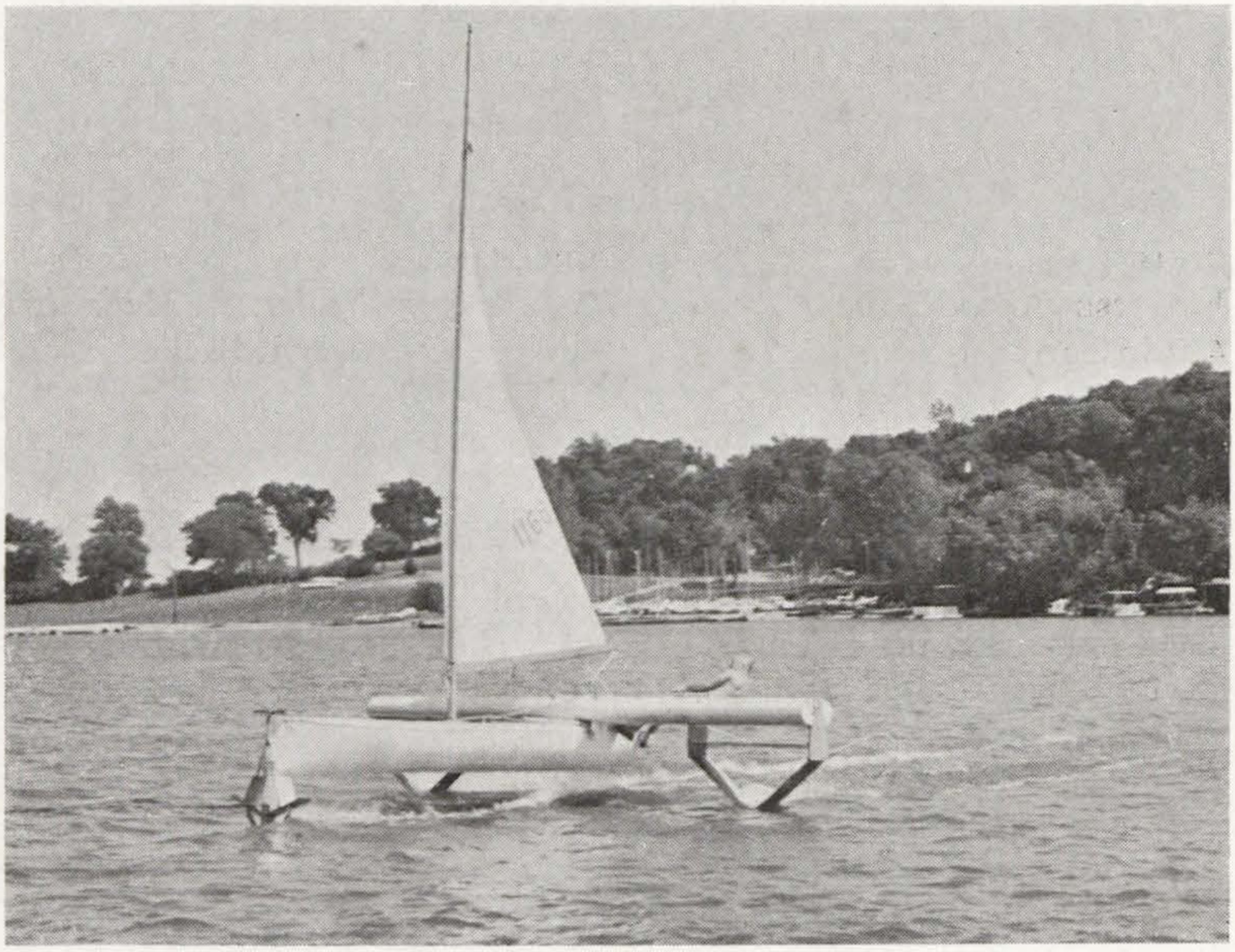
# FOILS, ICE YACHTS & SAILS

**A.Y.R.S. PUBLICATION** **No. 66A**



*Don Nigg doing 20 knots on a close reach*

## CONTENTS

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(Founded June, 1955)

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# EDITORIAL

## The Annual subscription is now due

The British subscription has now been raised to £2 to keep in line with the American $5.00. The Australian subscription is also $5.00. Subscriptions should be sent to Woodacres, Hythe, Kent, England as we distribute publiations for most members, but French and New Zealand members can either subscribe to their 'National Organisers' or to us, as they wish. If subscriptions are not paid by January 1st, 1969, No. 67 will not be sent out.

Bankers Orders are enclosed for the convenience of members. Where, however, a Bankers Order was previously in force for the sum of £1, a new advice to your Bank must be made to alter this to £2. You will have already been sent such a form but others are available from Woodacres.

If anyone has had a misbound or faulty copy of a publication or has not had his full four, will he please let me know.

## The 'Ayrsfoil' flying hydrofoil 'development' class

The A.Y.R.S. Committee are happy to announce that we at last can offer plans to members of Don Nigg's flying hydrofoil craft at the prices mentioned later. Based on the dimensions of Don's boat, we are keen to get flying hydrofoil sailing races going in all countries and urge our members to buy plans and build boats. We also appeal for 'Class Secretaries' for all areas.

The preliminary rules for the class must at first be vague until we see what factors make for speed and seaworthiness. The only rules with which we start are that the overall dimensions of the hull are those chosen by Don Nigg. As it is a 'development class', every item including sail area may be varied at the builders' whim. Various foil shapes, sail areas and rigs must be tried to see what is best.

Undoubtedly, the foundations of the 'Ayrsfoil class' is the most exciting thing we have done so far in the A.Y.R.S. We can now offer our members the most exciting sailing boat the world has yet seen with the opportunity of exercising their ingenuity to improve it.

## Winter meetings 1968-9

Local sections will be circulated separately about these.

## A.Y.R.S. Ties and Windsocks

A.Y.R.S. ties with a single device cost $3.00 or £1-1-0 each. Dinghy sized windsocks are 5½ inches long and cost $2.00 or 14/-. The Cruiser sized windsocks are 16 inches long and cost $4.00 or 28/-. The windsocks are lettered with A.Y.R.S. on each side.

## Our Book on Self Steering

The hard backed edition costs $4.00 or 22/6.

## Advertisements

A full page advertisement in our publications costs £12 or $40.00 for an inside page and £20 or $60.00 for a back page (only for regular advertisers). These low prices only just cover the cost and matter for them is only accepted at the discretion of the Editor and must be in our hands at least two months before the publication is due.

### Complete sets of publications

We wish to thank everyone who has written to tell us that they have complete sets of publications. Michael Gilkes has asked me to thank the various people who have offered to complete his set, which has now been accomplished. Anyone else with a near-complete set might like to let us know.

### Group organisers

A. T. Brooke, 75, Craiglockhart Rd., Edinburgh 11.
Dennis Banham, Highlands, Blackstones, Redhill, Surrey.
F. Benyon-Tinker, 49, Pillar Gardens, Northfield Land, Brixham, Devon.
M. Garnett, 7, Reynolds Walk, Horfield, Bristol.
John R. Novak, 23100, Vanowen St., Canoga Park, Calif., U.S.A.

### Foils, Ice Yachts and Sails

With increasing work at Woodacres (often 40 letters or more in a day), I have found that I have become more an 'A.Y.R.S. Manager' than an Editor. Thus, I find that I cannot do the routine work of Editing, though I can write the letters which ask members to send in their articles. Fortunately, our loyal members have rallied round and Ruth Evans and Jock Burrough produced our last issue, TRIMARANS 1968, Dudley Soulsby has produced this one and David Gaffyne and Joyce and Ron Doughty are working on the January publication, CATAMARANS 1969. Ian Williams has next year's trimarans issue in hand.

### Other publications being prepared

Peter Shreve and Peter Steward are doing a Multihull Safety Study as described elswhere in this issue.

Ruth Evans has now undertaken to produce a 'CONSTRUCTIONAL METHODS' issue for us which was to have been concerned with Ferro-cement boats quite largely but two excellent books have now been produced on this subject and the emphasis may now be in other methods.

Keith Clarke and others are preparing the publication on the 1968 Single-Handed Trans-Atlantic Race, starting with our meeting last year with Prince Philip in the Chair.

We now need someone in California to start work on the Single-Handed Trans-Pacific Race as a future publication for us.

### A.Y.R.S. Correspondents'

This brings us back to an early idea which was to have various members responsible for various subjects with the idea of eventually producing a publication for us. This idea was a partial failure at the time because of our small membership but we could well try it again. Its major success was the appointment of Tom Herbert as our 'Self Steering Correspondent', which eventually resulted in our book on the subject.

Various members already seem to have become specialists in various subjects, for instance Dick Andrews on Ice Yachts, but, if any member has an interest and would like to answer questions—he need not necessarily be an expert—on any subject, would he please let me know? We will give the names in each publication and he will soon become very well informed indeed.

## Geschwindigkeit und optimale Höhe

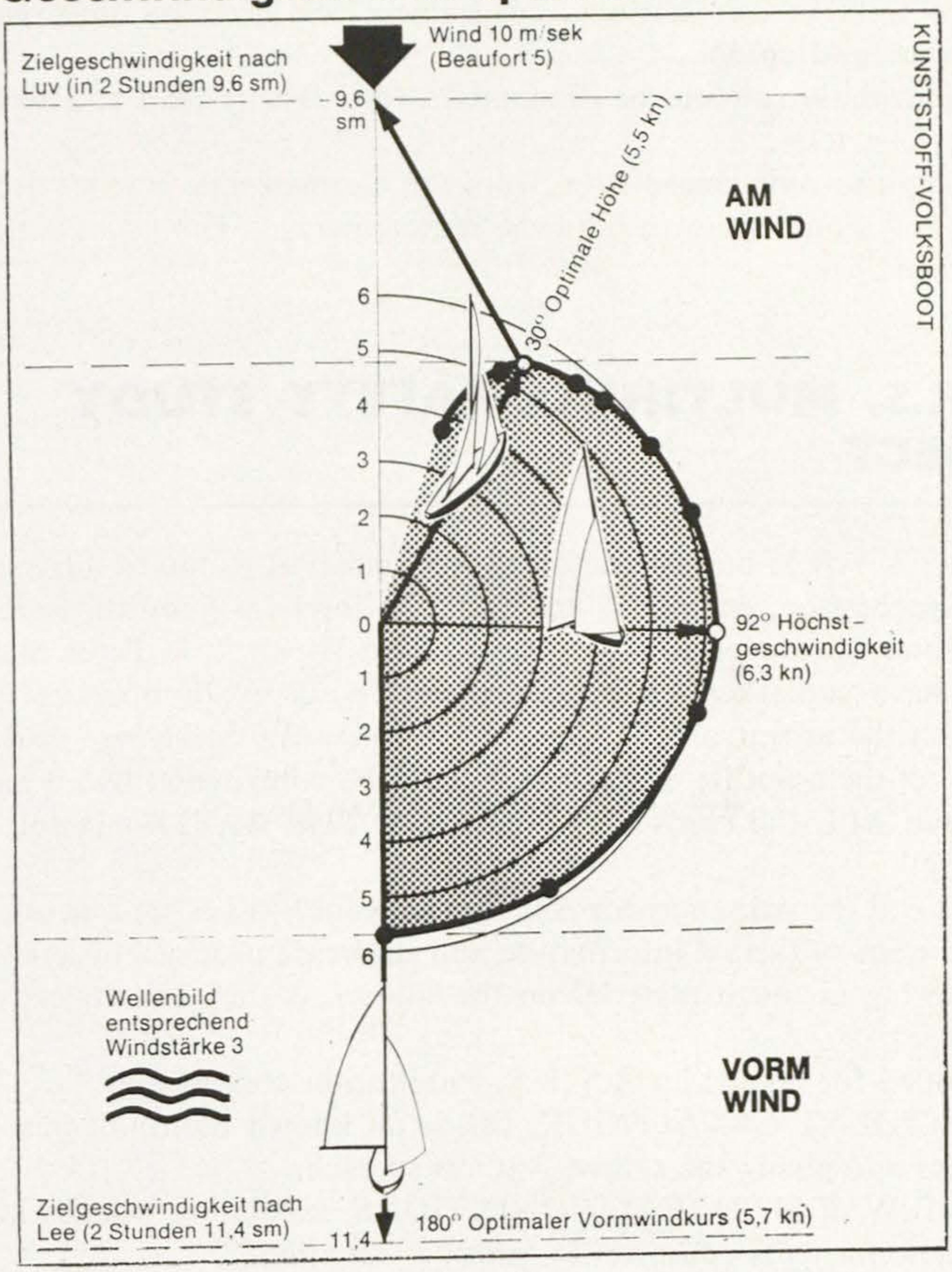



*Fig. 1*
*Polar curve of FOLKBOAT*

## Querstabilität

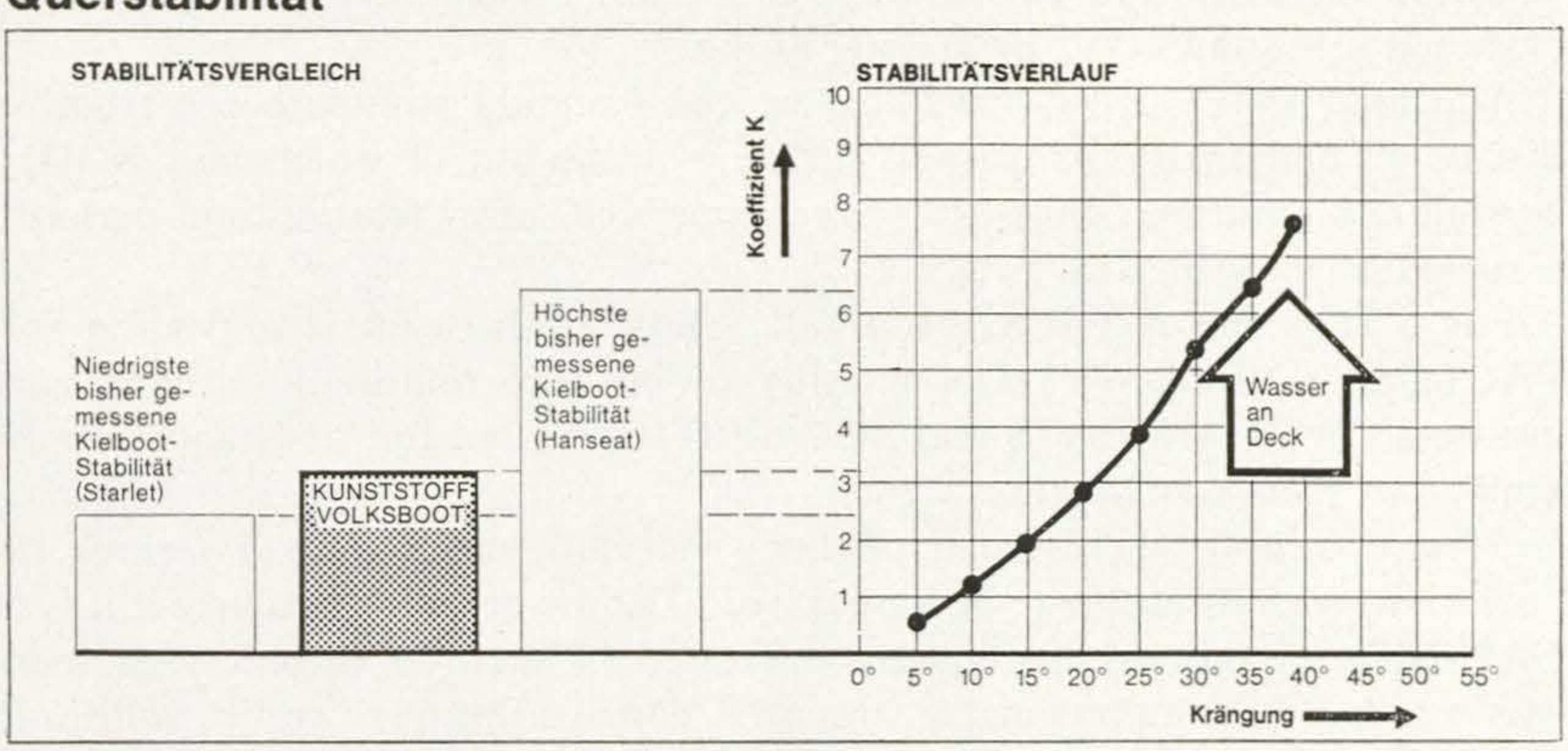



*Fig. 2*
*Stability curve of FOLKBOAT*

**Speed and Performance diagrams**

The boat tests in our national magazines lack accurate information on performance and speed.

This information should be of standard form, easily read and comparable with previous tests.

The diagrams reproduced here, from the German 'Die Yacht', are a good example and would seem to fulfil the requirements. The yacht concerned is a 'Folkboat'.

# A.Y.R.S. MULTIHULL SAFETY STUDY PROJECT

Flying the A.Y.R.S. burgee and aided by a panel of technical advisers which includes yachtsmen, engineers, and scientists (and for good measure a computer), Peter Shreve of Johannesburg, South Africa, and Peter Steward of Ipswich have embarked on a comprehensive survey of offshore multihull safety with the accent on the facts and problems of capsizing—and after.

As one of them put it: 'Let's have debate and controversy by all means but let us have ALL the cards in the pack ON THE TABLE—in full view of everybody!'

To this end the pair—anyone else for the team?—have set out to assemble a 'central mine of factual information and showcase of ideas' by summarizing and reviewing as much material on the subject as they can collect from all sources.

The hoped for result: an A.Y.R.S. Publication comprising:

1 an ACCIDENT CATALOGUE, listing all known multihull mishaps and disasters and giving the salient features of each.
2 a REVIEW of SURVIVAL CONDITIONS, tabulating what is known of the requirements for survival in 'unusual situations'.
3 a systematically arranged DISPLAY of TRIED SAFETY and SURVIVAL MEASURES, PROMISING SUGGESTIONS, and pertinent VIEWS and OBSERVATIONS on accident prevention and on dealing with the situation should a mishap occur or disaster strike.

And after that? This encyclopaedic effort should stimulate constructive discussion and the exchange and sifting of ideas out of which may SOON crystallize a tentative 'short list' of recommended safety features and perhaps a suggested capsize 'drill'.

For a start the A.Y.R.S. Multihull Safety Study team is appealing for FACTUAL INFORMATION relating to offshore multihull mishaps and disasters, for COMMENTS and SUGGESTIONS, and for 'assistance of any kind'. In their own words:

'Whenever and wherever an offshore multihull meets with a serious or potentially serious accident we would like to know of it: particularly if it is a CAPSIZE, though we are equally interested in such contingences as man overboard, fire, and appreciable structural damage thorough strain, collision, grounding, or action of wind and sea. We would like to know in detail, and from as many different sources as possible, WHAT HAPPENED to which type of craft UNDER WHAT CONDITIONS. To whom, when and where: so we may identify each event in correlating the data accumulated. What measures were taken, and how did crew and craft fare during AND AFTER the accident? We would also like to know the origin of any information volunteered: whether coming from a participant or eye witness, or derived from verbal or written reports.

In addition to factual reports and items of information we would welcome any comments and suggestions participants might care to make—or anyone else, amateur or professional, concerned with multihull sailing, design, construction, or safety at sea, or IN ANY WAY interested in matters that may have a bearing on these topics.

We are also inviting accounts of situations which MIGHT have led to an accident but did not, and would like to hear about any measures or design features that are thought to have prevented a mishap or averted disaster.

And we are keen to communicate with anyone who has had personal experience of SURVIVAL UNDER EXTREME CONDITIONS—on land or at sea, or is closely concerned with such matters and may be able to supplement our own study of the literature on this subject.

We would greatly appreciate ANY help . . . information or suggestions, directing us to any likely sources of such material, permission to use material previously published elsewhere, or broadcasting our appeal.

Peter Shreve,
P.O. Box 17117,
HILLBROW,
JOHANNESBURG,
South Africa.

Peter Steward,
63, Burke Road,
IPSWICH,
Suffolk,
England.

# MY AMERICAN VISIT

## by John Morwood

I always have to arrange my holiday about six months ahead. This year (1968), I had planned to sail down the river Thames from Lechlade to Richmond in my new boat, *KINNEGOE*, which was described in HYDROFOIL VICTORY, A.Y.R.S. No. 62. Accordingly, I had arranged to have two weeks off at the beginning of August for the first time in 22 years of medical practice. I usually have May and October holidays.

As the time for my holiday drew near, it was obvious that my boat would not be ready for sailing and I had visions of spending the two weeks with a scythe, cutting down the long grass in the clearings in the wood around my house, a thought which did not particularly please me.

At that moment, a letter arrived from Tony Rose on behalf of a group of members in California, inviting me out there to meet them all and see the World's Multihull Championships. It appears that I had picked exactly the correct time for this, which is an instance of the extraordinary luck which has followed the A.Y.R.S. right from the beginning. I accepted like a shot.

### The passage out

Aeroplanes are undoubtedly the most devilish invention of the modern age. During the war, I was flown hither and thither and, apart from some hours piloting a 'Tiger Moth' myself, I disliked the whole thing. Indeed, to myself, I had 'opted out' of the 'Aeroplane Age', deciding that, if I wanted to travel, I would go by boat, preferably my own. My yachting studies and the founding of the A.Y.R.S. are, in fact, the practical expression of a childish romantic notion to sail to California in my own boat. The first four years of my life were spent in Reedly, near Fresno, on my uncle's olive 'Ranch'.

I still dislike aeroplanes. You have to sit still for hours on end, packed like sardines which doesn't suit me at all. I peered out of the windows, trying to see something, read books but got nothing whatever out of it. Still, they do get you there.

### Marblehead

Landing at Boston, I was met by Harry Morss and Jack Stoddart and taken to meet Betty Morss, Mrs. Stoddart and Edmond Bruce at the Morss' delightful home in Marblehead, where I spent four wonderful days.

Marblehead is on a peninsula stretching out into the Atlantic, 12 miles from Boston, with Marblehead Neck, a smaller peninsula on the south side, the two resembling a human hand in a mitten. Marblehead Harbour lies between the 'thumb' and 'fingers' and has no less than seven yacht clubs. It is completely packed with yachts at moorings, of all kinds and types. The sailing and sailing weather are perfect, except for an occasional easterly gale which can wreak a bit of havoc.

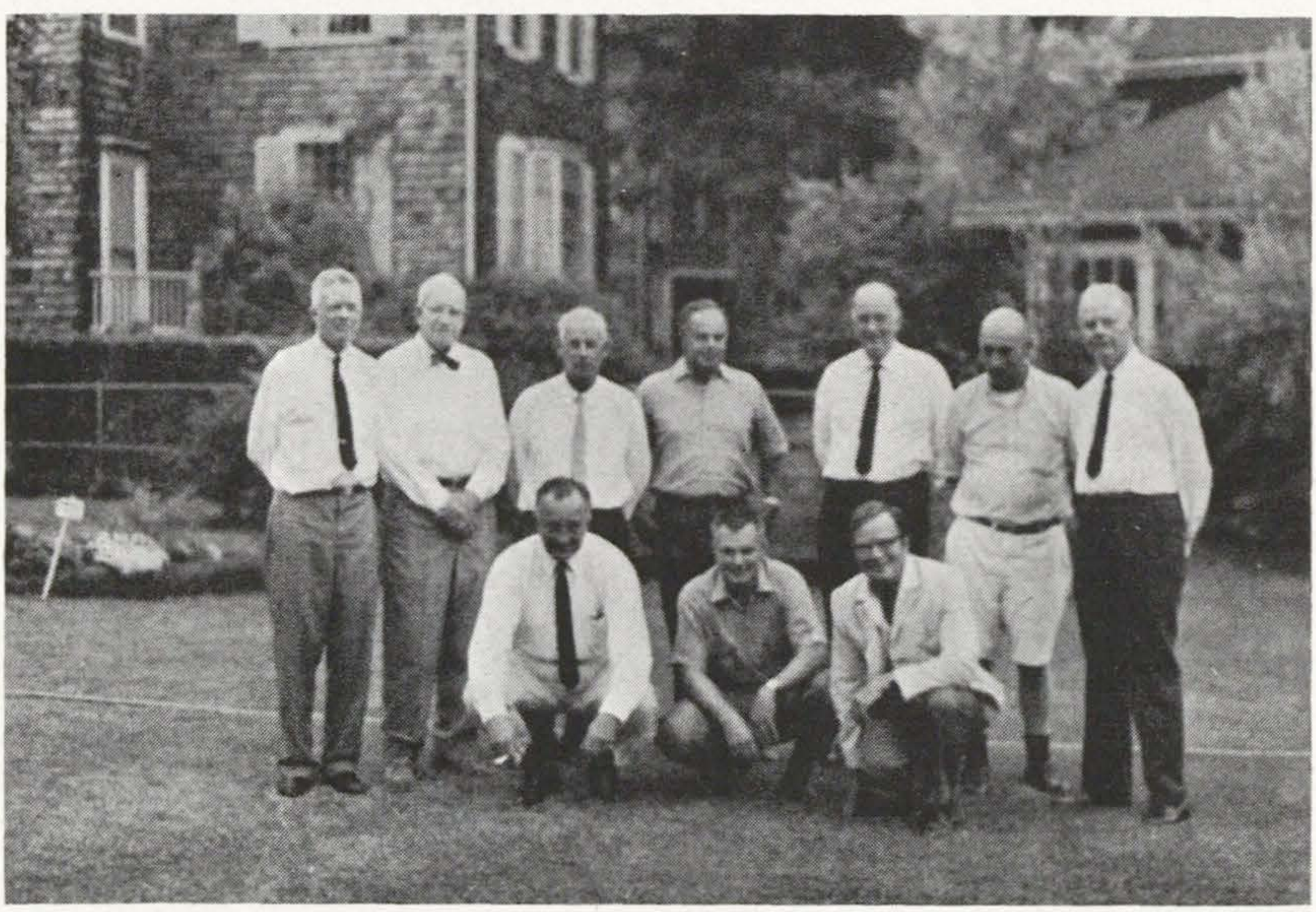
The houses in Marblehead contrast between the old houses in the old part of the town which are made of wood and are therefore cool in summer and warm in winter and the larger modern houses in Marblehead Neck, each set in a quarter to half an acre or so, built much like our modern English hou es, not half as thermally insulating but with central heating and 'air conditioning' —really, air cooling for the summer. Harry Morss uses an air blowing system with the air ducted to all rooms. We used to call it the 'Plenum' method.

On two days we sailed; first in Willoughby Stuart's beautifully kept forty foot single hulled *REVEILLE*, built by Hinckley, of Southwest Harbour, Mt. Desert, Maine; secondly in Del Keily's NIMBLE on which he was trying to find the effect of extra lateral resistance on the floats. Edmond Bruce has shown in the tank and several people have shown in practice that Nimbles benefit from this, often quite startingly.

The Morss' laid on a party for the local A.Y.R.S. members and we had a short discussion on general A.Y.R.S. policy, finally ending up just talking boats.

On the technical side, I was pleased to find that I could follow Edmond Bruce's and Harry Morss' lines of thought and was most impressed with Edmond's tank figures of his hydrofoil tests, which we have later in -this publication. Harry's *CONSOLE* for his figure taking, though not in a neat box as favoured by Edmond and John Hogg, looked quite as effective to me.

