lifts it from the ground completely, especially if the yacht runs into soft sand. The good point of this design is that being rear wheel steered the yacht will turn very quickly.

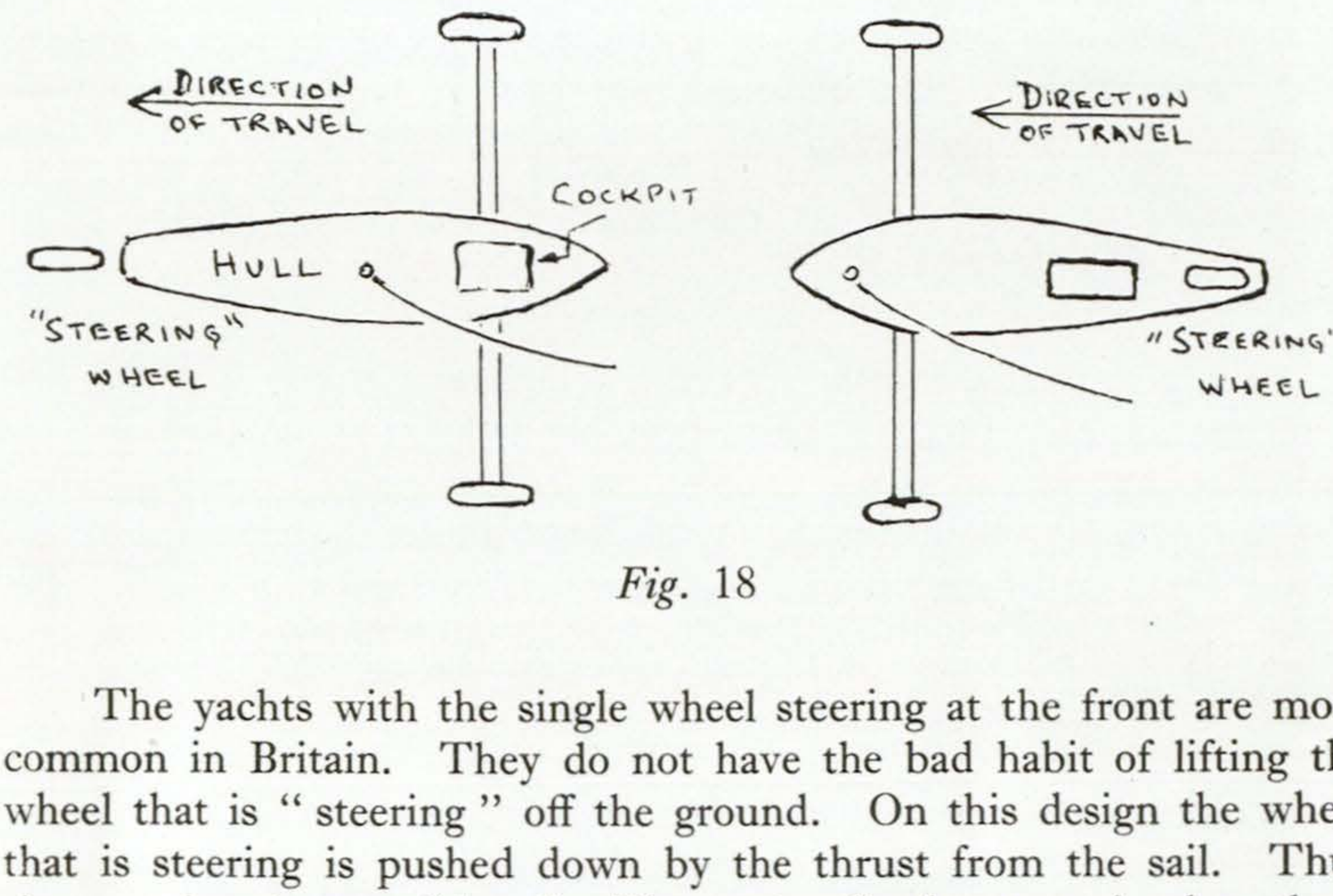


Fig. 18

The yachts with the single wheel steering at the front are more common in Britain. They do not have the bad habit of lifting the wheel that is " steering " off the ground. On this design the wheel that is steering is pushed down by the thrust from the sail. Thus the steering is not " lost." The main disadvantage is that these yachts do not turn as fast as the other design.

Faster than the Wind. As these yachts travel much faster than the wind, the yacht and sail must be very streamlined. The body being very similar to a glider fuselage, with an open cockpit. The axle, etc. being as streamlined as possible.

Until recently the sails used were of orthodox Bermudian design, but with a much flatter section to the sail, because of the speeds at which the yachts travel. The latest design of sail is very similar to the Delta wing of a plane. The masts used on this design of sail are of elongated section some 12″ in length and $2\frac{1}{2}$″ across, the luff groove being some 4″ inside them. This type of mast is very streamlined and eliminates most of the " mast eddies " caused by the orthordox mast. Also the mast acts as part of the sail, i.e. on a mast 12″ wide by 20′ high there would be 20 sq. ft. of " active mast." Thus the mast is not just " dead weight " as it is fully pivoting.

