SAILBOAT TESTING

A.Y.R.S. PUBLICATION No. 32

CHEETAH speeding at Sea Cliff Regatta

CONTENTS

PRICE 50 cents **PRICE 2/6**

THE AMATEUR YACHT RESEARCH SOCIETY

(Founded June, 1955)

Presidents :

THIS NUMBER EDITED BY AMERICAN DIVISION H.Q.

EDITORIAL

August, 1960

This publication has been written and edited by the American H.Q. of the A.Y.R.S. Unfortunately, our finances would not run to the full copy which was sent over and a very interesting article on "Analog Computing in Yacht Design" by William Baur and Walter Bloemhard has had to be held over, along with the verbatim tape recording of the A.G.M. of the A.Y.R.S.-A.S. Each was about as long as our ordinary publications. In this deferred material, some information was presented of an "Electrolytic Test Tank" in which it would appear that a model was placed in an electrolyte (tap water), an alternating electric current was then run around it and the potential found at various points in the electric field. This tank was, apparently, fully described by Bill Baur and Al Llewelyn at the A.G.M. but the verbatim tape recording does not bring out the nature of the tank well enough to make sense to someone who was not at the lecture. We hope these two gentlemen will prepare an article for us.

New York Vice-Presidency. It is with regret that we have to announce the resignation of Victor Tchetchet as Vice-President of the New York area. However, he remains as a contributing member of the A.Y.R.S.

The A.Y.R.S. 7 foot Tunnel. Owen Dumpleton has undertaken to organise all the working parts of an approximately quarter scale model of the Yacht Wind Tunnel described in publication No. 24. Already, he has mounted the 35 h.p. Austin 7 engine and got it going; he has designed the fan and is in the process of making it. But perhaps of most interest is the fact that he has made a cheap and sensitive anemometer which is believed to give accurate readings down to very low wind speeds. It depends for its action on the cooling effect of the windflow upon a heated element.

We now need to organise the construction of the tunnel and, if any member or members would be prepared to come to Woodacres to help to make it, quick progress could be made.

The Bruce Tank of Publication No. 30. A great deal of interest has been taken in the "Laminar Flow" test tank devised by Edmond Bruce. He has had many letters from universities and yacht designers as well as amateurs, in not one of which has there been technical criticism. However, there has been a wish expressed for details of full size confirmation and he has now sent me this which he has obtained by towing tests from a power boat. The correspondence between the predicted performance from the model and that of the full size boat is perfect. The full details will be given in a future publication. At least two " Bruce Tanks " will be made in England this year.

Fibreglass Supplies. John D. Graham, GRAMPIAN ENTERPRISES, Gatherick, Duddo, Berwick-on-Tweed, is prepared to reduce the prices of materials to any bona fide experimenter who wishes to make a boat of plastics. Mr. Graham has been most helpful in publicizing the A.Y.R.S. in his district.

Atlantic Trimaran. I am sure the A.Y.R.S. will join with me in congratulating Arthur Piver and his crew on their Atlantic Crossing in *Nimble*, his 30 foot trimaran in 26 days at sea. They averaged 135 miles per day.

Leaving Massachusetts on May 11th, they had three light days followed by ten days of N.W. gales. At first, they trailed warps from the stern but found the steering sluggish so they took them in and ran under the jib only. Eventually, they surfed happily down the fronts of the gale waves and, toward the latter part, even went at an angle to get more on course, at the same time getting greater speed. On several occasions, an untrue sea swung the stern round and she broached-to at some 14-18 knots. When this happened, the following sea struck the weather float a blow which drove the craft some two feet to leeward, heeled them to an angle which they think was 45° and then broke over the boat. Only at that moment did anything ever fall off the cabin table.

Even in beam seas, the boat apparently never assumed an angle of heel. It appeared to go straight up and down. We feel that this was because the acceleration and deceleration of the wave motion horizontally nullified the angle of heel to the observer.

Because the N.W. gale had driven them south of their course, they put into Horta in the Azores but still maintained a speed of about 100 miles a day in the light winds of the Azores " High Pressure System." Leaving the Azores after a five day stop, they again had gales and strong winds on the rest of their passage to Plymouth.

Conclusion. Arthur Piver's *Nimble* is a fully seaworthy boat which gives an upright ride of far less motion and far greater speeds than the conventional cruising yacht of the same length and much larger. Manoeuverability and comfort underway were maintained even in gale conditions. Nothing broke or carried away, though the wire span for the shrouds stranded a bit and was replaced by chain at Horta.

Dan Campau is now finishing a cruising trimaran of the same general configuration as *Nimble*, using a Prout *Flamingo* hull and almost identical floats to *Nimble*. The plans show a lovely boat. Dan intends to take her across the Atlantic by the Trade Wind Passage in the future.

The Padang Design of A.Y.R.S. No. 30. George Benello, who crossed with Arthur Piver, criticizes my *Padang* design for not building out the bunks over the water between the cross beams in order to give free passage along the main hull, a feature used by Dan Campau in his craft and by George himself in his *Nugget* (A.Y.R.S. No. 27). This would definitely improve the accommodation at the expense of weakening the main hull somewhat.

JUMPAHEADS v. SHEARWATERS

A Letter from Roland Prout

Dear Sir,

The 1958 Hayling Island series was won by me in a very battered standard *Shearwater* which I came to Hayling to collect. It had battens hanging out of sail pockets and many other items needing attention. I was carrying a lady crew not strong enough to handle the jib sheets in the prevailing conditions. Chris Hammond did win one of the races in this series in a specially lightened *Jumpahead.* All credit to him for sailing a fine race but other races during this weekend were also strong wind races and the *Shearwater* won. John Fisk also had his own troubles and in fact retired half way through the race in question.

Now to the claim that *Jumpahead* was faster than *Shearwater* in strong wind reaching in the 1959 *One of a Kind.* First let us say that *Shearwaters* beat Chris Hammond's *Jumpahead* in five races out of six in the series. Chris Hammond's specially lightened *Jumpahead* did come in in front of the standard *Shearwater* in No. 2 reaching race, but then so did the smaller *Swift* catamaran, which came in 3 minutes, 40 seconds in front of the *Shearwater* and was only 1 minute 50 seconds behind the *Jumpahead* after about 1 hour's sailing. I do not know what happened to the *Shearwater* because certainly she is not slower than a *Swift* in any conditions. Incidentally, *Swift* beat the *Jumpahead* in the 4th race with *Shearwaters* coming ahead of both boats. This does not therefore prove *Swift* to be as fast as a *Jumpahead.*

I am sure it will be agreed by all, that even considering the above events, it follows that the A.Y.R.S. statement that *Shearwater* is only the barest fraction faster than *Jumpahead*, was in fact an understatement.

Roland Prout.

GENERAL ADDRESS BY PRESIDENT

A.Y.R.S.-A.S. 1960 A.G.M.

(Re-written and abridged)

Dear Members,

The A.Y.R.S. is now in its 5th year and the American Division in its 4th year. The American Division is now about 400 members strong. Its growth has been slow but extremely steady, and it was achieved without benefit of advertizing. This circumstance surely is an index of the appeal which the group has. So far, the appeal has been almost exclusively for catamaran adherents. And it is based on solid facts. We—in the A.Y.R.S.—do not claim to have invented the catamaran, or even to have modernized it. The catamaran is presumably as old a form as the history of ships is. It was brought to quite a high state of development by Polynesian migrants and it enjoyed a brief interest in Europe, after its discovery.

The modernization of the age-old sailing catamaran is unquestionably to the credit of three workers : Nathaniel Hereshoff, Woodbridge Brown and Roland Prout. Unfortunately for Hereshoff his effort came at the wrong time in history. This was not so for Woody Brown and Roland Prout. After their initial success many others have joined in and each of the newcomers have contributed some improvement. But the art of modern catamaran design is still extremely ill-defined and it has—as many letters in our files testify—been the experience that good information was not to be had, not even at the fountainheads of the developments.

It is in this area that the A.Y.R.S. has done very good work. Repeatedly we are pleasantly surprised by unsolicited comment to the effect that " the only place in the world where you can learn something about catamarans is at 143 Glen Street, Glen Cove, A.Y.R.S. headquarters." Such remarks are made in California, the East Coast, in Brazil, even in Saudi Arabia and the Philippines. And we in the A.Y.R.S. are justly proud of it. Let me add immediately, that it has never been so much 143 Glen Street from which the information on catamarans has come, but Dr. John Morwood, Woodacres, Hythe, Kent, Great Britain. We should all recognize the terrific job that he did in collecting the data which has been put down in the 31 books which have been produced so far. Indeed, as I have said before, John Morwood has been and remains to be the soul of A.Y.R.S. and even now, if we were to do without him, we would stand an excellent chance of collapsing forthwith.

Two years ago a policy was formulated, whereby it was agreed that the British editor would continue to stimulate general membership interest through the bi-monthly publication, while the American Division would try to get well-organized scientific research going. After all, if we call ourselves a Research Society we had better do some. Since then the British group has announced that it, too, plans to acquire scientific apparatus and undertake research work.