*Trying to make REVEILLE self-steer*
*Left to right: W. I. Stuart, Molly Stoddart, H. A. Morss, Jr., John Morwood, Edmond Bruce and Betty (Elizabeth W.) Morss*



*Standing left to right: Henry A. Morss, Jr., Howard P. Hart, Delbar P. Keily, John H. Thomson, John Morwood, B. J. Goldstone, Edmond Bruce*
*In front: John O. Stoddart, A. M. Heitman, W. D. Antrim*

### The 'Better or Worse Meter'

One use of figure taking which we have not stressed so far is its combination in a 'Better or worse meter', which is a simple balance of boat speed against wind speed. This can be done electrically, as described by both Edmond Bruce and John Hogg in *Sailing Figures, A.Y.R.S. No.* 56. However, it could also be done mechanically by balancing a ball in the air against a small ball in the water. This was suggested by Edmond Bruce, balls being used to prevent directional corrections.

Except for the A.Y.R.S. only a tiny fraction of yachtsmen are at present technically informed. Any kind of sophistication, therefore, is not for most people and we have to wait until they are replaced in time by the younger generations. In the meantime, they could probably be persuaded to use a very simple device and the 'Better of worse meter' seems to me to fit the bill exactly. It could be placed on the bows of any boat and would be a far better 'competitor' to sail against than any human helmsman. We hope that this apparatus will soon be produced commercially, by some firm.

In all, I had a most enjoyable stay at Marblehead, thanks to the hospitality of the Morsses and to all the delightful people I met. The fact that the sun came up in the morning and shone all day and the sailing winds were light and steady was certainly a contrast to our dreary and wet summer in England.

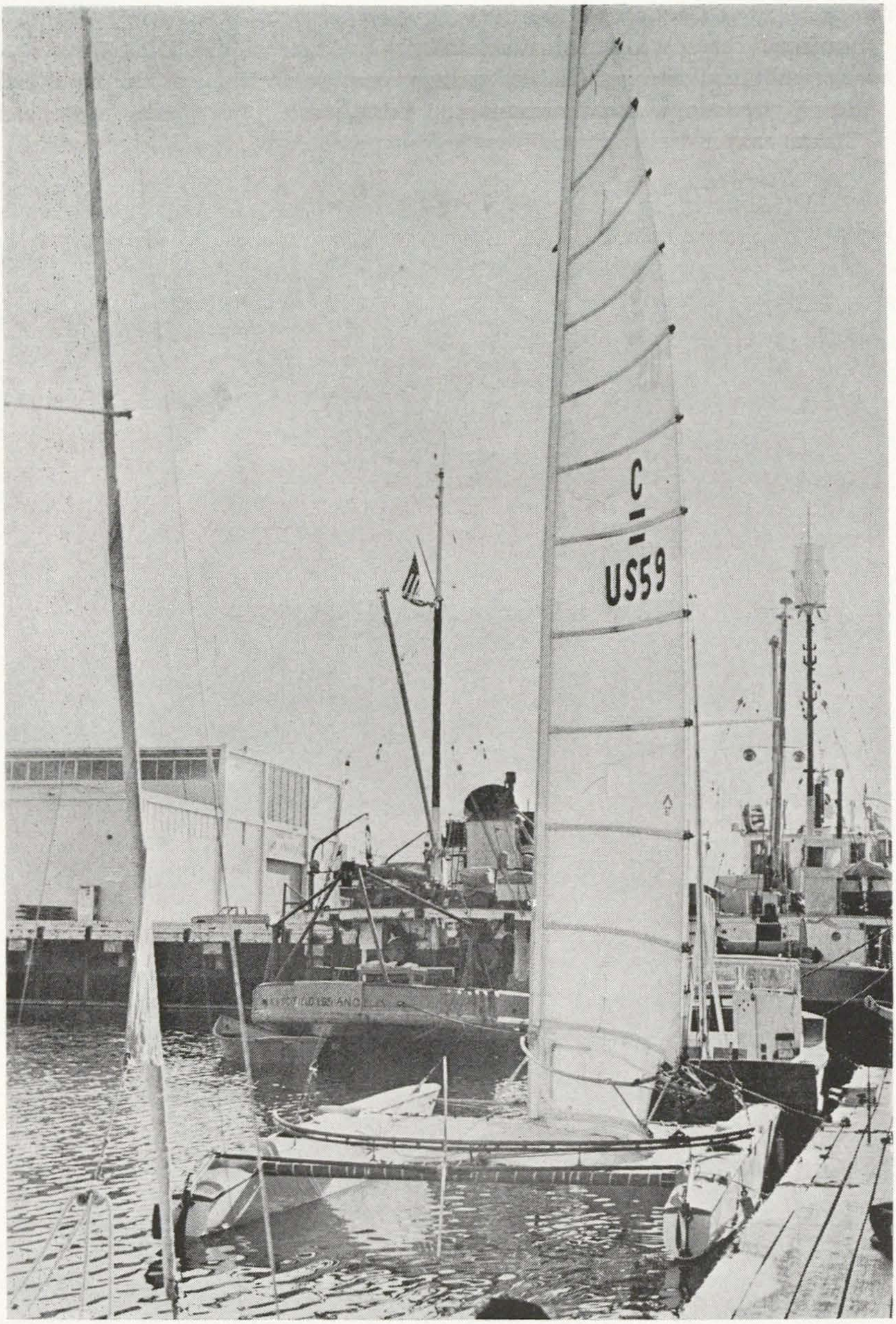
### California

Flying out to Los Angeles, I was met at the Airport by Hugo Myers and taken around the local Marinas to see the multihulls. Each Marina had a forest of masts. I have never seen so many boats together before. I noticed with some pleasure that the sailing boats predominated everywhere with motor cruisers in a small minority. The 'Cal' series of fibreglass sailers, mostly 'Cal 26's', seemed everywhere and very deservedly so, from their reputation. However, I was there to see multihulls and see them I did, from the veteran *MANU KAI*, through *AIKANE* to Hugo's plans of his latest *SEA BIRD* which was in Hawaii. Hugo's ideas now favour deep symmetrical hull sections for his catamarans and Rudy Choy is also moving in the same direction. From England, I could not see the reason for this but now, having seen their sailing conditions, I tend to agree with this shape—for them. This will be discussed later.

Hugo eventually took me to the home of Dave and Bernice Bradley on Palos Verdes, a hill overlooking the various towns, San Pedro, Seal Beach, Santa Monica and many others which the stranger, in his ignorance, would lump together with Los Angeles, just as one might be forgiven (but probably would not) for lumping Bromley or Beckenham with London.

The Bradley's house is built in the Spanish style with a 'Patio' where we had breakfast the first morning I was there, surrounded by lime trees growing in the open. The house is really beautiful in a most marvellous setting of lawn, olive trees, a banana, oleanders and shrubs whose names I have forgotten. The nocturnal skunk roamed the garden while all the birds differed from those of the old world—even the 'sparrows' were not the same as ours.

The birds and plants may be different from ours but the Californians themselves are just like the British when the sun is shining, cheerful, optimistic and full of life. It is only the climate which makes us depressed at times.

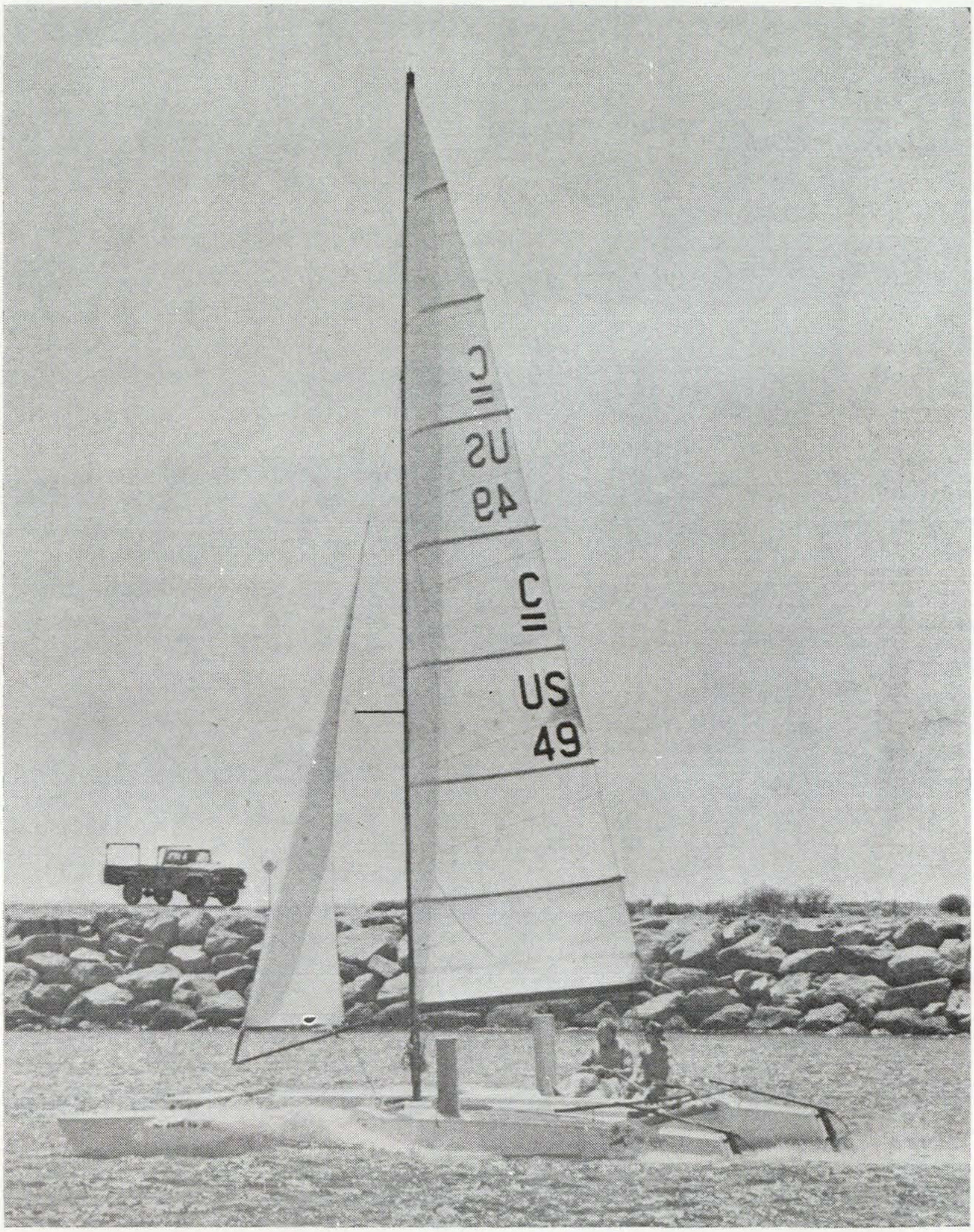



*Dave Bradley's and Gerry Marlotti's WHIPLASH*

Indeed, as there is nothing better that I could wish for myself than to be a Californian, I was greatly pleased by Alex Kozloff's remark that my Kent-Irish accent was almost identical with theirs.

I suppose that it is obvious that, when all is going well with a person's life, he often—almost deliberately— sets out to make trouble for himself. For instance, it was the boredom of the early days of my medical practice which induced me to study the theory of sailing and to start the A.Y.R.S. To my way of thinking, all is going very well indeed for the Californians and, in nearly every conversation, the word 'problem' appears. For instance, 'That man has a problem' (his mast had just come down). 'The problem is . . .' or even: 'It's no problem'.

I took the matter up with my brother Bill, whom I visited in Santa Monica. He has lived 40 years in America. 'It's quite simple'. he said. 'Just a matter of status. No problems—no status'. This only goes to show how all is going with the country, despite what they say about themselves.




*Alex Kozloff's* '49er' *in the speed trials* 20 *kts.*

**The World Multihull Championships**

The entrants were from the West Coast with the exception of a *FLYING KITTEN* which had been trailed down from Canada. Some 5 or 6 C class


*Dave Bradley's and Gerry Marlotti's WHIPLASH*

cats made of fibreglass-polyurethane foam sandwich race regularly in the Long Beach district and these, with the D Class *WILDWIND* were the most spectacular of the boats. Norman Cross had brought along a *CROSS* 24 and two pretty tris (*TRADEWIND* 28) had sailed down from San Francisco. *TORNADOS*, *PACIFIC CATS*, the *HOBIE CAT*, designed by Hobie Alter, the tiny *AQUA CAT* and some others were all raced together to study the rating formulae of Norman Riise.

The first two days of the regatta were devoted to a study of speeds on a beam reach. Hugo Myers' *DREAMER* and Don Landauer's *CROSS* 38 trimaran, most beautifully made by himself, his wife and two boys, were the marker boats and windspeeds were taken.

## Results

In a 10 knot wind, the C Class and *WILDWIND* could sail at 15 or 16 knots. In a 20 knots wind, however, the speeds were only in the 21-22 knot region.

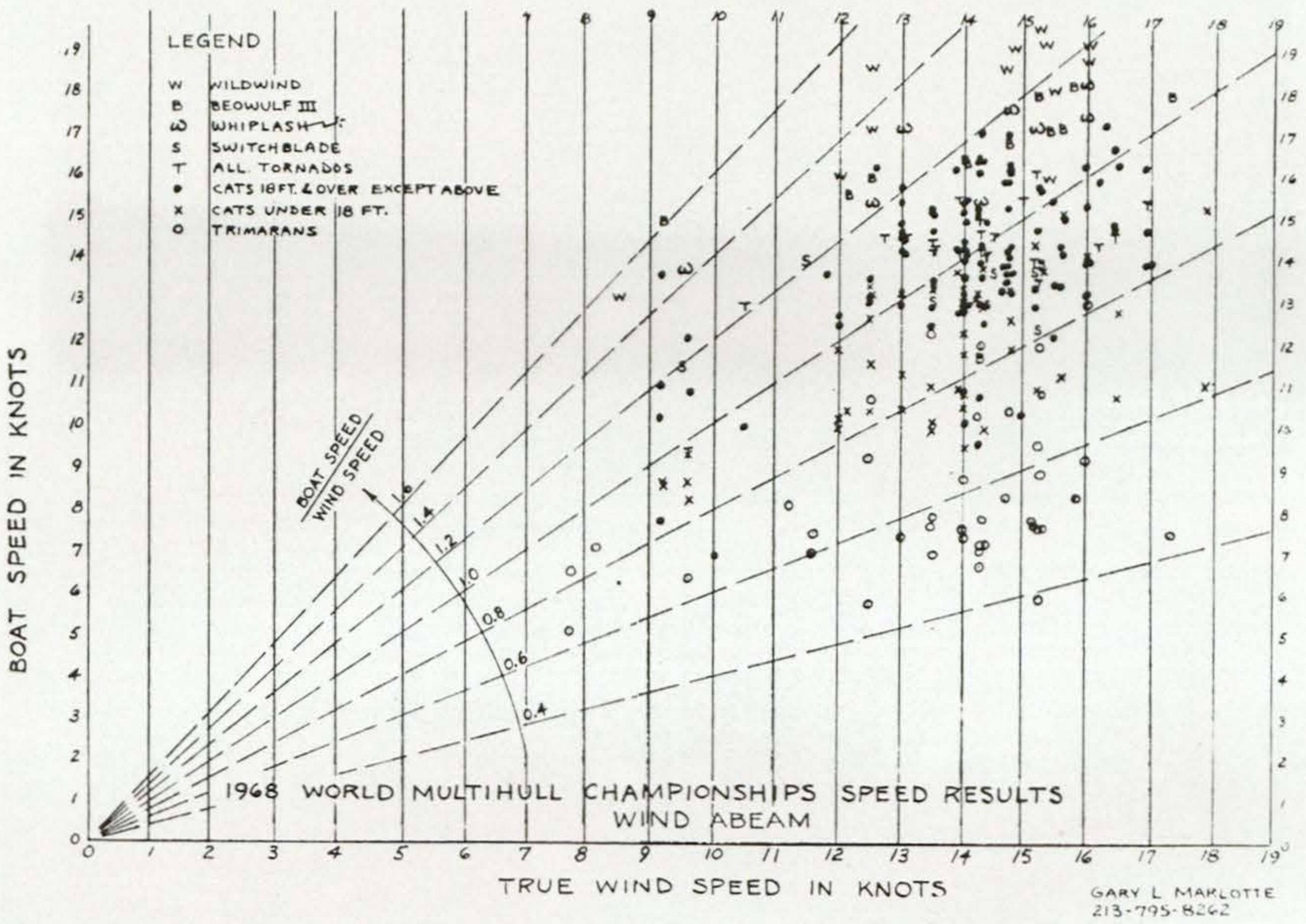



*Fig. A*

## Wildwind

After the speed trials, Chuck Tobias, the new owner of *WILDWIND* invited me to sail with them. Apart from the sheer speed, the thing which impressed me most was the acceleration when we caught the wind. This actually pressed one aft as the boat jumped forward. The sailing technique was just a little different, too. To sail a free wind course, one first sailed close enough to the wind to get the sail 'unstalled'. Then, the course was gradually freed, the sheets being left more or less untouched. The acceleration kept the β angle (course to the apparent wind) much the same and the sails did not stall. This is, of course, ice boat sailing technique.

## The Racing Results

| August 8, Speed Trials | | | Boat speed / Wind speed | $= \frac{VB}{VW}$ | Efficiency |
|---|---|---|---|---|---|
| 1 | *WHIPLASH* | G. Marlotte | 18.20 / 16.00 | 1.138 | 1.246 |
| 2 | *WINGDING* | W. Fogg | 16.10 / 12.58 | 1.281 | 1.215 |
| 3 | *WHIPLASH* | G. Marlotte | 13.58 / 9.60 | 1.412 | 1.197 |

## The Racing Results—continued

| | | | | | |
|---|---|---|---|---|---|
| 4 | *WHIPLASH* | G. Marlotte | 15.28 | 1.221 | 1.181 |
| | | | 12.50 | | |
| 5 | *WILDWIND* | C. Tobias | 19.03 | 1.289 | 1.172 |
| | | | 14.78 | | |
| 6 | *BELIEVER* | T. O'Keefe | 14.84 | 1.141 | 1.170 |
| | | | 13.00 | | |
| 7 | *HOLY MOLEY* | T. Taylor | 14.60 | 1.122 | 1.160 |
| | | | 13.00 | | |
| 8 | *THE 49ER* | A Kozloff | 17.20 | 1.058 | 1.148 |
| | | | 16.29 | | |
| 9 | *BELIEVER* | T. O'Keefe | 14.48 | 1.112 | 1.142 |
| | | | 13.00 | | |
| 10 | *BEOWULF III* | S. Dashew | 14.81 | 1.622 | 1.140 |
| | | | 9.13 | | |
| 11 | (*FLYING KITTEN*) | F. Van Zuiden | 15.21 | .854 | 1.138 |
| | | | 17.82 | | |
| 12 | *SWITCHBLADE* | N. Harvey | 13.41 | 1.168 | 1.135 |
| | | | 11.50 | | |

August 9, Speed Trials

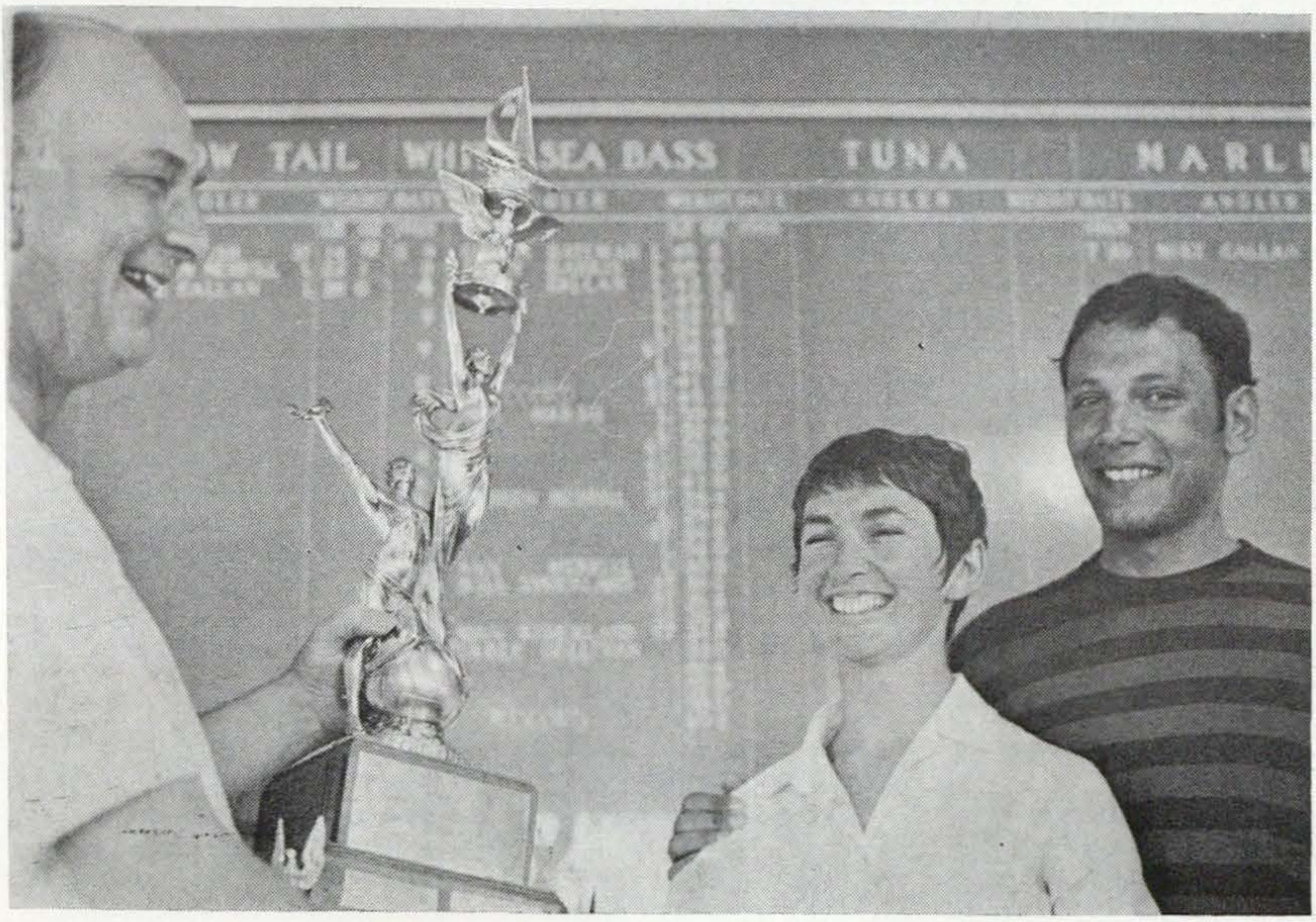
1 First and second places are still undecided at time of printing.
2 *WHIPLASH* and *AQUA CAT* are still battling it out.

| | | | | | |
|---|---|---|---|---|---|
| 3 | (*HOBIE CAT*) | H. Alter | 13.00 | 1.040 | 1.253 |
| | | | 12.50 | | |
| 4 | *WHIPLASH* | G. Marlotte | 17.51 | 1.191 | 1.249 |
| | | | 14.70 | | |
| 5 | (*HOBIE CAT*) | H. Alter | 13.30 | .986 | 1.235 |
| | | | 13.50 | | |
| 6 | *WILDWIND* | C. Tobias | 18.55 | 1.483 | 1.240 |
| | | | 12.50 | | |
| 7 | *WHIRLWIND* | D. Bradley | 17.00 | 1.190 | 1.215 |
| | | | 14.30 | | |
| 8 | *WHIPLASH* | G. Marlotte | 17.19 | 1.130 | 1.205 |
| | | | 15.20 | | |
| 9 | *MOTILE* | C. Schudel | 15.88 | 1.080 | 1.199 |
| | | | 14.70 | | |
| 10 | (*HOBIE CAT*) | H. Alter | 14.00 | .875 | 1.193 |
| | | | 16.00 | | |
| 11T | (*FLYING KITTEN*) | F. Van Zuiden | 13.33 | 1.068 | 1.192 |
| | | | 12.50 | | |
| 11T | (*HOBIE CAT*) | H. Alter | 13.64 | .899 | 1.192 |
| | | | 15.20 | | |

| August 10-11, World Championships | | | | Total Pts. | Div. Place |
|---|---|---|---|---|---|
| 1 | *WHIPLASH* | G. Marlotte | 2-2-4-5- | 13 | 1 |
| 2 | *SWITCHBLADE* | N. Harvey | 3-10-3-3- | 19 | 2 |
| 3 | *SOKITCUM* | B. Stewart | 7-3-5-4 | 19 | 1 |
| 4 | *THE 49ER* | A. Kozloff | 6-6-6-8 | 26 | 2 |
| 5 | *BEOWULF III* | S. Dashew | 1-29-1-1 | 31¼ | 1 |

## The Racing Results—continued

| | | | | Total Pts. | Div. Place |
|---|---|---|---|---|---|
| 6 | (*TORNADO*) | K. Rosskopf | 8-4-7-15 | 34 | 3 |
| 7 | *CAPT. AMERICA* | F. Miller | 5-12-12-7 | 36 | 2 |
| 8 | *WHIRLWIND* | D. Bradley | 9-9-8-12 | 38 | 4 |
| 9 | *MALAHINI* | Cross/Tabler | 4-11-13-11 | 39 | 3 |
| 10 | *WILDWIND* | C. Tobias | DNF-1-2-2- | 39¾ | 3 |
| 11 | *HOLY MOLEY* | T. Taylor | 11-7-11-20 | 49 | 4 |
| 12 | *BELIEVER* | T. O'Keefe | 23-13-9-6 | 51 | 5 |
| 13 | *BLUE BLADE* | H. Pons | 13-15-15-9 | 52 | 1 |
| 14 | *FORCE* 10 | R. Jewett | 10-5-10-DNF | 60 | 6 |
| 15 | *WINGDING* | W. Fogg | 15-8-18-19 | 60 | 5 |
| 16 | *BOUNDER* | T. Rose | 14-24-19-18 | 75 | 6 |
| 17 | *GATO-GO* | J. Beasley | 12-20-17-28 | 77 | 7 |
| 18 | *KALY KAT* | J. Hjorth | 17-18-23-21 | 79 | 2 |
| 19 | (*HOBIE CAT*) | H. Alter | 26-17-16-22 | 81 | 3 |
| 20 | (*FLYING KITTEN*) | F. Van Zuiden | 22-14-26-24 | 86 | 10 |
| 21 | *WIZARD OF ID* | Melvin/Cram | 25-19-25-17 | 86 | 8 |
| 22 | (*AQUA CAT*) | R. Smyth | 18-27-28-16 | 89 | 4 |
| 23 | *PRECIOUS* | D. Finkhouse | 21-23-24-23 | 91 | 7 |
| 24 | *DOS EQUIS* | J. Walti | 20-25-21-26 | 92 | 9 |
| 25 | (*SHARK*) | T. Meinzer | 24-21-22-27 | 94 | 9 |
| 26 | (*SHARK*) | C. Schudel | 27-16-DNF-25 | 103 | 8 |
| 27 | *SOFT SOUNDS* | P. Messineo | DNF-26-29-13 | 103 | 4 |
| 28 | (*GLOBEMASTER*) | J. Lyons | DF-DF-20-14 | 104 | 6 |
| 29 | *HAMBONE* | M. Beiley | 19-22-DQ-DQ | 111 | 5 |
| 30 | *TOM CAT* | A. Hardy | 16-DS-DS-DS | 121 | 11 |
| 31 | *PUSSY CAT* | J. Mullin | DS-DS-27-DF | 132 | 5 |
| 32 | (*MARLIN*) | R. Olshausen | DS-28-DS-DS | 133 | 6 |
| 33 | *THE CITY* | F. Mieuli | DF-DF-30-DF | 135 | 7 |
| 34 | *TOAD* | G. Thompson | DS-DS-DS-DS | 140 | 12 |

