CATAMARAN DEVELOPMENTS

A.Y.R.S. PUBLICATION No. 18

Uffa Fox's BELL CAT

CONTENTS

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THE AMATEUR YACHT RESEARCH SOCIETY

(*Founded June*, 1955)

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Tom Herbert,
25, Oakwood Gardens,
Seven Kings,
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American :

Yvonne Bloemhard,
143, Glen Street,
Glen Cove,
New York.

New Zealand :

Charles Satterthwaite,
Box 2491,
Christchurch,
New Zealand

South Africa :

Brian Lello,
S.A. Yachting,
58 Burg Street,
Cape Town.

Editor and Publisher :

John Morwood,
Woodacres,
Hythe,
Kent.

Amateur Yacht Research Society
BCM AYRS
London
WC1N 3XX UK
www.ayrs.org office@ayrs .org
Contact details 2012

EDITORIAL

April, 1958.

It has been my intention for the past year since *Amateur Research* was produced to keep the April publication as a technical number. Naturally, it was hoped to give the results of members' researches but no one to my knowledge has so much as put a spring balance in a mooring line and taken the water speed. Nor has anyone tried to find out the ratio of thrust to side force of their sails or of the head to lateral resistance of their hulls. Nor has anyone towed a catamaran with a spring balance in the tow. My own efforts to do some sail work were frustrated by the tremendous amount of work which has increased our membership from about 200 to almost 500. In fact, the year would have been almost blank except for the kindness of Professor Nutku who has given us the results of some catamaran tank tests. For this publication, therefore we have the very interesting evaluations and semi-technical articles of Lord Brabazon's experiments and Commander Gandy's catamaran evaluations.

On the practical side, we are lucky enough to have an account of Uffa Fox's *Bell Cat* for home building. This is a comfortable, dry and easy-to-build catamaran with deep V sections. It is an elegant example of its type with the hulls reminiscent of the old " plank on edge " cutters which were very fast for their length and also the " Patines a Vela," the rudderless catamarans of Barcelona, in Spain, of which there are over 200. There is no centreboard. Irrespective of its speed relative to a *Shearwater*, by which all British catamarans must be judged, it is a craft which is well worth having. We wish it every success.

Undoubtedly, most of the A.Y.R.S. members look to the Society to develop and produce the kind of craft which they, individually, want. This means that we have to have a constant flow of new designs using the principles and devices which we are discovering. Owing to the kind offer of Professor Nutku, we can have these designs tested for us. But, owing to the difficulty in getting the four main types of catamaran hull designs for testing from our yacht designing members, I have had to draw those designs myself which were lacking, though it is not my intention to enter the yacht designing business. However, we will soon have the tank test of 1, *Shearwater*, 2. a catamaran with deep V sections, 3, a " planing " cat *Gemini* and 4, a cat with right angled V sections, *Tuahine*. The tests of these craft will let us know how to design the best catamarans. In this publication, we have only the results of the deep V and the right angled V catamarans. However, Commander Gandy has made an evaluation of several different types, including three of the four main types, which will act as a guide for the present.

Uffa Fox has consented to become a Vice-President of the A.Y.R.S. Uffa's place in the yachting scene can be summed up by saying that he wrote five wonderful books on yachting (we all wish he would write more) and that he did more than anyone else to convert yachting from a rich man's sport to an ordinary man's necessary recreation.

Walter Bloemhard and his wife Yvonne have temporarily taken over the A.Y.R.S.-A.S. from Bob Harris in order to try and get some academic research under way. Both Bob Harris and I have had great difficulty in starting anything of this kind, largely because of the time consumed in the day-to-day writing of letters to members and the publishing side. Walter feels that he can organise some worth while research and we wish him every success.

In the meantime, Bob Harris will be as active in the A.Y.R.S. as ever ; but not as the A.Y.R.S.-A.S. secretary. He has a couple of interesting publications which he is going to write for us, one on *Hydrofoil Craft* and the other on the amateur building of catamarans and trimarans. *American Catamarans*, which he wrote, was one of our most popular and interesting publications.

Mr. Marshall, The Old House, North Hayling, Hants has a test tank which he wants to dispose of. It is 33 feet long, 2 foot 6 inches wide and 10 inches deep and suitable for testing 18 inch models. This tank has glass sides for observations of the waves. 6 dynamometers have been used for all forces and moments.

R. Millett Denning, 108, Haverstock Hill, Hampstead, London, N.W.3, wants a crew for his sand yacht *Coronation Year* Mk. II for September next. He sails at Southport, near Liverpool.

Thurstan James has sailed small wheeled yachts on the runways of aerodromes with a *Firefly* rig at speeds of 50 m.p.h. He states that, starting off with the wind over the quarters, as the speed increases, the apparent wind draws farther and farther ahead till one becomes tight on the wind. The sails are then set in the close hauled position. This is the " Apparent Wind Barrier " mentioned by Walter Bloemhard in No. 16, where the speed is limited simply by its effect in drawing the apparent wind forward.

Several members have suggested the use of small wheeled yachts as a method of testing the efficiency of sails. Undoubtedly, it is a good idea, but, from Thurstan James' experience, only the close hauled efficiency would be tested.

Arthur Piver has now designed a 12 foot trimaran for home building. This is a modification of his 12 foot Junior Trimaran which was on the cover of No. 16, *Trimarans and Outriggers*, with fuller sections to give the extra displacement.

Arthur is hoping soon to start the development of a 33 foot " Lifter " hydrofoil trimaran made from Polystyrene foam covered inside and out with fibreglass. With such a craft, he estimates that he could beat the steamer from San Francisco to Honolulu. If anyone can develop such a craft, it is Arthur Piver. An idea of what such a craft would be like can be seen in the *Parang* design, described in this publication. A *Parang*, doubled in size and with longer hydrofoils might do just what is wanted.

AMATEUR YACHT RESEARCH SOCIETY

Annual General Meeting 1957/58. Held at the Cedars Hotel, West Kensington.

MINUTES

Chairman : Dr. Davies.

The meeting opened at 11.45 a.m. with a message from the President, Lord Brabazon, and the good wishes of overseas secretaries. 17 members were present.

The President's message read :

Although much research has been done on wind at high speed relative to aerofoils, very little has been done on the low speed end and still less on the reaction of wind on a non-rigid sail. There is much fundamental research waiting to be done by somebody on such things as the cuts of sails with the eventual shape taken up therefrom and on the maximum benefit to be derived from the influence of jib on lee side of mainsail. The position and sheeting of the jib is of paramount importance and has been studied very little theoretically. The apparatus should not be expensive as wind speeds for a quarter model want very little power, but to be successful, one must have a team of high class technicians with imagination and technical ability and this, of course, is an expensive amusement from which no great fortunes could be expected !

Item 1. *Minutes of the last A.G.M.* These were read and a motion accepting the minutes was proposed by Mr. Bangert and seconded by Mr. Bowman.

Item 2. *Matters Arising.* None.

Item 3. *Election of Officers.* The two vacancies for Committee Members have been filled by Mr. Lawrence, proposed by Dr. Morwood and seconded by Mr. Manners, and Mr. Reid, proposed by Mr. Dumpleton and seconded by Mr. Lawrence. One Vice-Presidency has yet to be filled and the names of three men prominent in their own field of yachting were suggested by the meeting. The Committee undertook to take the necessary action.

Item 4. *Financial Report for the Year* 1956/57. The Research Fund stands at the moment at £7 6s. 0d. On the Editorial side, the income from subscriptions has covered publishing costs and enabled us to have a stand at the Boat Show once more. The present financial arrangement is that subscriptions are made over to the publishers for which six periodicals a year are printed and distributed. The Society is thus freed from liability to meet the cost of unsold copies, and the other commitments involved in producing our booklets. Our publisher and Hon. Editor, John Morwood, has freed the Society from a great deal of financial worry in order that the Society can develop quickly and healthily. A vote of thanks proposed by the Chairman, and seconded by Erick Manners was carried unanimously. The value of his work is best shown by the fact that in addition to the cost of publishing, he has been able to obtain a stand at the Boat Show once more while maintaining our subscriptions at a modest fifteen shillings per annum.

Acceptance of the Financial Report was proposed by Mrs. Evans and seconded by Mr. Lawrence.

Item 5. *Committees Report.* During the year the A.Y.R.S. museum has been established at 123, Cheriton Road, Folkestone. Preliminary sail tests were organised by John Morwood but had to be abandoned due to lack of time. As reported in Booklet 16 *Jehu* has been sailed with Sandy Watson's outrigger, but has not been sailed enough to prove anything except that she is fast and well behaved. At Southend, Erick Manners has obtained for us the use of covered space on the pier where full sized boat tests can be carried out at all states of the tide, and where the tidal flow can be used to make hydrodynamic tests. It is an achievement that the Society has the Thames Estuary as a test tank. The Committee were instructed to thank the Corporation of Southend officially for this facility, and a vote of thanks to Erick Manners for his valuable work for the Society was proposed by Tom Herbert, and seconded by Norman Davies.

In New Zealand, Charles Satterthwaite has been doing research on pitot type speedometers and should be in a position soon to provide the Society with information for a do-it-yourself speedometer. The problems of calibrating the speedos to enable members' work to be directly compared are being studied.

Item 6. *Matters Arising from* 4 *and* 5. During discussions of the past year's work it was suggested that to improve the Society's lines of communication, members in a particular area should be able to find out where neighbouring members are. Mr. Lawrence proposed that a list of British members is issued as a supplement to the booklets, giving their addresses, equipment available, and main interests. This was seconded by Mrs. Evans.

Item 7. *Executive Policy for the Coming Year.* The main work of the Society will continue as in previous years to build up our resources and prestige.

The Editorial Policy is to keep the booklets as interesting and non-technical as possible, the more scientific information being exchanged individually between interested members. Every effort will be made to improve the lines of communications, particularly to encourage members to form regional groups, as has happened already in Essex.

Item 8. *Matters Arising.* None.

Item 9. *To Discuss the Possibility of Obtaining a Wind Tunnel.* John Morwood stated that most wind tunnels available in colleges etc. were too small for our purpose. At the moment we have not the resources to build our own but the Committee have the matter under active consideration. Charles Satterthwaite has been doing some delving into wind tunnel design and has practical information available.