The experience we have had here in promoting the idea, has provided us with definite clues as to how we shall obtain our objectives and when. The main lesson we have learned is that, unless we display a great measure of dogged determination, which will prevent us from giving up and going away, we shall *not* succeed. On the other hand, if we stick to our objectives, I sincerely believe that in time we will succeed in growing into a real research society. Not only that, but that we will become *the* research society, which a number of outstanding people have said they would like to see, but which so far has always remained a hazy image. This implies first of all that we prove conclusively that we can be *the* society.

I shall try to summarize briefly the course that the American Division has taken in the 2 years since it drew out its guiding line. At first, we tried to appeal to the greater membership for a concerted effort in winning new members and in organizing local groups which we thought would debate and take on suitable group projects, under their own steam, Undoubtedly, this effort was a glorious failure. It is clear now, that with members being all busily occupied with this and that, mostly the vital business of making a living and squeezing some fun out of it too, A.Y.R.S. projects—in addition—would lay a little heavy.

The booklets still form—and probably will be forever—the backbone of the Society, which is why I said, that Dr. Morwood—who edits these booklets—is the soul of the Society. " Without booklets, no Society," you might say in truth. So we have given up this line of group projects etc. but we did not give up our objective. And it appeared that among the many members, there are a few who on the strength of a personal inclination will stay and work for, and with A.Y.R.S. and this is after all just as good and would serve the purpose equally well, provided—and this is our problem now—there are some funds for these people to work with. The only way by which we can get funds is by having many members. And while the inflow of new members is pretty steady, it is also very small. It seems then that the one way to get more members is to expose a vast number of people to the existence of the Society, as would be possible if we had an exhibition on say the New York Motor Boat Show. That is how the British group got its 500 members and that is how we might get the 2,000 members or so, that we need in order to do some worthwhile research. So, the thought of going on one or more Boat Shows is very strong in our minds. However, since the " care and feeding " of the American Division is practically the sole responsibility of me and the secretary-treasurer alone, it may take a while before we actually will erect a booth on a Boat Show, and we are naturally open to suggestions and/or help!

Some time ago we wrote a letter to the Netherlands, which carried the message of A.Y.R.S. and advanced the idea of a Dutch Division. We got a favorable response at that time. Unfortunately, due to all kind of matters of immediate import the matter lay there for a while, unattended. Recently, we renewed the contact and it appears that the good-will is still there, for which we are thankful. We are therefore looking forward to welcoming a Dutch Division soon. It will undoubtedly improve our muscle tremendously. There is a lot of fine intellect in Dutch sailing circles, we know, and we would surely like to have it with us in the Society.

Our other main concern is that, if we are to do research, it must be worthwhile research. We would rather wait a few more years while slowly building up strength, than move too quickly and do things on insufficient resources with the end-result of not having done anything at all. Neither is there any need to hurry. The things that Von Schullman, Frey, Davidson, Sopwith, Burgess, Currey and others wrote 20 years or so ago are still as good today as when they were fresh in print.

So, we suffer no anxiety on that score. In view of this requirement for accuracy and thoroughness, I wanted very much to go and see for myself just what installations were available within A.Y.R.S., and whether we could do anything with them. This was early last year.

Those members who have been with us for a while will remember the study program which we formulated for the American Division. We are still holding on tight to this, even though progress is mighty slow for the reasons given before. Be assured however that we will carry it to completion, if it takes us 10 years to do!

I will re-state this program here for the benefit of the newcomers:

(1) A parametric study of the sailing catamaran, including tests on a systematic series of hull forms.

(2) A study of the possibility for employing analog computers in yacht work.

(3) Design and construction of a semi-automatic open air sail test stand for extensive studies of yacht sails.

(4) Construction of an electrolytic tank for balance calculations (new program point).

It was mainly to see whether we could do anything to advance the above program that I asked the general membership meeting which was held in Glen Cove on 25 April 1959 to approve a trip to Chicago, Detroit and Pittsburgh for this purpose. The approval was granted. In Chicago I looked over Mr. Mehaffey's recirculation-type test tank.

A report on this trip, as far as RCT testing within the cadre of the study is concerned, will be found in " INTERIM REPORT ON PARAMETER STUDY OF THE SAILING CATAMARAN " (*A.Y.R.S.-A.S. 1958 study program*). This report is at present being prepared for the printer and will shortly be available as a special A.Y.R.S.-A.S. publication. The report will contain a rather complete discussion on the current " state of the art " in catamaran design. An outline of the projected tests for this study will be given in an appendix.

In Detroit I was shown the analog computer installation and had some good exchange of ideas with members Bill Baur and Al Llewelyn. Analog computing is not anybody's work and all we can report here is that we are doing the best we can to go ahead with it. If we are not going to succeed with this installation and its crew we will never succeed at all.

In Pittsburgh I met Frank McMurtry, who is to build our sail test rig. The impression was definitely one of great competence and the facilities at Mr. McMurtry's disposal are more than adequate.

The only problem here is a current lack of money for materials and parts. We hope to be over this, soon. A description of the projected rig is in this issue.

I had meanwhile contacted Mr. Bruce in Red Banks, New Jersey who for years had been doing work with a laminar-flow tank. Mr. Bruce has since then joined A.Y.R.S. and delivered a fine paper

The visits to the Bruce- and Mehaffey-tanks definitely strengthened my impression that amateur work with small tanks must be considered possible.

However it is only in the best interests of the Society to be very conservative in these matters and to refrain from hurriedly rushing into expenditures of time and money, before the returns are fairly certain.

I *do* expect that in time the American Division will have at its disposal a small test-tank, which based on the excellent pioneering work of Messrs. Bruce and Mehaffey, will stand as a fully reliable, scientific tool.

We have—since the program was formulated—added a new point. This concerns an electrolytic tank, which we hope to use in studies of hull-balance (of sailing yachts). This tank is now under construction by Bill Baur and Al Llewelyn and we will in time report on it.

As you can see, it is not an easy path that we have chosen to go, but we are rather unconcerned about its outcome and are slowly, but surely, advancing towards our dream for A.Y.R.S. The dream includes a modest, but nicely made-up office headquarters for A.Y.R.S., which will have a well-stocked technical library. It will be a place where everybody can drop in to get himself a reference-book, to talk, to work or to just hang around and enjoy it. It also includes a little machine shop where we can work on crazy ideas ; maybe a boat or two on the moorings for members to have a day's sailing. The dream includes . . . well many things? Will we ever succeed and when? Oh, well, why worry about it! Whatever will be, will be!

To save time and space now, we will hold off on a few matters. They will be dealt with in a mail-referendum to be put out some time soon. They concern the newly written Constitution and Bylaws, which were never formally approved ; the question of electing new officers (are we running again? You bet!) the financial report read at the last meeting and the minutes of the previous meetings which have never been passed. As Bill Cox jokingly said at the last meeting: " We ought to fire you for the way you are doing things." Well, admitting that I am a " bum " on corporation laws and parliamentary procedure, I still mean to do it right . . . so we will smooth the wrinkles out in a little while.

THE 1960 ANNUAL GENERAL MEMBERSHIP MEETING OF THE AMERICAN DIVISION

The American Division had its annual meeting on Saturday, 21 May, 1960, in Kings Point, Long Island, N.Y. The turn-out was not overwhelming ; 23 members and guests attending the evening and about a dozen who went on the towing tank excursion, which took place during the day. On the other hand, some members came from as far away as Chicago, Detroit, Philadelphia and Toronto and all who did come agreed that it had been a nice and instructive day. It started off at 10 a.m. in Kings Point, where members arrived to take a charterbus to the famous Davidson Laboratory of the Stevens Institute of Technology in Hoboken, N.J., where the group was to see a demonstration of yacht model testing. On arrival we were greeted by Mr. Paul G. Spens, staff-member at Stevens', who kindly gave of his free time for this. Mr. Spens led us inside the building where the so-called " small " tank is located. This tank is semi-circular in form, about 9 ft. wide and 100 ft. long. Models of about 3 at 4 ft. waterline-length are tested there, using sand-strips on the bows for induced turbulence. The tank room is an experimenters' delight. Models of famous yachts including " Ranger " are stored in racks overhead, and one wonders what exciting work goes on here on seeing the collection of mathematical ship forms, bulbous bows, various types of barge forms, model propellers etc. which lay all around. The atmosphere is most delightful. It is quiet in there, not the quiet of a lonely and deserted place, but the quiet of a place which knows dedication but no conflict ; a place of thought, of a wealth of past achievement and of permanence. The permanence which is in pure knowledge and truth, but never in fickle appearances.

Standing at the head of the tank around the model the group heard Mr. Spens explain the purpose of model testing, the fullfilment of the prime conditions of mechanical similarity, the workings of the carriage with its dynamometers and the equipment on the model. Mr. Spens did so in a most lucid manner, progressing orderly from point to point, and responding willingly to questions. His perfect, unhurriedly spoken English farther reinforced the general impression of clarity.