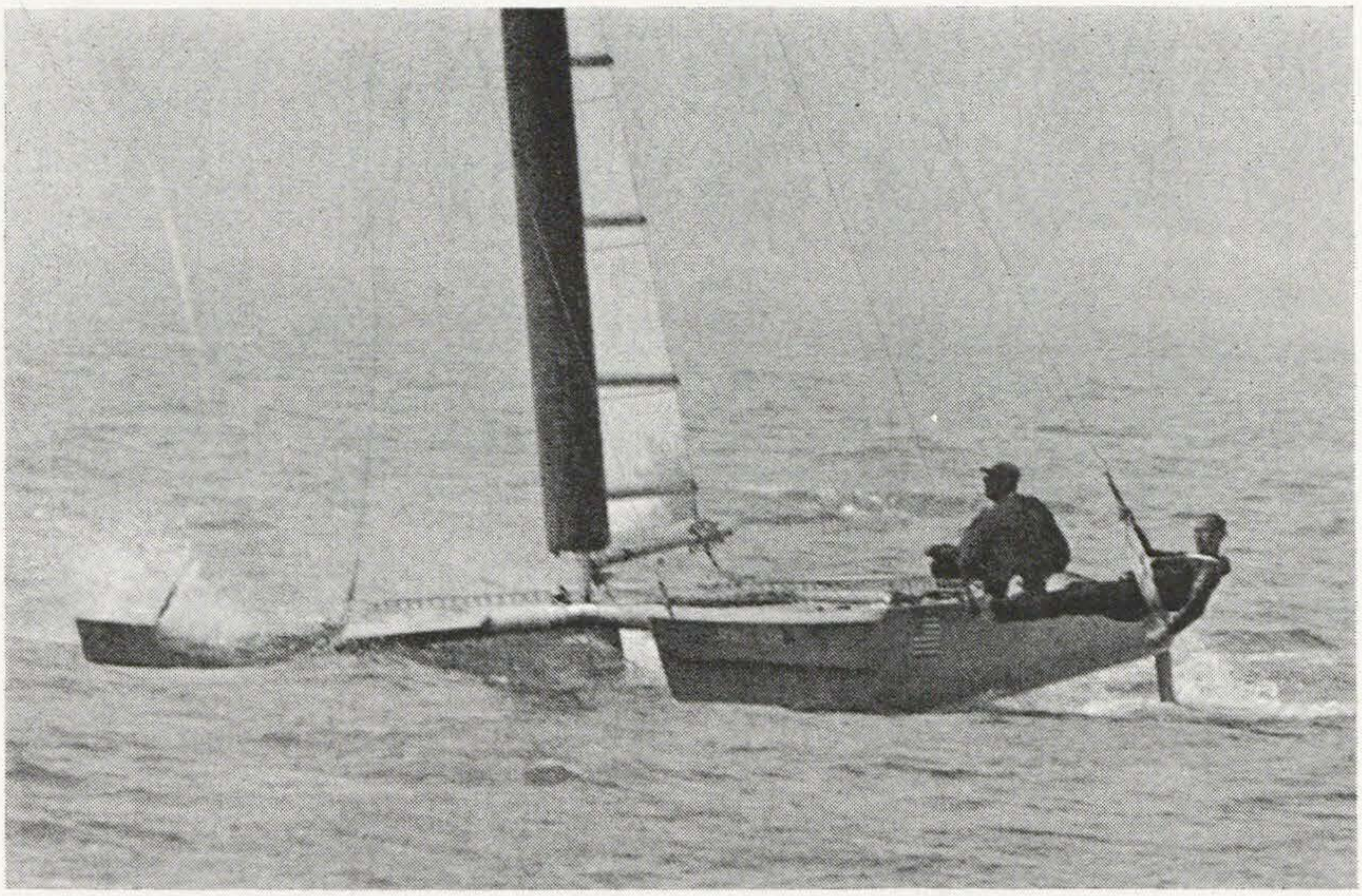



*Linda and 'Skip' Dashew getting their trophy*

### Californian multihull design

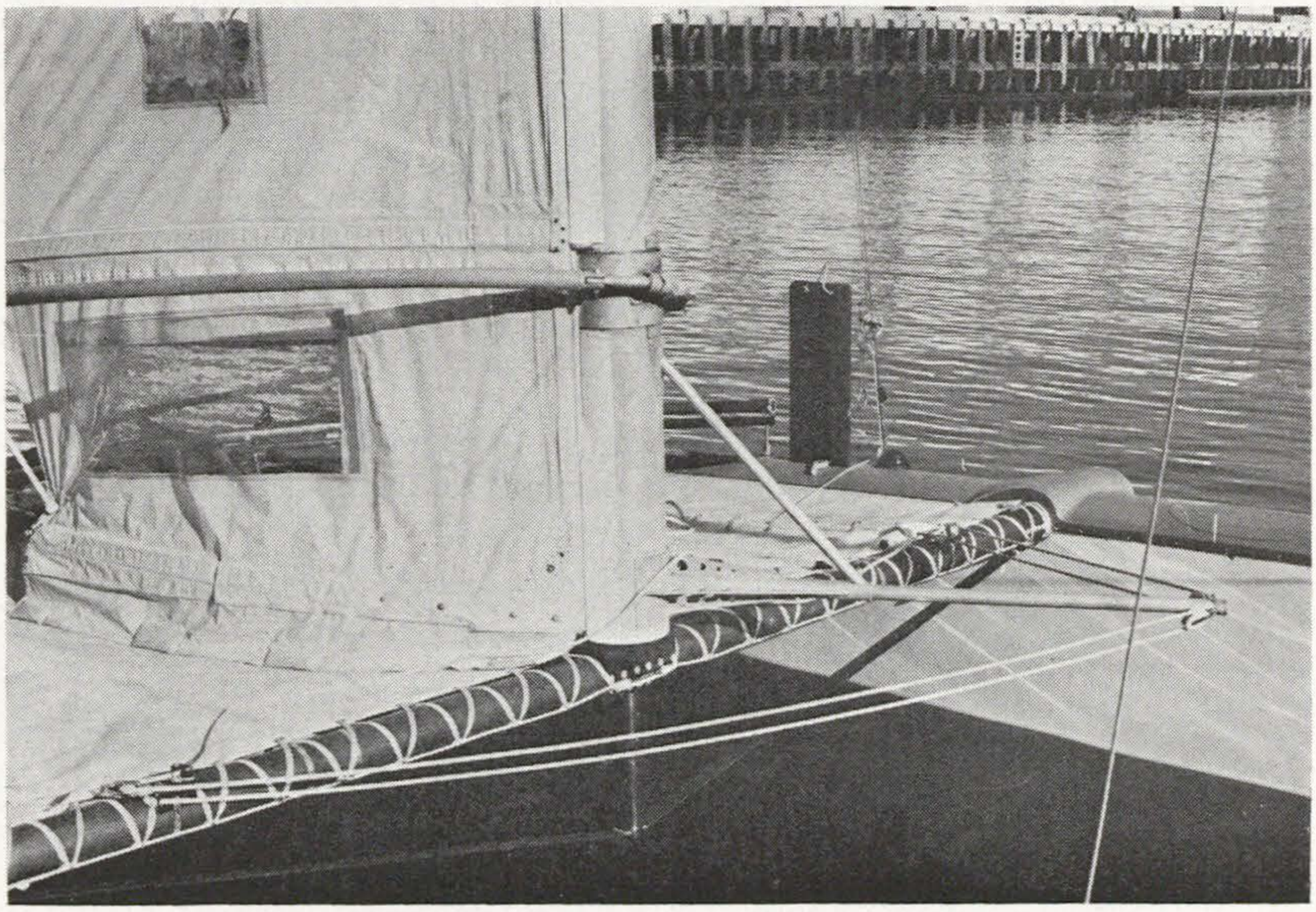
All the racing cats were of 'orthodox' design with narrow hulls and transoms. Normal sloop rig was used with the exception of the *AQUA CAT's* lateen on a bipod mast and Dave Bradley's C Class sail on *WHIPLASH*. The *TRADEWIND* 28's had canoe sterns on all three hulls and rather low buoyancy floats which, I thought, buried rather too easily. They were, however, most beautifully made of fibreglass and are nice cruisers.


*The TRADEWIND 28 from San Francisco*

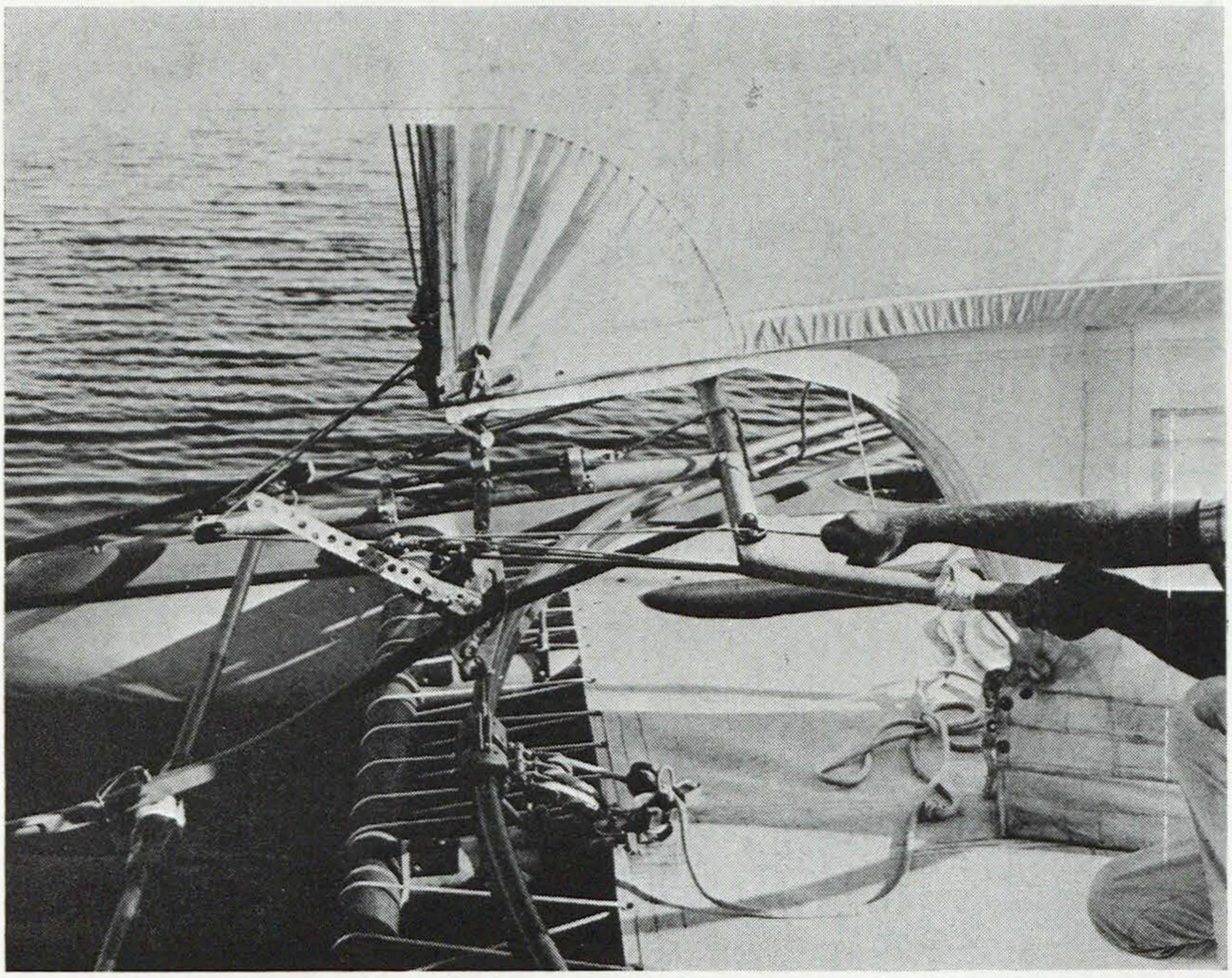


**Dave Bradley's sail on Whiplash**

This consists of two fully battened sails set to lie together from the corners of a D shaped mast, thus giving a clean windflow with no mast eddies. A very well engineered boom downhaul track and a single wire sheet to a freely running carriage give perfect boom control through a several part sheet to the carriage. Winches and wires at the boom end give camber or 'flow' control. An innovation is taking the sail down to the trampoline to reduce



*Note: Sail on trampoline below boom*



*Note: Flow or camber control*

the boom eddy. This is done below the boom so that there can be a gap below the clew for the crew to get from side to side on tacking. In all, it is a most ingenious and well built 'power plant'.

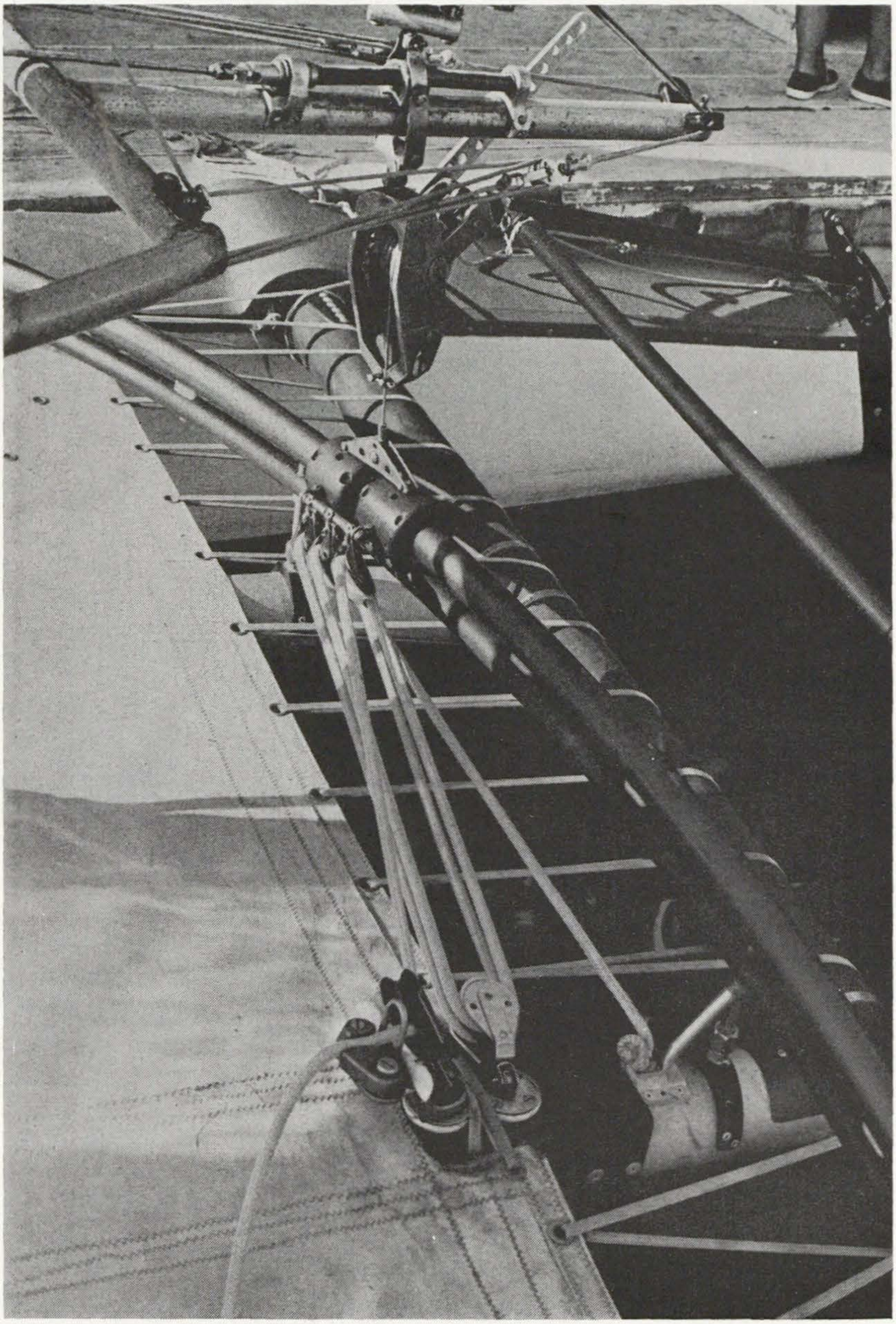
Writing the previous paragraph has reminded me of a complaint of Dave Bradley's and of other Americans that some of the technical terms used in the A.Y.R.S. are not the same on both sides of the Atlantic. This is, of course, valid criticism and, when I know that there is a difference, I try to put the alternate term in brackets. But I do not always know that a difference exists.

## A trip to Catalina Island

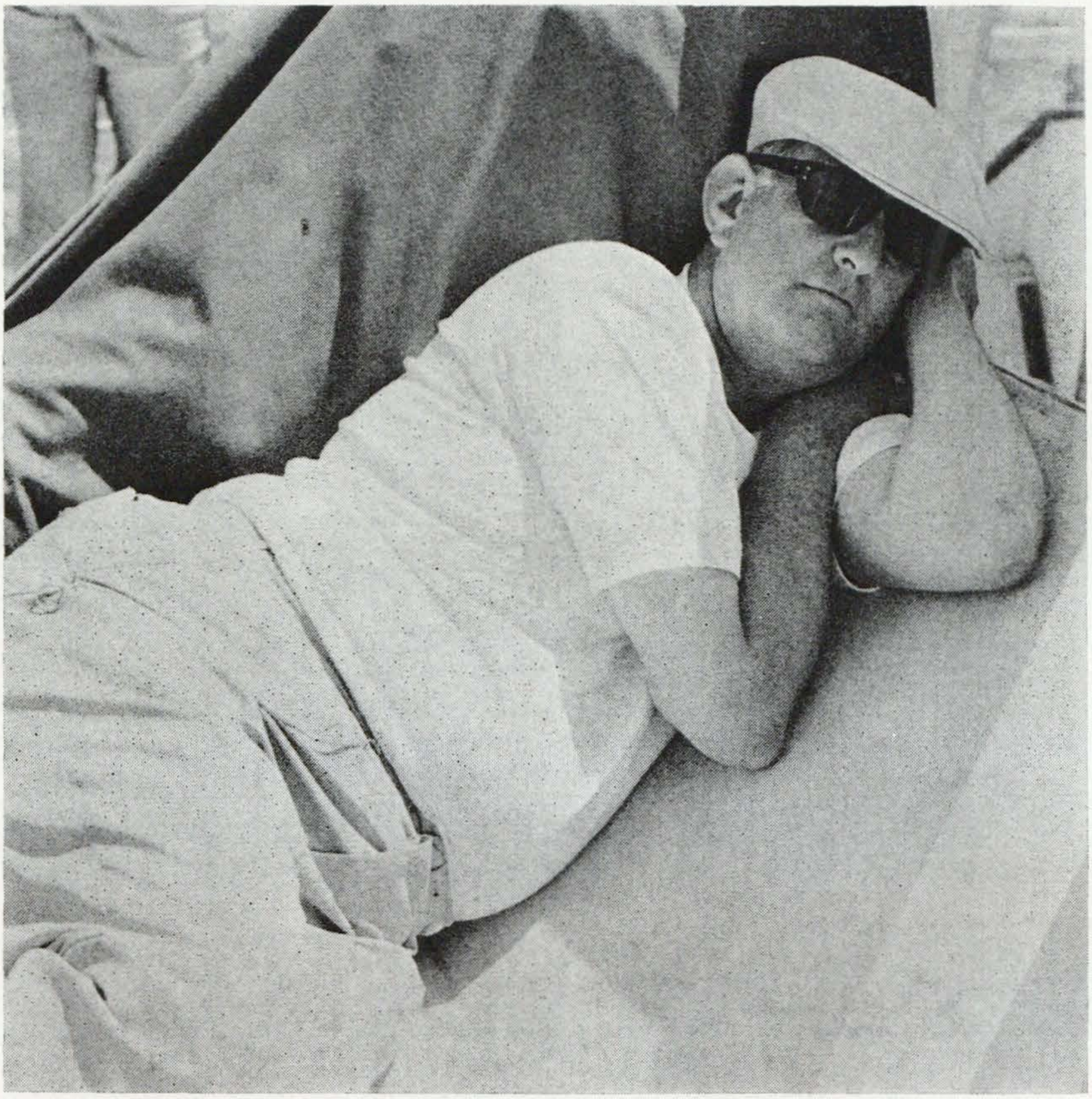
After the regatta was finished, Don and Lindy Landauer kindly took me for a day trip to Catalina Island in their Cross 38 trimaran, a distance of some 20 miles from San Pedro. This was most instructive to me as showing the conditions of much of American sailing.

We set off in the early morning calm and motored all the way to the Island in 4 hours with a 20 b.h.p. motor (diesel) driving a large propeller through a reduction gear. Owing to the small range of the tides and the marina system, the boats are afloat at all times and all year round. The main problem is to get the boats out of the water for cleaning. We therefore had some weed but not enough to affect us materially.

After an enjoyable couple of hours at Catalina, we sailed back in 3 hours with the winds slowly getting up to force 5. On the way over, I saw my first shark fins, a flying fish, a dead seal and a school (or is it 'pod') of dolphins in the distance. It was most enjoyable.



*Note: Track, carriage, sheet and inhaul*

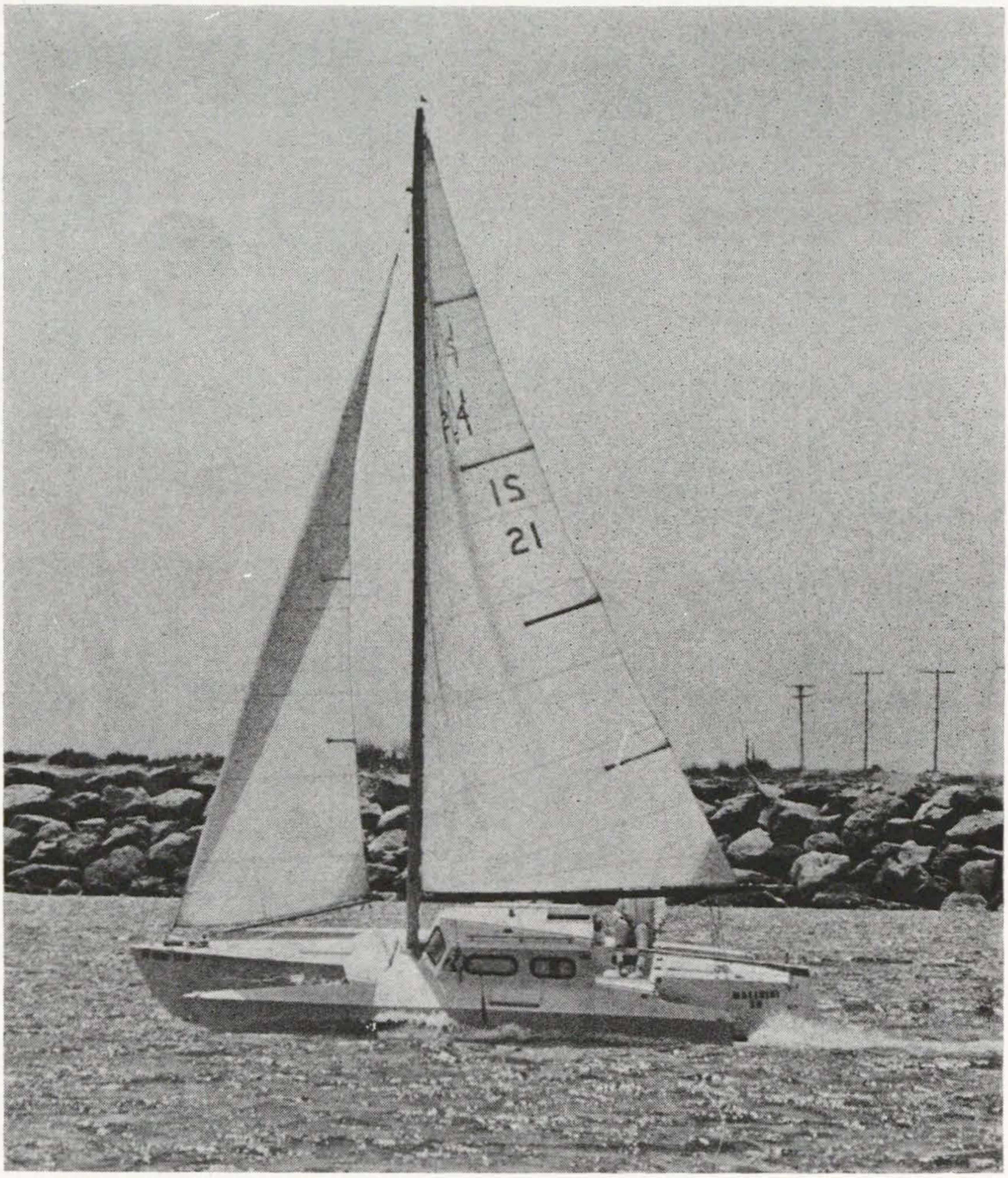


*John Morwood planning A.Y.R.S. activity*

## San Diego

'Jetting' south to San Diego, I was met by Norman Cross at the Airport. San Diego is a lovely city with beautiful views from Point Loma across to the Coronado Islands out at sea. Norman is now designing trimarans and advising builders of them, full time. I had spent a most enjoyable afternoon with him at Los Angeles, meeting the amateur builders of his well designed and pretty boats. The designs are most carefully drawn, accurate and easy to understand. Some of his latest designs are made with laminated, cold moulded hulls and these seem to be popular with the builders. 'No problems.' They said.

Norman again took me around to see craft building and launched and, after seeing so many amateurs at work, I began to wonder if there were any commercial boatyards on the West Coast at all, except for some enormous factory somewhere, building the *CAL* series of single hulls. Still, I did see two commercial boatyards doing excellent work on a variety of craft, though mostly multihulls.




*Norman Cross in his CROSS* 22*—speed trials*

Norman then took me home to meet his wife Delia and daughter Claudia. They live in a most attractive bungalow whose styling and accommodation I thought just about perfect and just the kind of place in which I would want to live. Most people in California appear to live in bungalows in their own ground, though the absence of rain for nine months of the year makes daily watering necessary for all plants. However, the guaranteed absence of rain made our barbecue meal a delight, instead of the 'pick up and get inside when the rain comes' barbecue of England.

In the evening, Norman had invited some A.Y.R.S. members to come along. Delia Cross laid on a grand buffet and we talked boats for a few hours. It was very pleasant.

## Design conclusions

Racing boats will develop whatever shape is fastest for their conditions. As regards multihulls, the shape of race-winning craft is more or less the same the whole world over, though the canoe-sterned Australian catamarans can beat the transom sterned ones on occasion.