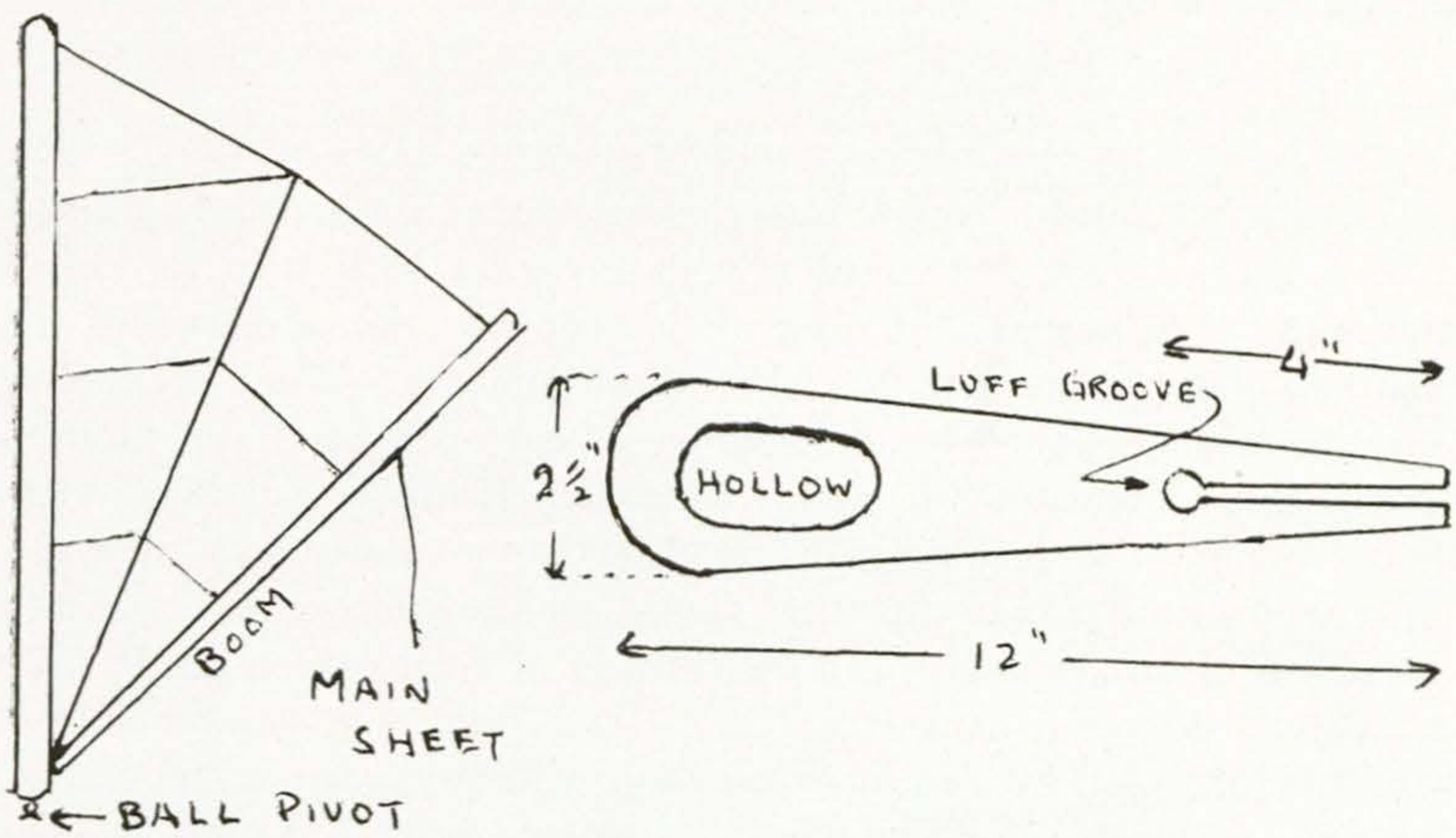


Fig. 19

I will now explain in more detail the " Delta Sail." This is of quite high aspect ratio, the boom being swept up at an angle, the " goose-neck " being only about 2″ from the base of the mast. The " Delta Sail " is interesting in one point in particular. The part of the sail that is swept up may seem to cut down the area of the sail for boom to mast ratio, but in fact cutting the sail away makes hardly any difference. This is because the eddies from the hull or body of the yacht would normally affect the performance of the lower part of the sail, especially in upwind sailing, so in the " Delta Sail " this part is simply cut off. These sails can be sheeted in so much that the sail becomes almost " flat " for upwind sailing. The trailing edge of this type of sail is also much shorter than the conventional Bermudian sail, so eliminating the twist.

The pressure on the sail is very evenly distributed, due to the " Centre of Pressure " being almost halfway up the mast.

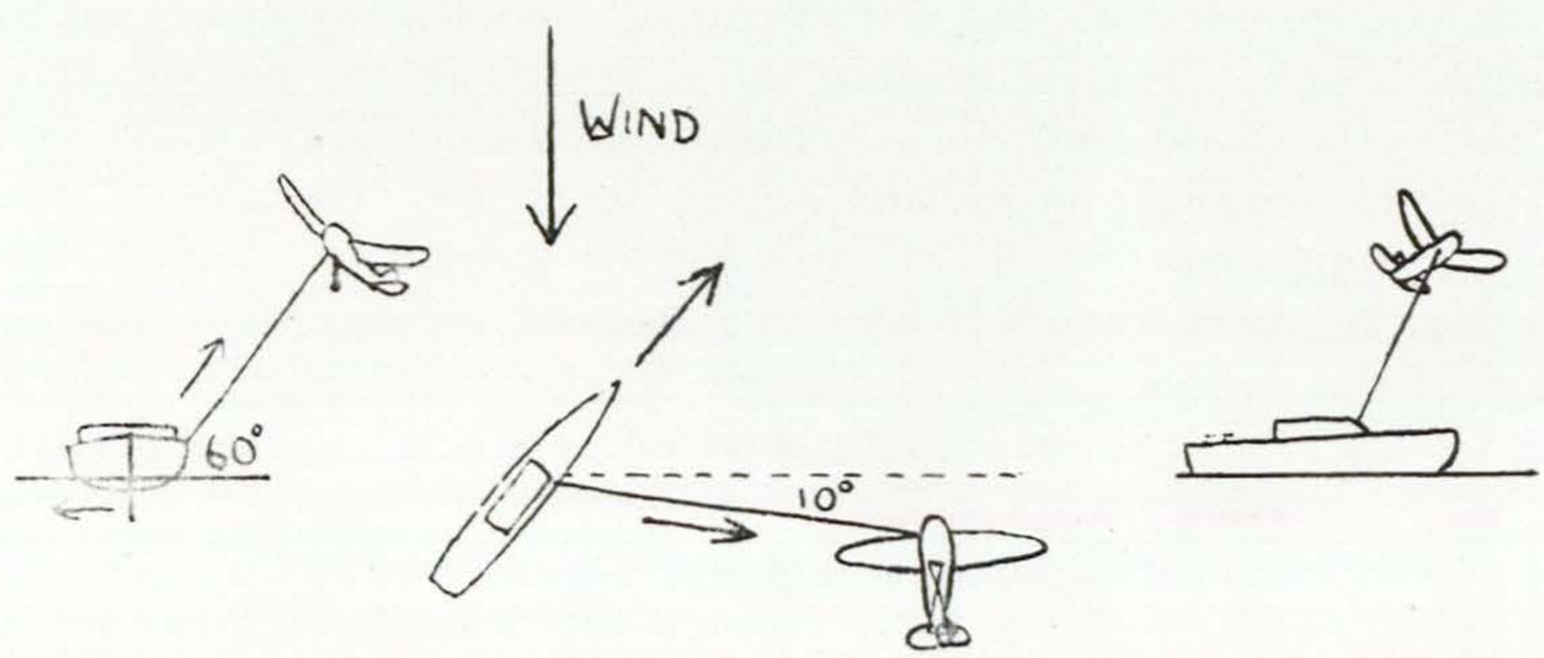
The " Delta Sail " is more efficient than the Bermudian sail on sand yachts, but I do not know how it would perform on a sailing yacht.

I seem to have run out of information now, but if your members wish to see some sand yachts in action, there is in existence a film made a few years ago at our Club of sand yachts in sail. This film was made by "Esso Petroleum," and I am sure you could hire it for showing to your members. The yachts on the film are not of the latest design, but they will give your members an idea of the speeds the yachts travel.

THE FREE FLYING KITE RIG

Cody, who did so many experiments with kites at the beginning of this century, once attached one of his kites to a boat in Dover Harbour. The course was more or less down wind and, before the boat had gone far, the kite had fallen into the water. The Polynesians were more successful with kites towing boats and used the method several times according to their traditions. However, all these kites flew "Stalled" and could only fly directly down wind so they can be of no use to us. On the other hand, if a kite were to be made into the shape of an aeroplane and be capable of flying at an angle *from* the wind's direction *under the stall*, it is certain that greater speeds would be obtained by a sailing boat than with any other arrangement.