He explained how the model was positioned under the carriage ; how by trial and error the heel angle is set until the model—experiencing some vertical lift on the keel—runs at the intended angle (10°, 20° or 30°) and how the leeway is adjusted until the model supports the applied lateral force, at the given speed. Also how the lateral force is applied and how with the help of mirrors and light-beams the correct position of the pan for the weights representing lateral force, is found.

After the model is so positioned—which may take 2 or 3 trial runs with the test engineer walking briskly alongside the model and observing its position—the test can commence. The test engineer now takes his station at the end of the tank near a stop button, while an assistant starts and slowly accelerates the carriage. (Speeds can be varied by switching to different gearing ratios of the drive).

When the model passes the observer, it will have settled down to a steady running condition and a reading is taken on the long dynamometer. The carriage is immediately thereafter brought to a gradual but rather short stop. A standard 2 minute waiting period between runs will allow the water in the tank to come to rest. There are also washboards at the sides of the tank to minimize slop. As many runs as required are made. At each speed 3 different lateral forces are usually tried and at each heel angle 3 different speeds. It may take several hours to complete a full heeled test. Mr. Spens then took the group in an adjoining office where there was a blackboard and explained the use of the standardized S.I.T. sail force (Gimcrack) coefficients, how they were obtained at the time and how they are, under suitable assumptions, used in all SIT tests to determine the best speed made good to windward, as well as to link the heel angle to the wind vector. In this procedure the specific value of ratio of longitudinal to lateral forces, obtained in test is used to enter the Gimcrack tables, which will give the angle ($\beta + \lambda$) (angle between course and apparent wind). The well known velocity vector diagram then produces true-wind velocity, angle of true wind to ships head and speed made good. This calculation is repeated for each of the three speeds normally run at each heel angle, and the envelope touching these curves (V_t on basis V_{mg}) gives the optimum close-hauled performance. All these points are explained in detail in S.I.T. Note No. 509, " Sailboat Test Technique " by Paul G. Spens, which can be bought from the S.I.T. Davidson Laboratory, Castle Point Sta, Hoboken, N.J.

With this discussion the excursion came to an end. It was a very interesting and instructive excursion for the group, especially since we aspire to engage in yacht research ourselves, and could here see with our own eyes what model testing involves in the way of outlay, procedure, mental effort, accuracy, etc. What strikes the visitor especially is the complete ease and modesty with which the tank people discuss the meaning of their work, the accomplishments as well as the limitations.

To be able to talk with complete sincerity in uncomprising adherence to truth, is the first law for any scientist. It should also be the ideal for every civilized person, no matter what field of endeavor he is in. Alas, too often one finds today—in commerce, in politics, in human relations, yes, even in science and technology—that this is not always the case.

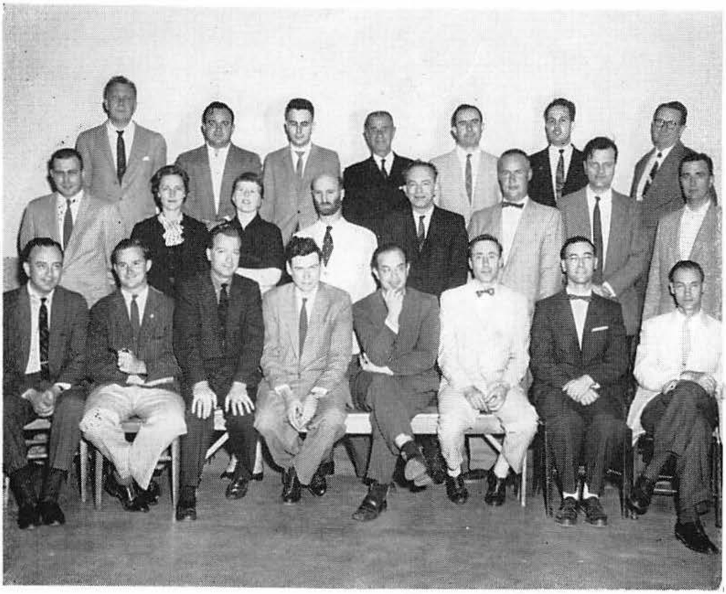
After a stop for lunch in the midst of the hustle and bustle, which is the glorious city of New York, the group returned to Kings Point, by now running considerably behind schedule. Catamaran demonstrations were under way there, with the boats docking in front of the beautiful and restful community beach-park.

Four of the latest American catamaran models were available : *Shere Khan*, Commodore Robinson's (Bayside Yacht Club) Tiger-O.D. class boat, one boat of the *Cheetah* design, a *Waverider* and an *Aerocat*. For most of those present, including the writer, it was the first opportunity to take a ride on these boats.

Tiger, famous by her exploits at the Miami One-of-a-kind regatta in February 1959, where the catamaran age broke for the U.S.A., represents the crème-de-la-crème in this field. It is true that faster boats have appeared by now, but for soundness of construction, and class-organization the *Tiger* one-design boat still holds out as the queen of the daysailers. It is little wonder that the class, under the firm leadership of catamaran ace and chief promoter Bill Cox, and class secretary Bob Smith, has grown to include some 70 boats, within the space of 1 year. We are confident of a great future for the boat, and she deserves it. Whenever people like Cox and the Pearson Corporation who builds them, work for a dream the way they do, they deserve success and it will come with or without praise on the side.

Cheetah is a good-looking little racing catamaran, capable of quite some speed, and apparently her designer's pet. The cockpit-size is just right for " a man in a boat," but it is by design a two-seater.

Waverider and *Aerocat* are representatives of the latest trend toward more diversification and general usefulness of catamarans. Not primarily designed for speed, they have each a unique feature of interest to offer. *Aerocat* has immense transverse stability, and a very roomy cockpit, while *Waverider* can be completely dismantled which of course simplifies the transport problem. Both boats behave very well over the range of windspeeds, notably at the lower end of the scale and as such they represent progress. The " Aeronautical " Inc. people especially are very dedicated and have worked hard at their product. I have no doubt they will succeed. For their good-spirited cooperation in the day's program Messrs. Harris, Lyman, Robinson and Smith deserve the sincere thanks of the membership.



L. to R. Top row : Lyman, Guest, Guest, Comm. Tchetchet, Rickert, Boronico, Comm. Robinson.

Middle row : Llewelyn, Mrs. Stoddart, Mrs Bloemhard, Spens, Mehaffey, Baur, Andrews, Broggini.

Bottom row : Stoddart, Robinson Jnr., Smith, Glenn, Bloemhard, Harris, Wagner, Cox.

The members reassembled again later in the evening in a meeting room inside the U.S. Merchant Marine Academy at Kings Point.

Don Broggini, member, had been so kind as to bring his tape recorder, surely the best way to preserve proceedings of a meeting for a later date.

The meeting opened with an address by the president. Mr. Mehaffey, Vice-President of the Great Lakes Region, then talked about his work with a recirculation tank.

Bill Bauer and Al Llewelyn talked about the electrolytic tank which they are constructing for A.Y.R.S. and Walter Bloemhard about the proposed sail test rig. It will be noted that things move rather slowly in the A.Y.R.S., since these same things had already been under discussion one and two years ago. However this is what can be expected. There are as yet no funds for research and as long as we number in the hundreds rather than in the thousands, things will proceed at a slow pace. However, as said before, we are confident that in time we will get all the members we want. The recipe here is : " Don't go away and never give up." The meeting was again very typical of this early stage of the American Division. So far there has been a total of 5 meetings, viz. the charter meeting in Great Neck, L.I., N.Y., February 1957, two meetings in Glen Cove, respectively in 1958 and 1959, one in Chicago (December, 1959) and finally the present meeting in Kings Point. The Great Lakes Sector had a few meetings of its own. At least one more general meeting is planned for 1960, which will either be in the Great Lakes region or in California. The meetings are as a rule highly informal.

Speeches are made rather than papers read, interruptions from the floor are frequent, the fine points of parliamentary procedure are often missed. However amusing and disorganized they may be however, they truly represent the youth of a Society, which being active in a very apart corner of this already exclusive " business of boating " finds the going rough. It is therefore all the more remarkable that the Society keeps growing in this country—at a slow but very steady rate.

One thing seems sure, it will not fade away, as did some other kindred organizations in recent years. More than that, its growth seems assured and one may confidently look forward to the time, when the Society will count among its members many thousands of the country's yachtsmen and small-boat sailors, when it will have its own experimental laboratory, library and office headquarters ; its own test vehicles and waterfront workshop.

I imagine that our findings will by then be presented in solemn voice, after advance circulation so that they can be subjected to serious debate, all of it to be neatly preserved in voluminous yearbooks. Yes, that is the goal all right. But we will still miss the charm and genuine atmosphere of the early, chaotic meetings.

THE RECIRCULATION TANK

By W. R. Mehaffey

The problem of predicting the tow resistance of a new design from tests of a scale model has been one of the greatest marine challenges.