As regards cruisers where they can be often slightly foul or choose to carry large engines or large propellers with reduction gears, one should start to argue hull shape from a basis of minimum wetted surface. This means that any designer must have a clear reason in his mind for any deviation from a hull with the following attributes:

1 Side to side symmetry.

2 A canoe stern, or small transom.

3 Semi-circular underwater sections from bow to stern.

4 A lateral plane of 4 per cent of the sail area.

## San Francisco

Flying from San Diego to San Francisco, I was met by my uncle and aunt and spent the day sabbatically visiting cousins. The next day, as a fitting climax to my trip, Dave Keiper took me out in his hydrofoil trimaran of most excellent conception and construction.

The boat was at the dock when we arrived. The retractable ladder foils and the fore and aft foils were all bolted in the 'down' position.

'You are a good weight' said Dave. 'She hasn't got much stability from the floats and has to be held up until the foils take over. Would you mind hanging out there?' He nodded to the weather shroud.

The boat moved off on a reaching course, and as we got the wind, I leant out as much as I could. The apparent wind moved forward. The boat picked up speed and the foils started to vibrate. Obviously, tremendous energy was being exerted.

I looked over the side. She still seemed to be on the water, though travelling fast. I began to wonder if I were taking part in yet another 'failed yachting experiment'. The foils now seemed to be roaring with sound.

'We're up' said Dave in what I though was a quiet voice, though he probably had to shout. I looked over the side. The water level seemed to be about 6 feet below the boat, though she would only have been one or two feet out.

The surface of San Francisco Bay shot by us at an enormous rate. The foils' vibration was now only a slight hum. The boat seemed very stable all of a sudden.

After a few minutes flying, I thought of the long beat back when she would not fly and asked to return to Sausalito. Dave later asked me if I were scared, to which I replied 'Yes' but I had noticed how robust the light alloy struts and foils were. I was not so scared of the flying but of beating back with such an unstable boat when she was *not* flying. However, all went well and we eventually got back to the mooring, almost without mishap.

I cannot, of course, claim that during this sail, my mind was working at any high level of abstract thought. It was an experience and an excitement to be enjoyed, not thought over. I can only say that it is one well worth having and working for. Looking back, it can only be likened to a giant aircraft lumbering along a runway with the engines at full blast. Suddenly, you are airborne, the engines are throttled back and you settle down to go somewhere quickly. This later led me to conclude what had not been in my mind for some years—that a sailing boat is a vehicle for going places as well as a method of being out in the fresh air and (if possible) sunshine.

### Hydrofoil conclusions

David Keiper, Don Nigg and others are flying on foils. Edmond Bruce, Paul Ashford, Bruce Clark, David Buirski, Clayton Feldman and others are stabilising narrow boats with foils. It will only be when these two lines of development meet that we will have the hydrofoil boat we want which will sail faster than catamarans as a displacement craft—and even faster when flying.

After sailing in Dave's marvellous boat, I had a few hours to spend before my plane left. We had a meal at 'Trader Vic's' and then my uncle ran me around the 'night spots' of San Francisco. All down one street were-neon signs in red 'Topless', though just a few had the cryptic word 'Bottomless'. It was a good thing that I hadn't got my late batchelor uncle from the middle of Ireland with me. We would have been inside.

That night, I caught the plane to Kennedy Airport, New York, and was back in England the following night, exhausted because I was worked hard but having had the experience of a lifetime.

### Conclusion

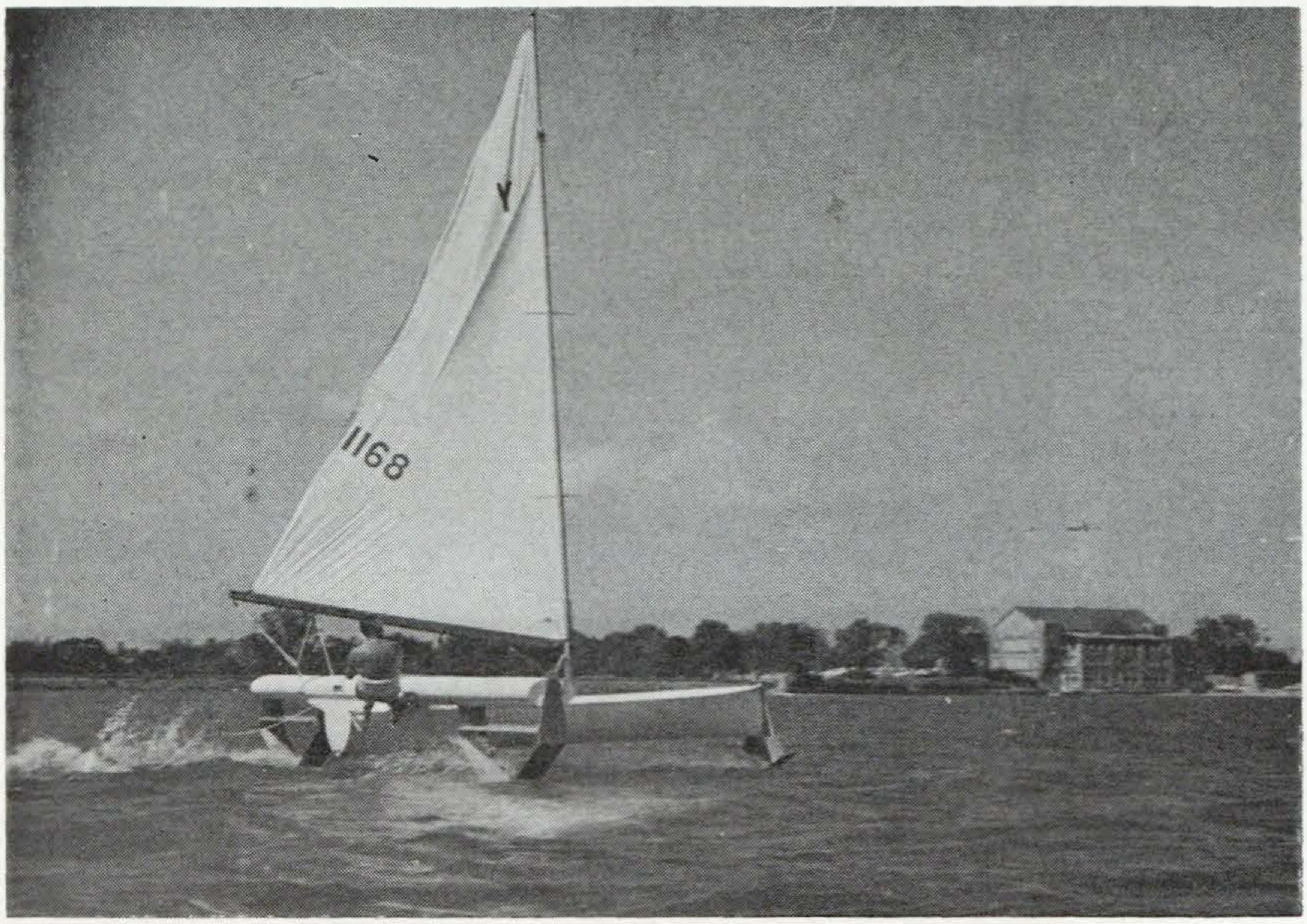
America is a great country. The Americans are a great people. They have status and hence 'problems'. But they are determined to beat then and will, I believe, do so. They are sympathetic to the Negroes and the Vietnamese and this must eventually solve those, their two greatest conundrums. It is true that they are horrified by their eccentrics (Hippies) though these are surely the inevitable associate of their greatness where certain of their young folk 'opt out' of their too powerful pressures, responsibilities and 'problems'. Incidently, yachting is one of the ways in which this group can express its individuality constructively.

I want to thank most sincerely all the kind people who made my trip possible, Norman Cross, Alex Kozloff, Tony Rose, Harry Morss, Edmond Bruce, Jack Stoddart, Dave Bradley and many others whom I didn't even hear about and to my kind hostesses, Betty Morss, Bernice Bradley and Delia Cross who did so much for my comfort. I am afraid that I function better with a typewriter than as a social being. I guess that I am a bit of an eccentric myself and, if 'good luck' had not been with me all my life, I, too, might have been a 'Hippie'. And, I think I would have enjoyed it.

I had a whale of a time. I am now once again dealing with my 40 to 80 patients a day, trying to clear the backlog of A.Y.R.S. correspondence, read through yachting and medical magazines, go through a huge heap of medical advertisements, plan future A.Y.R.S. publications and activities, not forgetting the rigging and completion of my new boat *KINNEGOE*, trying to get some fresh air and giving some time to my rather neglected wife. And, the long grass has still to be scythed down at Woodacres. I have a few problems of my own.

Dear Dr. Morwood,

In my last letter to you, Dec. 22, 1967, I indicated that construction had started on a new monohull design for a flying hydrofoil. It was to be a design suitable for home construction and further development by others. This craft was completed and launched in May of this year. Unfortunatejy, five weeks were lost early in the tests due to a broken mast, but the boat is now again operational.



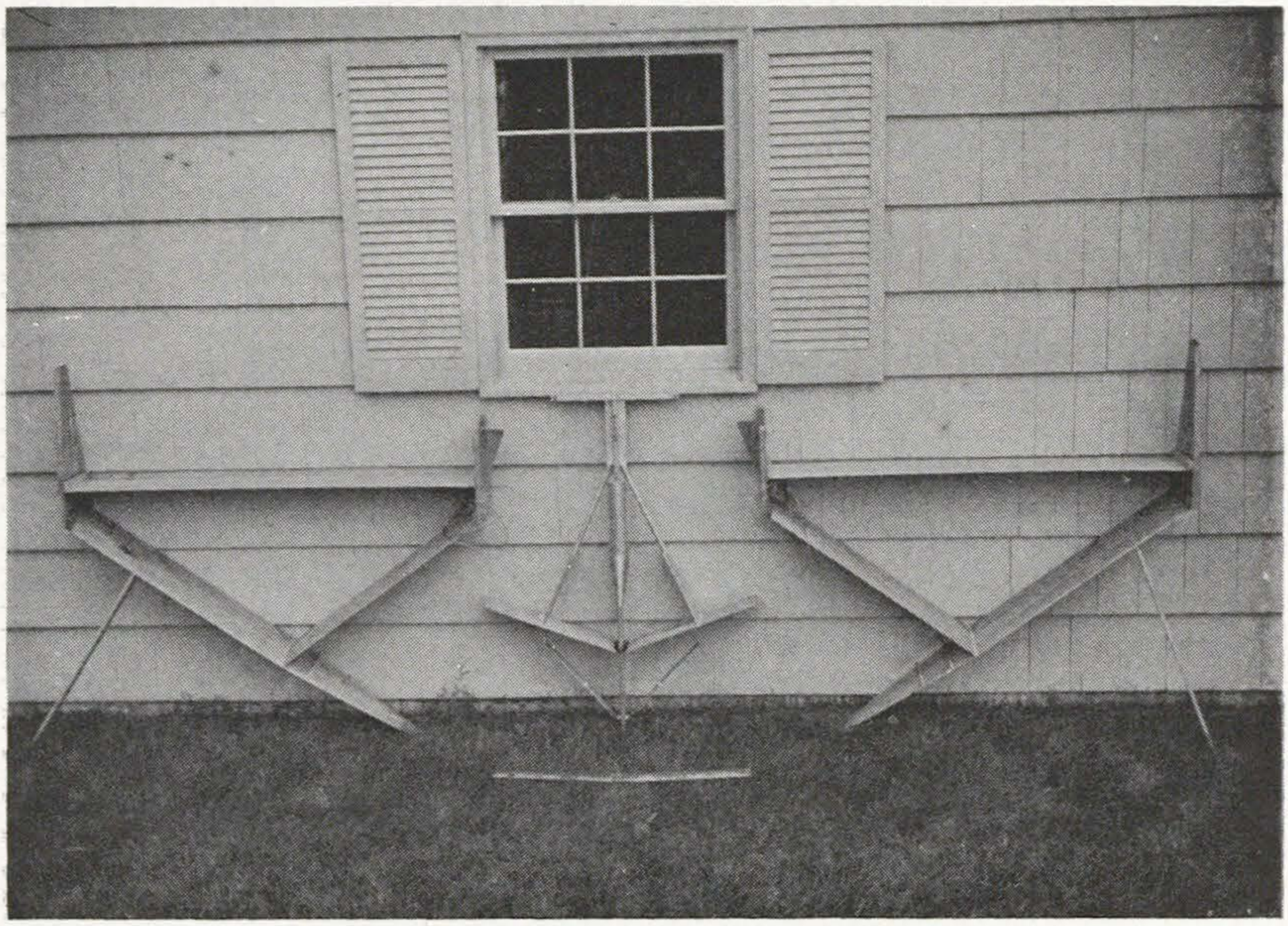

*Don Nigg: A broad reach in a moderate breeze*

We have now accumulated enough sailing hours on this new boat to say that it is performing pretty much as calculated. Several minor changes have been worked into the designs—primarily to improve the ease of handling. The final plans are now drawn up and are available. I have kept a file of the persons who have written inquiring about plans over the past two years. These persons have been notified directly as the plans are ready, with their cost.

The same hydrodynamic principles demonstrated to be feasible by the experiments with *EXOCOETUS* (A.Y.R.S. No. 58) have been applied to this new craft. These principles are dealt with in depth in the article 'A Sailing Hydrofoil Development' appearing in the April 1968 issue of *Marine Technology*, a publication of the Society of Naval Architects and Marine Engineers. The big differences in the new craft concerns the structure. Whereas *EXOCOETUS* was an experimental platform supported by three floats when at rest, the new design utilizes a monohull with a buoyant cross-beam. This provides a number of practical advantages, and looked like the way to go for establishing a development class. It has been suggested that such a development class might be called the 'Ayrsfoil' class, and since I haven't any better ideas, the name is alright with me. Unless a better idea comes along, this is probably the class name that will appear on the plans.

Now for some details about the design. It was decided at the outset that most persons who would want to build such a boat are undoubtedly already small boat sailors, and probably own a dinghy with a mainsail in the range of 100 to 150 sq. ft. If a basic hydrofoil design could be developed to give good performance with this size sail, then experimenters could share the rigging and sail with their existing boat and thereby drastically reduce the cost. This brings the material cost down to between $150 and $200, depending on how fancy the builder wants to get. The model in the photographs is shown with the sail and rigging from a Y-Flyer, which has a mainsail area of 125 sq. ft. The boat, less optional rigging and sail, weighed in at 266 lbs. complete. With crew, Y-Flyer rigging, and Y-Flyer mainsail the gross weight was 477 lbs. This is about 40 lbs. more than the original objective and a little cleverness in weight reduction by the builder would no doubt pay off in performance. The waterline length is 16 ft., and the cross-beam is 20 ft. Total submerged foil area is 15.3 sq. ft. at take-off and 2 sq. ft or less through the design centre cruising range of 20 to 30 knots.

The sealed hull is $\frac{1}{4}$ in. marine plywood with the skin carrying the torque loads, and an internal structure coupled with the skin carrying the bending loads. The crossbeam is eliptical in cross section. On the minor axis, a fabricated beam carries the vertical bending loads, while the $\frac{1}{8}$ in. skin carries



*Don Nigg's foils. Note yard rule*

the torque load associated with foil drag forces. The crossbeam is secured by four bolts and two stays, and is removable for transporting. The front steering feature has been retained, and the foil details may be seem in the photograph. The yardstick shown beneath the front foil system provides size perspective. All foils are quickly removable for dry storage or transporting. The lifting foils are all oak except the small high speed aluminium foil at the base of the front foil system. The horizontal foil shown at the top of the rear foil system is not a lifting member. It is made of pine and performs the dual function of a structural member, primarily for the foils when detached, and a safety feature to be described. All foils have a 7 per cent fineness ratio and are plano-convex, i.e. flat on the underside and a circular arc on the upper surface. Again, this favours the home builder while remaining competitive with other hydrodynamic shapes.

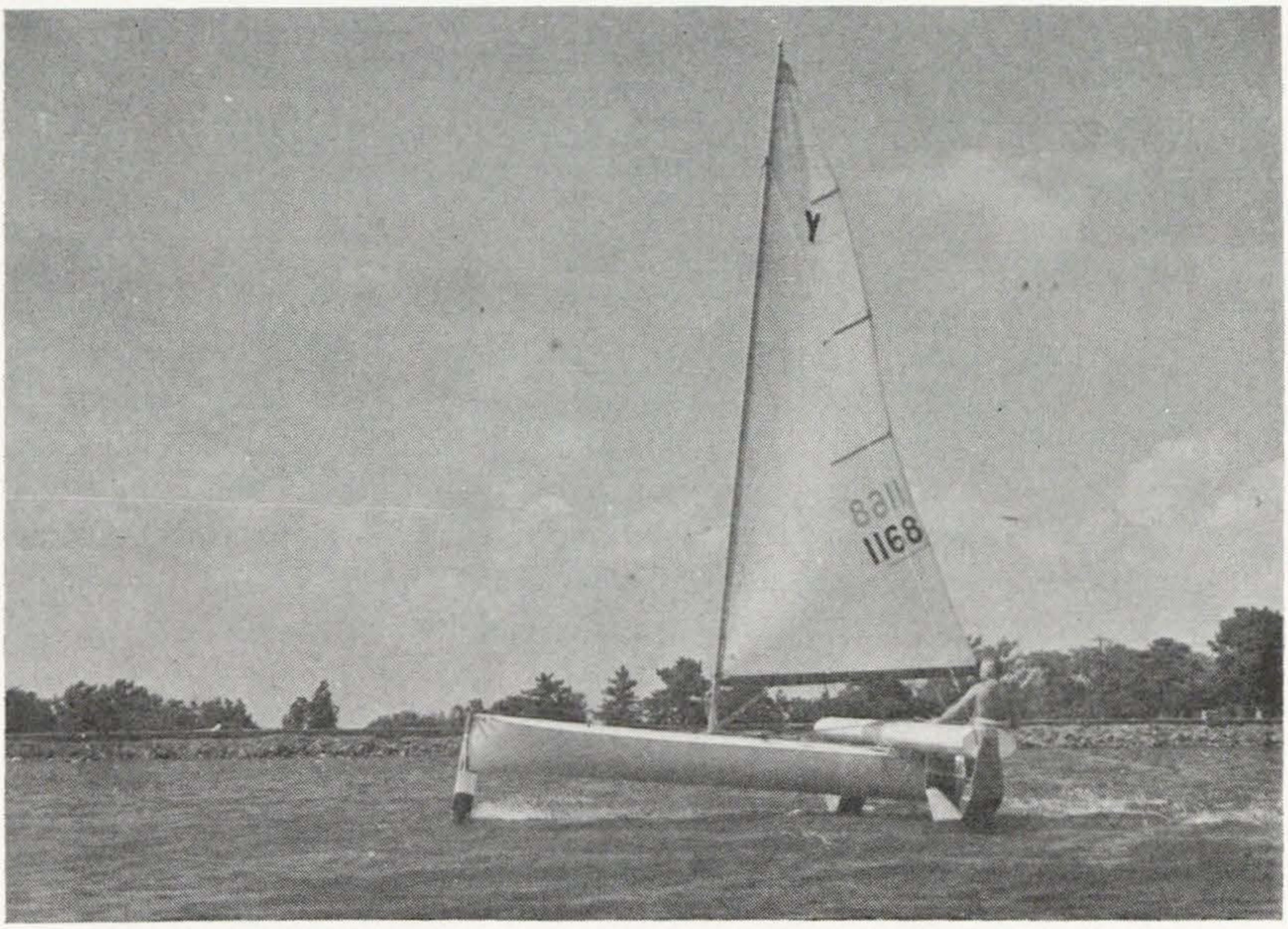
The crossbeam is sealed and provides roll stability while floating at the dock and at very low taxi speeds. The horizontal member in the rear foil system has the same foil shape as the rest of the foils. However, it is set at an angle of attack near the stall point for maximum lift, and its use as a foil surface is two-fold. At the dock, the buoyant crossbeam provides the stability allowing one to walk all over the boat; even out to the beam ends. At taxi speeds up to about 2 knots, the end of the crossbeam frequently touch the water momentarily as the result of sail forces and crew weight off centre. These horizontal foils are out of the water when the boat has zero heel, both at rest or at low speeds, as seen in the pictures. At about 2 or 3 knots, they begin to develop enough foil action to provide an increasing amount of roll stabilization and tend to keep the ends of the crossbeam from dragging in the water.

The take-off speed is 5 knots, and at this speed the regular rear foils are providing most of the lateral and roll stability, along with the off-centre crew weight, and the boat does not have to drag these high-incidence-angle safety foils through the water as it takes-off. Once foil borne, they provide a real safety feature in the event of a sudden roll transient. They provide great lift when driven into the water and prevent the possibility of hooking the end of the crossbeam in the water and thereby setting up a potential cartwheel capsize condition. The test trial results of this roll stability sequence has been especially gratifying.

As a generality, the craft handles better than *EXOCOETUS*. It was felt that lowering the minimum required wind from 13 knots to 10 knots and lowering the take-off velocity from 6½ to 5 knots would greatly increase the number of days in the season when flying the boat would be possible. These changes meant larger foils and sails, but appeared to be worth it.

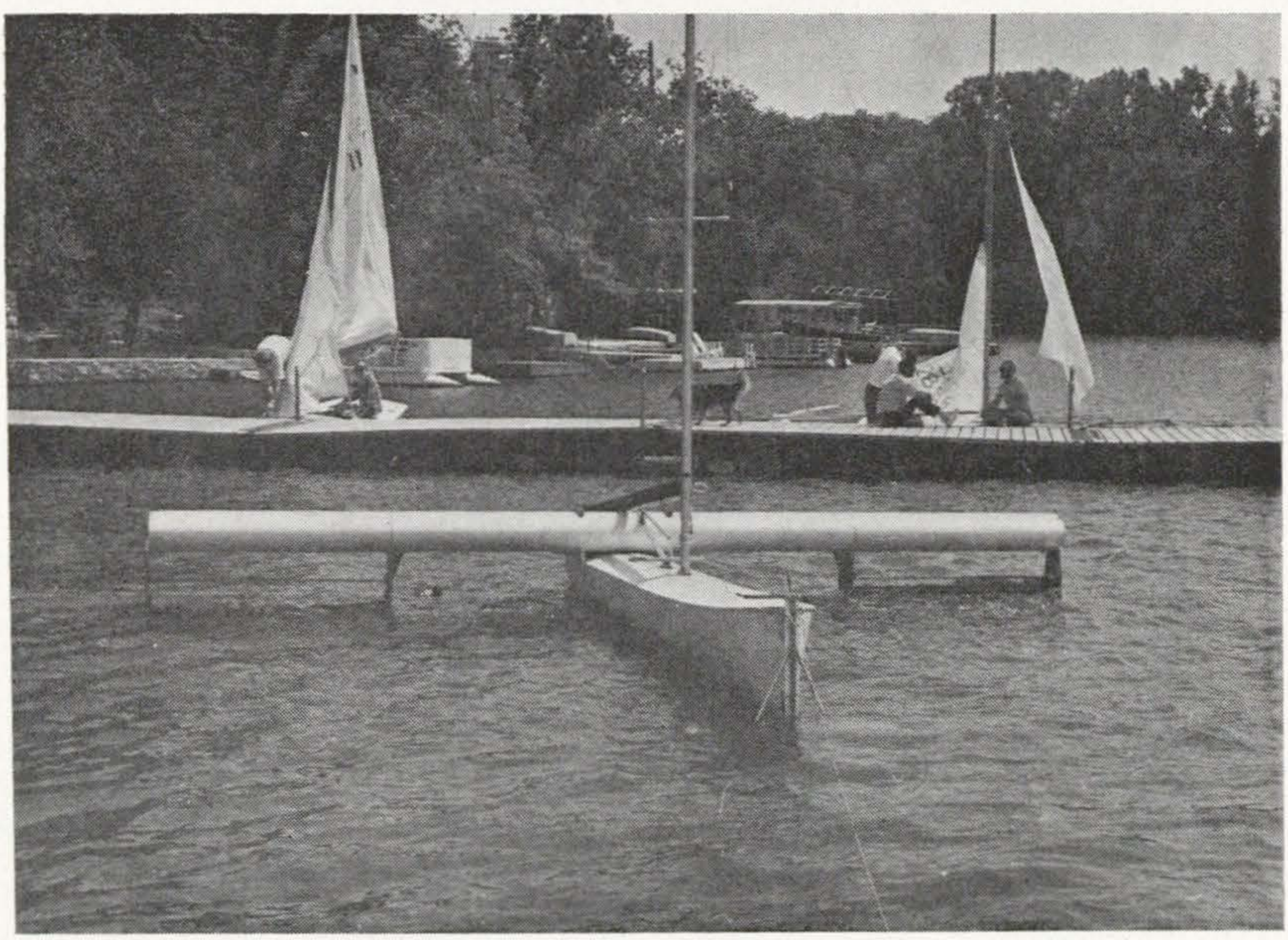
A larger sail results in a higher centre of effort and thus a wider beam to retain roll stability. The increase from 16 to 20 ft. in beam width more than compensated for the larger sail. It resulted in a basically more stable craft, and hence one easier to handle.

One penalty that might not be obvious is some sacrifice in higher wind conditions. It is paradox of these craft with their nearly flat drag-velocity curves that one needs a substantial breeze to fly at all, and then one doesn't need a whole lot more to attain full capabilities of the boat. Overpowering soon becomes a problem. The larger sail areas quickly become a burden as the wind rises, or in handling the heavy puffs so characteristic of this part of the country. I have had to come in off the lake on several occasions because the wind was more than I could handle, while the Snipes and other small craft were weathering it fine. This is an area that others can develop—roller reefing on the boom, or something to shorten sail rather than having to carry a heavy luff.



*Take-off attitude—Climbing out*

I don't know how fast this boat might have gone had I felt capable of letting it out on several occasions. I have held it to what I estimate to be within the 20 to 30 knot range for which it was designed. At the top of this range it is riding pretty high in the water and the foils are beginning to feel



*Don Nigg's hydrofoil at rest*

the waves. It is entirely on the cantilevered tips of the rear foils and riding on the bottom half of the small foil in front. This is another area for other experimenters to carry on—those who want to see how fast they can go. This boat would surely destroy itself in seconds if turned loose in a 25 knot wind.

The surface buoyant mode handling characteristics of this boat are also somewhat better than *EXOCOETUS*, but it still leaves a lot to be desired. This is not unique to these two designs, all the other experimenters I have talked with have complained about this. The boats all seem to get into irons quite readily when not on the foils, and they are hard to get out. They will not come about because their light weight and high drag when floating is too adverse to permit them to headreach through the wind. This means that they must be jibed about or boxhauled. Here again is an area for more development. It might be noted that the front steering configuration appears to be less of a weathervane. It is therefore probably less of a problem in irons than are the rear steering types.

I hope other will pick up this development from here, as this is probably the last one I will build. I've had my fun, and after getting the plans drawn up and released, I'll probably turn my attention to other matters.