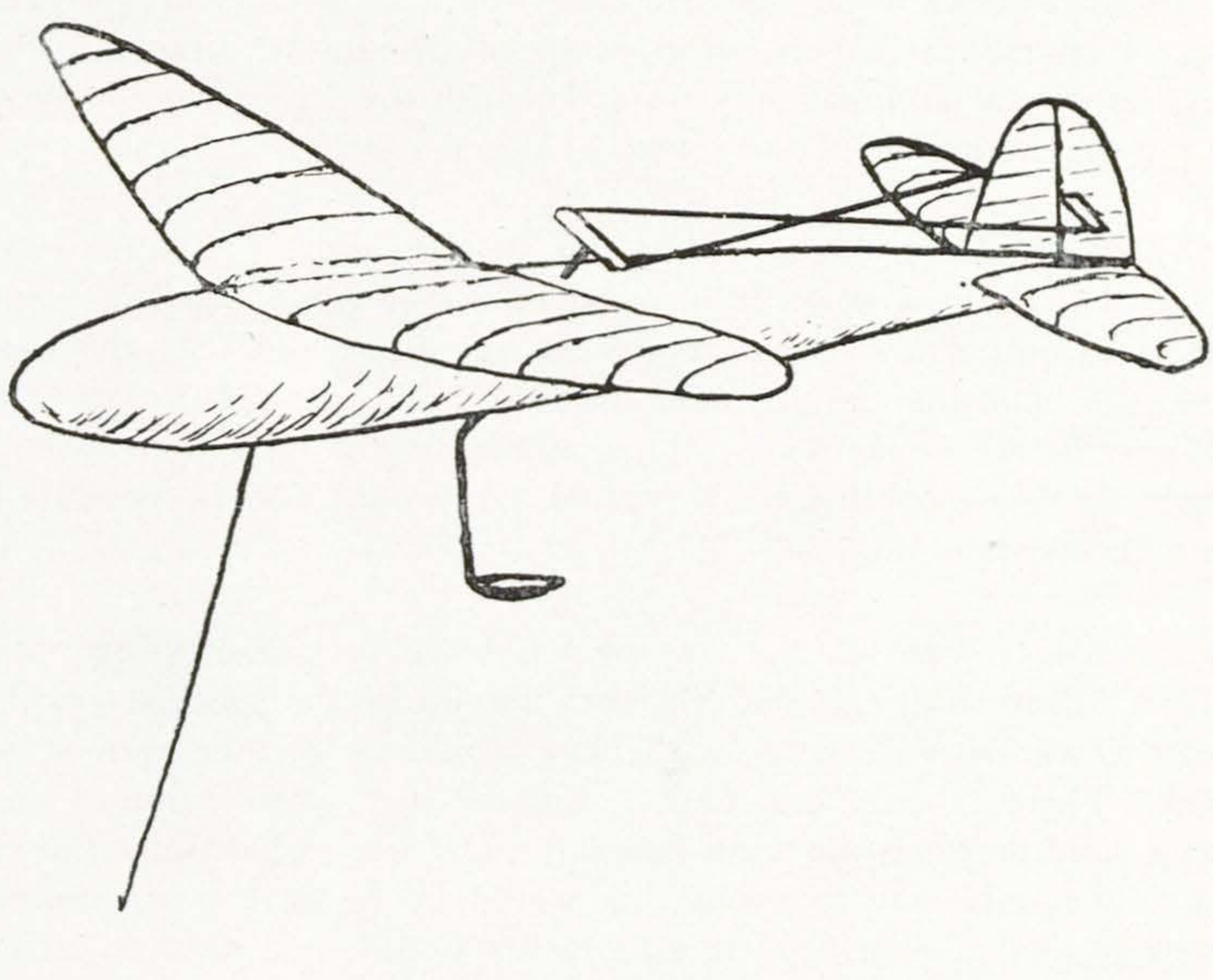
It is perfectly possible for a kite to tow a boat on a close hauled course and so get to windward. This seems to be a very difficult thing for many people to understand because, of course, the string of the kite cannot pull to windward. However, if the string were to pull at an angle of, say, 80° from directly down wind, the kite would be pulling in about the direction that a good sloop rig pulls a boat. It is because the force pulls forwards of the beam that the yacht goes to windward. The diagrams show the forces.



A model glider will not fly as a kite. It will rise well enough and it will climb till it is more or less straight overhead. Then it will side slip to the ground. The reason for this is that the tail must be large enough to bring the centre of lateral resistance aft of the string's axis to make the kite point into the wind. It can only fly in unstable equilibrium, therefore, because, if a side slip starts, it will be kept going by the tail.

My successful model is shown in the sketch. It was made from one of the construction kites for a glider but the nose weight was not, of course, used. The tail was modified to have a steering rudder acting on thread hinges and this rudder was fitted with a cross bar. A light alloy tube passed through the fuselage at an angle of 45° being held in bearings at the top and bottom. Below the fuselage, the alloy tube was bent so that its lower part was vertical and its lower end was weighted. At the upper end, there was a cross bar which was linked to the rudder bar with crossed strings.

In operation, if the starboard wing starts to drop and a side slip begins to the right, the weight also moves to the right and this gives port rudder and steers the kite back up to the top. The cross



bar on the alloy tube must be much shorter than the cross bar on the rudder, otherwise the movements are too jerky which may bring the kite down.

Unfortunately, my own experiments have only reached as far as the kite, which has been described. All that would be needed to produce a kite to pull a boat would be to put a mechanism in the control strings to the rudder so that it could be controlled from a yacht. The weight would then stabilise the kite at different angles from the wind.

Operation. The kite should be made to have a " Lift to drag " ratio of about 20 : 1. When going to windward, it would be controlled to take up an angle of about 60° from the vertical and this would put the string at an angle of about 80° from down wind. The yacht would then be able to make a course of 45° from the wind with great ease. Various " Relief " mechanisms would be needed to spill the wind in very strong gusts and also to control the speed of the boat below, though this would usually be done by varying the angle of the boat from the string.

If the kite were flying at a height of 200 feet, it would get stronger winds than at sea level. No stability would be needed in the yacht and, of course, no ballast, so great speeds should be attained. Self steering should automatically occur because the string would always be put on the leeside of the centre of lateral resistance.

Putting about. This should not be difficult. The kite would simply be trimmed to go from one tack to the other which it would do by executing a sweep through the sky *downwind*. At the same time, the helmsman would steer his boat from one tack to the other *through the eye of the wind*. This should be the only time when it would be necessary to steer the yacht. It would also be possible to wear the boat round.