The tow resistance of a ship consists of the viscous shear of the water along the wetted surface of the ship, the eddy resistance due to flow separation, and wave making resistance due to the effect of gravity on the surface water which tends to return after being given a dynamic head or elevation when the bow wedge enters undisturbed water.

The great English mathematician William Froude was the first to propose a logical method of handling this problem of ship and model testing. He divided the tow resistance into a skin friction part and a residual resistance portion which consisted of wave resistance and eddy resistance. He made three basic assumptions which were in his time very controversial. The first assumption was that the tow resistance could be divided into two parts and these parts could be treated independently. The second assumption was that surface tension could be neglected. The third assumption was that a plank test for skin resistance could be used to evaluate the skin resistance of both ship and model. The best justification for his three assumptions is that correlation of the results with many full scale tow tests shows good agreement.

The assumption that the skin friction can be obtained from plank tests of course requires that the flow around the model and ship must both be of the same type. That is, if the ship has a turbulent flow we must be sure that the model also has a turbulent flow or the analogy breaks down.

The neglect of surface tension is of little importance when large models are used, but can cause some trouble if very small scale models are used. The small model may have a bow wave which tends to cling to the model instead of breaking away as it would in the ship.

The normal still water tank is a long rectangular channel of considerable width and depth. A carriage is arranged on one or two rails along the tank. The models are attached to this carriage by the measuring dynamometers. The carriage and the attached model are towed along the tank and the dynamometers are read or photographed at a test point where the velocity is reasonably constant. The dynamometers must be capable of standing the required acceleration and deceleration at the ends of the run and still have sensitivity sufficient for measuring the small tow forces.

Although the cost of such an installation is well within the budget of governmental agencies and colleges, it is too high to be justified for the average design office or amateur research group.

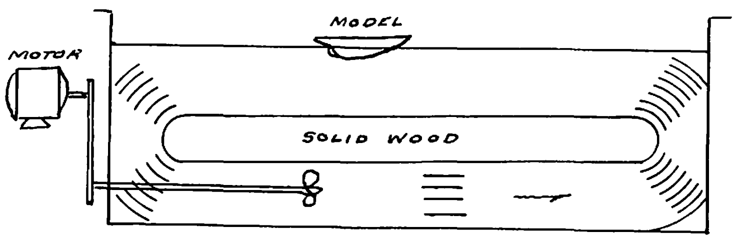


Fig. 1. *Vertical cross section of RCT.*

Since we specialize in unusual designs some form of tank was essential. During the war I remembered some work done at the David Taylor Model Basin on a recirculation or moving water tank and decided to try a small model tank in order to obtain data for the design of a larger tank.

The outstanding advantages of the recirculation tank are as follows:

1. The dynamometers and model are at a fixed position and can be readily adjusted during a test.

2. Since only the water is accelerated and decelerated a relatively short tank should be effective.

3. Waves can readily be produced by modulating the drive or the resistance to flow.

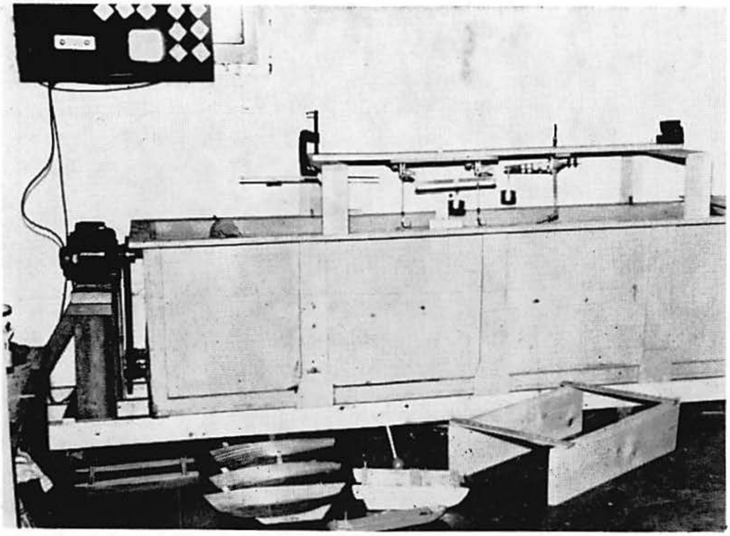
4. Since a fairly high order of turbulence will result in the water the conditions should be closer to actual sea where the water is rarely free of turbulence.

5. When small models are tested the water turbulence may be sufficient to make induced turbulence unnecessary. Our work to date indicates we still need induced turbulence.

There are several disadvantages of the RCT when compared to the still water tank :

1. A still water tank requires very little horse power to pull the carriage compared to that required to move the water at the same velocity.

2. It is fairly simple to know the velocity of the still water tank carriage when compared to measuring the velocity of moving water.



Recirculation tank with dynamometers for tow and lateral forces.

3. Although from theoretical studies the resistance of a model should be the same if the water moves or the model moves relative to the water, experimental evidence shows that there is a slight difference due to the type of eddy or vortex formation. The moving water system forms a more stable vortex or eddy pattern and offers slightly higher resistance usually of the order of 3 to 5 per cent for this portion of the total tow resistance.

4. In the RCT there is always a hydraulic slope to the water surface so the model must always be free floating on its designed LWL and the tow bar will receive a component force due to the model weight and water slope. In practice this effect is not serious except at very high speeds.

After considering the advantages and disadvantages of the two types of tank we decided to try a model RCT.

The first step in designing a tank must be to determine the width and depth of the cross section. From the literature on flow in open channels waves can be expected when the water velocity reaches a critical value which depends on channel depth.

The relation is as shown below.

$$\frac{V^2}{2g} = .5D$$

Where D is the depth of water.

Thus we see that we must pick a depth of water which is ample to be well below this point at our maximum test velocity.

The second problem is width of channel. The literature on this subject is not quite so convenient. Early papers on tank cross section indicated that a tank width four times the model beam was satisfactory but failed to state whether this gave quantitative results or merely suitable appearance to the waves around the model. Dr. Davidson gave a criteria that the channel cross section must be at least 100 times that of the model section.

Since this first RCT was to be a model tank for studying the problem, we made the width of measuring channel three times the depth.

Since the horse power available was limited, we made our model channel 18 inches wide and 6 inches deep with a length of eight feet. Two propellers were used driven by variable speed dc motors through 2 to 1 reduction gear. We can reach a maximum water velocity of five feet per second.

The wave making point occurs in the range between 3.5 and 4 feet per second which agrees well with the equation given above. There is considerable turbulence in the boundary region at the sides of the tank.

We ultimately hope to eliminate the boundary turbulence by one of the following methods.

Dr. Lloyd Lewis, one of our members, suggested making the bottom and sides of the channel of rubber belts travelling at water speed so the loss of energy at the walls would be minimized. This approach has not been investigated but has many merits if the speed can be synchronized.

Another approach which we have considered is due to Prandtl. The sides and bottom of the measuring channel are provided with small holes through which the slowly moving water particles are removed before a counter flow at the walls can start.

A third possible solution is to line the channel with the new synthetic porpoise skin anti-turbulence material which Goodyear is presently developing.

The basic configuration of the tank is shown in the photograph and Fig. 1. The cross section is rectangular with width equal to three times the depth. There are four turning vanes which turn the water through 90°. These turning vanes are of course critical and we are presently on the second set.

The practical top water velocity without serious wave formation is three feet per second. With the small models we use this is satisfactory for hull speed of conventional types and to about $2\sqrt{L}$ for catamarans.

The next problem was to measure the velocity of the water. Pitot tube measurements in this velocity range were found to be unreliable although several elaborate systems were tried. The use of

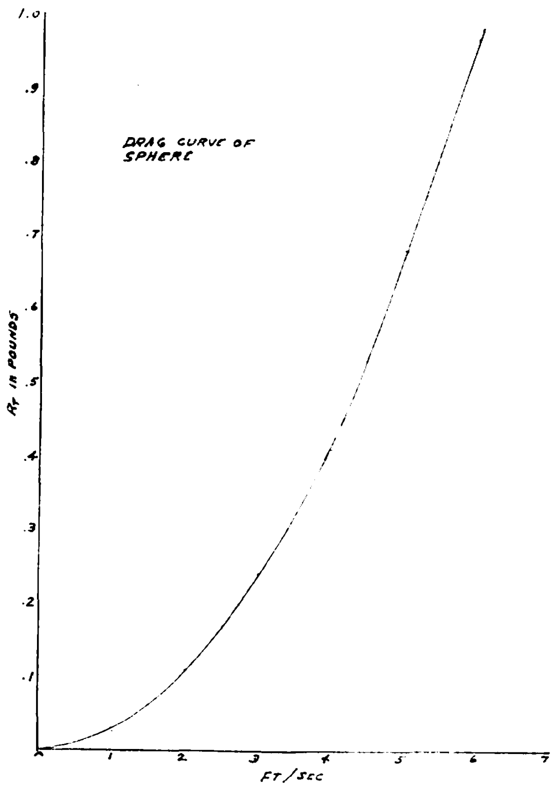


Fig. 2. Drag curve of sphere.

hook gauges to determine the hydraulic slope of the channel and calculating the velocity from the head was found to give velocity values which agreed closely with the best of the Pitot measurements.