Very truly yours,

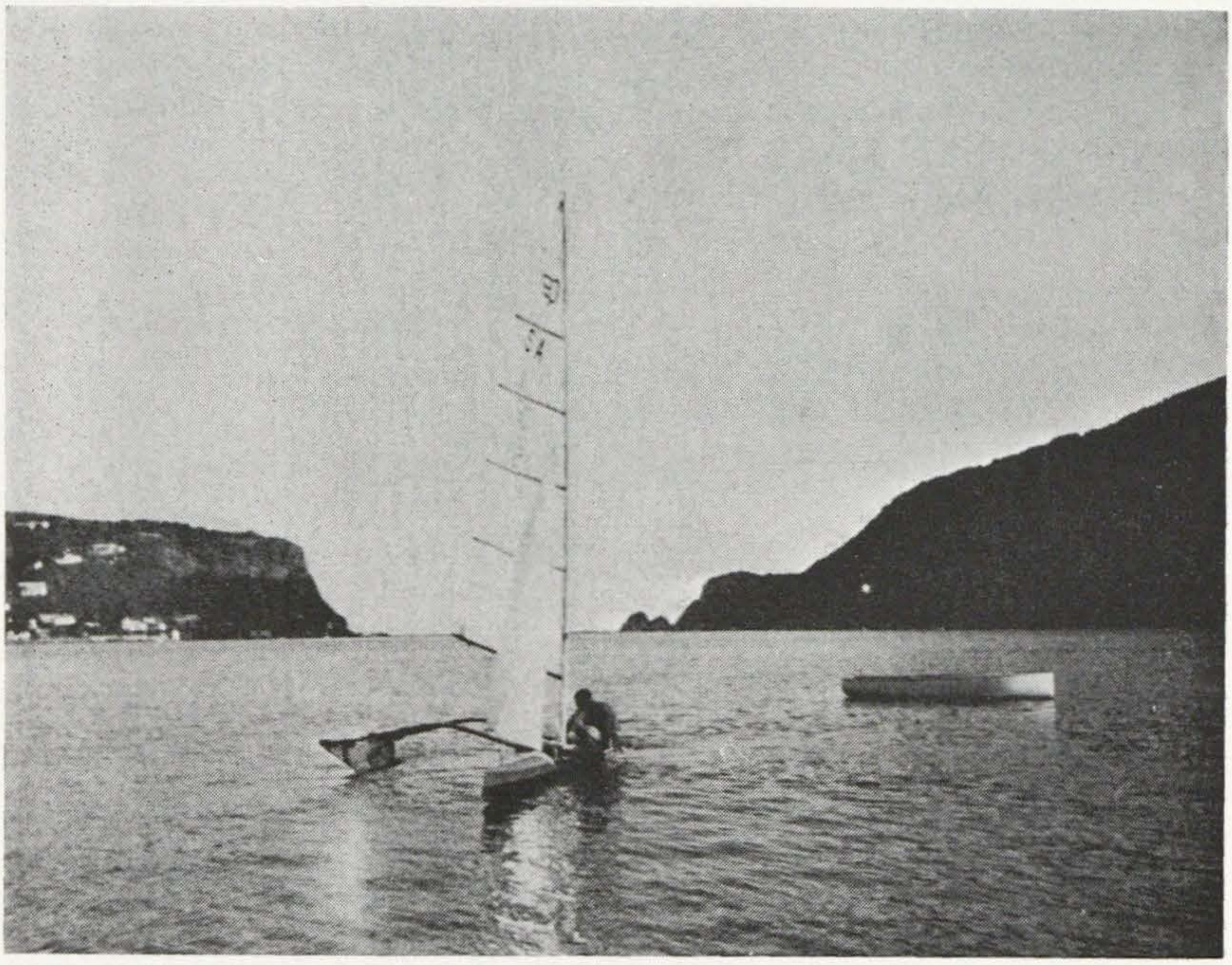
DONALD J. NIGG,
7924 Fontana,
Prairie Village,
Kans., U.S.A.
July 22, 1968.

*Ed.*—Plans now available from Don Nigg. $20.00, U.S.A. $21.50, Canada and Australia. £10, U.K. Or from the A.Y.R.S. Woodacres, Hythe Kent, England.

Dear Mr. Morwood,

Please find enclosed copies of photographs taken recently. Since last writing to you I have made and sailed with both high aspect and low aspect foils. I first made a high aspect foil, which I found was adequate in heavy wind, but, as suspected, stalled badly in light winds. It had another severe failing in that it hobby-horsed in a chop.

I then proceeded with making a low aspect foil, as can be seen in the photographs herewith, which was perfect in both heavy and light wind conditions. Incidentally, because the foil is not flat on each face but naturally curved because of its foil shape, and as only the centre is at 46°, it does not hold quite as well as the flatter centreboard type, thereby giving me an additional bonus in that on the runs I am able to get all the board out of the water. Although it was not easy to get the foil out, it comes up very slowly and is perfectly controllable. The same thing applied to a beat in light winds, just allowing tip of foil in water, thereby cutting down drag and wetted surface.



*Dave Buirski's buoyant Bruce foil, mostly lifted out*


*Dave Buirski's boat, showing float-foil. Low A.R.*

The boat is very fast in both light and heavy wind and drag from the foil seems negligible.

A rig tried out a few days after the photograph was taken, using a much bigger Genoa further forward, which gave me a total sail area of 210 sq. ft., was far more satisfactory than that illustrated in the photograph, which indicated that the sail area had to be moved further forward. Unfortunately, this will mean using a heavier mast, as the mast in the photograph will not be able to handle the sail area in a stiff blow.

While sailing solo a friend of mine did actually overturn this craft—a sheet jammed and while he was busy freeing it the boat came up into the wind, stopped, and a sudden gust tipped him over. It proved a simple matter to right it . . . every bit as quickly and easily as a normal dinghy.

Someone remarked 'It's fast alright—perhaps that's only because it's 21 ft. long'. 'A 21 ft. catamaran', he said, 'with two hulls like yours, might be just as fast'. He overlooked, of course, the weight and wetted surface aspect. Nevertheless, he had a point and I realised that to prove that it is indeed faster I will have to compete against an existing catamaran using an identical single hull fitted with my low aspect foil. The ideal craft to compare with would be a Thai Mark 4, as it has proved to be one of the fastest catamaans of its size in the world, and as there is one in Cape Town and also a mould from which I can have a hull made, I intend doing just this, coupled with your suggestion of using an ice yacht rig. If it is convincingly faster than the Thai, the same comparison can be drawn with a C Class cat, proving, as you think, that it is the fastest craft in the world.

I would therefore be most happy if you could let me have details of the ice yacht rig if they are back from the printers.

Yours faithfully,

DAVID BUIRSKI,
Suikerbos,
The Grange,
Camps Bay.
S. Africa.,

# THE SUPREME YACHT DESIGN METHOD

## by John Morwood

*Note:* I (J.M.) have been criticised by several members for writing too much. Our informed members have been most kind in refuting this. However, in general, my writings have been in the form of 'leading questions' to induce people to think and, if possible to extract factual information from those who have it, or to pose the questions which will cause the appropriate research.

What makes the best reading in our publications, however, is controversy and I think that everyone who reads my 'essays' should try to make some comment, favourable or otherwise to extend the basic ideas.

**Instruments needed**

1 Re-circulation laminar flow test tank.
2 Drawing board and usual apparatus.
3 Models of 15 inch L.W.L.

**Principles involved**

The overall performance of racing yachts as regards speed can be estimated by an assessment of their light wind performance ONLY. This holds even more forcibly for cruising yachts. The reason for this is that 1, most sailing takes place in relatively light winds and 2, windward speeds are mostly determined by wetted surface and sail area ratios, which amounts to the same principle.

**Conclusion**

In the past, a lot of time has been spent on test tank studies of upright and no leeway studies. These tests have proved to be useless in practice bearing no real relationship to racing performance. In my opinion, it is only necessary to study the drag angles of any yacht produced on the drawing board. Not only will this study show the windward performance but it contains within it an index of the resistance to forward motion because the smaller this is, the lower the drag angle will be. The overall conclusion is that the yacht with the lowest drag angle will be the best performer, on all courses.

The above opinion is, of course, arguable in theory and these would be of interest to us. However, the empiric fact that the lowest drag angle-ever obtained by Edmond Bruce was 9° with a trimaran and a trimaran should be the most efficient hull available at the present time for the test tank—the catamaran under test tank conditions will have more wetted surface.

**The design method**

Irrespective of the yacht being designed, single hulled catamaran or trimaran or even single outrigger or hydrofoil, the method is the same. The lines and sections are drawn up with what salient keel or centreboard is deemed reasonable; a model is made and a set of drag angles found for a range of leeway angles. The salient keel or centreboard is then varied in size and shape and a further range of drag angles taken. For a guide, Edmond Bruce in a note elsewhere in this publication indicates that an aspect ratio of 1 : 1 has been found by him to give the best values, for a centreboard or hydrofoil.

**The re-circulation test tank**

As pointed out by Edmond Bruce, such a tank will have an error due to the water gradient, i.e., it flows downhill across the test section. However, this error will be very slight and the same for all models, if of the same weight. It is, however, so much more convenient and appropriate to private ownership and to taking drag angles than the full Bruce tank, that it seems to me to be preferable.

**Summary**

The only reasonable and rational method of yacht design which is within the means and capabilities of the amateur and most professional yacht designers is described. It is believed that an adequate and good comparison of designs can be achieved by a single drag angle curve to the leeway angle.

# A YACHT OR KEEL PROFILE RESEARCH

In this publication, there is some discussion of keel profiles. It is quite likely that the shape which is found best for the keel profile will also be the best shape for a centreboard or a short salient keel. Research on the matter therefore becomes of the greatest importance for every yacht, no matter of what type of configuration.

### The research

For each shape of profile, two wooden forms are made which are identical. These are joined at the top at some distance from each other to make a variety of 'catamaran' and, with an extension in the midline protruding aft, the profiles can be made to float at their designed waterlines.

A variety of profiles are then tested in a re-circulation tank and that one with the minimum drag angle found. I guess that the shape so found will be the best one for a centreboard or a beamy single hull keel yacht.

Multihulls and very narrow yachts derive a considerable proportion of their lateral resistance from the hull itself and with these, a lower aspect ratio centreboard or keel might be better.

# THE HYDRODYMAMICS OF LATERAL RESISTANCE

In our publication *Keel Yachts*, we had a collection of the modern type of keel yacht where a fin and bulb keel stabilised a low resistance hull on the surface of the water. Eric Tabarly's magnificent *PEN DUICK III* illustrates the type to perfection. This type of yacht is, of course, the hydrodynamacist's delight. The hull merely supports the structure while the fin provides the vast majority of the lateral resistance.

On the other hand, traditional sailing fishing boats with a reputation for windward ability and a few very fast and impressive yachts such as *NINA* and *DORADE* have no fin whatever and appear to get adequate lateral resistance from the hull shape alone. All of these have what is called 'drag' to a long and either straight or slightly convex keel which simply means that the greatest depth is at the heel of the rudder. The word 'drag' here is a traditional term and bears no relation whatever to hydrodynamic 'drag' in any form. To avoid confusion, I will call it 'keel slope'.

### Keel slope angles

Measuring these for a variety of yachts and work boats we find: Dorade: 13°. Nina: 12°. Newport Boat, Friendship Sloop and Old Bermuda Sloop have a keel slope angle of 6° or 7° but with a convex shape. The Boston Hooker: $6\frac{1}{2}$°. The Penzance Lugger: 2°. Only the Boston Hooker and Penzance lugger have straight keels so the measurement of these angles is only approximate.

### The bow profile

All sailors want to get the maximum sailing length from a given length of boat and this is most cheaply obtained by having a rather hard turn up of the keel line forward below the water line. This feature is most marked in the Penzance Lugger and the Boston Hooker but is found in all of the above boats, except for *DORADE.* When one watches a Penzance Lugger in motion (now with diesel engines, of course) the bow wave is actually ahead of the stem so she is getting a bit of absolutely free length.

### Rudder profiles

We were all recently amazed that Olin Stevens suddently started using a rudder with a horizontal bottom which became narrower higher up. All designers immediately followed his example but the Bermuda Sloop and its derivative, the Newport Boat as well as the Galway and Boston Hookers had used it 100 years ago and more.

### General observations

All these boats have very low aspect ratio profiles and yet all have been noted for their windward ability, *DORADE*, for example crossing the Atlantic from East to West by a more or less Great Circle course in 21 days. Due to this low aspect ratio, we cannot look to the usual hydrodynamics for their lateral resistance but have to hypothesize other factors.

The primary conclusion from what we have considered so far is that hulls such as these are not hydrofoils and this leads us to think that the lateral resistance comes from a difference of the water level on the two sides of the hull, that on the lee side being the higher. At one time, I thought that the low aspect ratio keel might merely prevent passage of water underneath the hull, thus allowing the hydrofoil-shaped waterlines to create true hydrodynamic lift and this may be so of narrow catamaran and trimaran hulls. But I rather doubt if the conventional beamy single hull would function in this way.

The clue may lie in the keel slope angle. If the keel were horizontal, water would be passing below it from the lee (high pressure) side to the weather side. But, when the keel slope angle becomes greater than a critical size, the water will not flow under the keel but will flow from fore to aft, even though the yacht or boat is making leeway.

An interesting conjecture arises from the foregoing which may or may not be valid. This is that, in resisting leeway, a yacht behaves like a two-dimensional object without beam and research into the best possible profile shape might be done with thin flat sheets.

### The hollow waterlines of the Work Boats

All the examples of 19th Century work boats we have used in this article had hollow waterlines fore and aft. In my opinion, these were used to get the proper curve of sectional areas with the deep forefoot they used to get seakindly boats. I may be wrong but I don't think that these hollow waterlines contribute to lateral resistance, and they certainly increase wetted surface. If seakindliness were all important to me, I would use them—otherwise not.

### Conclusion
Conventional deep keeled yachts derive their lateral resistance from the keel slope angle. This partially or completely prevents water from flowing from the lee side to the weather side under the keel. The lateral resistance then appears from a higher water level on the lee side, as compared with that on the weather side.

# CENTREBOARDS

## by John Morwood

*With help from Edmond Bruce. Drawings: Ron Doughty.*

The main function of a centreboard is to increase the lateral resistance of the hull of a sailing boat, when required by the course, at the minimum cost in drag due to the increased wetted surface, 'induced drag' and drag due to eddies produced by the board shape. The overall difference in the yacht is that, when it has leeway of an angle which Edmond Bruce thinks should be 5°, the 'drag angle' or 'lift to drag ratio' is decreased or increased respectively, to make the boat sail closer to the wind.

### History
Dagger boards were used in the Formosan bamboo sailing rafts and in the South American Jacanda and balsa rafts. The leeboard was invented by the Chinese and (with the spritsail) was taken up by the Dutch. The centreboard, however, was a true invention because it would be against any sailor's instinct to cut a slot through the hull of his boat. Both English and American patents for centreboards appear in the early 19th Century so it must have been more or less unknown before that.

### The workboat centreboard
The centreboard had its best development on the American east coast where the water is often shallow. Catboats and the New Haven Sharpie are good examples. The shape finally developed is, when dropped, a triangle about twice as long at the top as on the 'drop', an aspect ratio of 1 : 1. This shape gives an excellent performance and might well be used for any cruising boat.

### Dinghy centreboards
The modern light racing dinghy appeared on the yachting scene with the high aspect ratio Bermudian rig and the science of aerodynamics rapidly becoming known. The result was that the value of aspect ratio was known and many people tried very high aspect ratio boards. For instance, there is a story of Beecher Moore sailing a *Merlin Rocket* with a board 6 feet long and 6 inches in chord, an effective aspect ratio of 24 : 1. Apparently, he could sail it and beat others to windward with it but but nobody else could. In fact, of course, an increase of aspect ratio for an aeroplane wing above 6 : 1 is almost useless

due to high parasitic drag elsewhere in the plane. Because a centreboard has only one 'wingtip' we need not think of any ratio above 3 : 1. Greater aspect ratios than 3 : 1 will only improve windward performance by a fractional amount and they will decrease heeling stability. The modern trend is towards even lower aspect ratios, even for catamarans.

### Centreboard construction and design

Deeply immersed dinghy and catamaran boards can be made of square strips of wood, glued together to make a plank which may be shaped as follows:

1 The profile should be a semi-ellipse of an aspect ratio span$^2$/area of 3 : 1.

2 The section should be pointed fore and aft with the maximum thickness at one third of the chord from the leading edge, though some put it at the mid chord line.

3 The thickness to chord ratio should be 1 : 12.

The reasons for all these dimensions are as follows:

1 Making the board of glued square sectioned strips avoids warping. Plywood is a poor material for strength in a long axis and a board made from laminated veneers whose grain runs along the length is unstable and can warp.

2 The profile and aspect ratio given are the result of sub-sonic aeronautical theory backed up by wind tunnel tests and full sized aeroplanes. Whether or no this need hold for a centreboard so near the surface is another matter which will discussed later.

3 The pointing of the section forward has been found to be useful in actual sailing practice as well as in tank tests of hydrofoils. It eliminates vibration in water.

4 The maximum lift to drag ratio with symmetrical aeroplane wing sections is found with a thickness ratio of 1 in 8. Such sections are, of course, rounded at the leading edge. Because we have found that pointing the leading edge of our centreboard section is valuable, this reduces the thickness to chord ratio to 1 in 12. The position of the maximum thickness of an aeroplane wing is usually about one third of the chord from the leading edge. Yachtsmen can also use this position for the maximum thickness of their centreboards—or, they can put it at the mid-chord point, which seems a more logical place, though it doesn't seem to matter much in practice.

In all the above on dinghy centreboards, the arguments are more or less orthodox and commonplace but, if any member has any criticism or extension of them would he please send a letter for publication.

### The low aspect ratio centreboard

For boards operating near the water surface, various factors may be taken into account in deriving what may be the best shape. These are:

1 The American workboat centreboard of a triangle twice as long at the slot as in the 'drop'.

2 The value and use of the quarter circle centreboard as in the International Sharpie and other boats. The term 'stable' is frequently used for these boats.

3 Edmond Bruce's tank finding that the lowest drag angles for boats appears when a thin surface-piercing board has an aspect ratio of 1 : 1 though only rectangular shapes have been tested, so far. He also finds that most multihulls have boards which are too small.

4 Centreboards are not completely analagous to aerofoils or hydrofoils deeply immersed in a fluid, which is 'incompressible'. Being so near the surface, the water acted upon by the board seems 'compressible' since it is pushed aside, giving surface waves. Conventional sub-sonic hydrodynamics are not therefore relevant and we must discover the best by trial and error either at full scale or in the tank.

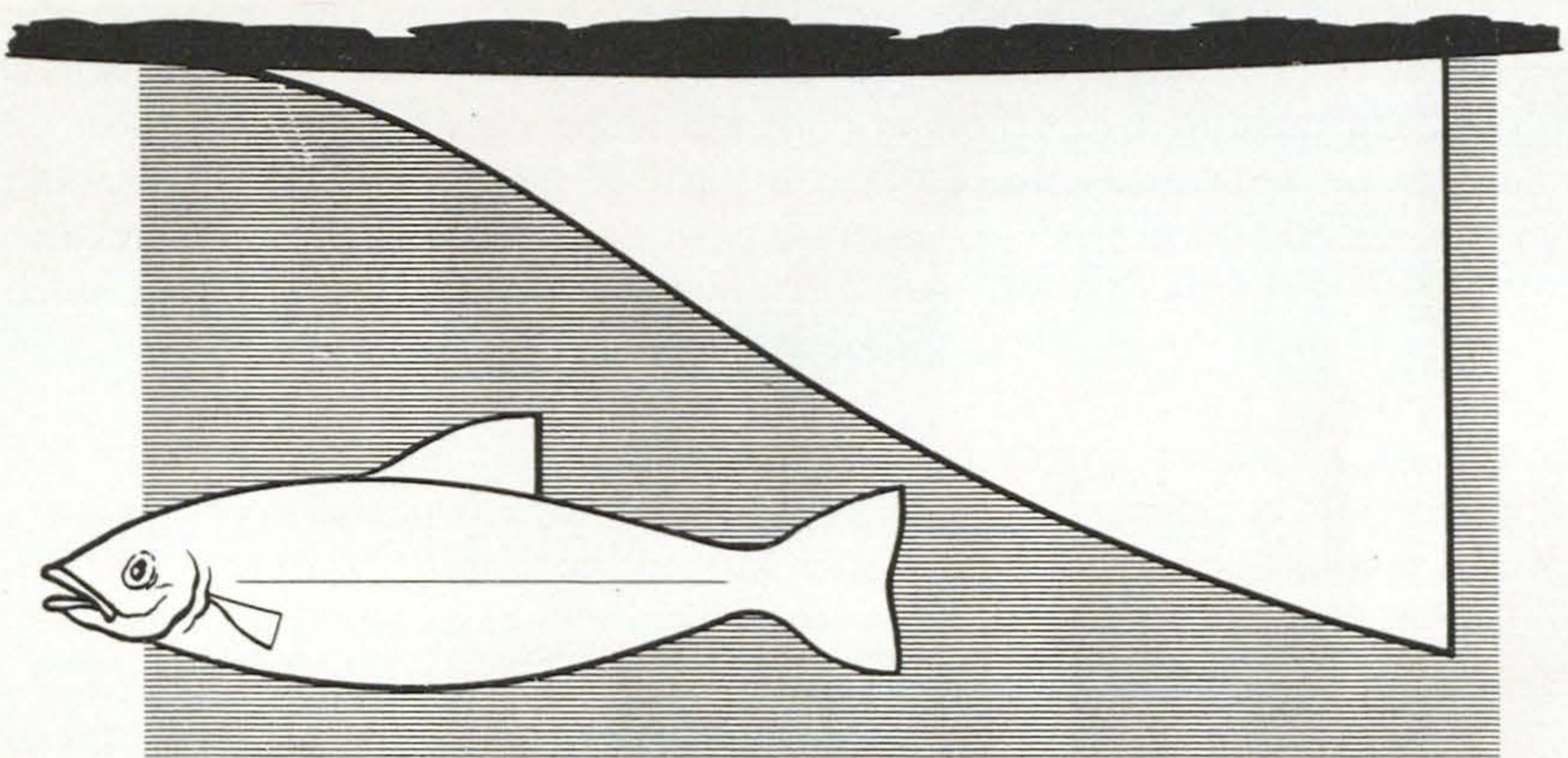
5 The forward upper corner of a low aspect ratio keel should be 'faired' into the hull by a concave shape—Smith *Why Sailboats Win and Lose Races.*

6 Hull drag angles get less with increasing 'sweepback' angles to the leading edge of fin-keels—Southampton University's study of keel sweepback angles in the 5.5 metre. A sweepback angle of about 25° seems to be about the optimum.

7 A study of the fins of fishes shows that Nature likes a convex curve to a fin behind the concave fairing into the body. A study at the Stevens Institute a few years ago showed the the maximum pressure on the keel of a 12 meter type occurred at the leading edge half way down it. A convexity here seems likely to be of value.

8 The trailing edges of fishes fins can be straight, concave or convex and no fairing into the body is used.

Combining as many of these 8 factors as I can, I have drawn a profile of a fin which seems unlikely to be far off the optimum for a centreboard or rudder and, for good measure have drawn a fish with these kinds of fins which doesn't seem to be too deformed, though what kind of a fish it is, I don't know Such a fin could be used as a centreboard, salient fin or rudder.



## Centreboard size

Harrison Butler (Cruising Yacht Design) gives the total lateral plane area of a yacht below the LWL as between 1/25th to 1/35th of the sail area. This seems an odd way to work as sail area is a function of the whim of the designer, the length of the boat and whether or no it is 'light displacement'.

Skene (*Elements of Yacht Design*) is more rational in that he related lateral plane to the immersed 'mid-ships' section by a factor of between 4 and 6.

Neither of these authorities is therefore of much good to us and neither helps us with multihulls. Lateral plane does, however, seem to be related to hull displacement in a general way and this angle could be explored. Moreover, multihulls seem to fit in with this rule.

To be precise, the optimum size of centreboard is that which gives the smallest possible drag angle which appear to be in the region of 10° for a multihull. I do not know a figure for a drag angle for a single hulled yacht to which one could aim.

## The very low aspect ratio fin

As seen in the Prout *OCEAN RANGER* or the Cross and Macouillard trimarans, this is a shallow fin with a horizontal lower edge about one third of the waterline length, sloping up to the hull fore and aft. Various depths are used, the Nicol trimarans being the shallowest, the Cross ones the deepest. Though these fins are not centreboards, it is logical to consider them here.

Because some people have found it difficult to get Nicol trimarans to windward, especially in rough water, one must feel that their hull drag angles are too large. The Prout *SEA RANGER* type with a close-hauled leeway angle of 3° in smooth water (which would probably become 5° or more in rough water) seems about right while it is likely that the Cross fin is also correct because of the extra hull displacement.

Hull drag angles are probably hard to measure at full scale in calm water and impossible to measure in a seaway. Leeway angles, on the other hand, are fairly easy to measure and are a fairly good way of assessing the efficiency of a hull to windward because resistance to motion in the direction of travel increases rapidly as the leeway angle increases. There is therefore a good case for saying that any hull has the proper amount of lateral reistances of the kind chosen if the leeway angle has been reduced to, say 3° in calm water. In rough water for the boat concerned, the leeway angle is then likely to be about 5°. It is unwise to take Edmond Bruce's observation that the best drag angle is obtained at a leeway angle of 5° absolutely uncritically.

Members will remember my arguments for considering these very low aspect ratio keels as 'fences' for multihulls, where they act by preventing water flowing under the hull, thus allowing the hull waterline to develop the windward force. I still hold to this view but am not now quite so sure that such a keel will show an all round improvement in speed over the low aspect ratio centreboard as described earlier.

## Comparison between centreboards and keels

It seems probable on the present evidence that one should either have a high aspect ratio centreboard or, alternately, a low aspect ratio centreboard of the type described, compromises between them being not very likely to be successful. Edmond Bruce finds the lower aspect ratio board giving the best figures in his tank if rectangular in shape, thin and surface-piercing.

The very low aspect ratio keel, as used in *SEA RANGER* probably has to be greater in area than a low aspect ratio centre board (1 :1) and thus has probably more resistance even close-hauled, though this will only be a matter of a few percent. It is unlikely to be a race-winning shape where other things are equal but its greater robustness and protection of the hull when taking the ground make it the shape of choice for a cruising multihull.

### Summary

I hope that all the evidence concerning centreboards and low aspect ratio keels has been assembled here. A profile shape for a centreboard of an aspect ratio of 1 : 1 is suggested which could be of value. I hope that any member who has any comment or criticism of the material put forward here will send in a letter for publication.