Item 10. *To Discuss the Possibility of Obtaining and using a Test Tank.* The Society has the facilities on Southend pier, though no work has been done there. Its value for hydrodynamic tests cannot yet be assessed. It was agreed that a test tank of any size was beyond us at the moment.

Item 11. *The Building of Basic Hulls for the Direct Comparison of Various Types of Multihulled Craft.* John Morwood stated that for specific Society projects Thames Plywood Ltd. were prepared to let us have plywood at cost ex works, and that he has a design which has been tank tested by Prof. Nutku. If several members were in a position to do research using the basic hulls, and were prepared to build, then the Society could obtain this concession from Thamesply.

Item 12. *To Discuss the use of a Cine Camera for Sail and other Dynamic Tests.* The possibility of ex-government cameras suitable for our purpose was discussed, and the Committee is investigating. It was agreed that photography is a useful research aid and that there are perhaps some members who are equipped with both cine and still cameras who would be prepared to co-operate in experiments.

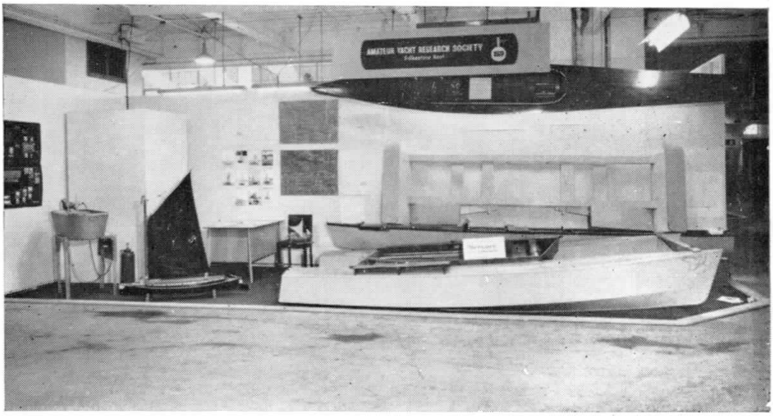
Item 13. *To Consider Whether the Society could do Research on De-Icing of Ships' Superstructure.* It was considered that the aircraft industry know more about de-icing than most bodies and that we could contribute little.

Item 14. *The Formation of a Central Library.* It was agreed that it would be more efficient to compile a bibliography which members could use to help them obtain books from their local libraries.

Item 15. *The Design of an A.Y.R.S. Burgee.* It was agreed that a design competition should be held (no prizes) from which the Committee will select the most suitable.

THE LONDON BOAT SHOW 1958

The photograph shows our stand at the London Boat Show. Thanks to the organisers, the S.B.B.N.F., we were allotted more space than last year.



The A.Y.R.S. Stand at the Boat Show.

On the extreme left of the stand are two charts showing the route taken by James Wharram in his Trans-Atlantic cruise in his catamaran, *Tangaroa*, an account of which we hope to publish soon.

Next comes a water flow test tank made by Owen W. Dumpleton which sent water in motion around a model yacht. The water flow was taken around the ends of the tank by " splitters " and its flow was " straightened " by a honeycomb, before it entered the part in which the model yacht was moored. Though " standing waves " appeared when the water was given a speed equivalent to more than the waterline length of the model (12 inches), one thing appeared which was of great interest. That was, that about 15° of heel of the model was due to the water flow past the hull when close hauled at a speed of $\sqrt{L}$ knots. This speed is about the greatest possible close hauled speed of a yacht.

A Norfolk Wherry is then seen which we showed as an example of a traditional craft directly descended from a Viking " Longship." The hull is only very slightly different from the ancient Viking ship but, of course, the rig was altered from the traditional Viking squaresail to a gaff sail without jib about the middle of last century. We gave out leaflets for the Norfolk Wherry Trust as well as for the Humber

Keel Trust to help those two organisations maintain their craft. The Humber Keel, though a more modern type of hull than the Wherry, has the ancient Viking squaresail as shown by our last publication *Traditional Sail.*

Above the table are photographs of the Baker hydrofoil sailing craft, Arthur Piver's trimarans *Rocket*, his 12′ *Junior Trimaran* and his 14 foot dinghy, A. E. Bierberg's Micronesian outrigger, a *Jump-ahead*, a *Mercury* catamaran and Arthur Piver's Catamaran.

Above these photographs is the construction plan for my Trimaran with hydrofoil stabilisers *Parang* and, to the right of this, the plans for the *Quickcat* and the *Yvonne Cat* from Australia.

On the chair below these is a model of a Phillipino double outrigger canoe, with traditional sail.

To the right of the Australian plans are plans of my *Tuahine* 16′ 6″ catamaran and *Tamahine* 12′ catamaran.

At the top of the stand is Dr. Davies two-seater paddling canoe *Swan of Mersea* which has won several races but whose main feature is that it is made of developed plywood surfaces but has a very good shape.

At the back of the stand is *Jehu* on which is placed her cross beam with surf board floats and hydrofoil stabiliser leeboards.

In the front of the stand at the right is the *Mercury* catamaran, designed by Bill Prangnell, of Eastbourne, which has a better shape for planing than any other catamaran I have yet seen. It is reported to be very fast. We will soon have some idea of its speed relative to a *Shearwater III.*

As in 1957, we enrolled many new members, met many people who are willing to help us and interested yachtsmen in the potentialities of yachting research and multihulled sailing boats. The two Boat Shows which we have attended have got us far more new members than any other method of publicity and we have to thank the kind people who helped man the Stand ; it is a tremendous strain to keep going for eleven hours daily. Mrs. Morwood, Lt.-Cdr. Poland, R.N., Owen Dumpleton, N. R. Bangert, Tom Herbert, Lieut. Clark, R.N., Dr. Davies, E. Kenward and Bill Prangnell did a wonderful job.

SOME WIND TUNNEL EXPERIMENTS

made by

LORD BRABAZON OF TARA

The wind tunnel was of the type called a " Blower tunnel " in A.Y.R.S. No. 12 *Amateur Research* and the models had masts about

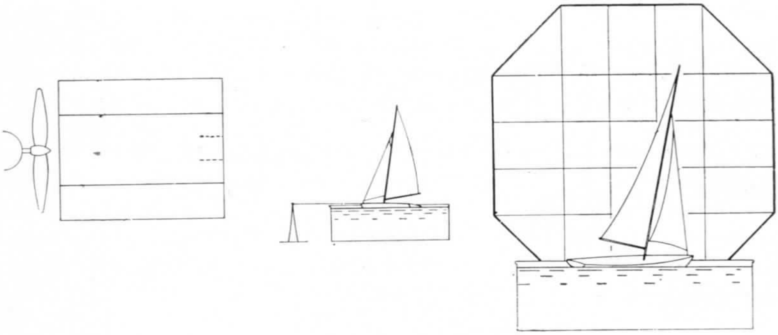


Fig. 1

2 feet high. The motor was ½ H.P. driving a fan giving a scale wind speed of 20 m.p.h. The draught from the fan was made to traverse a box with a grid of slats in it to get the twist out and also in the box was a sloping piece of wire netting to cause a slight wind velocity gradient. In other words, more wind was wanted high up than low down.

A circular bath was then made about 4 feet in diameter and about 8 inches deep and in this, the model yacht was floated. To the bow and stern of the hull went two pieces of thread of equal length and these were attached together at their outer ends to a balance to take the side force of the rig. The balance was well outside the bath on a circle concentric with its rim and it will be seen from the diagram that the boat when the draught hit it would take up a definite known angle which could be varied by moving the thread attachment and balance round to points on the greater circle. The thrust force was taken by an indicator attached to a thread from the stern of the model.

Lord Brabazon's main interest was in the *Redwing* class and the hull was first rigged with as close an imitation of the standard *Redwing*

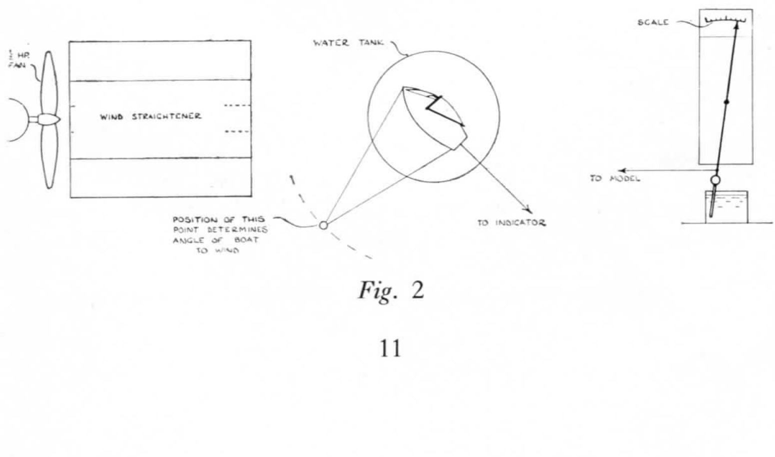


Fig. 2

rig as could be made. On turning on the fan, the boat naturally tried to sail but was held by the threads by which one could read the side force and thrust. Readings were taken from a broad reach to the highest course possible where the thrust force disappeared altogether.

The method of reading the forces at first caused trouble due to " hunting " but a very satisfactory solution was found in attaching the thread two-thirds down a heavy pendulum, the end of which consisted of a square foot of surface immersed in water. With this damping, little hunting occurred and the readings became constant and reliable.

In doing a series of experiments such as these, one must stick to only one variable as far as possible. The problem which was studied here was to discover if there were any fundamental rearrangement of the sails which would improve on standard practice.

Various rigs were made very accurately by W. J. Daniels, of international fame as a maker and sailer of model craft. The first difficulty was found in having to rig the model whenever it was wished to check back. To overcome this, every rig was a complete unit with mast and deck and the whole thing was dropped into the hull. When not wanted, it remained perfectly rigged and adjusted, to be used at a moment's notice. This was found to be satisfactory and it saved an enormous amount of time and fiddling.