In order to check the velocity measurements a paddle wheel of undershot type equipped with a counter was tried. This was found to work fairly well over a limited range at the higher speeds but did not track well at very low speeds.

Our next velocity measuring system was to measure the drag of a circular disc normal to the flow. The drag coefficients for various size discs were available from the literature. A balance was constructed with the disc in the flow path and a level to indicate when the disc was normal to flow. A set of fixed weights for velocities in steps of .1 foot per second was then constructed. We find this method of velocity measurement to be the best system.

After solving the water velocity measurement problem, we measured the drag coefficient of submerged spheres. The drag curve was parabolic in form as shown in Fig. 2 but the coefficient was too high. From the literature Prandtl gives a drag coefficient of .5 at Reynolds number of 1 x 10^5 in a very wide deep channel. He also gives data that a sphere of one ninth the diameter of a cylindrical channel has 15 per cent higher drag coefficient than the same sphere in a channel of 14.7 times the diameter.

We next arranged to measure the sphere drag in narrow channels by dividing our channel as shown in Fig. 3. The probable error of channel width is shown in Fig. 4. The percentages are based on

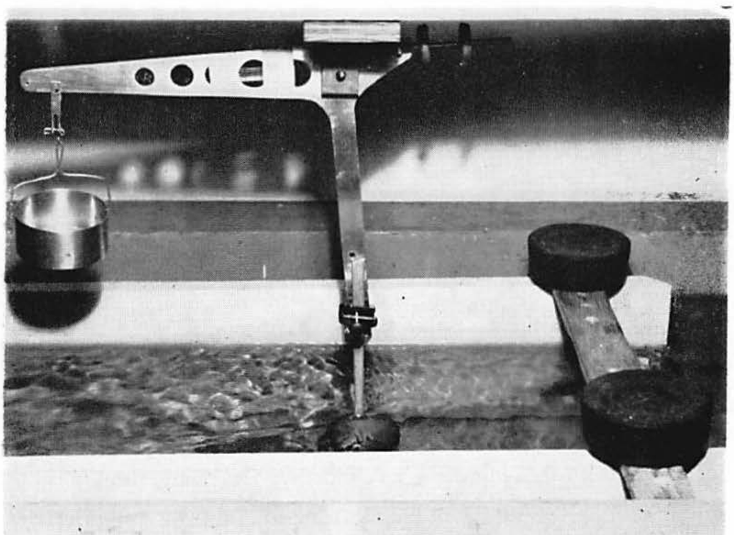


Fig. 3. Narrowing of tank to find error due to small tank width.

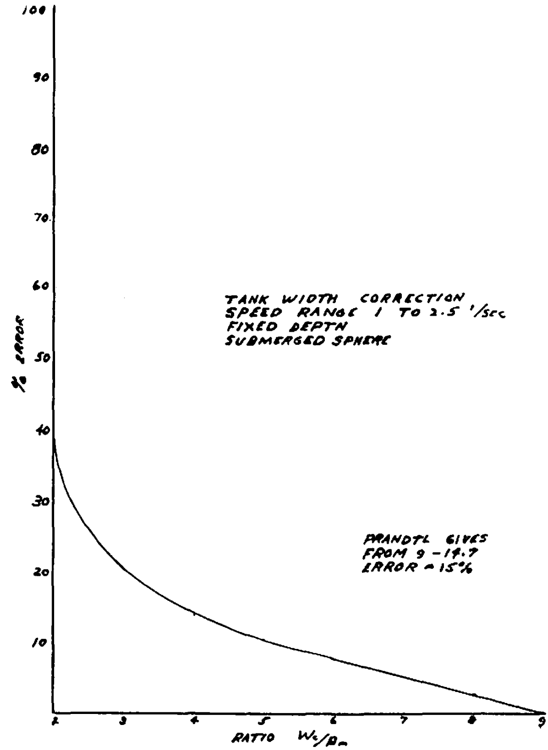


Fig. 4. *Tank width correction as a function of channel width and model beam.*

considering a channel width to model beam ratio of 9 as equivalent to open sea. The percent error in increasing from a ratio of 9 to 14.7 agrees well with Prandtl. Thus we see that the skin friction portion of the tow resistance of a body is greatly affected by channel width and depth probably has a similar effect. Since varying channel depth will produce a similar change in the resistance curve we can use the same curve for selecting depth of channel.

If we return to our test of two spheres of different diameter at the same Reynolds number and correct for depth and width of channel our drag coefficients are .561 for a large sphere and .554 for a small sphere. This is fair agreement with Prandtl value of .5. If we corrected for the vortex stability effect by subtracting 5 per cent to bring our values into agreement with the towed data of Prandtl, the agreement would be extremely good.

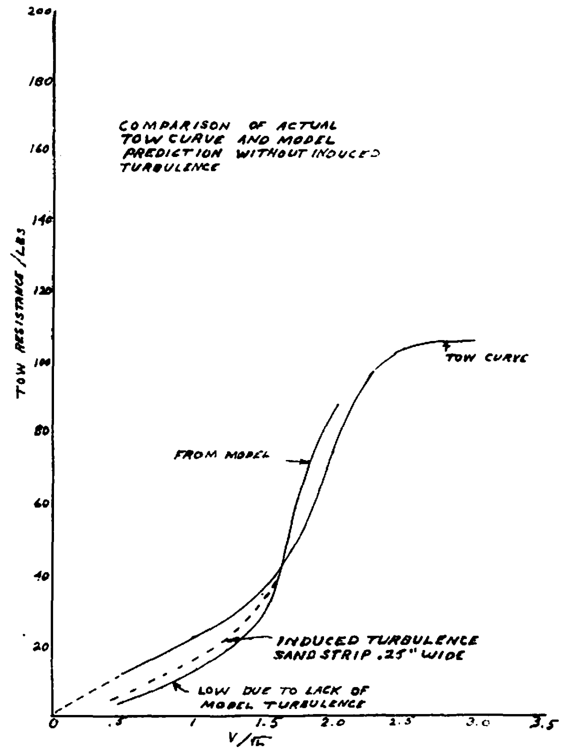


Fig. 5. Test of $14\frac{1}{2}$ *foot catamaran.*

We next attempted to find the effect of channel width on residual resistance. This problem is still under investigation as it is very hard to separate residual resistance effects from total tow resistance when the skin resistance is also effected by channel width. Preliminary tests indicate that total tow resistance is considerably less effected by channel width than skin resistance.

When the channel is very narrow, phase velocity of waves predominates and residual resistance may have large changes for small changes in channel width.

In order to test a tank we must compare against a full scale tow test. Last summer we towed a 14.5 foot catamaran to 3 $\sqrt{L}$ and measured the tow curve with a dynamometer. The speed was measured with a Pitot tube mounted on a strut well ahead of the catamaran. A 200 foot towline was used to get clear of the wake of

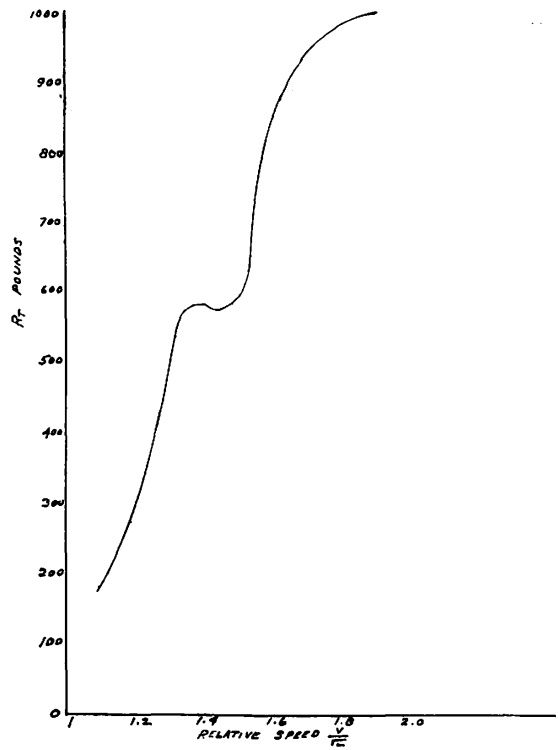


Fig. 6. *Model test of large catamaran expanded to full scale.*

the towing vessel, and the dynamometer was mounted on the catamaran to avoid measuring line drag.

The results of the full scale towing of the catamaran and the results of towing a 1/12 scale model are shown in Fig. 5. The expanded model curve was without induced turbulence. The lower speed portion tends to follow the Prandtl transition curve instead of the fully turbulent Schoenherr resistance line indicating that the model should have induced turbulence. We then tried adding sand strips as in the Stevens Experimental Towing Tank system and the dotted curve shows some improvement but was not sufficient. We are presently experimenting with sand size and strip width to find better conditions of induced turbulence.