Summary. In all, the kite rig has some very interesting possibilities. Both hull and sail efficiency should be the greatest possible and the windspeed acting on the kite would be greater than at sea level. There is only one fault. This is that when running dead down wind or when the wind falls light, the kite would drop into the sea. The only way to avoid this would be to have a streamlined fuselage filled with hydrogen, and yachts would then need to have a

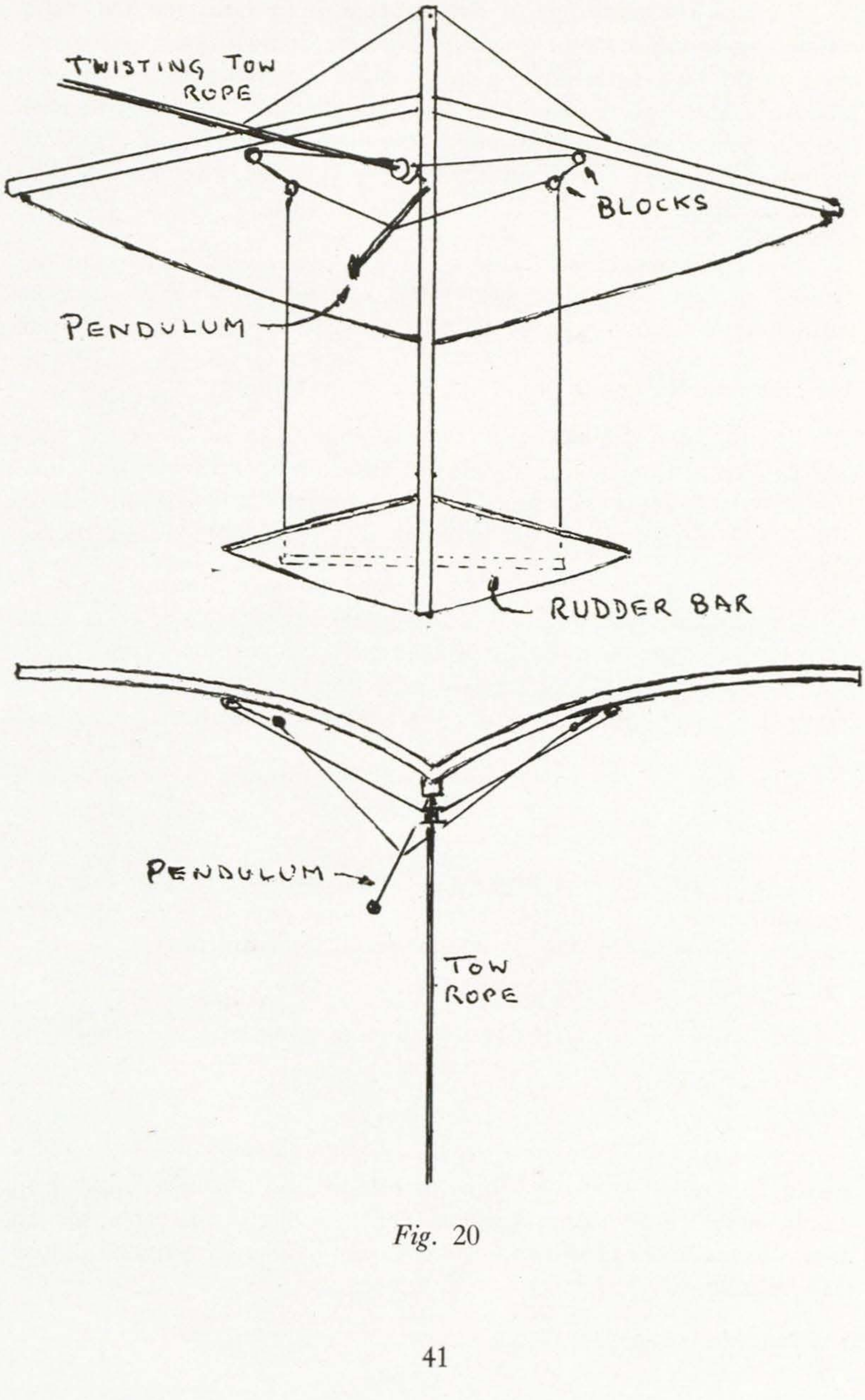

TWISTING TOW ROPE
BLOCKS
PENDULUM
RUDDER BAR
PENDULUM
TOW ROPE

Fig. 20

cylinder of that gas as part of their equipment to " top up " the fuselage when the gas leaks out.

Perhaps the moorings of the future will be occupied by yachts rather like to-day's motor boats with a kite flying from each. Such kites would have little more windage than the masts and rigging of modern yachts but, if they broke loose, they could cause trouble with the aviation authorities. It might be better if the yacht yards of the future had " Hangars " in which the yachtsman, after his weekend cruise to Spain and back could put his kite.

Since this article was written, Major General H. J. Parham has devised his bent wing glider which has a better lift to drag ratio than the orthodox Bermudian rig and control methods have been devised.

The principles of design of a flying kite are as follows :

The Leading Edge Spar. This should be swept back on each side so that a line joining points on all chords of the wings which are at 40% from the leading edge run straight across from side to side. This places the wings aerodynamically at right angles to the airflow.

Dihedral should be given of about 15° on each side for control. Each leading edge spar should be bent with the concavity downwards as in General Parham's glider (see page 35 A.Y.R.S. No. 26). This places the maximum dihedral near the wing roots which may be useful.

The Wings. The aspect ratio, using the formula $\frac{\text{Span}^2}{\text{Area}}$ should be 6 : 1.

The Fuselage. This may be a single stick bent at its fore part to conform with the shape of the sail. The tail may be raised up above the level of the mainplane, or it may be on the same line.

The Tailplane and Rudder. These are orthodox glider type, though the tailplane can be similar to the mainplane. It should be set at a few degrees of longitudinal dihedral. The rudder has a cross bar for steering.

Stability. As compared to the complex system of the previous article, it is now felt that a simple pendulum may be used, hung from the fusilage. Side strings, passing through blocks on each side go to the rudder bar, as shown. Instead of blocks, right angled cranks may be used.

Control Strings. Two control strings may be used, passing through blocks about half way along the spans on each side and then attached to the stability blocks. They will alter the angle at which the kite will fly. These two strings may be replaced by one string, attached to a swivel block, as shown in the drawing.