The various rigs of curious design which were tried are shown in the diagram but all had the same area of jib plus mainsail. None of them, however, had any outstanding merit over the standard. Possibly

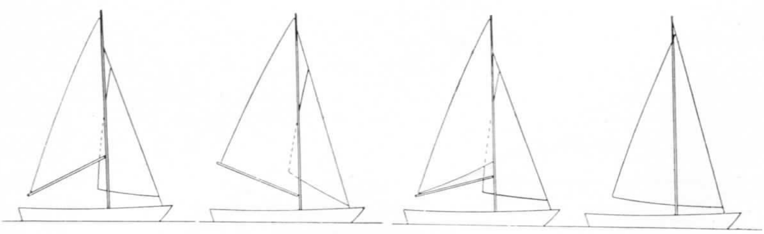


Fig. 3

one of them pointed higher but an equal angle to standard, it showed no advantage. Just off the wind, the standard more than held its own.

The knowledge gained from these experiments was what might be called " negative." That is, that with the proportions of jib to mainsail used, the standard rig was as good as any of them. Other tests which could be done could deal with the ratio of jib to mainsail, the high and low cut jib and the cut of jibs and mainsails. These tests might again show that standard practice is the best but A.Y.R.S. readers need not be reminded of the value of such confirmation by experiments.

After these experiments, a further test was made of putting all the 200 sq. ft. in one enormous reaching jib, the rig on the right of the figure. The results were very extraordinary, beating the standard all along the line, but sheeting necessitated outriggers, some very far out. This, though allowed in *Redwings*, is not allowed in most boats, although, of course, the boom of a mainsail is an outrigger, in effect. The idea, however, of getting this great sail round the mast and on to its outrigger every time one went about, condemned it as not being practical.

All sailors will surely agree that testing at sea is an uncertain and awkward business. One can use the speedometer which assumes a constant wind or one can sail against another boat. Both methods are unsatisfactory. A quantitative approach, therefore, is long overdue and, as we are not likely to get any help at present from the many aeronautical facilities available, then the only thing is to do it ourselves.

The material for this article first appeared in the *Yachting World* of April, 1948. We are greatly indebted to the Editor of Y.W. for permission to quote from it and to use the illustrations.

R. J. Harrington Hudson, in a wind tunnel he is making, intends to assume a speed for the boat and to deflect the wind passing through the honeycomb by twisting it a few degrees to allow for the wind velocity gradient.

Though Lord Brabazon's method of making the wind velocity gradient by having a curved and sloping piece of wire netting in the tunnel is the simplest and probably the best, the same effect can be obtained by having several wire netting " fences " on the floor of the tunnel of gradually increasing height. This will take up less space.

In the A.Y.R.S., we have tried to produce practical ways of taking advantage of Lord Brabazon's findings with the large reaching jib. The rig, described on page 29 of *Commercial Sail* seems to be the simplest.

THE BELL CAT

by

UFFA FOX

L.O.A., 19 ft. 6 ins.
L.W.L., 18 ft. 6 ins.
Beam, 9 ft.
Weight, 600 lbs.
Beam on deck of each hull, 2 ft. 6 ins.
Sail Area, 155 sq. ft. (or 216 sq. ft.).
Draught, 1 ft. 4 ins.

South of the Equator in the steady Trade Winds and warm water, catamarans have existed and flourished for hundreds of years and have been noted for their high speeds and ability. Two hundred years ago, a replica of one of these did 20 knots in Portsmouth Harbour. Another one was built in 1860 by a member of the Royal Mersey Yacht Club. In my life, I have sailed in three catamarans and owned two but the catamaran has had to wait until sailing has become the full blooded sport it now is, with enough enthusiasts willing to endure the cold flying spray of these waters, before it flourished.

Such is the keenness for sailing today that youngsters in their hundreds are found strong enough and with enough courage and stoutness of heart to endure the flying spray of a catamaran at speed. So, catamarans are growing at a faster pace in this country than any other boat.

The rules I laid down in order to design the *Bell Cat* are as follows : Beam, Half L.W.L. ; Floats, Quarter of the total beam ; Space, Half total beam ; Draught, more than one eighth of the beam ; Sail Area, 10 sq. ft. per foot of L.W.L. ; Mainsail Luff, the length on W.L. ; Mast diameter, 1/72th of L.W.L. The strength of each stay and shroud to equal the all up weight. Just as a man walking bears all his weight on one foot, so must a catamaran bear all her weight plus the wind pressures comfortably on *one* hull.

The Lines. The plans show the shape of the *Bell Cat* for home building. It will be seen from the lines that the boat is just a simple V section, so that a man has only to make one mould, put his frames in this and make them to the different heights needed. Every section is exactly the same shape, the only difference being that some are deeper than others. The deepest part of this catamaran is well forward of midships. Therefore, each waterline is a true streamline with its greatest width 0.4 from the fore end and the deckline is also a true streamline. Streamlines give the right shape to cut through the water but they also give more buoyancy forward than aft. This is useful because one of the dangers of a catamaran is that she may run her

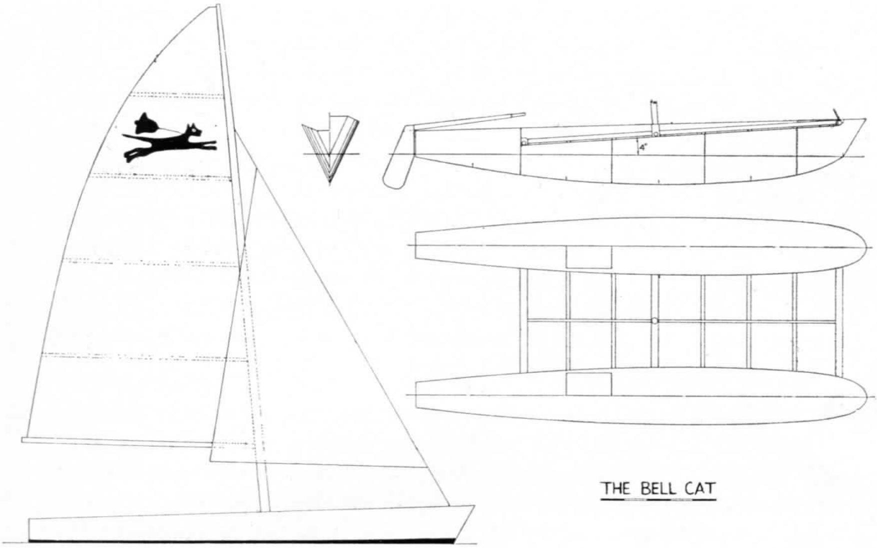


Fig. 4

bows under through her high speed as she comes from one sea into another. Such sections with the greatest buoyancy forward tend to stop diving.

Another danger with the catamaran is that she may dig the lee hull in. The flared off topsides of this design increase the buoyancy tremendously as the lee hull is submerged in an attempt to prevent this.

The stern was chopped off at the 19 ft. 6 in. length so that two and a half sheets of plywood only would be used on the sides. The stem rakes well forward to give reserve buoyancy forward and allow the wide level lines above the waterline to come into a well rounded stem.

The Bridge Deck. The bridge deck joining the hulls is a great problem as, being unsupported by water, it is like a parasite in that it has to be carried and must detract from the boat's speed through its weight. On the other hand, it can be designed as a source of safety in an emergency. A catamaran, chasing away before the wind at high speed in blowing weather, can be diving down the face of a sea at twenty knots and destroy itself by diving into and under the wave ahead. It is then that a well-designed bridge deck might well save its life.

This bridge deck has been given an angle of attack of 4°. In addition, its fore end is rounded up like the fore part of a water ski so that, in an emergency, it will tend to lift the cat up and out of the water. It must be strong enough to endure the enormous loads suddenly put on it under these conditions. So, this bridge deck is an enormous water ski set at the correct angle to lift and is a strong enough girder to support the thrust of the mast as well as the water strain of twenty knot sailing. Such a bridge deck weighs the same as the two floats, so it is half the total hull weight. While this long bridge deck slows the boat, because of its safety factor and the room it gives on board for ease of going forward to handle the head sail on its stay or to pick up the mooring, it is well worth while for those who are not after the ultimate speed.

Once a catamaran gets over 7 ft. in beam, she must come to pieces for trailing and this cat has three tubes across the bridge deck which go on three tubes protruding from each hull so she is built up with three units, the two floats, and the bridge deck. If the bridge deck is laid on an ordinary stool, first one float can be pushed on the tubes and then the other. Four people can do this in five minutes, if the tubes are greased. The bridge tubes are eighty ton Cadmium coated steel Reynolds tubes 1 7/8th inch in diameter. There are three of these and they slide over 1 5/8th inch diameter tubes extending eighteen inches out from the hulls of the floats.

The Sail Plan. I explored the dipping lug and the lateen sail, used by the old catamaran sailors of the South Seas but they all needed a great length of spar for the sail area set. In the end, a normal Cutter rig was designed as this sets the greatest area for the least amount of spar and rigging.

Only the two top battens of the main sail are the full length, the rest being short. Otherwise, when you are sailing on a wind, you cannot tell if you are starving your mainsail of wind as the battens hold it out to its shape with little or no wind in it. We only need the top long batten to extend the roach of the sail for the object of this sail plan has been to give the greatest area on the shortest mast possible. The shorter the mast and rig, the less possibility there is of a capsize.

The Rigging. The forestay is attached to a double plate wrapped round the 1 7/8th inch forestay beam and the two shroud plates for the prototype were put on the outside of the hulls. These would be better taken from the hull at the centre line as they would then be pulling square up on the hull and not twisting it on its tube. It is probable that the standard models will have their shroud plates through the float decks on the centre line, going straight down to the main keel as this will not only eliminate the twisting strains on the hull but also allow the jib to go out round the shrouds and always be clear on its lee side.

There are no rigging screws so that there are only three bolts to put in place to attach the stays. To get tension into the stays, the mast stands on a jack in the bridge deck and is raised by it to make the stays taut.

This simple catamaran was built in two weeks by the Bell Woodworking Company, the pioneers of home boat building in the British Isles and trailed down to Cowes on the 4th December, 1957, a period of calm, quiet weather with frosts and fog.