The tow curve predicted from a model of a large Hawaiian type asymetrical catamaran is shown in Fig. 6. This curve checks well with the actual power required to reach 1.4 $\sqrt{L}$.

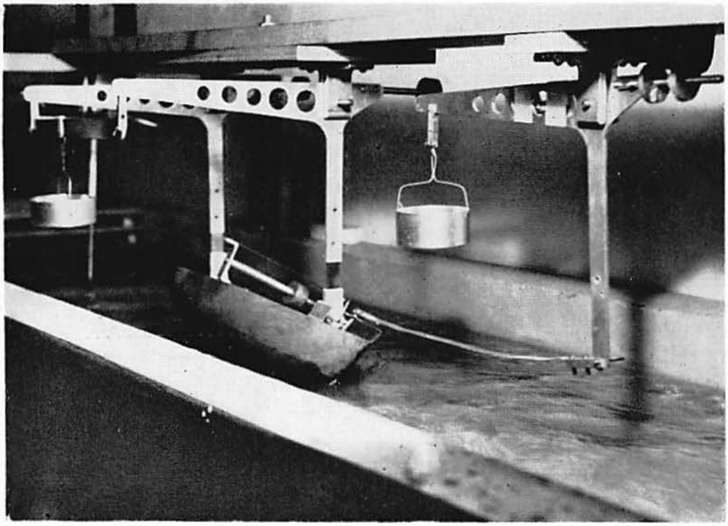


Fig. 7. Heeled test of Morc Keel Sailboat, note heeling weight and lateral dynamometers.

The upright and heeled resistance of a famous M.O.R.C. sailboat (see Fig. 7) is shown in Fig. 8. This curve is actual tow curve not expanded to full scale. We have finished testing a standard series of such hulls and we hope to test a similar series of catamarans.

The initial results from the recirculation tank are very encouraging. Although the model tank was made primarily to study the problem, it has already proven to be useful. We will complete a larger tank with a width equal to twice that of the present tank and a depth of three times that of the present tank. This will allow a top water velocity of 7.0 feet per second without waves. It will also reduce the magnitude of correction factors. The present tank requires approximately one horse power while the new tank will require 21 horsepower.

The tank will be lined with the new porpoise skin to eliminate boundary layer turbulence at the tank walls.

The recent paper by Mr. Edmond Bruce in A.Y.R.S. No. 30 on the laminar flow tank was of considerable interest because, if this system will give good results the use of models in the laminar flow range in the recirculation tank would greatly reduce power requirements, and minimize wall effects. There are several problems with laminar flow model testing, as follows :

1. Model accuracy—The models will require the use of a Gorton pantograph engraving machine to give the required accuracy. Such

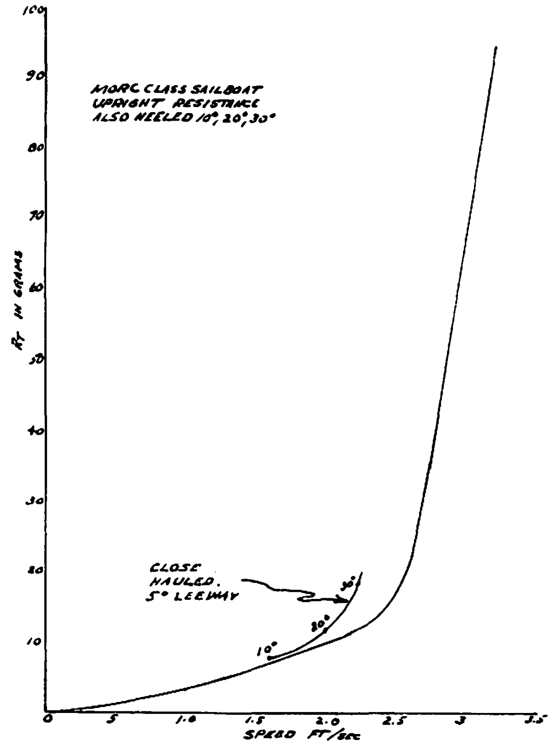


Fig. 8. *Test of a conventional keel sailboat* 3.2 *sec. corresponds to* 1.5 —*L*.

machines are available second hand in good enough condition for this work.

2. When very small models are used the wetted area exceeds that called for by the calculated displacement due to surface tension causing a wetting of topsides above the true waterline.

3. When small models are used the bow wave clings to the model and does not have the same appearance as the bow wave of the ship. A small amount of silicone grease wiped on the bow above the waterline improves the appearance of the bow wave. If the laminar flow approach is to be used we will have to correlate against a full scale tow curve to see if the greased bow is a satisfactory solution.

4. Mr. Bruce has a unique method of towing a floating plastic

skin to obtain the skin friction of the model. This skin will have a certain amount of residual resistance which will cause the model residual resistance to appear too small. It may be better to use a table of values for laminar coefficients as we normally do in the usual model testing.

GENERAL CONSIDERATIONS—SAIL TEST RIG

(*Shortened*)

The requirement is a fully automatic testing rig, which will produce a written record of predetermined length, for a range of chosen wind speeds. In order to cut cost and complication only thrust (T) and lateral force F_H will be measured, the latter on 2 scales so as to enable deduction of longitudinal position of C.E. (center of effort). Only 3 scales are needed in this case.

This rig circumvents the troubles which attend wind tunnel measurement of sails and it will utilize the natural wind.

Model size is arbitrarily set at 6 ft. on the leading edge, and only silk or nylon sails will be used. In this way it is hoped that a reasonable similarity between model and real sail will result with regard to porosity, elasticity and structural detail.

Pendulum type measuring heads will be used, because they are self balancing. The thrust will be applied to a platform scale which has the bearings approximately coplanar, so that it does not matter just where the workline falls.

Linkages strong in compression and shear but weak in bending will be used to properly separate the forces.

The download, trim- and heeling moments will simply be taken up by the linkages without being measured, but the yawing moment

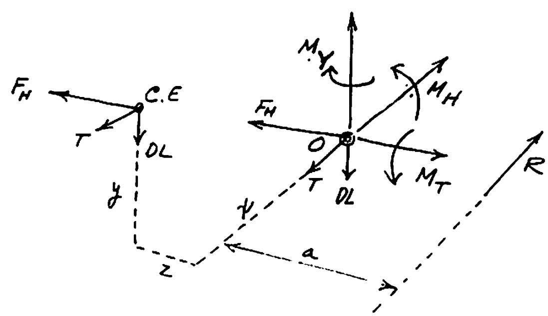


Fig. 1a. Force system of novel sail test rig.

must be compensated, so that it will not be read into the (F_H) measurements. A pendulum fixed to the casing will be used for this purpose. The forces and momentarms are shown in the following diagram (Fig. 1*a*).

The reference point (0) is aft of the model and the equivalent system at (0) is given.

The yawing moment will always be clockwise (looking down) becase $F_H \times \gg Tz$.

The necessary moment Ra = My must be supplied by the pendulum.

Counterweights and stops must of course be used to obtain a null setting before wind forces are applied. To save wear on the linkages, the heeling moment may also be compensated for in the same way as the yawing moment, but in both cases the stops (zero reading) will introduce extra friction forces, interfering with the (T) and (F_H) measurements. If small, this could probably be smoothed out in the calibration.

The principle of the thrust and (FS) measurements is that the small meter displacements will not introduce any appreciable errors, if the linkages are of sufficient length so that the arcs which are traced out may be considered as straight line segments. All the recording drums will be on the same shaft and the drive will simply consist of a

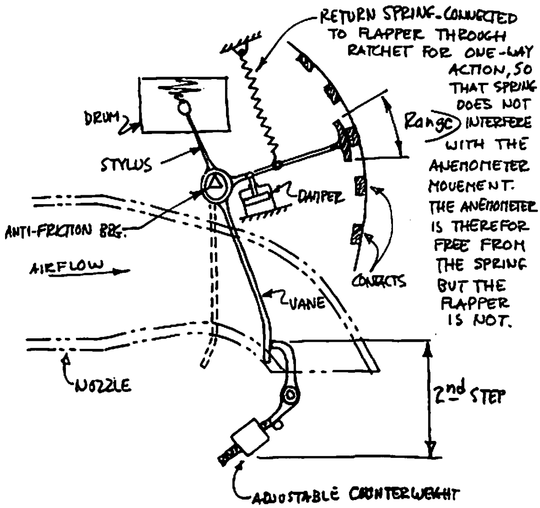


Fig. 2a. Anemometer and flapper.

properly retarded falling weight. Time progression is given on the record, but need not be converted to seconds for general studies, as synchronization only is of interest here.