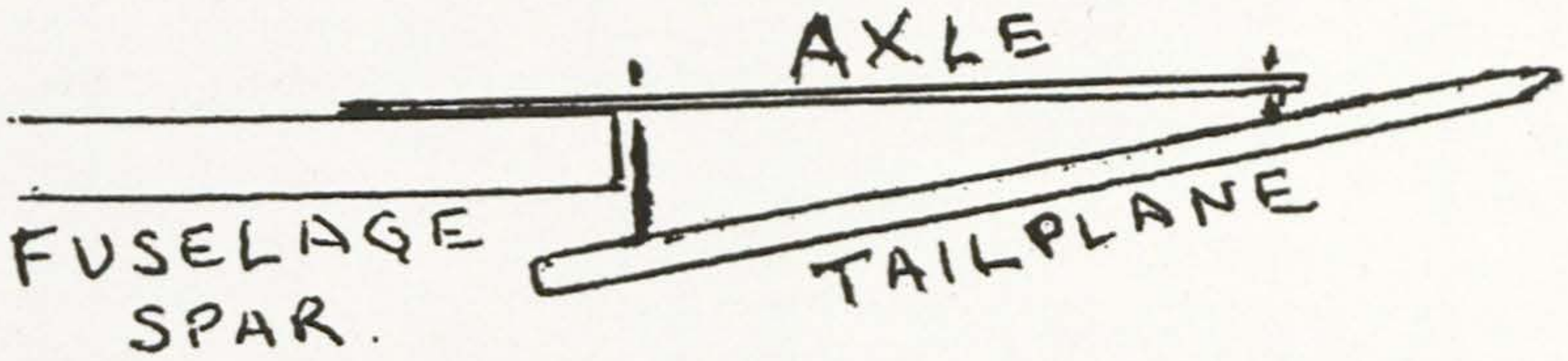


Fig. 21

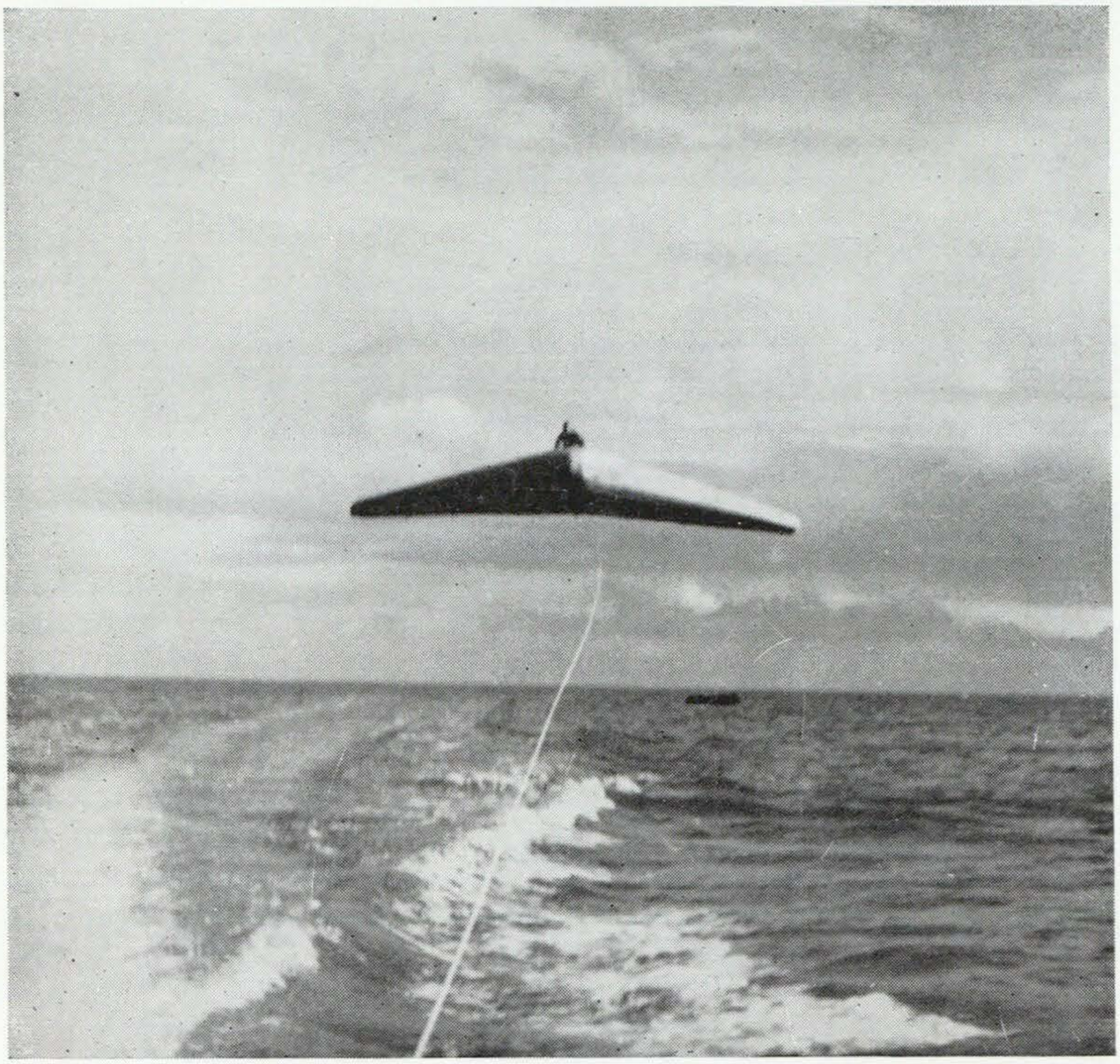
The Side Slipping Kite. By using only the tail mechanism as shown and two strings, I once found that a kite could be made to fly at 45° from dead down wind. Stability was poor, however.

The £10 Prize. The rules of the competition are simple. The prize will be awarded to the first person who sends me a kite which will fly stably in an " Unstalled " condition about 70° on each side of dead down wind. Such a kite would enable a boat to sail at four points from the wind. Any type or variety of kite is eligible of any size. The Hon. Editor's decision must be final in awarding the prize but successful models may be on our stand at the next Boat Show.

In order to give overseas members an equal chance to those who will get their publication earlier, the word " First " in the above paragraph will be modified to take into account the interval between the receipt of this publication and the dispatch of the model. A dated " Certificate of Posting " will therefore be needed for the model with the date of the receipt of this publication affirmed.

AN INFLATABLE KITE

The photograph shows O. W. Neumark being towed behind a motor boat on an inflatable wing of some 200 square feet, weighing about 40 lbs. This is the start of a series of tests which Mr. Neumark hopes will produce an inflatable kite for towing boats. In his opinion, piloted tests should be carried out before the glider can be converted into a kite. A different approach is made in the previous article. We all wish him every success.



O. W. Neumark being towed on an inflatable wing

SEMI-ELIPTIC AND SAIL ADVANCE

by

ERICK J. MANNERS

The A.Y.R.S. Editor tells me that some observers have informed him that I am experimenting with a single semi-eliptical sail and he has asked me to describe this. Since the formation of this research society the Editor has been advocating ways and means of advancing sail design. Similarly for the past eight years in my maritime technology lectures I have been criticising certain features of the very fashionable Bermudian rig. Unfortunately both these separate efforts, combined with a nucleus of other serious and often ingenious experimenters, has seemingly so far made little impression. This does not mean that as a consequence the tide could not quickly change direction with conspicuous advancement arising.