There were four of us and it only took five minutes to slide the floats onto the bridge deck and another five minutes to rig her. So, in no time, the boat was ready for sailing and we slung her out in the crane and Jack Blundell, the catamaran sailor from Hayling Island took her to sea. There was not a wag of wind and the red hulls and white sails reflected in the water made a delightful picture. We were delighted as we saw Jack sail out to Prince Consort Shoal Buoy and disappear into the mist for, still without a wag of wind, he continued on his way round Old Castle Point Buoy and home. At one period, as the *Queen Mary* was steaming in and blowing her siren, we thought she might cut Jack down but she dropped anchor, due to mist, and remained anchored for two days before safely berthing in Southampton. Jack arrived back alongside my home and we lifted him out in time for tea.

So ended the first trials of this cat and all we learned from them was that she did float and that she sailed well without any wind at all. She came about easily in spite of the fact that she has no drop keels and indeed she has been especially designed not to need these, either for tacking or to prevent leeway.

A week later in a December gale that kept the *Queen Mary* penned hard against the quay at Southampton only ten miles away despite the efforts of all her powerful tugs, we again sailed the *Bell Cat*. She sailed fast and cleanly enough and I would think that in the heaviest of the squalls, we scooted along at around 20 knots for short bursts.

In coming about, we had the usual catamaran trouble and missed stays several times. We were using 14 ft. dinghy drop rudders and, though suitable for the lower speeds of 14 footers, the elastics stretched and so our rudder blades were up at their highest levels. Such was our stability that, though we made a sternboard, we were never in trouble. A normal boat would have been knocked flat if lying dead or with sternway with such strong squalls hitting beam on. These rough weather trials delighted me and once more brought home to me the fact that catamarans need gear 50% stronger than normal centre-boarders of their length.

All the old original catamarans steered with a steering oar and there is a crutch for a steering oar at the back end of the cockpit. If this catamaran can be steered by an oar, it will eliminate two rudders, two tillers and the connecting bar — an expense of some £15 ($45.00) and make getting on and off a beach even easier. It will also enable the boat to be sculled up to a mooring or beach.

An outboard motor will be clamped on to the transom of the bridge deck for those who wish to drive this boat under power.

Summary

This catamaran was designed for home building and to be good in a sea-way. While she is undoubtedly fast in light airs, she should be at her best in a sea with strong winds.

Hull complete but without sails and battens — £190.

Complete kit set including screws and glue — £88.

Mast and Boom (kit) hollowed, glues and shaped read for sanding — £14.

Fittings and rigging, hull tubes and hallyards — £24.

All from the Bell Woodworking Company, Narborough Road South, Leicester.

The mainsail and jib in Terylene (Dacron) £46, Insignia 10s.0d. from Ratsey and Lapthorn Ltd., Cowes, I.W.

DIFFERENTIAL STEERING FOR CATAMARANS

by

PETER H. COLEY

Auckland, New Zealand

In an automobile, when a straight line is passed through the rear axles and produced beyond, it eventually passes through a series of points which would be the centres of various turning circles, provided the front axle steering arm knuckles and tie rods are in true Ackerman alignment.

In the case of the catamaran, I propose to use the same principle except that the steering linkage axis will follow instead of lead. In the drawing, the produced line SP, running through the centre of lateral resistance of each hull will pass through a series of points which will be the centres of various turning circles, if the tie rod, knuckles, tiller linkage are in true Ackerman relationship. This relationship could be worked out on paper but would not be 100% attainable in practice due to the centres of resistance moving with each change of trim, resulting in increased drag on one or other of the twin holes.

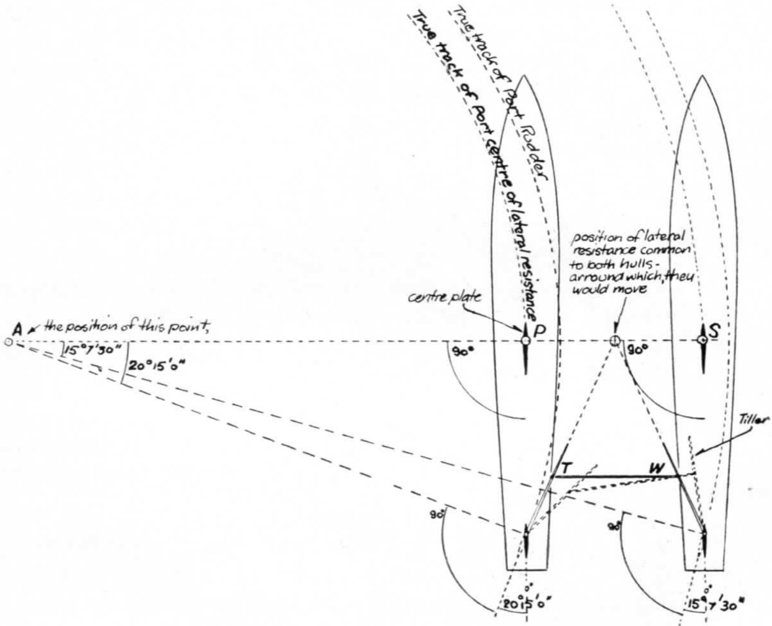


Fig. 5

On paper, with the tillers parallel at all angles, it appears that the outer tiller and hence the rudder does not travel in a true circle in relation to the other rudder, therefore acting as a brake. This might be one of the factors contributing to the poor " going about " qualities of catamarans.

Editor : This is one of the many accounts I have had of the use of the Ackerman alignment for catamarans. It is quite obvious that it is difficult to describe in words but the diagram with this account is almost self explanatory. In the *Tuahine* and *Tamahine* designs, the tiller linkage will be noted as giving this differential rudder action.

TACKING A CATAMARAN

Catamarans often fail to tack well. There are some factors in design which make this so and some tricks of handling which make it easier.

The long slim hulls of catamarans and trimarans have a much better grip on the water than the shallow hulls of dinghies. Also, a dinghy, when heeled slightly, has a curve in the axis of the centres of area of its immersed sections which causes a luffing movement which helps it to put about. Catamarans and trimarans have no such help. I do not think that the fact that there are two hulls in a catamaran make putting about any more difficult. A trimaran, balanced so that both floats are off the water, is just as slow in stays so, in my opinion, the difficulty is intrinsic in the hull shape.

The lightness of the multihulled craft also contributes to the difficulty in staying because, when the wind pressure comes out of the sails, the craft is quickly brought to a stop, losing steerage way.

In fact, no catamaran or trimaran will put about easily without a centreboard on which to pivot. Leeboards in both hulls of a catamaran or at the ends of the outrigger beam of a trimaran seem to be quite as effective as a centre board.

Handling. There are probably many ways of handling a catamaran to get it to come about most quickly. The method developed by Norman Naish is as follows :—

1. Put the tiller to leeward and leave it there. It does not seem to need to be held.

2. Pull in the mainsheet till the boom is in the middle line or even slightly to weather and keep it there till the weight of wind comes out of the jib. At this moment, the weight of wind will also come out of the mainsail and the mainsheet can also be let go.

3. Take the jib sheet out of its jamb cleat and ease the jib across. There is usually plenty of time to do this and, ordinarily, there is no need to back the jib to help the bows to fall off.

4. The jib is then put in the jamb cleat for the new tack and the crew take up their sailing positions.

5. The catamaran gathers way and the tillers come central by themselves. The helmsman then takes the tiller which has not been touched since it was originally put to leeward on the previous tack.

The rules to remember when putting about are :

1. Keep every sail drawing till the last possible moment.

2. Try never to let any sail come aback.

3. Use the rudders as little as possible. Once having put the tillers to leeward, let them align themselves with the water flow past them. They will then slow the boat as little as possible.

A MULTIHULLED EXPERIMENT

The origin of the three designs which follow was that sooner or later we had to be in a position to know the relative merits of all the multihulled craft. It was therefore thought to be worth while to design a hull which could be used for a double hulled catamaran and also for a trimaran and, by giving the hull a slight " bend " make it suitable for a Micronesian craft. Because the design was to be suitable for the A.Y.R.S., the craft would have to be easy to build. In the first place, no thought was given to making any of these craft so that it would be the fastest possible of its type.

To be suitable for all three types of configuration, the hull design had to be :

1. Capable of taking the whole displacement of the crew and craft for both the double hulled type and trimaran. It therefore had to be designed to sail well at several different water lines. This has resulted in the catamaran design having a displacement of 632 lbs. which is rather more than necessary.

2. It had to be symmetrical fore and aft to fit the Micronesian type, though for both the trimaran and double hulled type, the stern or sterns could be chopped off to make transoms.

The resultant hull design is most interesting and the system has resulted in some very interesting designs which appear to be far better than was expected, considering the handicap of designing for such varied conditions. In fact, the result appears to have a chance of being the fastest possible craft in lighter winds.

Professor Ata Nutku has now kindly offered to tank test all the variations of this design so that we will be able to correlate the sailing tests with the tank tests and thus gain valuable information. The tank tests of *Tuahine*, the double hulled catamaran design are already to hand and these will be given with the description of that craft.

Some people are already making prototypes of all these craft and it is to be hoped that we can have a " Sailing A.Y.R.S. Meeting " this summer with all these craft available so that members can try out any type they wish. So far, however, we have only one person offering to make the Micronesian type and perhaps we should have two of these.

We have been offered plywood at wholesale prices for any experiments of this type we do by Thames Plywood Ltd. This is indeed a kind offer which should save a good deal of expense for the people concerned.

It is hoped that the development of the following designs will be in the orthodox manner as follows :

1, The design ; 2, The Model tests ; 3, The Evaluation of the models ; 4, The Prototype, full size and sailing trials ; 5, The Useful Craft.

All the studies which have gone into the design have already been published in the A.Y.R.S. publications and are available to everyone.