The drive is started by a solenoid, which pulls out a stop. The solenoid in turn is operated by a flapper which is connected to the anemometer (Fig. 2*a*). The anemometer is simply a carefully hinged flat plate. If necessary to cover the higher range of wind speeds a second " step " can be used. The wind speeds will of necessity be high to satisfy similarity laws (Reynolds' number). The flapper will be so dimensioned and dampened as to give a small range, and so that the drive will not be started by a momentary gust. Once it is started a manual adjustment (made before the test commences) will set a limit to the recording period. The boom and tail assembly are self explanatory.

It is thought that the lag which occurs in the weather cocking movements is rather like the lag occurring in steering a boat on a constant (absolute) course and is therefore realistic.

The present rig is for a land based installation, as it is thought that a water based installation would give too many problems for a first attempt.

Screening may be added later to enable simulation of the natural wind gradient. A shroud will be used to protect the balance case from the wind and to simulate the water surface.

Smoke tests may also be performed at a later stage.

The general arrangement is as follows (Fig. 3*a*).

The platform is as follows (schematically) (Fig. 4*a*).

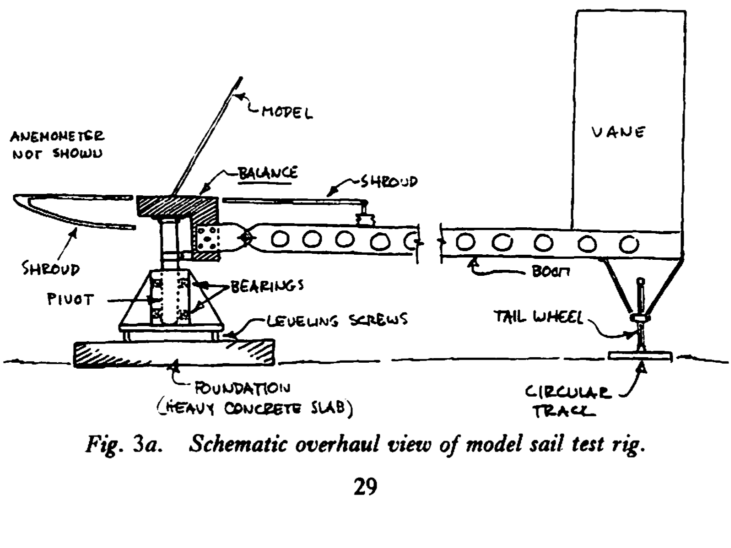


Fig. 3a. Schematic overhaul view of model sail test rig.

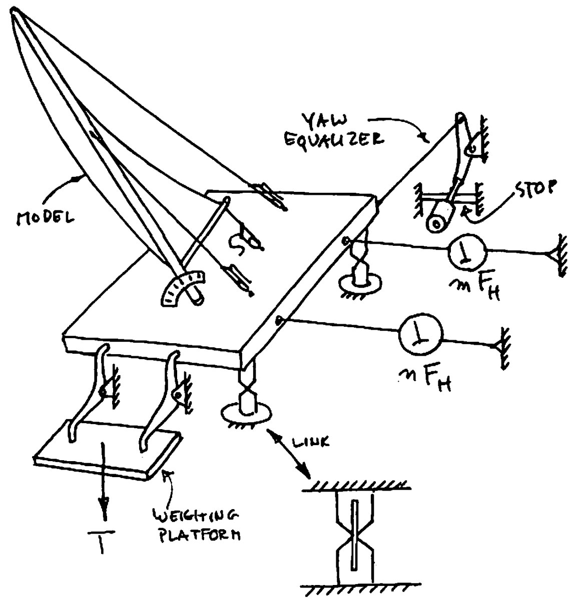


Fig. 4a. Weighing platform for thrust, and F_H measurement.

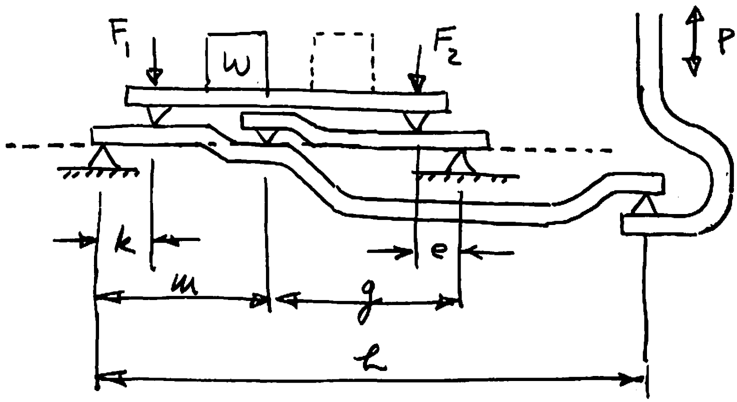


Fig. 5a. Linkage weighing platform.

The weighing platform is connected to the tension rod and the measuring head as follows (Fig. 5*a*) (taken from "Measurement Techniques in Mechanical Engrg," by Sweeney-Wiley) :

From the diagram $Ph = F_1k + F_2 \dfrac{e}{g} m$

Now if the system is so proportioned that $\dfrac{k}{e} = \dfrac{m}{g}$

$$Ph = k\,(F_1 + F_2) = kW$$

and it is seen that the relative magnitudes of F_1 and F_2 have no bearing on the result.

If necessary compound levers will be used to obtain the necessary multiplication ratios between here and the balance itself ; we will use Toledo scales whose inside look this this—Fig. 6*a*.

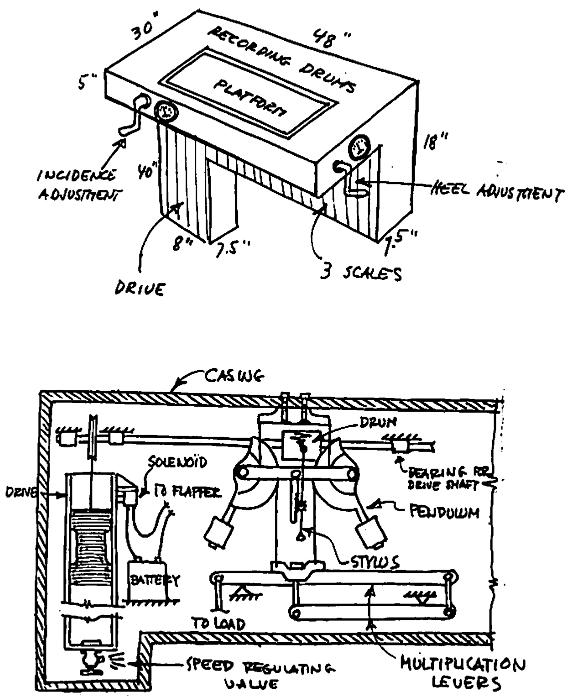


Fig. 6a. Platform and balance arrangement.

SEACLIFF REGATTA

A little while ago we had here, the first exclusive catamaran regatta on the East Coast. It turned out to be a great success, with some 25 boats appearing at the starting line. The weather was ideally suited for the event. A strong squall (abt. 30 m.p.h.) hit the fleet just before the first start and the ensuing action was worth coming from 1,000 miles away for. The cats of course began to fly like bullets, especially the bigger ones. The photo's can tell the story better than words. Unfortunately we have no space to show more than a few. The writer was on one of the following motor boats. Stanley Rosenfeld, the marine photographer was there. The pictures which are shown here has been kindly made available by him, for which our warmest thanks. Mort Lundt, reporter for Sport Illustrated was also on board and he took some footage, which he worked into a nice, little movie. He gave it to us to show at the meeting. Thanks to Mort Lundt too! Bill Cox provided us with the complete data on the final standings which goes hereby (see p. 38).

The following insights could be had from this most interesting catamaran rendez-vous.

(1) The *Cougar*—it is abundantly clear—is about the hottest cat around. The *Cougars* and *Tigers* are very evenly matched, it have been found here ; the *Cougars* seemingly having a slight edge over their arch-foes in medium winds, while the *Tigers* hold better in light and strong winds ; or so it is said. There can be no doubt that the hull form first developed by Prout (fine entrance, semi-circular midsection, flat transom) is the right shape for the racing catamaran, the difference between the *Tiger* and *Cougar* being mainly in that the *Tiger* is more solidly built and therefore somewhat heavier. It also has a wide U-shape at the transom, whereas the Prout cats carry the semi circular shape more or less to the transom, which may explain the difference in the medium speed range.

(2) While a *Cougar* won the race, the *Tigers* dominated the regatta in numbers and appearance. These—as most will agree—are the most beautiful catamaran daysailers yet seen. The workmanship is immaculate, the fittings rugged, the batwing sails perfection. The boats are plenty stable for their purpose, they do not pitch excessively, they run well in a light wind, and go to windward as well as can be expected. In all, not only a good basic design, but a very fine job of development and class-organization as well, and likely to be a standard for some years to come.

(3) There was a big catamaran in there, which at times outpaced

Cougar—The Winner.

Tiger flying a hull.

Tiger reaching off at close to maximum speed.