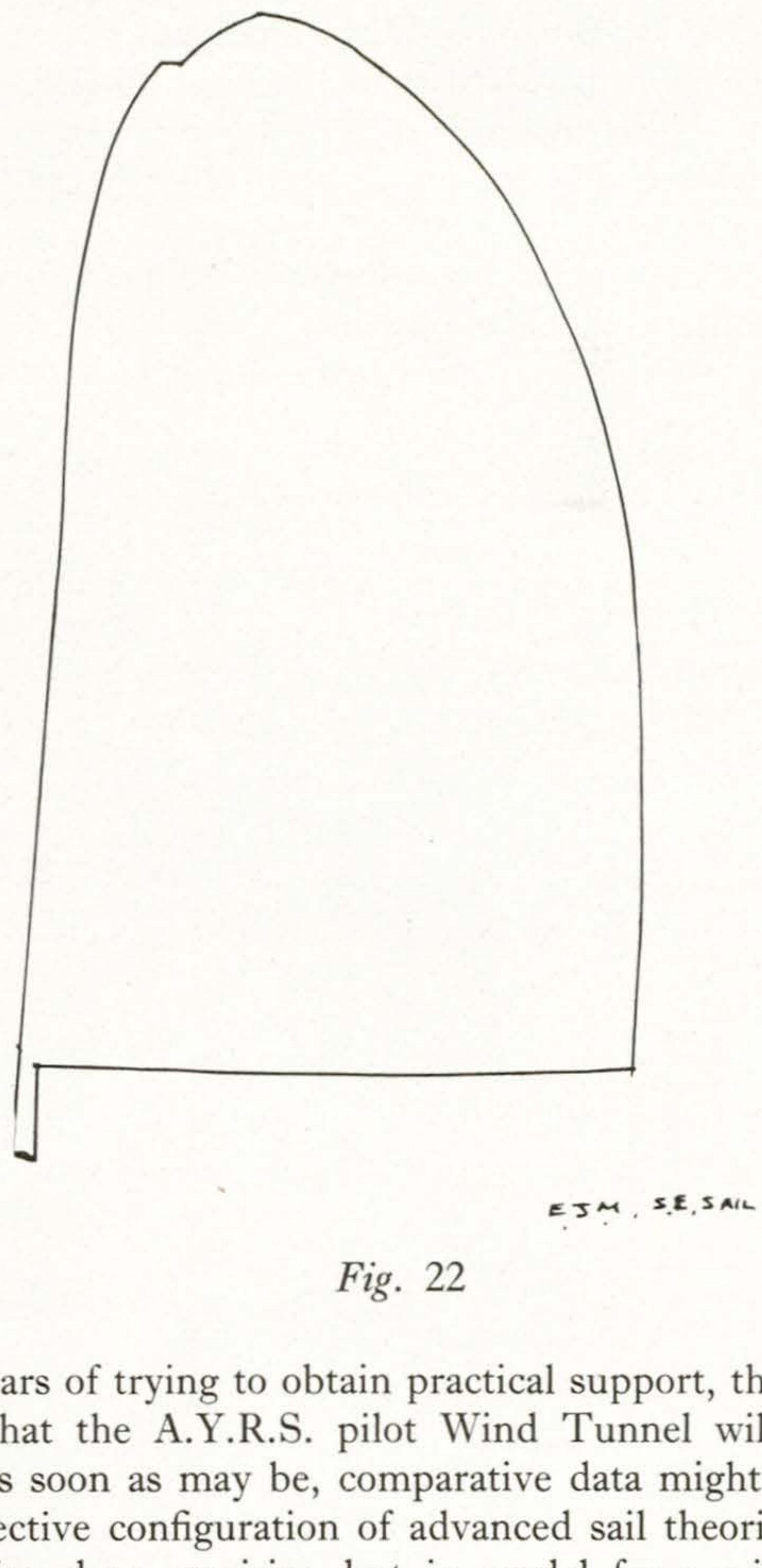


Fig. 22

After years of trying to obtain practical support, the most current promise is that the A.Y.R.S. pilot Wind Tunnel will shortly be a reality and as soon as may be, comparative data might start to reveal the most effective configuration of advanced sail theories. The scale effect calls for close precision but in model form sail trials can be achieved far more economically than the heavy expense attendent in full scale rigs.

As I emphasized in previous articles I feel certain our newest hydrodynamic multi-hull configuration are now in advance of the present best sail arrangements. These antiquated rigs were intended for the orthodox and slower monohull boats. Sails improved aerodynamically are now necessary. Care however, must be taken to avoid the gap between theory and practice. Paper theory often falls short of reality due to the fact that it is so difficult to provide for complex variations. The complexities of normally invisible air eddies, ruptured flow, pressure differentials and lift components in soft sails may be more involved than the fluid flow of water around hulls and foils. It is hoped that the A.Y.R.S. slow speed Wind Tunnel will facilitate observation of both air flow patterns as well as resultant aerodynamical effects.

Until the above experiments bring their weight to bear I certainly cannot add anything conclusive but shall be glad to pass on a number of practical pointers that may assist experimenters to improve on the rig illustrated.

ARTHUR PIVER'S "FORCED DRAFT SAIL"

The photograph and drawing show the mechanism of this sail. There are two full length battens with lines on each side attached