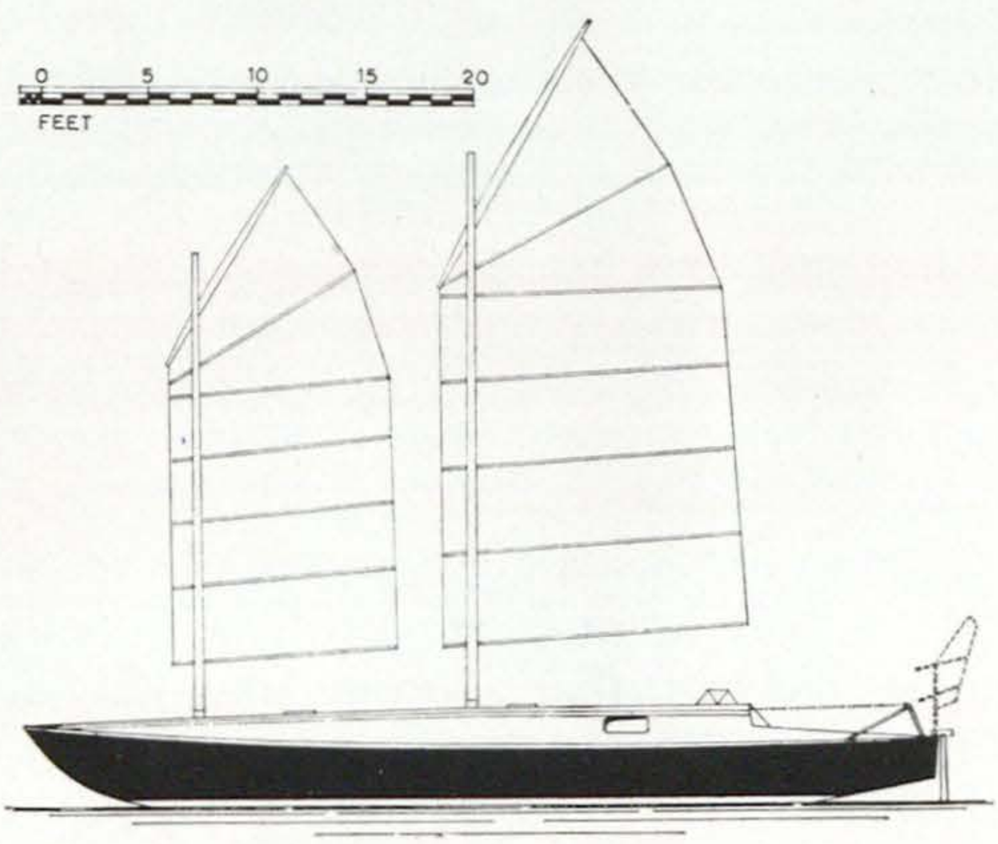
## GALWAY BLAZER II

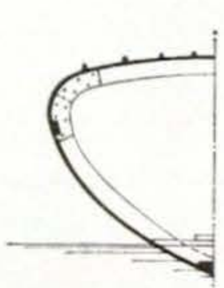
Owner: **Bill King** Designer: **Hasler-Primrose**

| | | | |
|---|---|---|---|
| LOA | 42 ft. | L.W.L. | 30 ft. |
| Beam | 10 ft. | Displacement | 4.5 tons. |

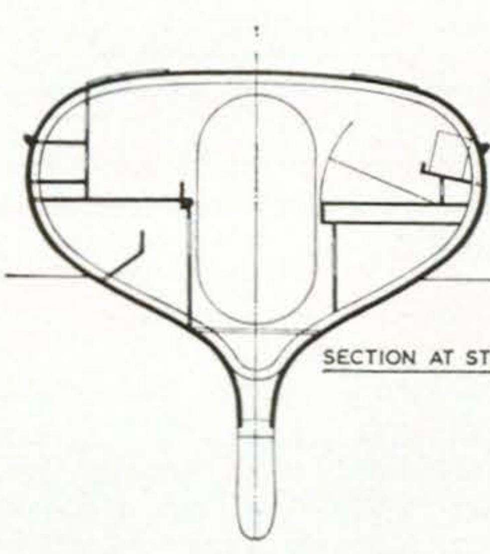
### Plans

*GALWAY BLAZER II* has been designed and built with one purpose in mind; that of taking a man around the world single-handed under sail in the least possible time and with the utmost efficiency.

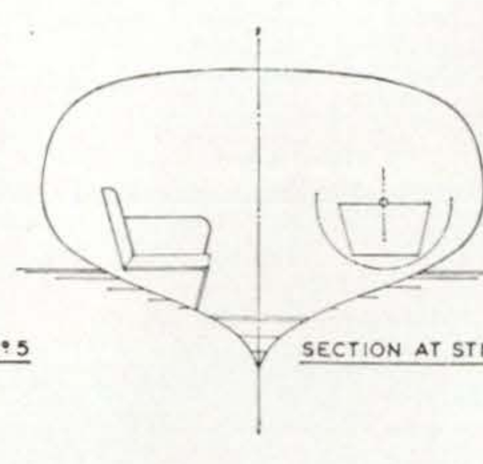


TYPICAL FRAME CONSTRUCTION



SECTION AT STN Nº 5



SECTION AT STN Nº 7

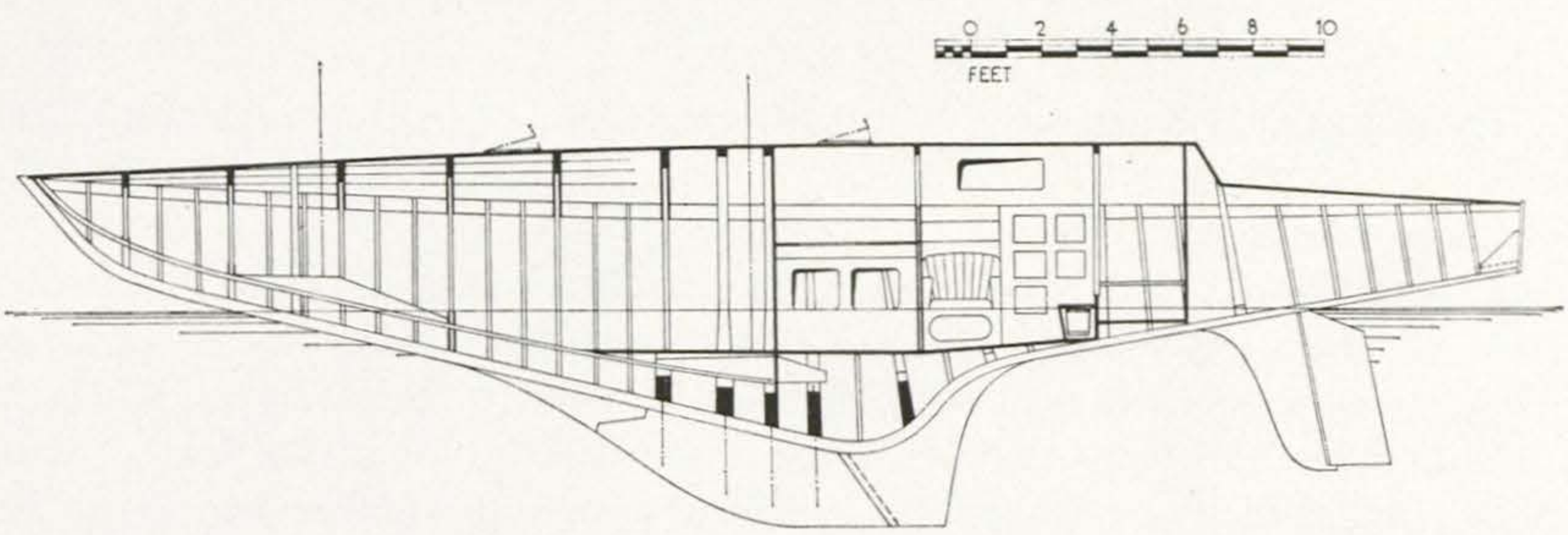
The whole concept of light displacement, ease of handling and method of construction will readily be appreciated by members of the A.Y.R.S.

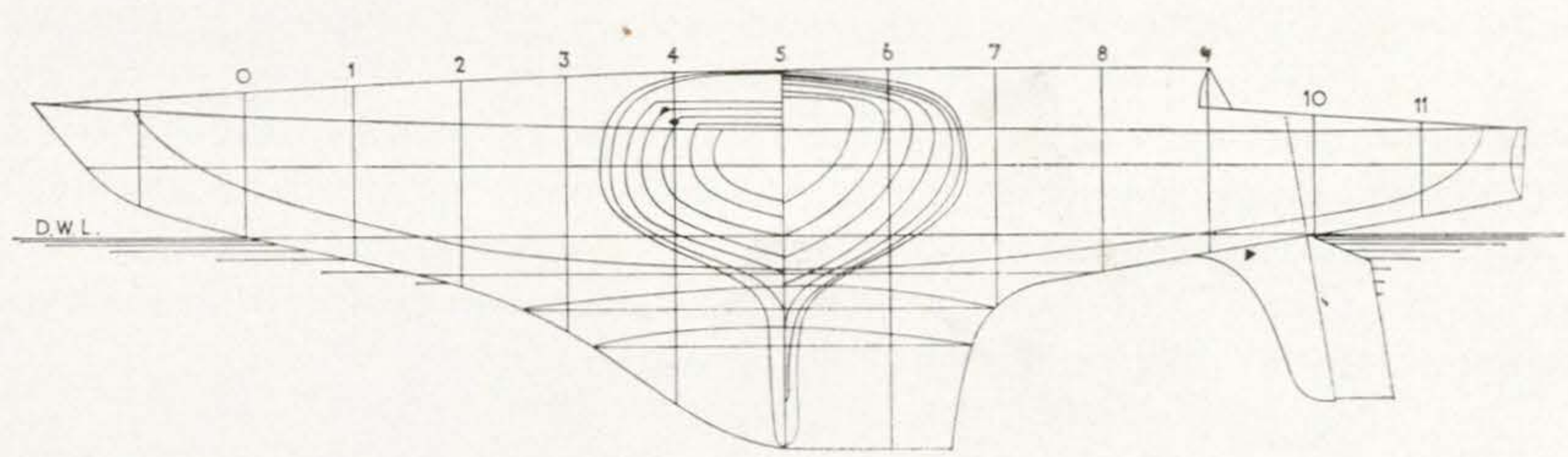
## Sail Plan

The hull which was cold-moulded by Souters of Cowes is first and foremost a 'lifeboat'. The entire hull and deck is in two separate mouldings and her main floors form a complete section right round the onion-shaped hull, interspersed with normally constructed frames. The risk of being rolled over or pitch-poled and dismasted has been accepted and there is special provision made for stepping a jury mast.

The deck lay-out, sail plan and vane steering gear is by Col. (Blondie) Hasler and there is no need to go on deck at all in bad weather—all of which is a straight development of *JESTER*, the Hasler Folkboat. The whole aim has been to conserve the energies of a man who is making a great effort of endurance and, whatever many of us may feel about being shut in, there is nothing so exhausting as exposure to the elements.

The big skeg suggests a full realisation of the need for directional stability in a vane-steered ship and the light displacement hull shows that need for a light air performer is equally important—a light ship also costs a good deal less. The accommodation is spartan, with one bunk in gimbals, one seat and a basic galley. The W.C. is a bucket and the hull has no seacocks whatsoever.




Dear John,

I am completely in agreement with your interest in low aspect ratio keels and centreboards, provided that it is not over-done. Over the years, I have varied many times the aspect ratio of keels and centreboards, as well as their area, on models in the towing tank. Always I have obtained the same answer. When an optimum area and angle of attack are employed, the best aspect ratio is approximately 1.0.

The above aspect ratio is not at all in accord with the teachings of subsonic aerodynamics. I believe that I know why. An air-foil or sail is deeply immersed with oceans of air above. There is no appreciable difference in static pressure between their top edge or bottom edge even when in a vertical position. Thus the top edge has nearly 100 per cent of the static pressure of the bottom edge.

For a surface-piercing vertical hydrofoil or rudder, the static hydraulic pressure of the top edge is 0 per cent of that of the bottom edge. Thus, the pressure distribution for air-foils and shallow water-foils is entirely different. Therefore their theories are *not* equivalent. Of course, dynamic pressures add to or subtract from these static pressures to get the total pressure difference between the two sides of a foil. The water surface-level adjusts accordingly.

Centreboard size is easily calculated by equating the sail side-force to the board sideways lift, when hard on the wind. This assumes that the hull does not contribute appreciably to the side resistance. The result is the formula:

$$\frac{\text{Sail Area}}{\text{Board Area}} = 257\left(\frac{V_B}{V_A}\right)^2.$$

where $V_B$ is the boat speed
$V_A$ is the apparent wind speed.

The formula is based on a board lift coefficient of 0.40 at maximum L/D as discussed on page 27 of *A.Y.R.S. No.* 61. The sail side-force component coefficient used was 1.30.

As an example, if the boat speed to apparent wind speed ratio is $\frac{1}{3}$, when hard on the wind, the sail area to board area ratio calculates to be 28.6. This agrees reasonably well with Harrison Butler's value of 25 to 35.

Note that a slow boat requires a larger board area than a fast boat. Also, if the hull contributes to the side-force, a somewhat smaller board can be employed. When a 45° canted board is used for non-heeling, it should be $\sqrt{2}$ or 1,41 times the size of a vertical board.

I hope that you will publish the two proposed articles which I return attached. Please pay little attention to occasional comments of 'too much Morwood'. Suggestions of yours, such as the simplicity of adding the drag angles of sail and hull for the course angle, rather than dealing with the more complicated lift-drag ratios, will live for years.

Sincerely,

EDMOND BRUCE,
'Lewis Cove',
69, Hance Road,
Fair Haven,
New Jersey,
U.S.A. 07701.
July 8, 1968.

# STABILIZING AND LIFTING FOILS APPLIED TO CATAMARANS

**by Edmond Bruce** Lewis Cove, Hance Road, Fair Haven, New Jersey, U.S.A.

A number of sailors now have had 'THE experience'. They have found that, in strong winds, heeling really can be stabilized by one or more laterally-canted water-foils. This heeling stabilization is dynamically derived largely from the usually wasted sail side-force on the hull, as distinguished from its driving-force component. In addition, useful speed-producing lift can by provided with certain configurations. It may be that this new type of lift is as important to sailing as the non-heeling feature, both of which can be provided simultaneously by this canted foil.

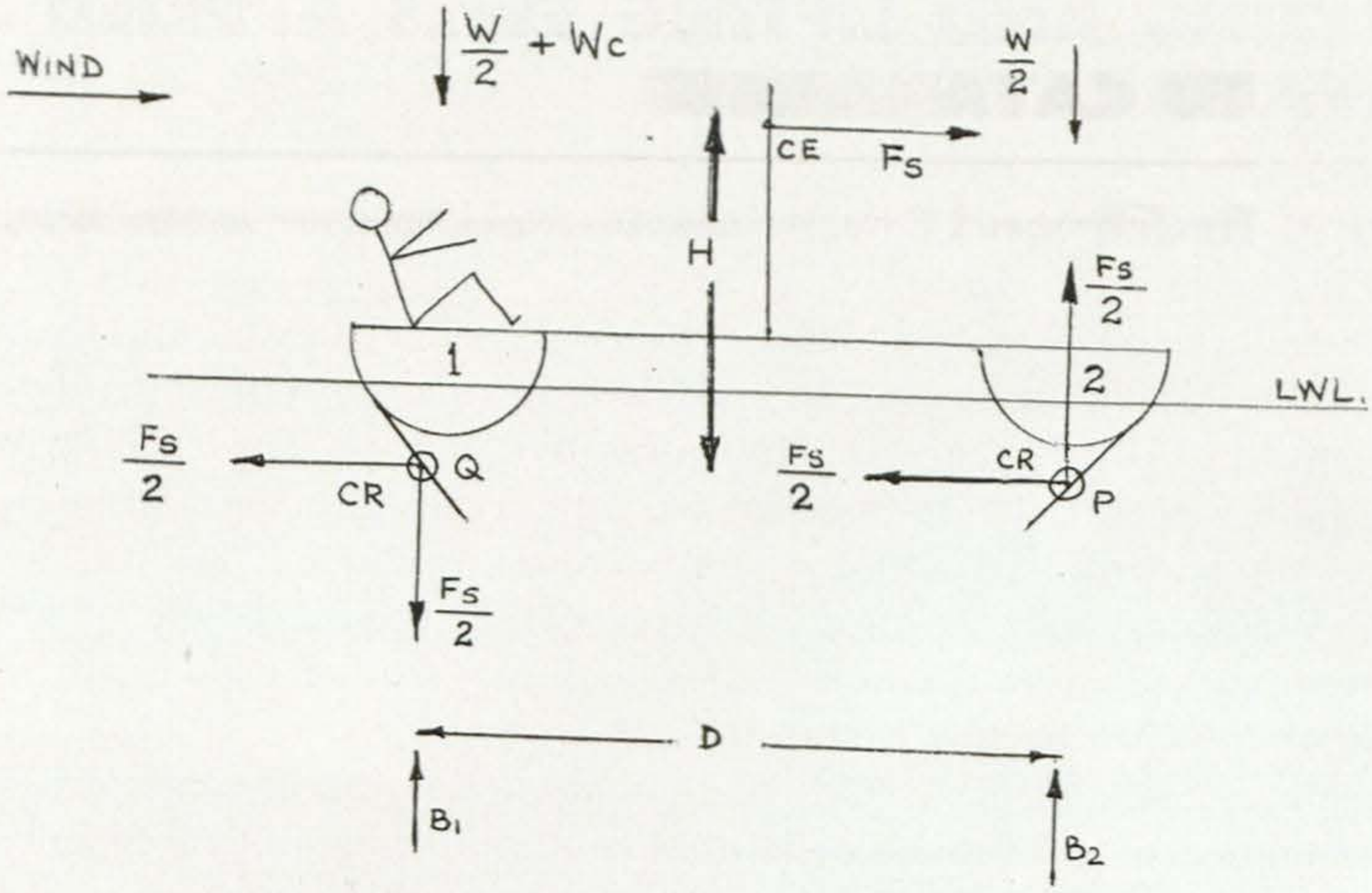
The writer's correspondence indicates that some catamaran enthusiasts appear disappointed by a mistaken belief that canted foils cannot be usefully applied to catamarans of existing beams. I am writing this extension of my article in *A.Y.R.S. No.* 51 to try to assure them that this is not the case. Existing catamarans can benefit greatly in strong winds. Personally, I much prefer the exciting but greater 'critical beam'.

I believe that the previous wrong impressions were created by an incorrect 'rule of thumb' of mysterious origin. It stated that an imaginary line perpendicular to the centre of a water-foil must extend through the sail's centre-of-effort. This was only an accidental coincidence in my *A.Y.R.S. No.* 51 article.

Actually, according to the theory of moments, as applied to the non-heeling boat, the sail plan can be placed laterally anywhere without affecting its heeling moment. The magnitude and direction of the total sail force would be unchanged if this were done. Also, the effective length of the moment arm would be unchanged. Since such lateral movement would displace the stated alignment with the sails' centre-of-effort, the rule of thumb cannot be correct.

Let us examine fig. 1 which represents the cross-section of a catamaran with its sail force having an abeam component. The crew is perched on the windward hull. A steady-state condition, without acceleration of deceleration, is assumed. The height of the sails' CE above the centres of resistance CR, of the pair of 45°-canted, flat, thin boards, is H. The separation of the CR of the two canted boards is D. The sketch also shows the two moments and the algebra involved in the calculations of buoyancy for those who are interested.

The distribution of weight between multihulls is highly important to an analysis. My diagram in *A.Y.R.S. No.* 51 was made easy since most of the total weight of the single outrigger and crew was in one hull. This permitted a smaller beam for non-heeling. The present fig 1, showing a catamaran, involves weight and buoyancy distributions between two hulls. Two moments are now required for a solution since two unknowns are involved. As shown on the sketch, the buoyancy required by the hulls for equilibrium are stated in terms of the weights of the catamaran and crew, the side-force of the sail and the ratio of the dimensions H over D.




W IS BOAT WEIGHT. $W_C$ IS CREW WEIGHT. $F_S$ IS SAIL SIDE-FORCE.

MOMENTS ABOUT P & Q:

$$M_P = F_S \cdot H - \frac{W}{2} \cdot D - W_C \cdot D + B_1 \cdot D - \frac{F_S}{2} \cdot D = 0$$

$$M_Q = F_S \cdot H + \frac{W}{2} \cdot D - B_2 \cdot D - \frac{F_S}{2} \cdot D = 0$$

REQUIRED BUOYANCIES:

$$B_1 \cdot D = \frac{W}{2} \cdot D + W_C \cdot D + \frac{F_S}{2} \cdot D - F_S \cdot H$$

$$B_2 \cdot D = \frac{W}{2} \cdot D - \frac{F_S}{2} \cdot D + F_S \cdot H.$$

$$B_1 = \frac{W}{2} + W_C + \frac{F_S}{2} - F_S \cdot \frac{H}{D}.$$

$$B_2 = \frac{W}{2} - \frac{F_S}{2} + F_S \cdot \frac{H}{D}.$$

*Fig.* 1

When the windward hull 1 is lifted just clear of the water so that its buoyancy is $B_1 = 0$, capsize is imminent. The limit of sail force for stability is then, from the fig. 1 equations,

$$F_s \left(\frac{H}{D} - \frac{1}{2}\right) = \frac{W}{2} + W_C$$

So far as heeling is concerned, it is seen that the sail force $F_s$ can be infinite if

$$\frac{H}{D} = \tfrac{1}{2}, \text{ or } D = 2H$$

Actually, this catamaran could 'pitch-pole' in violent winds, unless the main-sheet were released. It is no longer limited by its heeling stability, as is the common situation. Before this happens, the buoyancy of hull 1 would be, without variation, the weight of the crew plus half of the catamaran weight. The buoyancy of the leeward hull 2 would be steady at half the weight of the catamaran. These are quite independent of the sail force or wind strength. There is no real need for the crew to sit to windward as is shown. It is a glorious experience to sail such a boat in strong winds when other boats falter.

There seems always to be those who would prefer a lesser beam because of a measurement rule or for reasons of their own. While some benefit can still be obtained, they will miss 'THE experience'. If we let D = H or half the above, the limit of sail force before capsize or main-sheet release is,

$$F_S = 2 \left( \frac{W}{2} + W_C \right)$$

This is exactly twice the stability we would get if we re-worked the whole problem for a conventional pair of vertical boards. This reduced beam, canted board boat could still win strong wind races over the conventional catamaran.

While the first mentioned wide beam, canted double-board configuration describes a safe structure for very strong winds, we can be more adventurous and faster if we introduce our lift simply by pulling up the windward board. This case is shown in fig. 2. The remaining leeward board should have ample area available so that the leeway angle can be again adjusted to the optimum of about 5° (see writers' article in *A.Y.R.S. No.* 61). It now has double the water force it experienced when paired with the windward board.

A new situation now presents itself. In fig. 1, where two boards are used, if one adds the required buoyancies of the two hulls, they become simply,

$$B_1 + B_2 = W + W_C$$

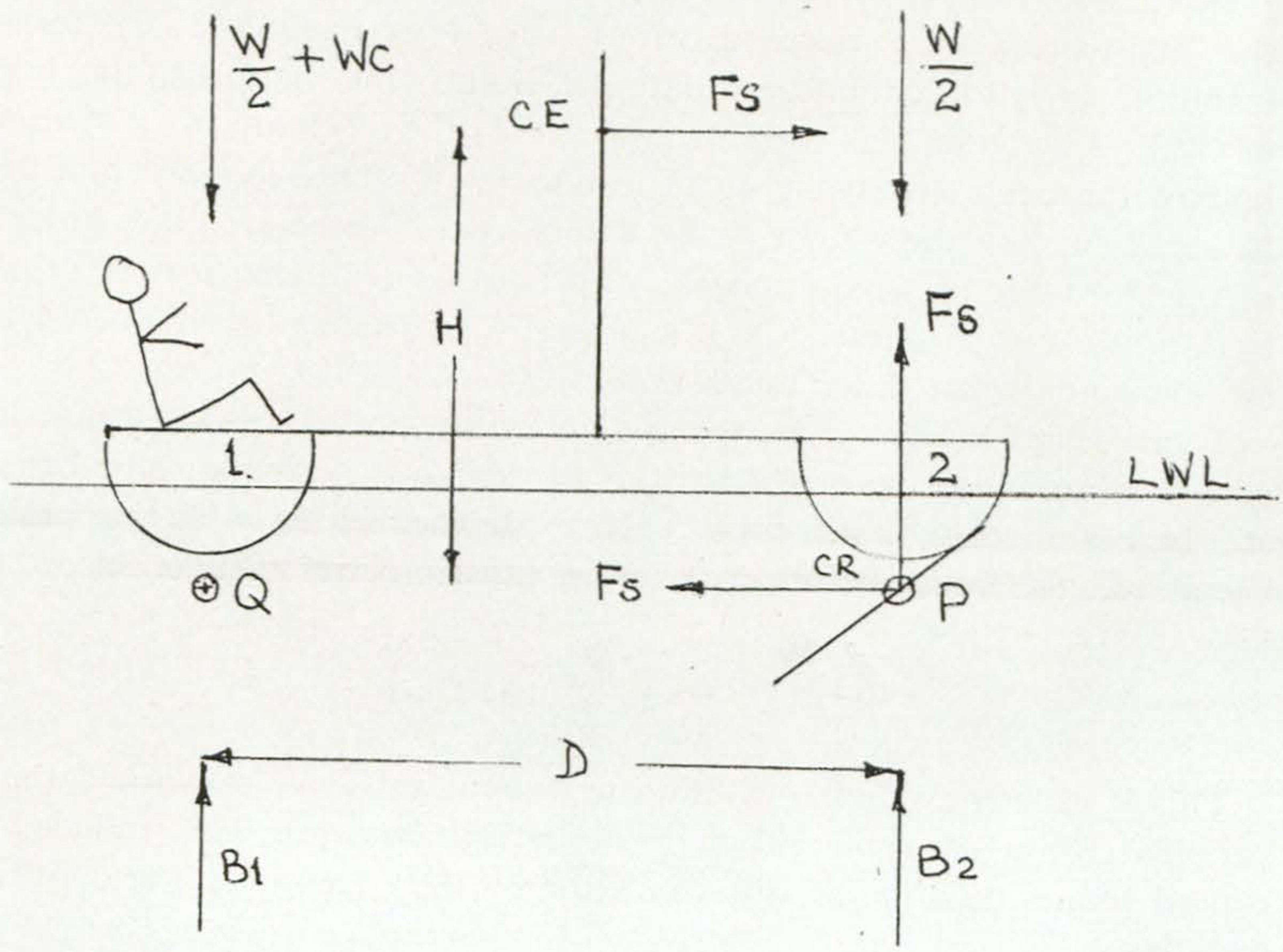
This is therefore independent of the sail force but experiences no lift. For the situation of the single leeward board in fig. 2, the sum of the buoyancies is,

$$B_1 + B_2 = W + W_C - F_S$$

This is quite independent of the ratio $\frac{H}{D}$. Therefore, we get a lift equal to the sail side-force regardless of any hull spacing we choose. However, the spacing does control how much lift each hull gets and therefore the heeling. For example, if D = 2H in fig. 2,

$$B_1 = \frac{W}{2} + W_C - \frac{F_S}{2}$$

$$B_2 = \frac{W}{2} - \frac{F_S}{2}$$




MOVEMENTS ABOUT P & Q:

$$M_P = F_S \cdot H - \frac{W}{2} \cdot D - W_C \cdot D + B_1 \cdot D = 0.$$

$$M_Q = F_S \cdot H + \frac{W}{2} \cdot D - B_2 \cdot D - F_S \cdot D = 0.$$

REQUIRED BUOYANCIES:

$$B_1 \cdot D = \frac{W}{2} \cdot D + W_C \cdot D - F_S \cdot H.$$

$$B_2 \cdot D = \frac{W}{2} \cdot D - F_S \cdot D + F_S \cdot H.$$

$$B_1 = \frac{W}{2} + W_C - F_S \cdot \frac{H}{D}.$$

$$B_2 = \frac{W}{2} - F_S + F_S \cdot \frac{H}{D}.$$

*Fig. 2*

Therefore both hulls experience equal speed-producing lifts from the wind and there is still no heeling with this preferred structure.