Log or hydrostatic pressure?

every boat in the race, by far. This was not so much surprising as that it was thrilling to see. The high speed was anticipated by most, while the boat was still sitting on the beach. Not only was it the biggest craft in the race but also of extremely light built. It gave the onlookers here an idea what the British are talking about, when they mention their latest speeders (*Thai*, *Freedom*, *Hellcat*, etc.). However, in the final race the boat floundered abruptly. It was said later that she had hit a log. Some observers on a nearby motorboat however doubt whether this analysis was correct. They never saw a log. The rupture (see photo) rather seemed to suggest that the hull was bashed in by sheer water pressure. If so, it would not be surprising since the hull consisted of a thin gel-coat and a single layer of mat, in all perhaps not more than .05 inch to .07 inch thick. The implication is clear.

To make catamarans still speedier than they already are is apparently not much of a problem. Just by going a few feet further in overall dimensions and keeping the weights at the same or even a lower level will pull the trick. Stability can be maintained in that case by increasing beam. Without desiring in the least to open up with derisive comment etc. the writer doubts very much that this is the way we should go. I am happy to know that Roland Prout has voiced concern over the question, and that there is a boat like *Tiger* around to clearly show what speed can be had with sound construction.

Last year the lesson to be learned was that catamarans do not stand a weight reduction to helmsman only in a breeze, but even more markedly is this so under light conditions, with the boat lacking headway and inertial balance when a new gust strikes, however slight. A number of bad capsizes occurred on various boats. Today the lesson to be learned, is in the methods of extremely light construction. To chuckle over experiments that went wrong, while the experimenter is acquiring new knowledge is cheap and despicable. Unfortunately, the derisive comments were not lacking last year. We have meanwhile grown a little wiser, it is hoped, and so we will now be able to look at the mishap mentioned above, with interest and eyes wide open. Undoubtedly a third generation of high performance catamarans is in the works, and undoubtedly we will see them come in time ; the highly powered hot-rodders, light and strong as big seagulls, and speedy as never before. They will outpace the current crop in just about the same way as these in turn do the planing dinghies. And when they finally make their formal entree they will stay together! Let no one complain about this drive for speed. After all, we are in the catamaran business, and " catamaran " means speed. He who does not give a hoot for speed, will buy a heavy displacement cruiser, and that of course is just fine, and the way it should be.

(4) There is a point somewhere between 12 to 15 feet or so, where the absolute speed which a catamaran is capable of, drops enough, for her to be put in one class with comparable dinghies. In other words in these sizes the advantage of twin hulls *for speed* begin to fade out. *Cheetah* definitely is clear of the line and belongs in the class of the speedsters. *Swift* seems to skirt it, while *Tiki*, *Aerocat*, *Aquacat* and *Whisker* are definitely below it. However, if speed is to be considered prime, *Whisker* certainly deserves a close look. Discounting *Cheetah*, which would—in fact—not have done badly on handicap in division I, as well as *Swift*, the *Whisker* was clearly the superior boat in class B. A very fine design indeed, considering the modest sail area, and smallness of the craft. The design was otherwise full of fresh ideas, well worth studying.

Aerocat, Broggini at the helm.

Whisker countering a gust.

It is in this area, that of the small catamaran, that there is room for loads and loads of ingenuity and study. Clearly, the advantages of the catamaran configuration still places her in a favorable position to the mono-hull dinghy. As for speed, it can be had by good design of hull-form and the right choice weight as indicated by *Whisker's* performance at Sea Cliff. There is one additional factor of considerable interest in the writer's opinion. Whereas in the bigger sizes the difference in performance between catamarans and mono-hull craft discourages all mixed handicap racing, in the sizes mentioned above, there is room for a healthy, free-swinging feud between the adherents of the two types ; a very attractive proposition on the frostbite circuit, I would say. In conclusion therefore, let me state that *Whisker* in particular and the small cats in general were by far the most interesting of the boats that came to Sea Cliff.

SEA CLIFF CATAMARAN REGATTA
May 14-15, 1960

3-RACE SUMMARY—DIVISION I

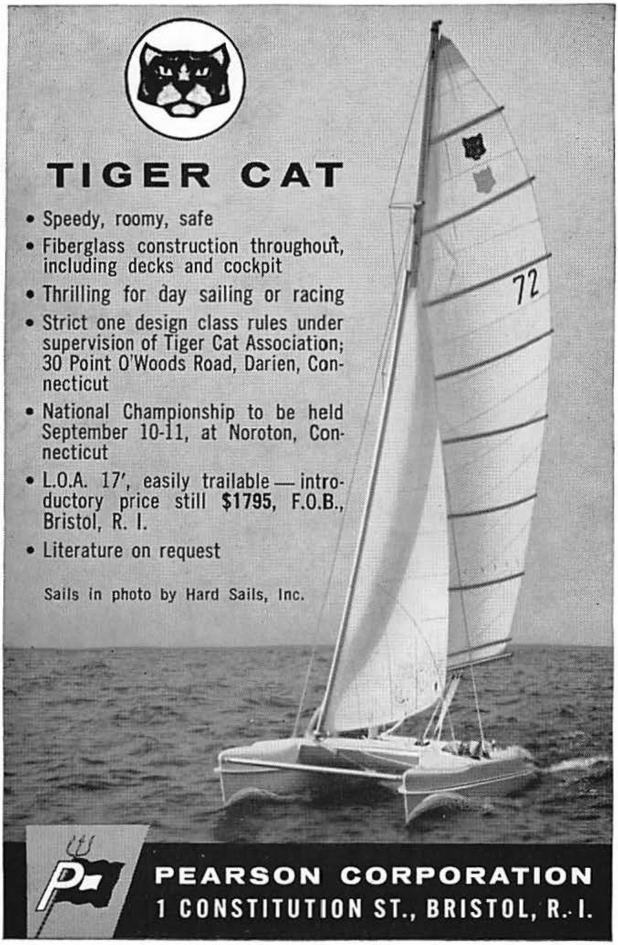
Skipper	Type Boat	Boat-for-Boat Places	Boat-for-Boat Pts*	Boat-for-Boat Rank	Handicap Places	Handicap Pts*	Handicap Rank
Cotter, E. F.	*Cougar*	3-4-1	8	3	3-2-1	6	1
Cox, W. S.	*Tiger*	1-3-3	7	1	1-3-3	7	2
Smith, R.E.	*Tiger*	2-1-5	8	2	2-1-5	8	3
Rheinberger	*Tiger*	4-7-4	15	4	4-7-4	15	4
Harris, R. E.	*Bobcat*	7-2-8	17	5	7-4-9	20	5
Robinson	*Tiger*	8-5-6	19	6	9-5-7	21	6
Blair	*Tiger*	5-9-9	23	7	5-9-8	22	7
Fox	*Cougar*	6-10-7	23	8	6-10-6	22	8
Erickson	*Cougar*	9-6-10	25	9	8-6-10	24	9
Gardner	*Cougar*	dnf-11-2	25	10	dnf-11-2	25	10
Cohn	*Tiger*	dnf-8-dnf	32	11	dnf-8-dnf	32	11
Reading	*Tiger*	dns-wd-dnf	36	12	dns-wd-dnf	36	12

* Points—total of finishing places. Lowest points win.

DIVISION II

Skipper	Type Boat		Boat-for-Boat Places	Boat-for-Boat Pts*	Boat-for-Boat Rank	Handicap Places	Handicap Pts*	Handicap Rank
Harris, R. B.	*Cheetah*	10	1-1-2	4	1	1-1-3	5	1
Ritchey, J.	*Whisker*	3	5-6-3	14	3	3-6-2	11	2
Bethge, P.	*Swift*		6-3-1	10	2	8-3-1	12	3
Broggini, D.	*Aerocat*	2	4-4-7	15	4	5-4-6	15	4
Deschamps, E.	*Cheetah*		2-2-dns	17	5	2-2-dns	17	5
Jacob, L.	*Flying Fox*	*'Squall'*	9-5-4	18	6	10-5-4	19	6
Sands, A.	*Aerocat*	1	10-8-6	24	7	9-9-5	23	7
Hinman, I. / Steever, Z.	*Aquacat*	1	8-10-dnf	31	10	6-7-dnf	26	8
Swiggett, J. E.	*Tiki*		dnf-7-5	25	8	dnf-8-7	28	9
Van Rynbach J. D.	*Cheetah*	7	3-dns-dns	29	9	4-dns-dns	30	10
Jacob, M.	*Flying Fox*		7-dns-dns	33	11	7-dns-dns	33	11
Rennie, R.	*Catnip*		dns-11-dns	37	13	dns-10-dns	36	12
Jacks, E.	*Waverider*		dns-9-dnf	35	12	dns-11-dnf	37	13
Weider, L.	*Flying Fox*	7	—			—		
Winslow, P.	*Flying Fox*	8	—			—		
Patterson, G.	*Whisker*	2	—			—		
Steever, Z.	*Aquacat*	3	—			—		

* Points—Total of finishing places. Lowest points wins.


TIGER CAT
• Speedy, roomy, safe
• Fiberglass construction throughout, including decks and cockpit
• Thrilling for day sailing or racing
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72
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