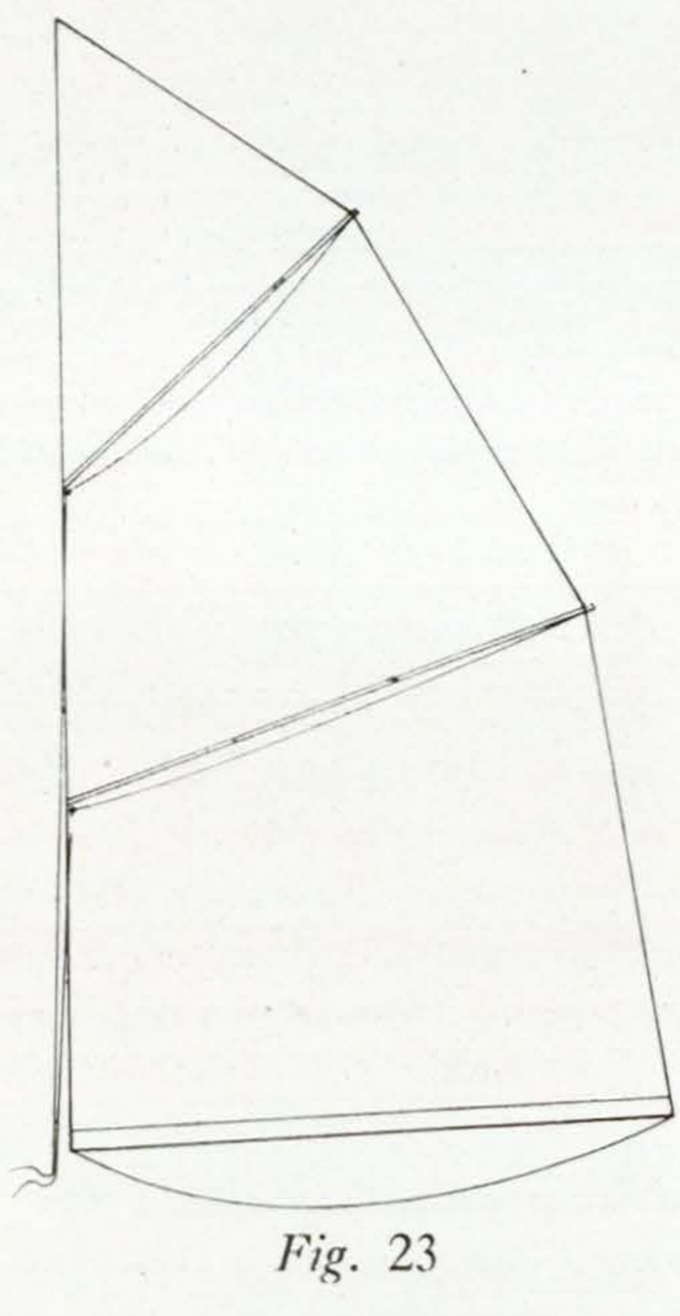
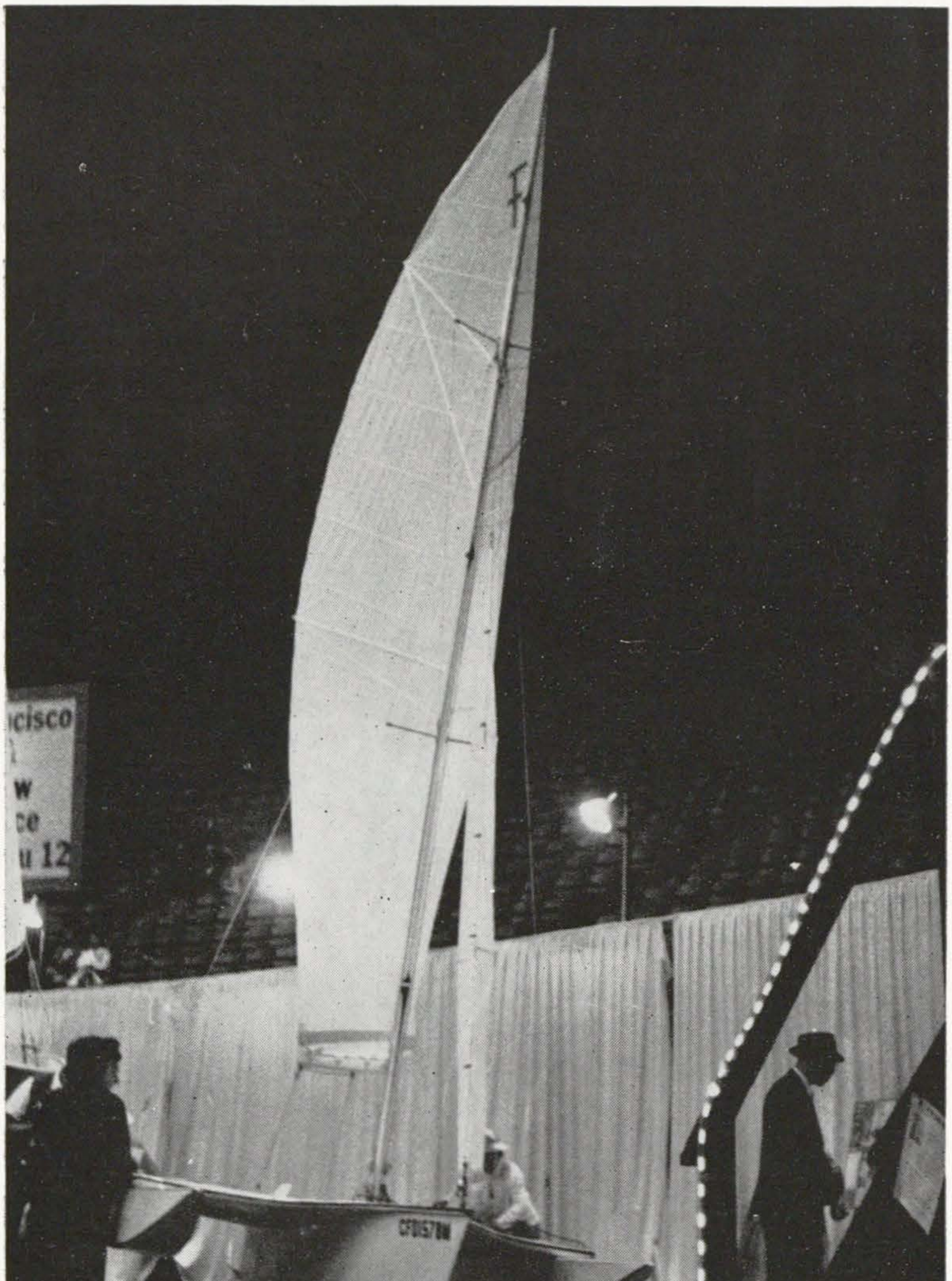


Fig. 23



" Forced draft sail " on Nugget

to the after end. Forward, the lines pass through blocks and then down to the deck. If one wants to throw full draft into the sail the weather line is tensioned and, as can be seen in the photograph of the designer's 16 foot FROLIC trimaran, far more draft can be put into the sail than can be used.

The correct set of lines is automatically activated by the boom swinging over when the yacht tacks.

This sail is made under licence by Simpson and Fisher, of San Francisco. We have no account of the usefulness of this sail in practice but one can say that it should be of value.

LETTERS

Dear Sir,

The Facts of Planing. Would someone who knows the facts of planing please tell me :—

(1) Why does a dinghy designer regard a significant bow wave as a sign of grace ; while the racing shell designer is disgusted by anything more than an insignificant trickle ?

(2) If planing gives added speed why does a cat, avoiding planing, beat the dinghy ?

(3) How can our well-beloved hydro-dynamic lift add to the speed when it is got by bleeding off enough energy from foreward drive to give vertical lift against the dead weight of the dinghy plus the live weight of the crew ? Are we supposed to believe that this heavy cost is repaid, with interest, by a slight reduction in wetted area ?

(4) Why does the resistance curve rise sharply when planing starts and continue to get steeper ?

The Heaven of planing is beyond the reach of sail boats. Their motto is " Per ardua ad ardua major."

If our experts leave this unanswered then let our readers regard so called planing for what it is, namely, dragging a boat up an inclined plane out of the water's grip so that it can bounce skitishly along the surface. And let the designers of racing dinghies aim to delay dynamic lift for as long as possible.

JULIAN ALLEN, A.M.I.C.E.
3 Kenystyle, Penally, Tenby, Pembs.

Dear Sir,

I feel that I should correct your statement concerning my flexible heel feeler system as it appears in your No. 36. The whole idea of the feeler has of course evolved since it was first tried out in crude form on my Mombasa Walrus hull.

In the beginning a feeler is as you say a wave follower, wave predictor and constant depth device. However in the course of development one comes to realize two important points, namely that incidence control provides very powerful lateral stability so that the line of flight can be increased in height with safety and secondly, as speeds go up it becomes more and more important to reduce the amplitude of the feeler signals. Since one cannot have a feeler that loses contact with the water completely the flexing heel is the next step and it tends to become longer and longer as experience is gained while the arm itself is powerfully restrained by shock absorbers. In other words we are tending towards the total elimination of wave effects of a higher and higher dimension (relative to hull length) and the ability to subtract this dimension as a constant from all wave heights beyond the size that can be totally ignored.

The necessity to smooth out waves becomes clear if you work out some actual maximum boat amplitudes assuming a chosen value of vertical "g," say 0.5 for example :

Boat response z is :

$$z = \frac{g}{2\,\omega^2}$$

where ω is in radians/sec and

$$\omega - 2\,h\left[\frac{V - (2.26)\sqrt{\lambda}}{\lambda}\right]$$

This is of course for the head sea. For the following sea the sign after V becomes negative.

Yours very truly,

CHRISTOPHER HOOK, Huso Verft, Tonsberg, Norway.

P.S.—It should be noted that a feeler arm that is powerfully restrained doubles as a crash preventer since the forward plane can take a direct load as well as producing the required instantaneous incidence change. An electronic feeler cannot do this.