Now if one compromises and uses a hull spacing where $D = H$,

$$B_1 = \frac{W}{2} + W_C - F_S$$

$$B_2 = \frac{W}{2}$$

It is important to note that, while the leeward hull gets no lift from the wind, its buoyancy has to support only its own weight in any wind strength. There is no degree of burying of the leeward hull as is usual if vertical boards are used in strong winds or weak.

The limit of sail force for heeling stability now becomes, for $B_1 = 0$,

$$F_S = \frac{W}{2} + W_C$$

This is the same stability as if a pair of vertical boards were used. However, the overall lift and the lack of any lee hull burying, with the windward hull lifted, will give a large dividend in increased speed. Catamarans of conventional beam can use laterally canted boards to advantage.

Let us sum up the predictions about the windward comparisons between a conventional catamaran and catamarans of each of the two beams which use canted-boards, as described. Equal sail areas and weight are assumed.

In light air, no appreciable heeling is involved in any of the three catamarans. Both of the canted-board boats would use only their leeward board. Little or no speed difference over the conventional catamaran will be experienced. While there is a small lift equal to the sails' side-force, the resulting slightly reduced hull drag may be compensated by the slightly increased overall friction due to a 40 per cent larger area required by the canted-board.

As the wind picks up, the conventional catamaran will transfer some of its weight from the windward hull to the leeward hull with a consequent lee hull depression.

The narrower beam, canted-board boat will have neither lift or depression in its leeward hull. Its windward hull buoyancy will be decreased. Consequently, with less displacement, the canted-board, narrower beam boat will be faster than the conventional boat. There will be only a small degree of heeling.

The broader beam, canted-board boat will have about the same speed as its narrower beam counterpart. However, there will be an equal lift on both its hulls and therefore still no heeling.

In winds that are still stronger, the conventional catamaran will be on the verge of capsizing when

$$F_S = \frac{W}{2} + W_C$$

Due to lee hull burying, its comparative speed will be poorer.

The narrower beam, canted-board boat will also be on the verge of capsize but its speed will be very much greater as its displacement will be only half the weight of the boat without a crew. Whereas the conventional boat is about to pass out of contention, by lowering the windward board, the narrower beam, canted-board boat can continue sailing until the sail force becomes twice as great. The displacement of the lee hull will be still half of the weight of the boat without crew. In still stronger winds, it will also pass out of contention unless it eases the main sheet.

The broader-beam canted-board boat will be perfectly happy in these strong winds. The lift will be equal on both hulls and therefore no heeling will exist. When the narrower beam, canted-board boat passes out of contention, the broader beam version will still be displacing half its weight without a crew. It can continue with its leeward board alone until the whole structure leaves the water. It can then save itself by lowering the windward board to neutralize the lift. The next step upward in wind strength may now result in 'pitch-poling', 'porposiing' or just plain disintegration. Crash-helmets are in order!

For my trimaran friends, if they can sail with the windward float and board out of water, a leeward, canted-board analysis would be the same as for the outrigger discussed in *No.* 51. We need a practical invention as to how to fold up or otherwise avoid the spread of that windward float which is doing nothing for us on a given tack. I begrudge this excess spread. The critical spread for the remaining two hulls is H rather than 2H as required by a catamaran. A favourable weight distribution accomplishes this on one tack only, in the case of the single outrigger, if both non-heeling and lift are to be simultaneous.

If the trimaran's total beam were half its critical beam, while it would get greater speed, due to the sail force lift, it would capsize when the sail force was half the total weight. This assumes that the crew weight is in the main hull. If the crew moved out to the windward float, its point of capsize would be the same as the above conventional catamaran having the same beam and a similar positioned crew. I must again recommend the critical, non-heeling beam. I hope for the above invention which could cut this beam to about half.

# SURFACE-PIERCING HYDROFOILS FOR HEELING PREVENTION AND LIFT

**by Edmond Bruce.** Lewis Cove, Hance Road, Fair Haven, N.J., U.S.A.

## Air-ventilation

In *A.Y.R.S. No.* 51, the present writer stated the critical dimensions, for the locations of canted hydrofoils, which would achieve dynamic neutralization of heeling. The dinghy, pictured there-in, originally was provided with a foil of high aspect ratio. Above certain speeds to windward, it was troubled with a loss of lateral lift. From observation of the water, it was quite apparent that this was due to 'air-ventilation', from the water surface, down the negative pressure side of the canted hydrofoil.

The dinghy was next equipped with a lower aspect ratio foil of larger area, as best pictured by the model in *No.* 51. As a result, the air-ventilation troubles disappeared, regardless of the boat speed achieved. Evidently, one cannot be guided by the teachings of aeronautical handbooks when designing surface-piercing hydrofoils or even submerged foils which are close enough to the water surface to cause any degree of wave-making or surface turbulence.

To gain more insight into the problems of surface penetrating foils, a series of tests were performed in the author's laminar-flow towing tank. These will now be described.

## Test arrangement

When the towing tank was originally built, it employed an over-head towing carriage on a track. When it became evident that towing by means of a single long cord, attached at a point equivalent to the sail's centre of effort, produced more accurate results, the overhead railway was put aside but kept intact. This was fortunate as we shall see.

John Morwood, in *A.Y.R.S. No.* 62, page 8, suggested an experimental arrangement for quickly measuring hull drag angles at various amounts of leeway, for a stated boat speed. This writer was so impressed with the labour-saving possibilities of this arrangement that he re-activated the former over-head railway and equipped it with the Morwood suggestion. It was arranged so that its pair of arms was attached to both the floating model and the carriage through universal joints located at the height of the centre of effort of the sails, chosen as L/2 for the model. This permitted simulating any heeling which would occur under natural conditions, also any lift.

A constant model speed was obtained since the towing carriage was operated from a properly geared synchronous motor. This produced a violent starting yank on the model but, fortunately, its progress was stabilized by the time it reached the end of the tank where readings were made. Readings were made somewhat difficult by the fact that the scale was moving. The violent means of accelerating the model should be softened for more complete satisfaction. A stationary scale, probably electrical, would also help.

## Measurements

We all want to know the optimum for size, aspect ratio and shape for our hydrofoils, whether vertical or canted, for best windward performance. We have learned that the criterion, for best windward performance, is the lowest possible drag angle for the particular hull employed.

The number of experiments required to determine the grand optimum foil would be the *product* of all the variations of size, aspect ratio, canting, curvature, shape, arm length, windward or leeward position, etc. This seemed overwhelming to a lazy individual. Thus, for an initial educational insight, only rectangular, thin, flat foils were studied.

The model hull chosen was a 15-inch long, Model No. 8 with a high metacentre as discussed on page 19 of *A.Y.R.S. No.* 45. It was connected to a single outrigged foil, without a float. The outrigger arm lengths were initially adjusted to one-quarter of the length of the model. This corresponds to many trimarans when sailing with the windward float out of water. A small rudder and an out-of-water counter-weight for the foil were provided.

Vertical foils were tested and also canted foils. The vertical foils were first positioned to leeward. The best combination was then placed to windward to obtain a comparison. The constant speed of the model was 0.65 feet per second. This is equivalent to the low speed of $V/\sqrt{L} = 0.35$ in order to avoid the complications of appreciable wave-making, with its increase in drag angle.

The canted foils were always to leeward so that, in addition to heeling compensation, vertical lift was also provided. A compromise outrigger arm length was studied for comparison with the critical arm length, for heeling neutralization.

## Vertical foils

Table A, for vertical foils, concisely presents the measured inter-relations and the overall optima between six variables. These are:

| *Variable:* | *Optimum:* |
|---|---|
| 1 Hull Drag Angle | 12° |
| 2 Leeway Angle | 5° |
| 3 Foil Width | 2½ ins. |
| 4 Foil Depth | 2½ ins. |
| 5 Foil Area | 6.25 sq. ins. |
| 6 Aspect Ratio | 1.00 |

Plotting six variables on two dimensional plotting paper with criss-crossing lines and various labels seems a confusing mess. For this reason, only the tabular form for data will be presented here. The reader may want to plot any pair of variables which may interest him.

The much discussed optimum leeway angle of about 5° has appeared again. An optimum 5° leeway for the model in laminar flow may well be 4° for full size in turbulent flow. The advantage of high aspect ratio for surface piercing foils apparently has been disproved since a unity ratio seems best. Both the width and depth of the vertical foil, for a hull equal to this one's high merit, is about one-sixth of the water-line length. A poorer hull probably would have different values except the tank optimum leeway of about 5° might still prevail.

Model Hull Drag Angles versus Dimensions for Vertical, Flat, Thin, Rectangular Foils. Outrigged to Leeward. Arm Length = L/4. L = 15″. Speeds = 0.65 ft per sec.

| Leeway Angles | Width = 1¼″ Depth = | | | | | Width = 2½″ Depth = | | | | Width = 5″ Depth = | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1″ | 2″ | 3″ | * 4″ | 5″ | 1″ | 1½″ | 2″ | ** 2½″ | ¾″ | 1″ | * 1¼″ |
| 0° | 49° | 37° | 38° | 28° | 25° | 47° | 32° | 27° | 27° | 43° | 38° | 34° |
| 2½° | 40 | 24 | 22 | 18 | 15 | 32 | 21 | 15 | 15 | 35 | 27 | 23 |
| **5° | 27 | 16 | 14 | * 13 | 15 | 22 | 18 | 14 | ** 12 | 23 | 20 | * 16 |
| 7½° | 20 | 17 | 16 | 16 | 17 | 18 | 17 | 14 | 14 | 19 | 19 | 17 |
| 10° | 22 | 21 | 19 | 18 | 18 | 22 | 19 | 18 | 18 | 22 | 20 | 19 |
| 12½° | 24 | 22 | 20 | 20 | 20 | 25 | 21 | 20 | 20 | 23 | 20 | 20 |
| 15° | 29 | 24 | 23 | 22 | 22 | 26 | 24 | 22 | 22 | 23 | 23 | 22 |
| Foil Area sq. ins. | 1.25 | 2.50 | 3.75 | * 5.00 | 6.25 | 2.50 | 3.75 | 5.00 | ** 6.25 | 3.75 | 5.00 | * 6.25 |

* Best of group.

** Best overall.

*Note:* The drag angle at 0° leeway is not 90° because the single outrigger is asymmetrical.

TABLE A

The question arises as to what the result would be if the best foil of Table A were placed to windward, rather than to leeward. Table A shows the measured data. A foil to windward, rather than to leeward would give greater directional steering stability. This is because the sail force is away from the centre of water resistance, not toward it. However, the table's optimum shows that no appreciable difference would result in their abilities to sail to windward.

Model Hull Drag Angles for Leeward versus Windward Placement of Foil 2½″ Wide by 2½″ Deep. Arm Length = L/4.

| Leeway Angles | 0° | 2½° | * 5° | 7½° | 10° | 12½° | 10° |
|---|---|---|---|---|---|---|---|
| Foil to Leeward | 27° | 15° | *12° | 14° | 18° | 20° | 22° |
| Foil to Windward | 21° | 14° | *12° | 14° | 16° | — | — |

TABLE B

## Canted foils

Now we will take up the questions as to how a 45° canted foil to leeward, which is used additionally for heeling compensation and also vertical lift, would affect the windward performance. The measured data is presented in Table C.

Model Hull Drag Angles versus Dimensions for 45° Canted, Flat, Thin, Rectangular Foils. Outrigged to Leeward. Width 2½″ throughout. Arm Length Varied.
Speed = 0.65 ft. per sec.

| Horizontal Leeway Angles | Arm = L/4 Depth = 2½″ | 3″ | 3½″ | | Critical Arm = L/2 Depth = 2½″ | 3½″ | 4½″ | |
|---|---|---|---|---|---|---|---|---|
| 0° | 38° | 33° | 31° | Some Heeling | 39° | 39° | 41° | Heeling Dynamically Neutralized |
| 2½° | 27 | 23 | 20 | | 31 | 26 | 32 | |
| 5° | 19 | 18 | 17 | | 17 | 17 | 15 | |
| 7½° | 18 | 17 | *16 | | 14 | *12 | 13 | |
| 10° | 21 | 19 | 18 | | 17 | *12 | 14 | |
| 12½° | 22 | 20 | 19 | | 17 | 14 | 14 | |
| 15° | 22 | 22 | 22 | | 17 | 16 | 15 | |
| Foil Area sq. ins. | 6.25 | 7.50 | 8.75 | | 6.25 | 8.75 | 11.25 | |

* Best of group.

TABLE C

Here we find that, for the 45° canted foil, the critical length of the outrigged arm of L/2, producing non-heeling, is far superior to the compromise arm length of L/4. While the best drag angle is the same as the best achieved with the vertical foils, a dynamic lift has been created also. Its advantage at still higher speeds than tested should be outstanding. The vertical lift will greatly reduce the parasitic resistance of the main hull.

Note that the optimum size of the canted foil is now approximately 8.75 sq. in. rather than 6.25 sq. in. for the previous vertical foil. The latter is nearly 0.7 times the area of the former. This is precisely what one would expect. The projection, on a vertical plane, of the optimum 45° canted foil area should equal the area of the optimum vertical foil. The sine or cosine of 45° is nearly 0.7, therefore this does occur.

It is interesting to note that the optimum leeway angle of some 7° or more, which was measured in the horizontal plane of the water surface, represents only about a 5° angle of attack to the canted foil. This results because an angle of attack must be measured in a plane perpendicular to the 45° canted foil. This plane must also contain the line of motion. So our convenient 'rule of thumb' of a 5° optimum angle of attack has been further supported by the canted foil data in spite of the added complications.

### A curved canted foil

While this completes the series of measurements made on thin, flat, rectangular foils, there is no doubt that swept-back shapes and curved foils also should be studied by someone. For curiosity, one 'stab in the dark' will be made with one curved thin foil. There is no reason to believe that its curvature is an optimum.

Table D shows the result of a formed circular segment, deflected by 7 percent of the cord, concave to leeward, for the best canted foil of Table C. It has a 2½ ins. cord, a span of 3½ ins. and employs the critical arm length of L/2 to leeward. In a full size boat, a separate foil would be employed for each tack because opposite curvatures are required. The single curved foil in use would always be to leeward. Thus a trimaran-like structure may be called for.

Model Hull Drag Angle Comparison for Flat versus Circular-Segment, Curved Foil of Same Dimensions and Leeward Placement. 2½″ Wide by 3½″ Span. Arm Length = L/2. Curved Foil Deflection = 7 per cent of Chord.

| Leeway Angles | 0° | 2½° | 5° | 7½° | 10° | 12½° | 15° |
|---|---|---|---|---|---|---|---|
| Flat Foil | 39° | 26° | 17° | *12° | *12° | 14° | 16° |
| Curved Foil | 23° | 13° | *10° | *10° | 12° | 15° | 17° |

TABLE D

Table D indicates that we still have a lot of scope for improvement. The resulting best drag angle of 10° is greater by only 1° than the best configuration ever measured by the writer. I can highly recommend canted foils which produce heeling compensation and lift, both horizontally and vertically.

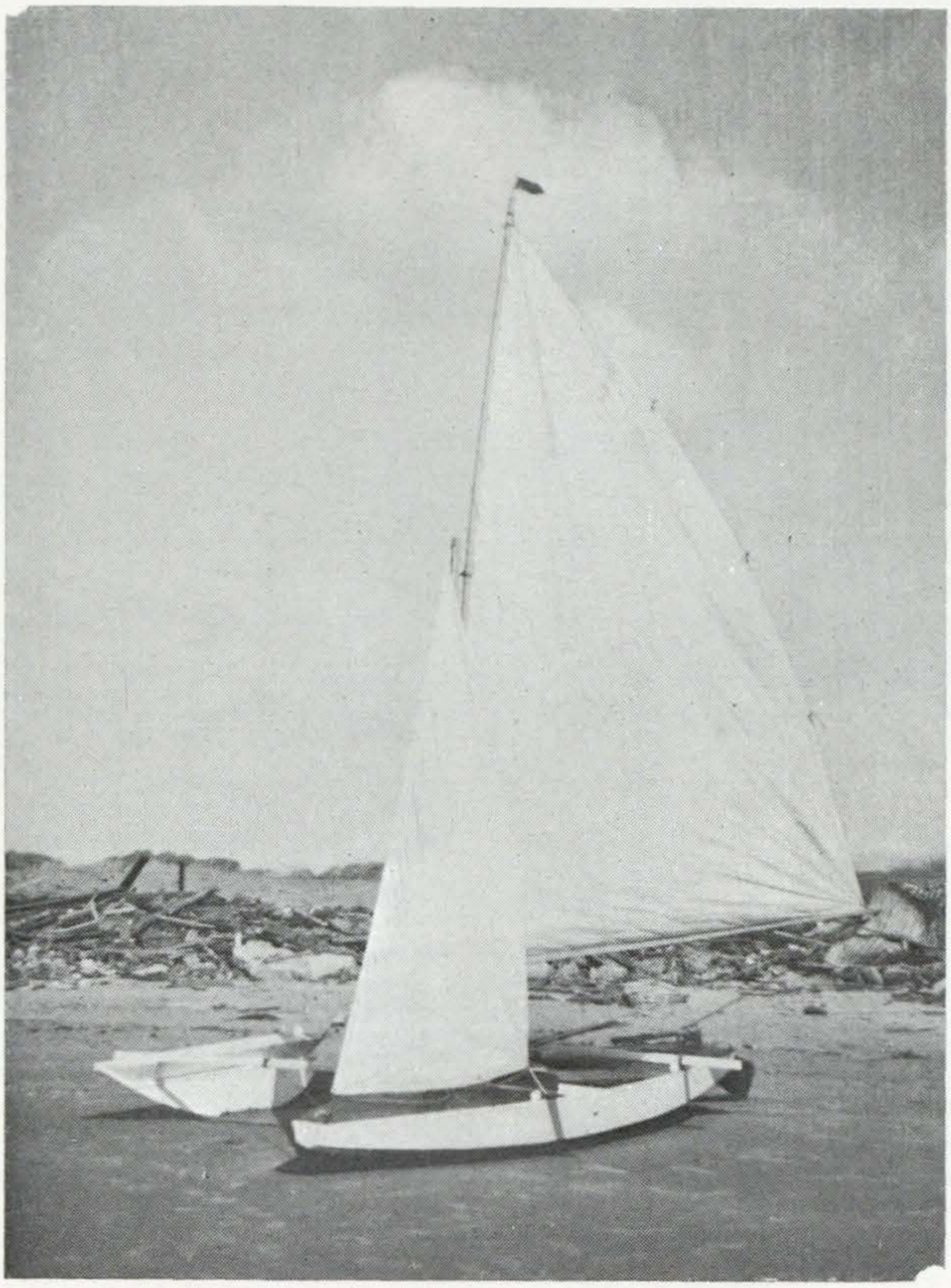
# SINGLE FOIL STABILIZED SURF BOARD

**Designer/Builder: George Bagnall.** 2, Hester Close, Hightown, Liverpool.

| | | | |
|---|---|---|---|
| L.O.A. | 11 ft. 6 in. | Beam | 3 ft. 2 in. |
| Depth | 11 ft. | 45° Foil | 6 ft. x 18 in. |
| Sail Area | 49 sq. ft. on unstayed mast. | | |

Main Hull is ply joined by copper wire, tape and glue at each seam. Hull weight 84 lbs.

The hull was designed to be sailed as a skimmer and sailed well on all points; but was difficult to handle and needed constant luffing and easing of the sheet to prevent a capsize. The result of adding the foil, as suggested by John Morwood, was a feeling of stability.

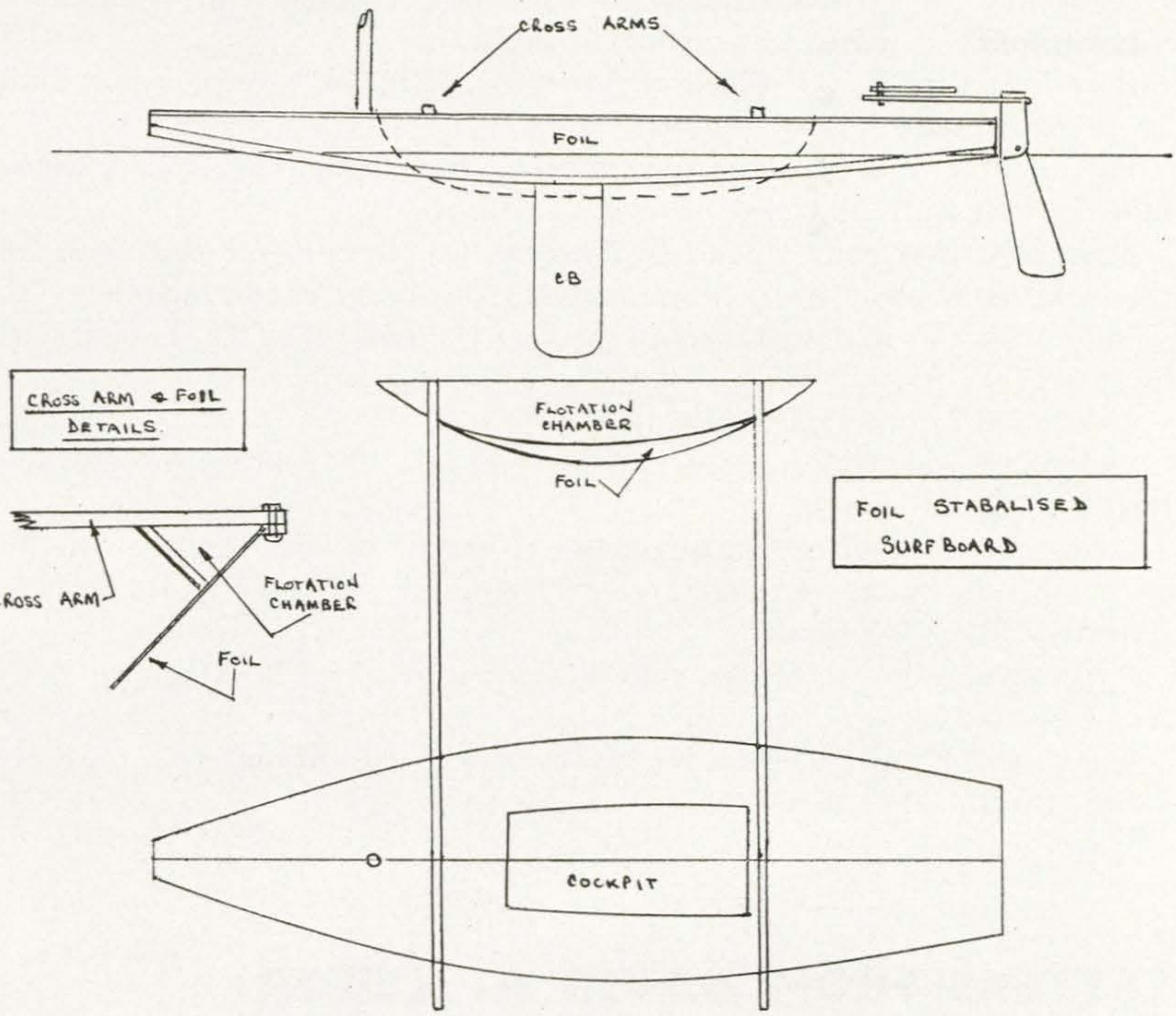


*George Bagnall's low A.R. Bruce foil*

*George Bagnall's foil*

The craft runs and reaches well, but when in a bumpy sea with the foil to lee a certain difficulty in tacking is experienced. With the foil to weather she tacks smartly. At first the foil was used without a floatation chamber but this was added later thus streamlining the foil supporting struts and eliminating any tendency for the foil to submerge. Very little centre board is needed when reaching or running but when beating without the centreboard the boat sags to leeward. Inferences from experience are:

1 The boat does not heel so it does not get the benefit of the long chine to prevent leeway,
2 The C.L.R. of the foil should be forward of the C.E.




*George Bagnal's hydrofoil stabiliser*

Latest developments have been to build a new main hull, 12 ft. 8 in. x 2 ft. 8 in. x 1 ft. 2 in. without a dagger board but the results with the existing foil were poor, the boat making leeway and being poor at tacking. Foils copied from Edmond Bruce and Paul Ashford's *TRIPLE SEC* (see *A.Y.R.S. Publication No.* 62) were tried but the new hull still made leeway and it is felt that a boat like this will not sail properly without a centreboard of some kind.

# THE FLYING HYDROFOIL YACHT 'WILLIWAW'

**Designed by: David A. Keiper, Consulting Physicist**
2101-C, Bridgeway, Sausalito, California, U.S.A.

| | | | |
|---|---|---|---|
| L.O.A. | 31 ft. 4 in. | Total displacement | 3000 lb. |
| L.W.L. | 28 ft. | Light weight | 2100 lb. |
| Beam: | | Sail Area (full working) | 380 ft.$^2$ |
| Overall hull | 15 ft. | —sloop rig, loose footed mains'l with camber control. | |
| Main hull | 3 ft. | | |
| Hydrofoil | 23 ft. | | |
| Draft: | | Hull material: mostly $\frac{1}{4}$ in. marine plywood, covered with $4\frac{1}{2}$ oz. fibre-glass. | |
| Main hull | 16 in. | | |
| Hydrofoils | 5 ft. (zero speed) | | |

Bow foil: deep-V, 30° dihedral (lower portion), 10° sweep, aspect ratio 26 (at zero speed).

Lateral foils (P & S): four rung ladder, 35° dihedral, 14° sweep, aspect ratio 7.7 (but with full chord struts at blade tips).

Stern foil: four rung ladder, 0° dihedral, aspect ratio 6.2 (but with full chord struts at blade tips), entire assembly pivots for rudder action.

Lift coefficients at design take-ofl speed of 12 knots: Bow 0.8, Lateral 0.65, Stern 0.3.

Calculated Lift to Drag ratio: 14-15.

Calculated wind velocity required for take-off: 12-13 knots (excess wind increases take-off speed).

Structure: designed to withstand water forces of one ton/ft$^2$. All foil units are retractable. Lateral foils may be used with bow and stern foils retracted (Force 2-3 winds).

Accommodation: 2 bunks, one in stern cabin, one in wing (room for 3 or 4 bunks).

Settee, galley table, shelves, bookcases, head. Headroom: 5 ft. plus.

See also *A.Y.R.S.* 58 and 62.

# LETTERS FROM DAVID A. KEIPER

March 15, 1968.

Dear John,

Please pardon my long silence. Possibly, though, Art Piver has mentioned to you that *WILLIWAW* was undergoing trials with its complete foil system. I enclose a couple of colour photographs (taken by Fergus Quigley) which show the hydrofoils in operating position.