TUAHINE

(" Sister " in the Tahitian language)

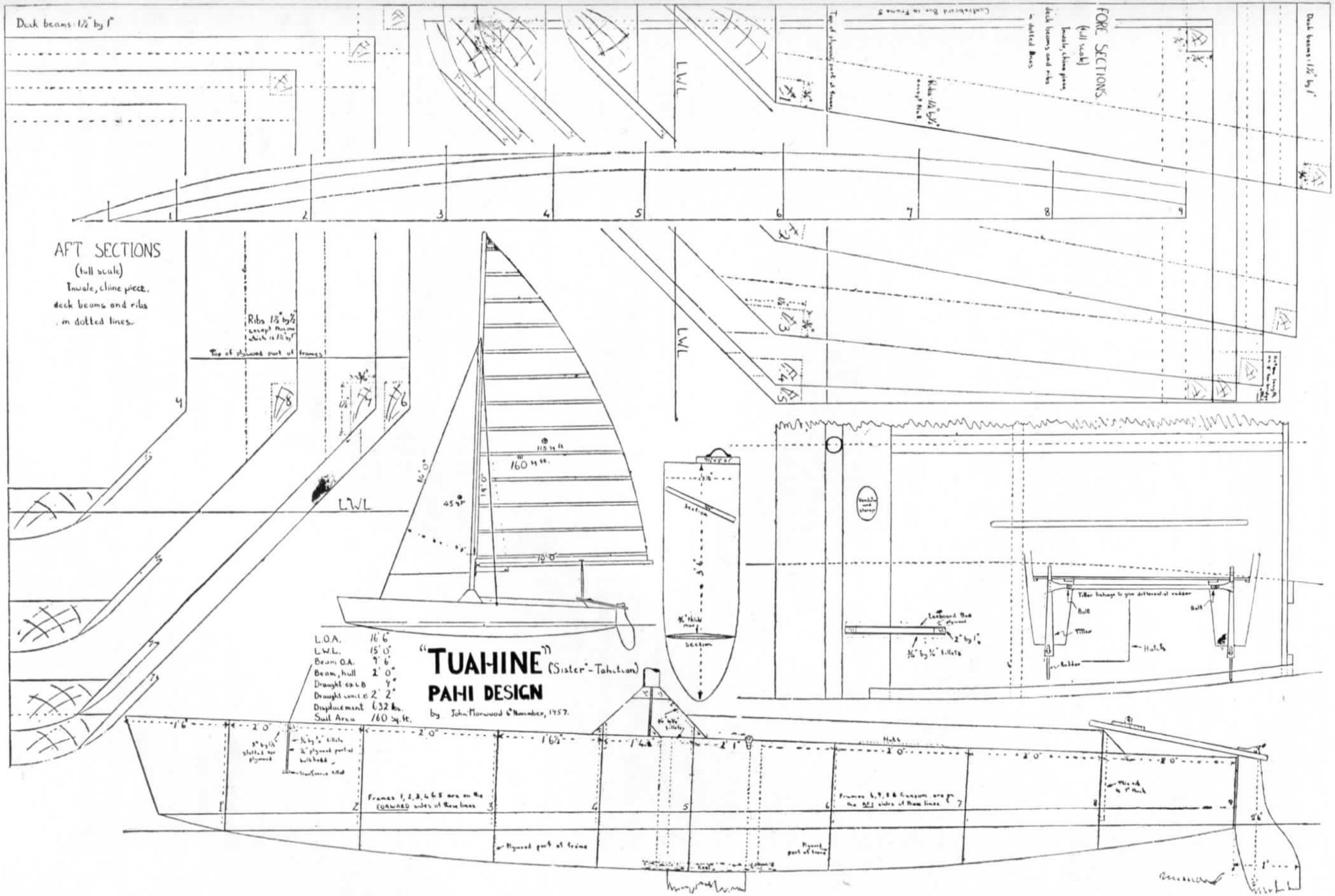
L.O.A., 16′ 6″	Beam (hull), 2′ 0″
L.W.L., 15′ 0″	Displacement, 632 lbs.
Beam O.A., 7′ 6″	Sail Area, 160 sq. ft.

Designer : John Morwood

The two essential features of this craft are firstly, the right angled V sections and secondly, the ability to take the full weight on one hull with efficiency. The right angled V sections make the craft very easy to build and reduce the wetted surface greatly when the craft heels only a few degrees. The ability to take the full weight on one hull allows the craft to be sailed heeled in order to reduce the wetted surface.

There is no compromise with this craft. I have given her the least possible wetted surface at the expense of increasing the " form resistance " somewhat. The ends are fine and most of the buoyancy is in the middle of the hull. This is because more buoyancy is added by an extra area of hull when it is placed amidships than when it is at the ends. This has resulted in a fine bow which may bury itself sooner than with a fuller bow. Because of the low wetted surface, the light wind performance should be improved with a loss of some top speed. Compared to a *Shearwater*, there is one square foot more wetted surface when on a level keel. There will be much less when heeled.

The greatest depth and beam of hull are placed amidships (if one ignores the transom " cut off "). This was done simply because the hull shape had also to serve as a Micronesian hull. However, there are some advantages in this which are as follows :



Deck beams: 1½" by 1"
FORE SECTIONS
(full scale)
Inwale, chine piece, deck beams and ribs in dotted lines.
AFT SECTIONS
(full scale)
Inwale, chine piece, deck beams and ribs in dotted lines.
Top of plywood part of frames
LWL
L.W.L.
160 sq ft.
10' 0"
L.O.A. 16' 6"
L.W.L. 15' 0"
Beam O.A. 9' 6"
Beam, hull 2' 0"
Draught ex C.B 4"
Draught with C.B 2' 2"
Displacement 632 lbs.
Sail Area 160 sq. ft.
"TUAHINE" (Sister - Tahitian)
PAHI DESIGN
by John Morwood 6th November, 1957.
Frames 1, 2, 3, 4 & 5 are on the FORWARD sides of these lines
Plywood part of frame
Keel
Hatch

Fig. 6

1. Professor Nutku's model catamaran (with deep V sections) was made fuller at one end than the other and was towed in the tank first with one end and then with the other end forward. The resistance was found to be less with the greatest fullness aft. The finer entrances probably allowed a greater amount of " laminar " flow with less resistance.

2. Concentration of the greatest depth amidships should give the hulls a greater amount of lateral resistance than when it is farther forward though this point is arguable. Now *Gemini*, described in No. 15, *Catamaran Design* will sail quite well to windward without her C.B., so *Tuahine* may not need her boards at all.

3. The final advantage of having the greatest depth amidships is that the centre of lateral resistance is then placed just aft of the position of the leeboards. This should make her faster in going about and this manoeuvre should also be helped by the concentration of weight, wetted surface and displacement in the middle of the craft.

The figure shows the constructional drawings. In them, the sections are laid out at full scale to make the frame construction easier. The lower part of each frame is a sheet of plywood. The tiller linkage to give differential stearing will be noted.

The Tank Tests. These will be shown in the next article. There is a " hump " in the curve at about 10 knots due to the interference of the hulls with each other. At 16 knots, the bows bury and the catamaran capsizes forward. The sketch shows Derek Norfolk's opinion

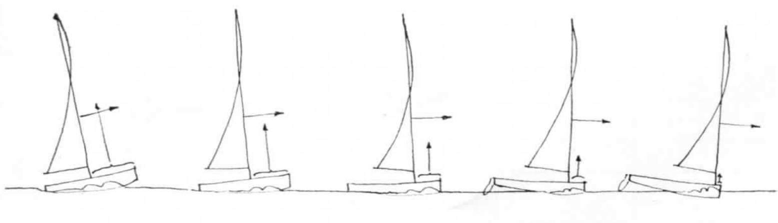


Fig. 7

of how this happens with a dinghy and a catamaran's bow burying is similar. The full forward capsize is unlikely to occur at full size for a variety of reasons, the most important of which is that the crew can and must move aft when sailing at high speeds. In the model, the cause of the forward capsize is that the bow wave at 16 knots (relative speed) lies *aft* of the centre of buoyancy and lifts up the stern, pushing the bows under. Full scale, the craft might dip her bows slightly but would meet with a sudden lessening of forward resistance due to the push forward of the bow wave on the quarters. This might allow the craft to bring the bow wave to the finer part of the stern by the increase of speed and she would then run in more level trim. Models, too, seem to get more dynamic lift from the water than full sized craft which might have accentuated the effect. Hydrofoil models, for example, work far better than full scale craft, which has been the undoing of many a hydrofoil experiment. The displacement of this craft at 632 lbs. as designed would also give earlier bow burying than if she were at her expected displacement of about 560 lbs.

Summary. *Tuahine* is a catamaran designed to have the least possible wetted surface compatible with easy construction. Owing to the fine bows, bow burying may occur at lower speeds than with a *Shearwater*. Owing to the uncertainty of her behaviour in this respect, no plans will be sold until the prototype has been tried out.

Commander Gandy's mathematical evaluation of *Tuahine* gives her a top speed of $1\frac{1}{2}$ knots less than *Shearwater* when sailing with an equal weight distribution between the two hulls. This loss might be retrieved by the less wetted surface when " flying a hull." This will reduce the wetted surface by 30%. It might be worth while to lift the *lee* hull off the water in light winds by having the crew on trapezes.

PROFESSOR NUTKU'S CATAMARAN TANK TESTS

The figure shows resistance curves of two catamarans, one resembling Uffa Fox's *Bell Cat* and the other *Tuahine*. The up and down axis is graduated in " Velocity heads " which corrects the resistance for speed and wetted surface. The horizontal axis shows speed corrected for the size of craft. By this method of presentation, model and full size ships of all kinds can be compared, one with another. These graphs show :

1. Up to $8\frac{1}{2}$ knots, *Tuahine* will be faster than Prof. Nutku's cat.
2. Above $8\frac{1}{2}$ knots, the Nutku cat will be faster than the upright *Tuahine* (if *Tuahine* is heeled, however, her wetted surface will fall and her speed rise more than with the Nutku cat.).
3. The deeper Nutku cat with the greater wetted surface will dig its bows in at a lower speed than *Tuahine*.
4. Spray guards forward prevent the forward capsize of both