Dear Sir,

The main function of your admirable A.Y.R.S. Journal being to make people *think*, I therefore throw this highly flavoured " bone " into the Arena and I bet one or two chaps will suddenly realise their hot bath has gone cold without them noticing it.

Here you are :—

Could one sail really fast (speed record sailing on selected waters) by employing two principles not normally associated with boats, namely the Caterpillar track, and an idea, due I think to General Martel, which was tried with some success for the speedy bridging of water obstacles in War. This involved spreading a floating mat, with transverse battens, across the river and driving vehicles across it fast enough so that the water beneath the mat could not escape sideways in time and was forced to sustain the vehicle.

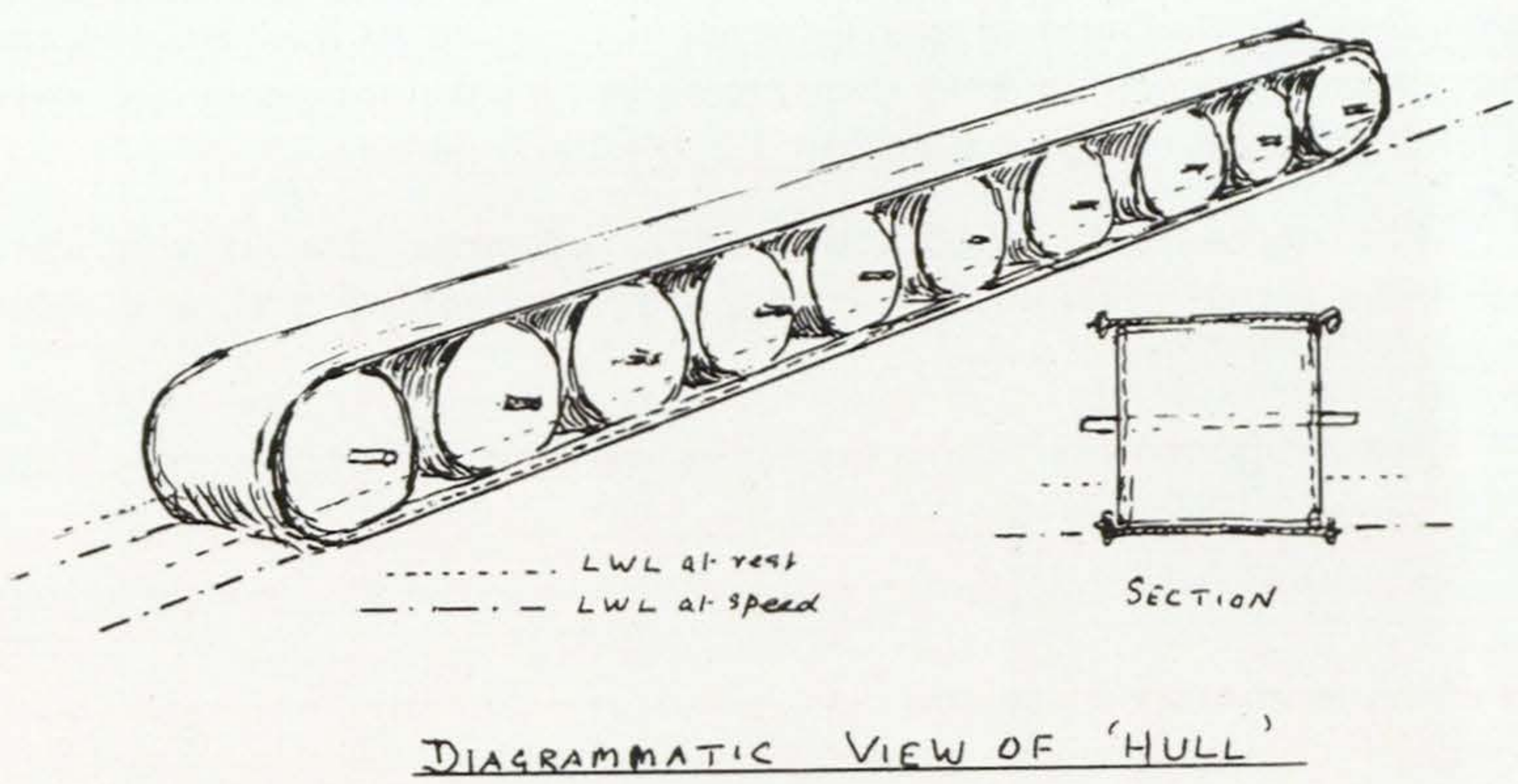


Fig. 24

Suppose one made a " hull " say 20ft long by 2′ beam, which was just a broad endless belt, lightly stiffened transversely by moulded-in battens, running on pneumatic rollers about 2ft in diameter and 2′ wide. Suppose this " hull " to be stabilised on the trimaran or Micronesian canoe principle (preferably assisted by hydrofoils).

What would happen ? It would obviously have a " hump " resistance, just before dynamic support came from the " track," but once over this might it not run lightly over the water like those entertaining small pond insects which scoot across the water's surface ?

The belt or track might need to have a shallow ridge moulded near each edge to hinder the lateral escape of water, but this wouldn't be difficult (it would probably have to have two such mouldings internally to keep it on its rollers).

The idea is very odd . . . . I doubt if it is new since no idea ever seems to be new . . . . but I have not met it before.

What about it ?

JACK PARHAM,
Hintlesham, Ipswich.

Dear Sir,

Members may be interested in my experiments with soft bottoms (porpoise skin, etc.)

I have an 11′ dinghy (Gunter rig with about 90 sq. ft. of sail). After two or three times out I covered the bottom with $\frac{1}{8}''$ thick foam rubber, and obtained a moderate finish by a skin of paint. The most noticeable effect was the disappearance of lapping noises under way, i.e., chuckling bow wave. In high winds the boat planed reaching and running (inland lake sailing) and once or twice seemed to be on the point of planing on a beat. A National 12′, on the same day, made much more bow and quarter wave without going any faster. However the National had a poorly setting reefed main. We were not reefed. My boat, incidentally, is very like a Heron, but with less beam and a sharper Vee on the bottom.

As would be expected, the foam rubber soon became a bit battered with landings on shingle, etc. It now tends to slow the boat. I may try a skin of polythene before closing the experiment. One promising material is a PVC car trim with foam backing. This is, I believe, obtainable from Storey Bros. of Lancaster, Bernard Wardle of Caernarvon, or Mellonide of Rochdale. I have no idea of the price.

On another matter, PVC sheet and box section seems to be an ideal material for boatbuilding. It can be glued, bent with heat (say steam) and is flexible but a bit stronger than marine ply. Cost is £8 2. 6. per 8′ x 4′ x $\frac{1}{8}''$. 1″ x 1″ x $\frac{1}{8}''$ box section is 2/- per foot (quoted Extrudex Ltd.) Built in buoyancy would be given by blocks of expanded PVC foam. So far as I know British Geon Ltd., (who supplied information on the various manufacturers) are the only people who have tried this material, and built a punt, demonstrated in advertisements.

G. F. M. SINGLETON,
108 Totley Brook Road, Totley, Sheffield.

Printed by F. J. Parsons (Kent Newspapers) Ltd., The Bayle, Folkestone.