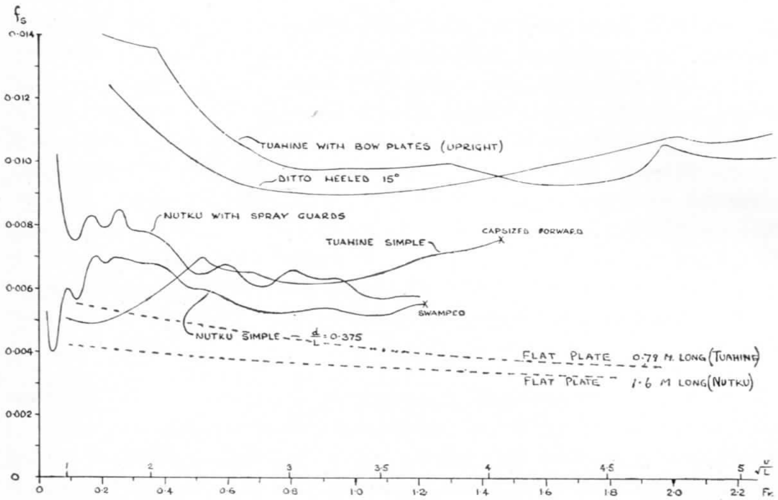
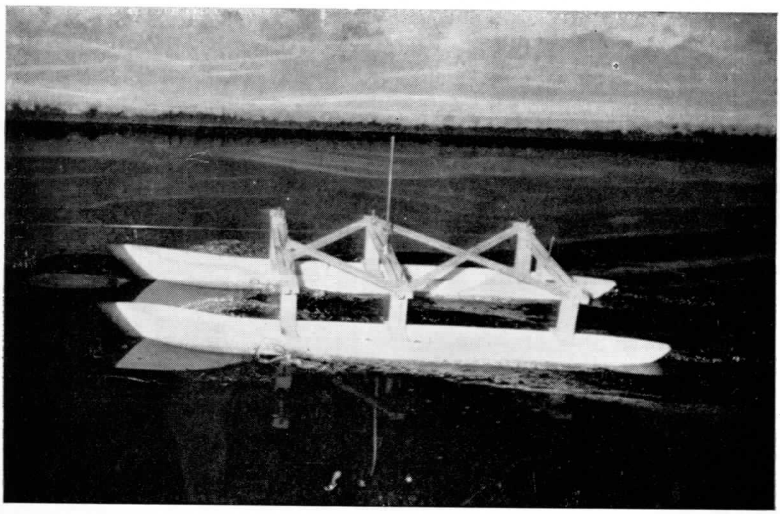


Fig. 8

cats but at the cost of greatly increased resistance. This may not be so great at full size.

5. The two top lines show *Tuahine's* lessened resistance when heeled.



Catamaran Model in the Test Tank.

6. The two dotted lines show the resistances of flat plates of the same length and area as the two models. The upper line shows that 75% of the resistance of *Tuahine* at $8\frac{1}{2}$ knots is due to skin friction which falls to 50% at 16 knots. This proportional resistance due to wetted surface is much higher than with conventional yachts and shows most clearly what has been stressed in all the A.Y.R.S. publications namely, that all multihulled craft must have the least possible wetted surface to be fast.

TAMAHINE

(" Daughter " in the Tahitian language)

L.O.A., 12′ 0″	Beam, hull, 1′ 6″
L.W.L., 11′ 3″	Displacement 267 lbs.
Beam, O.A., 7′ 0″	Sail Area, 110 sq. ft.
Designer : John Morwood	For Reginald Briggs, Esq.

This design is exactly the same in shape as the *Tuahine* design which was reduced to produce a catamaran for Reg. Briggs' two

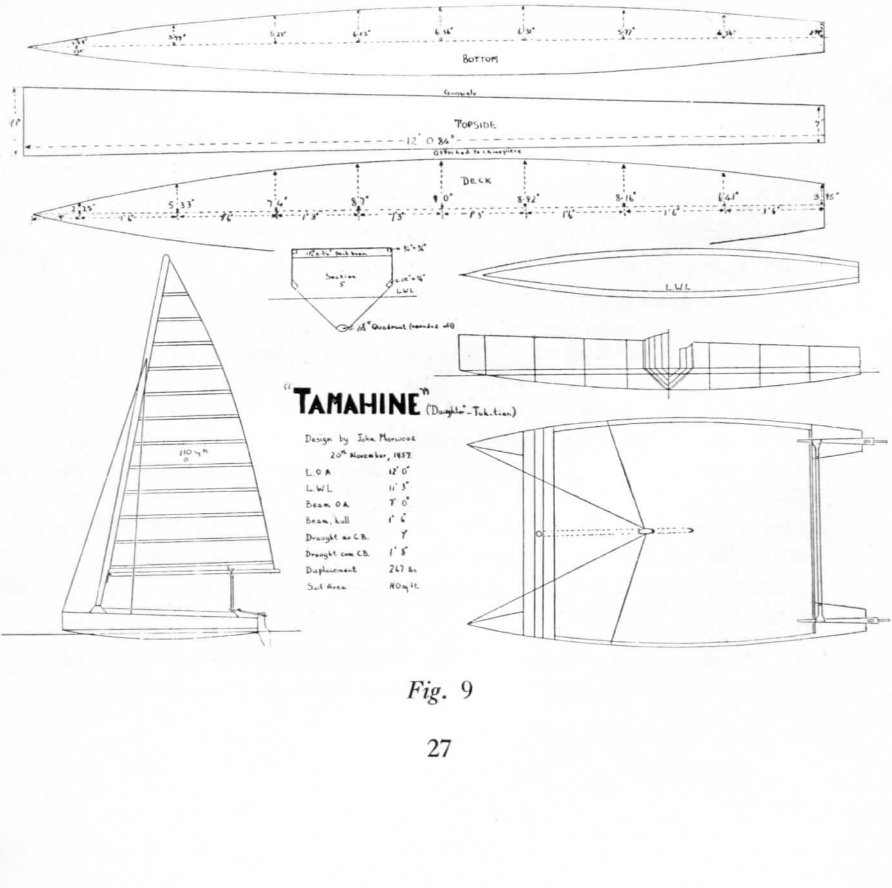


Fig. 9

daughters, hence the light displacement, the slightly excessive beam and the name.

The single sail was used to make her simple to sail and slightly safer though the weight of the mast would have to be kept to a minimum. The mast rake is in accordance with Ice Yacht practice and produces a sail which is aerodynamically at right angles to the wind flow and not " swept forward " as would be the case with a vertical mast.

The only reason why this design is shown here is because of the simple method of construction. Each hull is simply made from five long strips of plywood which are glued and screwed together at the edges. There are no frames. However, a couple of bulkheads or diagonals would probably be necessary to make the hull keep its shape and take the strain when running aground.

As with the *Tuahine* design, no plans of *Tamahine* will be sold till the prototype craft has been sailed and found free from vices.

Summary. A method of catamaran design and construction is shown which will produce a very easily made craft with a good performance. The present lines may not be ideal but alteration in these is not a matter of great difficulty and the simple method of construction can still be used.

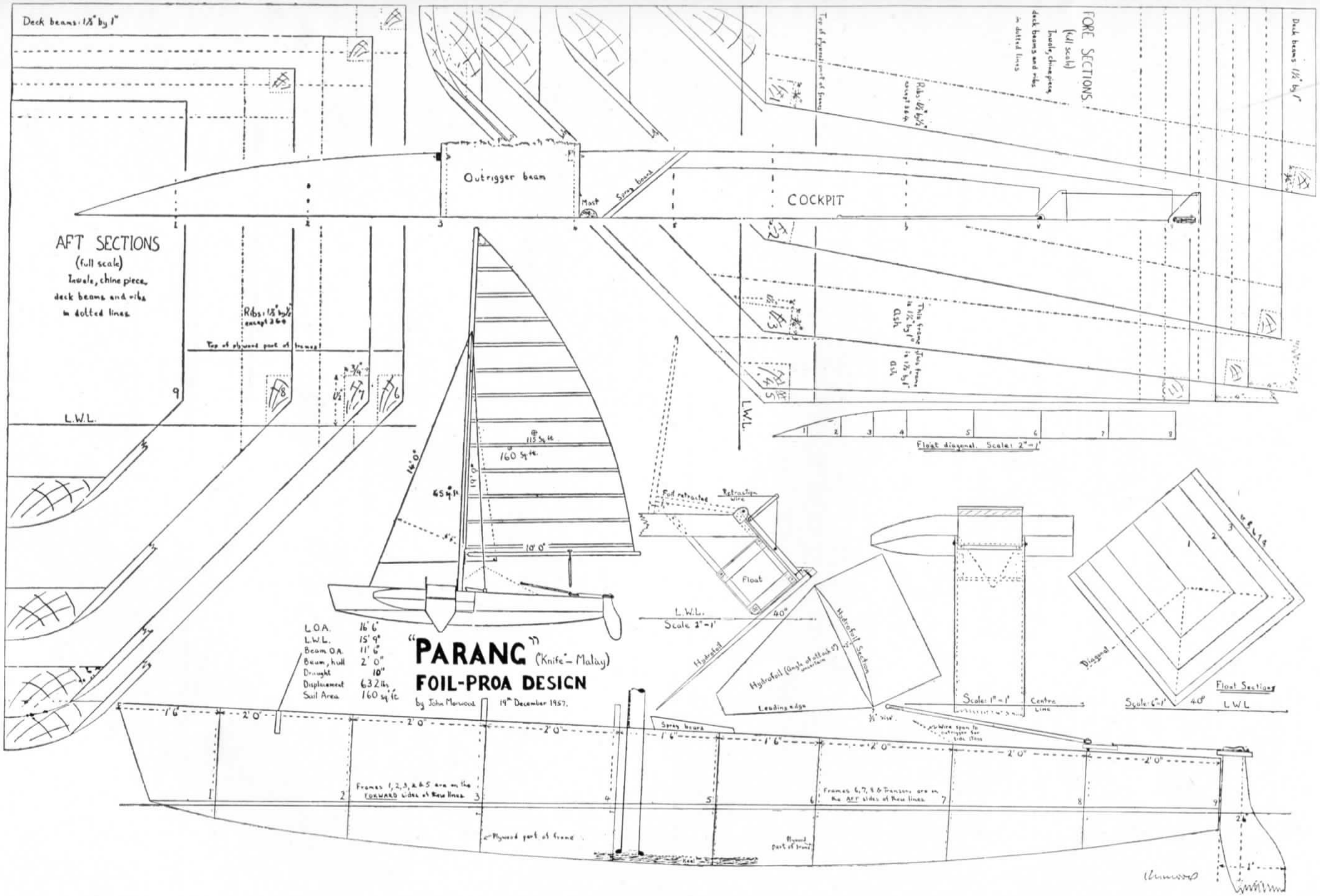
PARANG

(" Knife " in the Malay language)

L.O.A., 16′ 6″	Beam, hull, 2′ 0″
L.W.L., 15′ 9″	Displacement (designed), 632 lbs.
Beam, O.A., 11′ 6″	Sail Area, 160 sq. ft.
Designer : John Morwood.	

The same hull is used for this design as for *Tuahine* but, of course, it is sunk lower in the water. This is the Indonesian design with simple box-like floats on the end of the detachable outrigger beam. The floats have a square stern and a fairly fine entrance. They are set on edge so that their wetted surface can be adjusted to be the minimum and they should be filled with Polystyrene (Styrafoam) to prevent leaking. This material is available from Expanded Plastics Ltd., Mitcham Road, Croydon, Surrey, who can also supply this material through agents in America. The Dow Chemical Co. sell Styrafoam in America.

The Foils. The hydrofoils lift the floats off the water at speed. They have to be of fairly low aspect ratio to keep them from lifting



"PARANG" (Knife—Malay)
FOIL-PROA DESIGN
by John Morwood 19th December 1957.
L.O.A. 16' 6"
L.W.L. 15' 9"
Beam O.A. 11' 6"
Beam, hull 2' 0"
Draught 10"
Displacement 632 lbs
Sail Area 160 sq ft
AFT SECTIONS
(full scale)
Inwale, chine piece, deck beams and ribs in dotted lines
FORE SECTIONS
(full scale)
Outrigger beam
COCKPIT
Mast
L.W.L.
Float diagonal. Scale: 2" = 1'
Float Sections
Hydrofoil Section
Leading edge
Float
Scale: 1" = 1'
Centre Line
Frames 1, 2, 3, & 4 5 are on the FORWARD sides of these lines
Frames 6, 7, 8 & Transom are on the AFT sides of these lines
Plywood part of frame

Fig. 10

up the whole craft. They also have to be retractable and capable of being used vertically for light winds.

Expected Performance. *Parang's* tank tests are not yet to hand but they should be very similar to those of *Tuahine,* though possibly the foils will prevent the bow-burying at speed. The resistance at full size will be much less than that of *Tuahine* and I believe it will only be about half due to the lesser weight.

Summary. *Parang* is an Indonesian type of outrigger which should be extremely fast. If the hydrofoils were made a little longer and a retractable stern foil added, the ideal sailing machine would almost be achieved. In light winds, speeds would be maximum due to the low wetted surface. In medium wind strengths, speeds would be maximum as then the craft would be riding on her main hull with only the lee hydrofoil keeping her upright. Finally in strong winds, the craft would rise right out of the water and sail on her hydrofoils.

MICRONESIAN CANOE DESIGN

L.O.A., 18′ 9″	Beam, hull, 2′ 0″
L.W.L., 17′ 0″	Displacement, 632 lbs.
Beam, O.A., 12′ 0″	Sail Area, 115 sq. ft.

Designer : John Morwood.

This is the final of the designs for the experiment. The type is not much favoured by American or European yachtsmen, largely because of the difficulty in changing tack but at least we should have one or two examples made to see if any improvement is possible.

The Main Hull. The hull is the same as that used for *Tuahine* and *Parang* but the centreline is curved so as to give an angle to the midline of the bow of 6° from the average fore and aft line of the boat. It is assumed that the craft will make an angle of leeway of about 6° and the water flow will divide equally at the bows so that both the

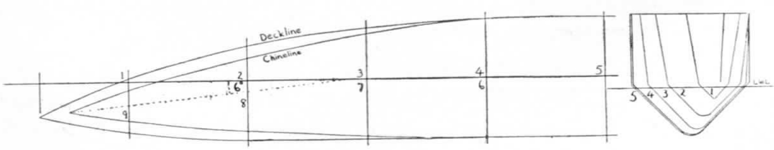


Fig. 11

weather and lee bow waves will be the same size. All symmetrical hulled craft have a bigger lee bow wave than the weather one. No centreboard should be needed.

The Float. The float is a *Tamahine* hull, which should give buoyancy of about 267 lbs. up to the chine with a good reserve of buoyancy should the sail be caught with the wind blowing from the large hull to the small one. The Micronesian craft have asymmetrical floats as well as main hulls but it is not thought worth while to use one with this craft. As far as possible, the float is kept raised above the water when sailing and the complication of asymmetry does not seem worth the extra difficulty of construction. As opposed to A. E. Bierberg, I believe that the float should be made as light as possible and the crew's weight used as a counterpoise.

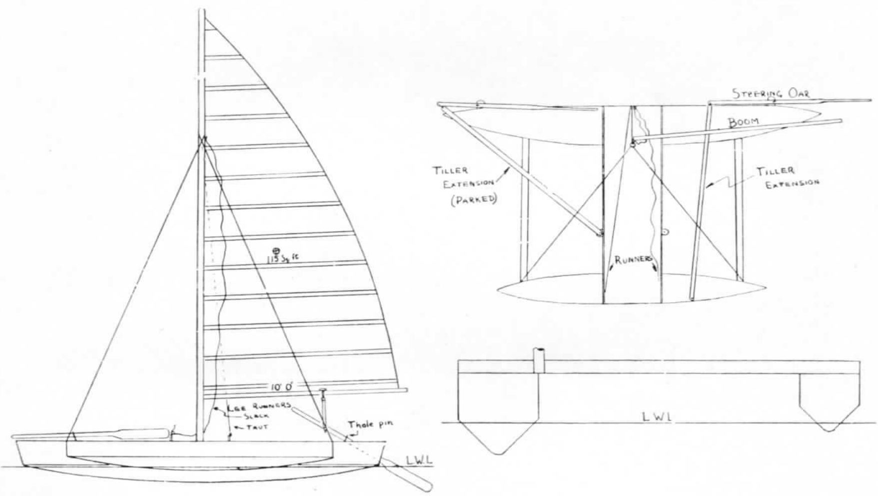


Fig. 12

The Outrigger Beam. This is simply made from two 4″ by 1″ planks with plywood glued and screwed below them.

The Sail. The sail is a Bermudian mainsail only and, with this sail, perhaps the craft should be called a "Motu" canoe because the modern native outriggers of Port Moresby, in Papua, have deserted their traditional Oceanic Lateen for the European spritsail, which they set on a mast placed amidships but slightly towards the outrigger

Modern Motu outrigger of Port Moresby

float. Sail balance with this design is not quite certain. It can be altered by change in the athwartships position of the mast. Moving the mast towards the float has the same effect as moving it forward. The luff groove is placed to leeward so that the sail comes off the lee side of the mast on each tack and therefore produces fewer mast eddies.

Steering. This is accomplished by steering oars at either end placed on the " thole pins " which slope slightly so as to allow the oar to be parked horizontally when not wanted. It is thought that this system would be better than that devised by Sandy Watson and myself three years ago.

Summary. A Micronesian (or Motu) canoe design is described which should be made and tried out to see if any yachtsmen will take to the type. It should be safe, dry and fast.

Postscript. These " backwards and forwards " craft can have their sail rig in four ways :

1. Traditional Micronesian, as used by A. E. Bierberg and described in No. 16 *Trimarans and Outriggers*.

2. Modified Lateen as used by Sir William Acland and described in No. 1, *Catamarans*.

3. The Melanesian or Motu rig, as described here.

4. A squaresail as used by Captain J. C. Mellonie of Mawnan Smith, Falmouth.

A final idea is that this type of craft could run on hydrofoils, all of which would slope upwards to *lee* as opposed to the dihedral needed with a normal type of craft or trimaran where the weather foil produces a *leeward acting* force.

ANOMALIES IN HIGH SPEED MODEL COMPARISON AND AN ALTERNATIVE METHOD OF PREDICTION

by

G. H. Gandy

As we all know, models are tested for resistance in a tank at various speeds and an evaluation made of the respective skin-friction and wave-making resistances, from which the resistances of the full size craft can be accurately foretold, usually by Froude's laws of comparison. Anomalies, however, have been found to occur particularly at high speeds to complicate the normal procedure.

Anomaly due to Laminar Flow. Even at very low speed, an anomalous effect may occur in the under water-line flow round the model when of suitable form. At low speeds and in connection with under water-line flow only, the model can have much better " laminar flow " than the full size ship, thus giving a too *optimistic* model performance. In order to obtain consistant results, therefore, tank testers put small pins or wires on the forebody of the model to vitiate its too-good laminar flow in relation to the big ship.

Anomaly due to Surface Waves. However, I am far more interested in the comparative resistance of craft capable of speeds up to

$5\sqrt{L}$ knots and I hope one day beyond that figure. In this field of high speed, the tank testing of models has a quite different anomaly due to the wave flow above water-line leading to an exaggerated scale effect and too *pessimistic* a model performance. The model at high speed sticks in its own bow wave and just won't go any faster, although the full size craft may be known to go relatively far beyond the limiting speed of the model.

Viscosity of the model bow wave is the main cause of exaggerated scale effect at high model speed. Skene explains it thus : " Surface tension (and viscosity) will hold the bow wave of a small high speed model in a thin glassy sheet, though at full size this wave, would be dissolved into spray. Even if the model wave should break (or be made to break) into drops, the drops will be relatively very large against the model, and relatively small against the full size craft. In this connection, I think it significant to notice that Professor Nutku's model catamaran, when fitted with spray guards, gave appreciably higher model resistance than without them, although in full size, the spray guards are known to make little difference.

To a certain extent, scale effect on moderately high speed models can be taken care of by expert and elaborate calculations using Reynold's numbers and a complicated set of coefficients ; but the hard fact remains that model tests of high speed power craft have often been useless as regards the calculation of full size maximum speed, although otherwise, the model tests were worthwhile in regard to porpoising and rough water behaviour.

The " K " Constant. However, there is no need to be defeated by what Peter Du Cane of Vospers describes as " the most important drawback to high speed model experiments ; the difficulty of scaling the model results to full size " because there is a very simple method of estimating the resistances of high speed hulls without going to the model tank at all. This is the " K " constant method (see Barnaby, second edition Art. 201), which is so simple that one may at first tend to distrust it, but it undoubtedly gives reliable results once a satisfactory " K " figure for the particular type of craft has been established by experience.

There is no text book authority for the following " K " table for small catamarans. The " K " values give not improbable results but must be regarded as provisional until further data can be gathered. In this connection, the performance of *Tuahine* when sailing is expected to act as a valuable check.

" K " Table for Small Catamarans

(values of " K " for various lengths and displacement ratios).

		Effective length in feet						
		15	16	17	18	19	20	Feet
$\dfrac{\triangle}{\left(\frac{L}{100}\right)^3}$ Displacement ratio	50	2.61	2 63	2.64	2.65	2.66	2.67	K
,, ,,	60	2 59	2. 61	2.62	2.63	2.64	2.65	K
,, ,,	70	2.56	2.58	2.59	2.60	2.61	2.62	K
,, ,,	80	2.52	2.54	2.55	2.56	2.57	2.58	K
,, ,,	90	2.45	2.48	2.50	2.51	2.52	2.53	K
,, ,,	100	2.35	2.40	2.43	2.44	2.45	2.46	K

Approx. Displacement ratio 200 K = 1.75 about.

Given the " K " figure, the drag or resistance at any speed *above* $2\sqrt{L}$ knots can be found by the following formula :

$$\text{Drag in lbs.} = \frac{\text{V knots x } \triangle \text{ tons weight or displacement}}{0.0061414 \text{ x K x K}}$$

The Probable Maximum Speed. Apart from consideration of sail area and capsizing limits, the limiting factor to speed is the drag/weight ratio, that is to say the ratio of the drag in lbs. to the loaded weight of the catamaran in lbs. At present, we are unlikely to drive the catamaran by wind power at a sustained speed higher than that at which the drag is more than one-fifth the weight of the loaded craft, although in short bursts a somewhat higher speed may be touched. Thus, when $\dfrac{\text{Drag in lbs.}}{\text{Loaded weight in lbs.}} = 0.20$, the craft is at predicted maximum speed.

Of course, the prediction of maximum speed in this way by the " K " method will not work out correctly for a totally unsuitable craft. Nor will the calculations alone be enough to ensure that our catamaran hulls are seaworthy.

CATAMARAN MATHEMATICS

Let us now examine the mathematical rules for designing a small catamaran of 15 to 20 feet in length. Firstly, we should be well advised, initially at least, to confine ourselves within the limits of present custom and see to it that, if our effective length is L feet, the spread apart of the hulls, centre line to centre line, lies between .35L and .5L ; the ratio of length to hull beam at the waterline lies between 9 and 18 and that the prismatic coefficient is not less than 0.5 (preferably 0.6 or more) while the longitudinal centre of buoyancy lies from 46% to 55% of L.W.L. for the bow W.L.

Secondly and highly important from the point of view of comparison both from boat to boat and equally from model to boat and vice versa, are the two similarity ratios, " Displacement Ratio " and " Wetted Surface Ratio."

The Displacement Ratio. This is the most important and also the easiest to calculate. It is simply the loaded weight of the craft in tons divided by the cube of one hundredth of L and should lie roughly between 50 and 80 for the type of small fast catamaran under consideration. If it should work out to a figure more than 80, it does not necessarily mean a bad boat ; only that the maximum speed will be more limited.

The Wetted Surface Ratio. This is a good criterion of moderate and low speed performance but is rather more difficult to calculate. The wetted surface S in square feet must be measured and then divided by the two-thirds power of the loaded displacement in tons and can be written as $\frac{S}{\triangle^{\frac{2}{3}}}$.

The displacement ratio and the wetted surface ratio are absolute criterions of similarity. For example, a model and a full sized craft, if they are of the same shape, will have exactly the same figures for these ratios. The Drag/Weight ratio is not an absolute measure of similarity between model and boat but is usually so close that, for our purposes, it also can be assumed to be a similarity ratio.

COMPARISONS OF CATAMARANS

The Table opposite, commencing with two existing and successful catamarans, should give an all-round view of similarities and divergencies among many different types. *Destroyer Cat*, *Prof. Nutku* and *Sken* are included because the resistance data from tank tests at $2\sqrt{L}$ knots is available from which comparisons can later be made.

Assuming that, when the drag is one-fifth of the weight of the craft, the maximum speed has been reached, the prediction of the

Table of Characteristics and Names of Catamarans.

	Ocelot	*Shear-water III*	*Tuahine*	*Destroyer Cat*	*Prof. Nutku Model*	*Prof. Nutku full size*	*Skeen Model*	*Skeen full size*
Single hull prism. Coeff.	.57	.68	.60	.64				
Single hull L/hull beam L.W.L.	16	15	10	10			6	6
Effective L.W.L. in feet, L	19	16	15	19.8	5.25	15.75	5.0	15
Spread of hull's centrelines	.42L	.375L	.367L	.45L	.42L	.42L	.5L	.5L
C.B. from bow % of L.W.L.	48	54	53	55			53	53
Loaded weights in lbs. : W	840	560	632	1,509	33	892	56	1,512
Loaded displacement tons: Δ	.375	.250	.281	.674	.0147	.3984	.025	.675
Wetted Surface in sq. ft. S	60	44	45	81.3	7.5	67.7	8.0	72.1
Displacement Ratio $\Delta / \left(\frac{L}{100}\right)^3$	55	61	83	86.5	102	102	200	200
Wetted Surface Ratio : $S / \Delta^{\frac{2}{3}}$	115	111	105	106	125	125	93.7	93.7
Remarks	good boat	good boat	not yet built	very similar to *Tuahine*				

maximum speed work out as follows by the " K " method formula,

$$V \text{ knots} = \frac{\text{Drag in lbs. x .0061414 } K^2}{\triangle \text{ tons}}$$

K = 2.65 from table	*Ocelot*	Maximum	19.3 or	4.43 $\sqrt{L}$ knots
K = 2.61 ,, ,,	*Shearwater III*	,,	18.7 ,,	4.68 $\sqrt{L}$,,
K = 2.50 ,, ,,	*Tuahine*	,,	17.2 ,,	4.44 $\sqrt{L}$,,
K = 2.54 ,, ,,	*Destroyer Cat*	,,	17.7 ,,	3.98 $\sqrt{L}$,,
K = 2.35 ,, ,,	*Prof. Nutku,* full size	,,	15.1 ,,	3.80 $\sqrt{L}$,,
K = 1.77 ,, ,,	*Sken,* full size	,, ,,	9.7 ,,	2.23 $\sqrt{L}$,,
K = 2.65 ,, ,,	*Bell Cat*	,,	19.3 ,,	4.55 $\sqrt{L}$,,

COMPARISON OF TANK TESTS AND " K " METHOD

Tank test data for speed $2\sqrt{L}$ knots can be examined with special reference to the drag/weight ratio. If this is excessive, one would suspect that the model showed an exaggerated " Scale effect " and was unreliable. The direct " K " method of full size resistance should then be adopted.

The " K " method gives its best results at speeds *above* $2\sqrt{L}$ knots but it should be tolerably accurate in giving a drag and therefore a full size drag/weight ratio for comparison with the observed drag/weight ratio of a model. The drag/weight ratio is assumed to be a similarity ratio.

" *Destroyer Cat.*" This is an imaginary full size catamaran 19.8 feet long formed of two destroyer model hulls. Each hull, when towed by itself in the tank at $2\sqrt{L}$ knots showed a resistance of 46 lbs. Formed into a catamaran the resistance can be estimated at 92 lbs. for the two hulls plus, say, 20% to allow for wave interference between them, giving a total tank resistance estimated at 110 lbs.

The weight of *Destroyer Cat* is 1,509 lbs., so the drag/weight ratio by the tank test is 110/1509 = .073.

Calculated by the " K " method at $2\sqrt{L}$ knots, the drag of *Destroyer Cat* is 151 lbs., giving a drag/weight ratio = .100.

There is thus an unexpectedly large discrepancy between *Destroyer Cat's* excellent and reliable drag/weight ratio on the tank test and the higher drag/weight ratio by the " K " method. Excuses for this discrepancy can be found in the fact that the tank was calm and " K " resistances are calculated for rough and tumble conditions ; that destroyer hulls are designed for particular efficiency at about this speed and that the " K " method only genuinely comes into its own at speeds *above* $2\sqrt{L}$ knots.

Prof. Nutku Model and Full Size. The model was actually towed in a tank as a catamaran and gave a drag at $2\sqrt{L}$ knots of 8.70 lbs. This gives a drag/weight ratio of .264 which is fantastically high and, if the tank test is to be relied upon as it stands, it would indicate that the full size boat could not sail at $2\sqrt{L}$ knots. Presumably, there is exaggerated scale effect and the " K " method would be preferable in this case.

The " K " method calculations for the full size Prof. Nutku catamaran give a resistance at $2\sqrt{L}$ knots of 93.30 lbs. and a drag/weight ratio of .105. This seems to be a more probable ratio and reasonable as regards full size performance.

Sken Cat. Like *Destroyer Cat*, the *Sken* model is formed imaginatively from two hulls of known tank tested resistance at $2\sqrt{L}$ knots. *Sken* is a small but heavy model and $2\sqrt{L}$ is near the limit of its speed. Results on the tank model and by the "K" method for full size give drag/weight ratios in much closer correspondence than in the two previous cases. For the model in the tank at $2\sqrt{L}$ knots, the resistance is 10 lbs. giving a drag/weight ratio of .179. The resistance at full size by the " K " method is 271 lbs., also giving a drag/weight ratio of .179.

LETTER TO THE EDITOR

Sir,

It was suggested in A.Y.R.S. publication No. 17, that a transparent polyester resin sheet might be a suitable material for making inflatable wings similar to the M.L. Utility Aircraft for use as kite wings.

I presume that you refer to the product of I.C.I. Ltd. called "*Melinex*" in the U.K., "*Mylar*" in the U.S.A. and "*Hotstaphan*" in Germany.

Although it is a wonderful material, it is very difficult to make up inflatable aerofoils from this film. The main difficulty is that it is too strong and will not stretch sufficiently to bring two edges into contact along a double curvature seam. It is also prone to permanent fold marks.

Experimenters are recommended to use neoprene proofed fabric woven from flat yarn well known under the I.C.I. trade name "*Terylene*" or "*Dacron*." Terylene is the yarn, Melinex, the film of the same material.

Neoprene proofed Terylene (Dacron) fabrics have been found to be stronger, lighter and more resistant to sunlight and oils than any other airholding fabrics. Unlike Melinex film, there is sufficient stretch for bonding double curvature seams.

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