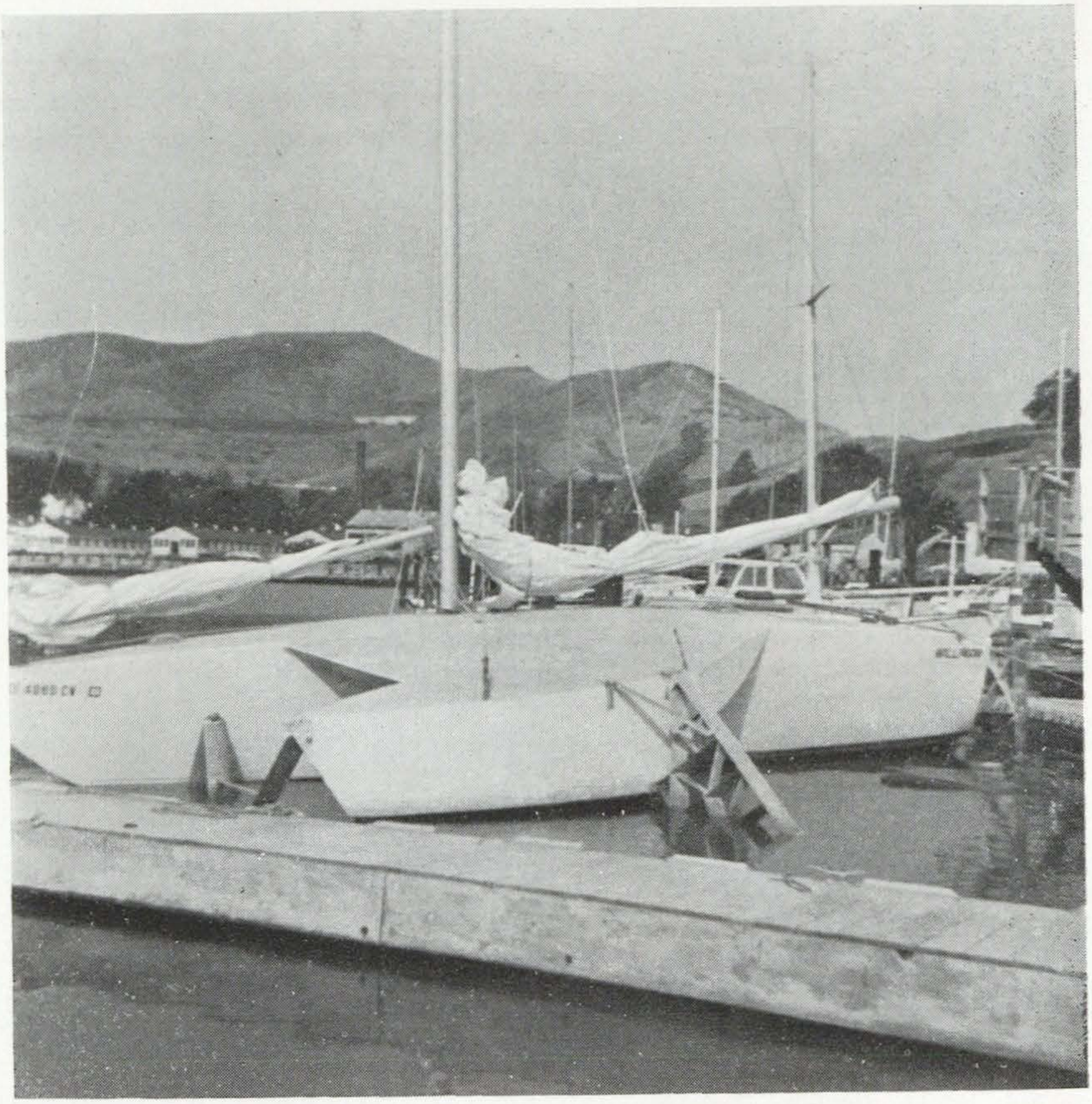
*WILLIWAW* didn't have hydrofoils until November. By then the westerly winds were pretty dead. The winter winds are too fickle for testing. A good wind has usually turned to pouring rain by the time I got a crew together for sailing. There was one reasonable testing day. Art Piver was crew and ballast. The wind reached Force 4 in several puffs. The craft reached a speed of 13-14 knots (measured with a pitot tube), and was about 90 per cent foilborne. A poor sail set and a foul bottom were working against that day. The wind dropped before I managed to get the main sheet hauled in, so we didn't get to 'fly'.

Above about 8 knots, the foils add a significant stabilizing effect to the craft, both lateral and longitudinal. At low speed, foil action is mainly a roll and pitch damping. The drag of the foils slows the boat in light winds, but in a chop this is partly compensated by increased sail drive resulting from the greater steadiness of the craft. All in all, this 3000 lb. craft has the feel of a 10 ton yacht in light winds, except that when coming into a dock one can put a foot to stop the boat without breaking a leg.

I had a couple of hair-raising experiences with the boat earlier—once a capsize with no hydrofoils, and once a wild 60 mile ride with a single lateral stabilizing foil.

Before any of my hydrofoils were fabricated, I was testing the boat and succeeded in capsizing it. The capsize was not planned, but I learned much from it. It occurred in a 20-26 knot gust of wind with 340 sq. ft. of sail up. At the time, the craft weighed about 1600 lbs. The capsize was gentle, the boat capsizing 'backwards' (bow lifting skywards) because of the rather far-forward pontoons. The mast trapped a column of air, and the boat settled at a 100° heel. The boat was righted easily with assistance from a power cruiser. There was no damage. Then I started making calculations of what the righting moments would be with the hydrofoils installed. Lo and behold, it looks as if the craft should be self-righting with the hydrofoils in operating position and the sails aloft. This results from several factors: (1) the low c.g. and 400 lbs. weight of the Aluminium hydrofoils, (2) the small pontoons, and (3) the high and rather buoyant wing section connecting the hulls. At any rate, after a capsize, several factors, one or a combination of them, would certainly right the craft: (1) lowering the sails, (2) windage on the skyward pontoon after the boat swings around, and (3) a crew member hiking out on one of hydrofoil ladders. However, I'm not planning any such experiments in these icy waters.

Last May, I moved the boat to the South end of San Francisco Bay to have it near the company assisting me on hydrofoil fabrication (Aquanautics, Inc. of Sunnyvale, California). At the time, the lateral stabilizing foil on the port side was finished. This was convenient, since the 60 mile trip South would be with westerly winds. However, in the eagerness for tests, I didn't bother to install some planned bracing in the foil ladder. During the first part of the trip, we (an adventurous young lady and I) experienced light winds. A good wind started picking up while between Alcatraz and Treasure Island. The boat came alive, and as wind and speed climbed, the hydrofoil stabilizer began eerie moaning and singing, changing its tune as wind and speed changed. The nearest description of the sound that I can give is that it is like the purring sound heard at sport car rallies, with cars up-shifting and down-shifting. After hauling in the sheets and putting the boat on its fastest heading, we were probably doing 15 knots, with a true wind of probably 15-20 knots. At this speed, the boat had zero heel. The hydrofoil was supplying all of the righting moment, as well as leeway resistance. The main hull was



*Dave Keiper's WILLIWAW showing bow and main foils*

obviously planing on its scow bottom. The craft handled beautifully. Suddenly I felt the boat take a tiny lurch to leeward. On glancing at the hydrofoil, I noticed that the struts were bent slightly. Obviously, sail side force alone had caused the struts to yield. The wind was picking up in force, and so when we got into the lee of one of the towers of the Oakland Bay Bridge, I furled the mainsail. The winds then picked up to near gale force, in the gusts. Steep waves rapidly built up. We started a wild unforgettable twenty mile ride with jib alone. The boat surfed wildly at times. Beam waves smashing on the main hull caused the foil struts to bend much further, but the blading continued to give lift. Surfing at high speed, the craft took on negative heel. Occasionally, my shallow temporary rudder came clear of the water, at which point the boat headed for the nearest wave valley at high speed. The foil always maintained positive lift and steadied the boat from rolling tendencies. Climbing waves, the boat nearly stopped and tended to heel considerably. The trip nearly ended up a disaster when the Southern Pacific Railroad failed to open up one of their swing bridges to allow us to pass.

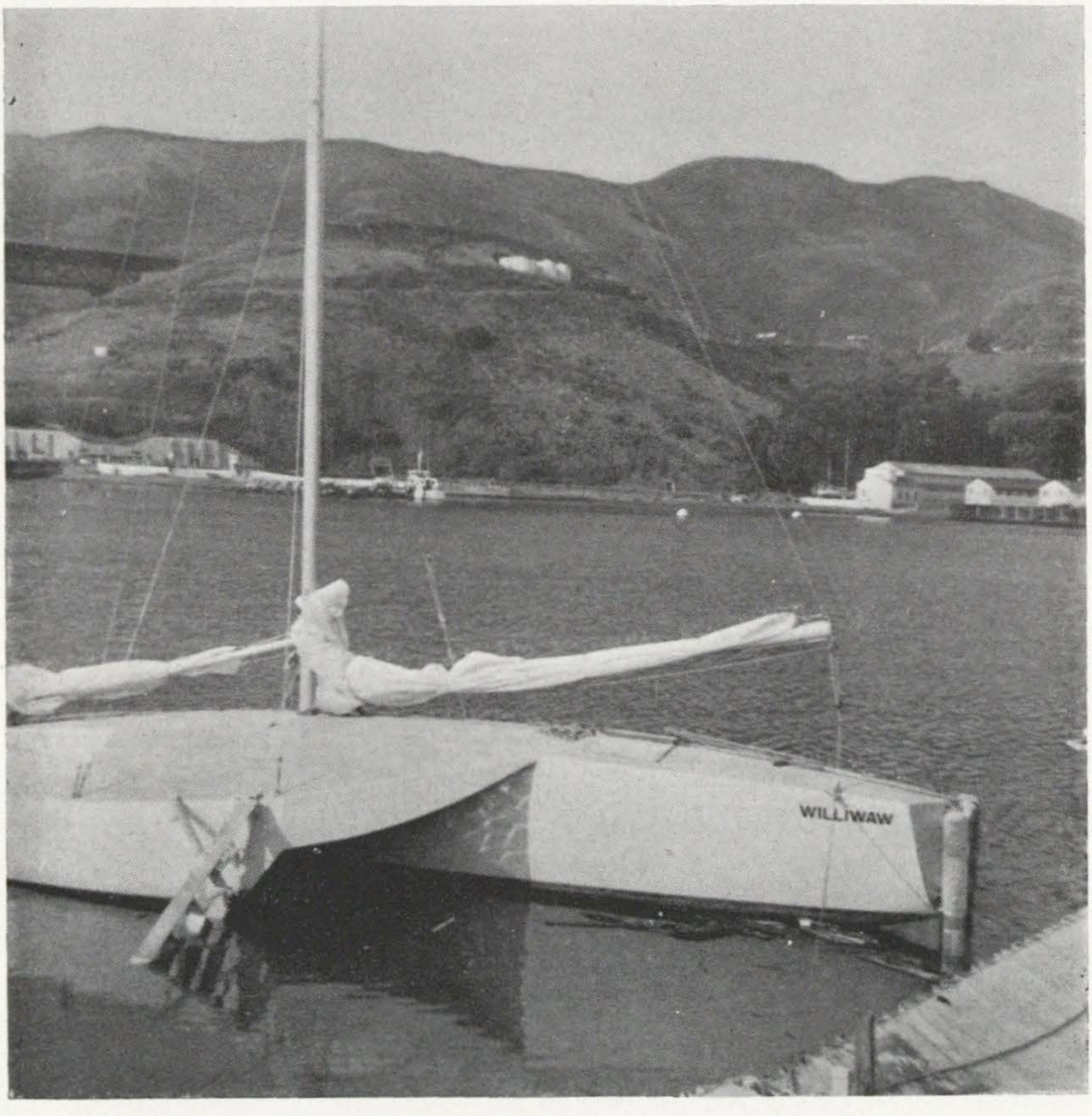
After this trip, I modified the design of the foil units so that they could withstand the maximum possible water force (which amounts to about 2000 lbs. per sq. ft. of surface). Now, with good structure, I feel a bit more confident when taking the boat out for tests.

May 1, 1968.

We've been having some good winds here lately. *WILLIWAW* has now flown on its hydrofoils on two separate occasions, doing 15 knots with five persons aboard. The transition between hull buoyancy and foil lift is very smooth, going up and coming down. The speed isn't very startling as yet, but we did leave a cruising trimaran far behind. Now I'm working on the problem of getting the boat to accelerate once it is flying.

Commenting on your letter of March 19:

To make a hydrofoil yacht self-righting doesn't strike me as a difficult problem. With pontoon buoyancy considerably less than craft weight and the weight of metal hydrofoils below the hull, it comes naturally. Sealing the mast is an extra guarantee. Because of the overall light weight of the hydrofoil craft, a knock-down is a distinct possibility, I would regard the




*Dave Keiper's WILLIWAW showing main and stern foils* self-righting characteristic on a hydrofoil craft as an essential for safety. On a trimaran, it is much more difficult to design self-righting into it, and also design for high performance. Since trimaran capsize is very rare, it doesn't strike me as necessary to have the craft inherently self-righting. With a hollow sealed mast, the trimaran can be prevented from settling at a 180° heel. With provision for filling the underwater pontoon with water, the trimaran could be righted.

June 26, 1968.

On the latest test of *WILLIWAW*, we got up to 20 knots with five persons aboard. Probably what is more significant is that we were exceeding true wind speed, and that we had comfortable, stable, and sustained flight at 18 knots speed for a couple of miles while crossing the Bay. The craft was heeled about 10°. As we approached Alcatraz Island, reflected waves created a very badly confused chop. In this mess, all that happened was that *WILLIWAW* slowed down a few knots, thereby gaining a greater share of 'submerged' foil stability, without any noticeable pounding.

Mainly, I've been working on foil drag reduction as a means to better performance. My sail rig and low-windage hull lines are working out beautifully. The biggest improvement in performance was noted after streamlining many of the foil struts, and cleaning and repainting the bottom. The boat can now reach the fully foilborne condition in about 10-12 knots of wind. I should be able to extend the top speed to about 30 knots by installing some more 'fences' on my foils.

David A. Keiper,
2101-C Bridgeway,
Sausalito,
California, U.S.A.

October 5, 1967.

Dear John,

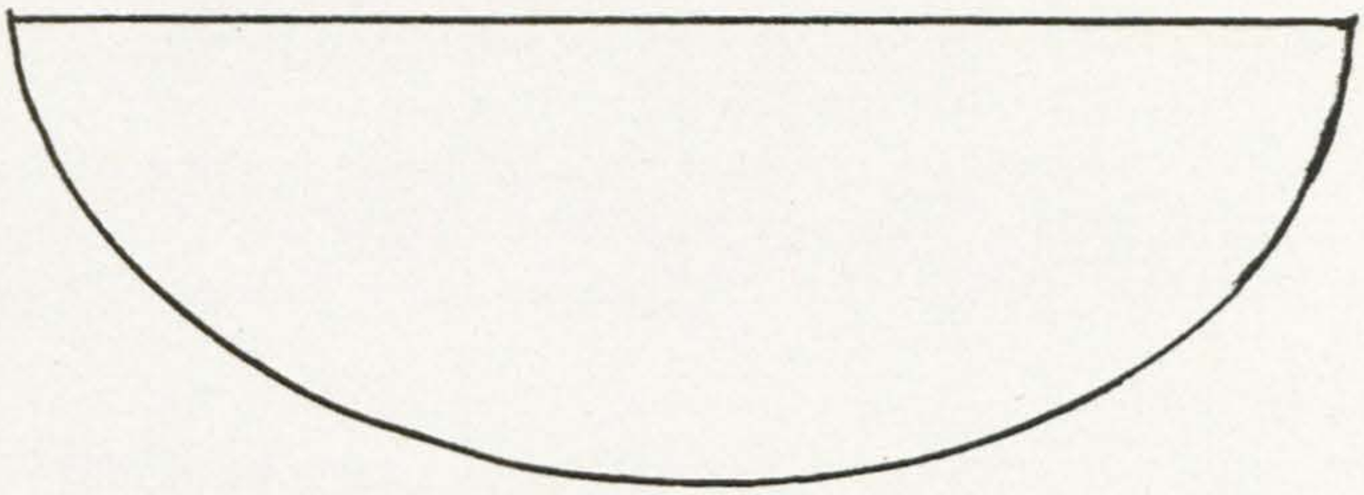
Disliking long delays in correspondence and having received your letter concerning low aspect ratio foils yesterday, I set about testing your concept of foil design, a few minutes in the workshop last night being productive of half-size models of the 4 foils and a 6 ft. pole with a 45° slot sawn into it. The foils made from $\frac{1}{8}$ in. hardboard snap into this slot.

Then to the backyard swimming pool where each foil was fixed in the slot and swung in an arc.

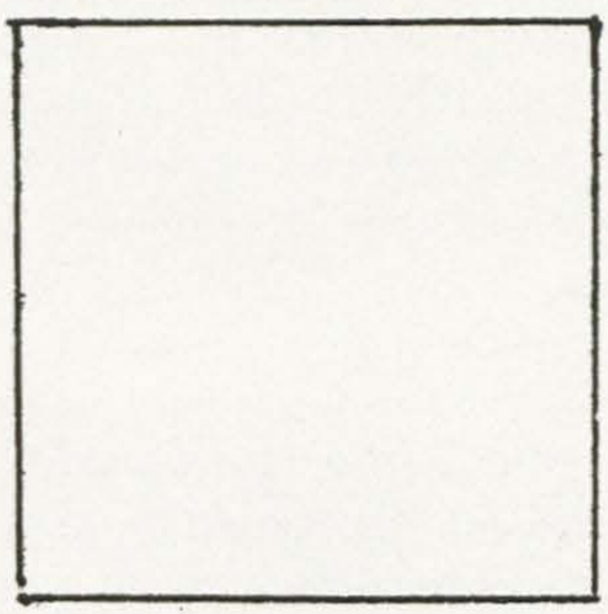
Again Morwood triumphs, for the low aspect ratio with 45° entry and exit clearly cut the water the cleanest, left the narrowest and sharpest wake, and had the least turbulent flow across the foil from entry to exit.

The rounded Bagnall foil (*Ed.*—See page 53) was next best with good entry and exit and little turbulence, the Ashford (See *A.Y.R.S. No.* 62, *page* 32) third with considerable turbulence and a broader wake, and my own rectangular foil clearly the poorest, with turbulence at entry and exit and considerable 'piling-up' of water across the face of the foil.

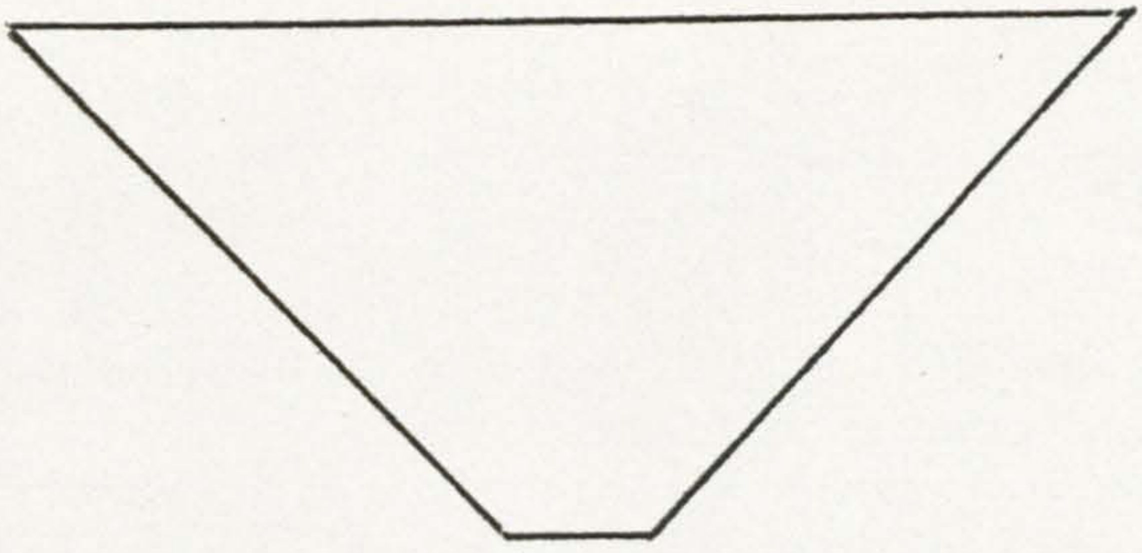
# TYPES OF FOIL



BAGNALL TYPE



FELDMAN TYPE



MORWOOD TYPE

As to which shape would give the most lift, one can only assume that the deciding factors would be the surface area and the aspect ratio, and these being equal, the shape with the least generated turbulence (the Morwood shape) should be the best.

In the next phase of the experiment in which you have entangled me, I think I shall build a crude 4 ft. L.O.A. narrow hulled boat and try the foils first in the pool before making a set for my little 8 ft. trimaran (See *A.Y.R.S. No.* 62, *page* 28). If I am convinced that the low aspect ratio foils can do more than just stabilize a float, I shall try them on the 8 footer, using some life rings for reserve buoyancy and do away with the floats altogether. This may seem over cautious but I still think that I shall get wet without floats!

May 26, 1968.

My little 8 ft. trimaran is semi-retired as I get a devil of a backache from cramming myself into the tiny hull for any length of time.

Earlier this year, however, I did pursue the hydrofoil findings of the last few publications. First I added a small jib on a bowsprit for a bit more speed, then I added longer crossbeams to make an asymmetric trimaran, the centre of the most distant float's foil being the 'Bruce Length ' of sail centre of effort to perpendicular intercept with the line drawn between foil centre of effort; the other float was left on at the usual distance from the hull for insurance. Well, it sailed well, was extremely stable (annoyingly so!), but came about with all the elegance of a log raft.

Having satisfied myself that the inboard float was not needed, it was promptly left at the dock and I went flying off with the single hydrofoil-float doing the job. The boat was then a good deal faster, quite stable, and much more manoeuvrable. In 15 m.p.h. winds, with the float to windward, I had to really lean out to even see the bottom of the float. Once the foil became to weather, it stuck in as though glued unless I suddenly threw my weight to leeward, then it would start to slowly lift out of the water. I never let it break out completely, as happiness is staying dry!

I am starting preliminary sketches of a 15-16 ft. hydrofoil stabilized trimaran, designed to A.Y.R.S. criteria, and hopefully to be constructed of polyester foam which should make a very light transportable boat.

Thanks for your (and A.Y.R.S.) encouragement and inspiration.

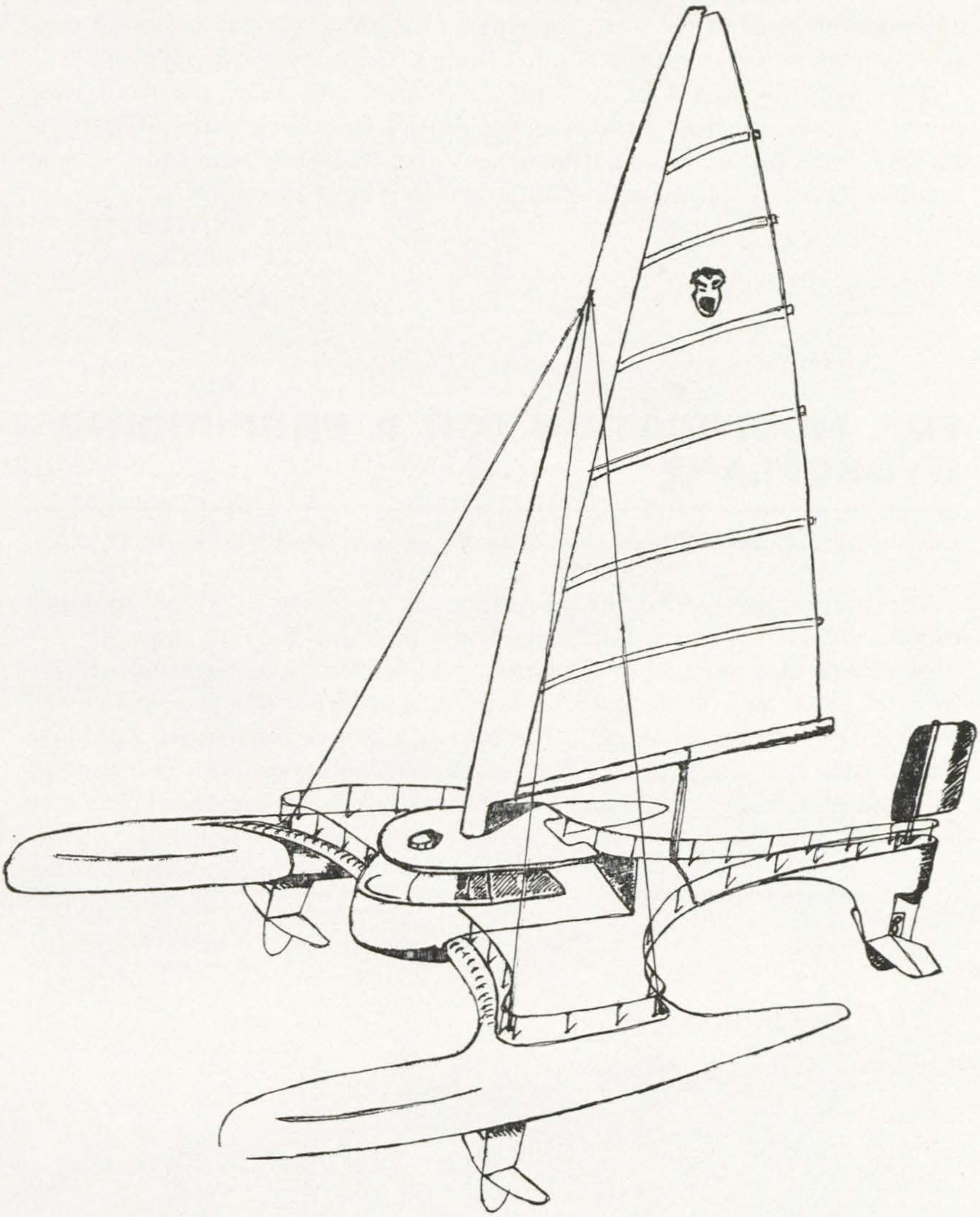
CLAYTON A. FELDMAN,
San Jose,
California, U.S.A.

February 14, 1968.

Dear John,

My contribution to future multi-hull development! I drew this up some while ago a propos of my research work into the hydrofoil system which I have incorporated in my recent trimarans.

I have always had a hankering for a fast safe day sailer to accommodate 3 or 4 bods to take me smartly across the Channel. The idea is that it would have hydraulic gear with aero-type joy sticks in the cabin*ette* to operate the trimming foils—which I would keep to stabilizing type rather than pure flying.



*Rodney Garrett's suggestion for a flying hydrofoil*

The tail unit accommodates the outboard type motor rather conveniently, and would have quite an amount of foam buoyancy—enought to support the weight at least. With a good motor, I suppose it would be possible to 'take-off'.

Overall size would be about 22 ft. to 25 ft. and beam 15 ft. Of course the cabin is well clear of the water, carried on the arched bridge deck and construction envisaged would be of alloy braced tubing clad with plywood.

The two hulls would be part rigid and part inflatable—the front ends beyond the bridge deck to absorb the impact from waves and relieve the racking stress on the bridge structure. Foam buoyancy filling in the rigid sections to ensure adequate floatation in the event of punctures.

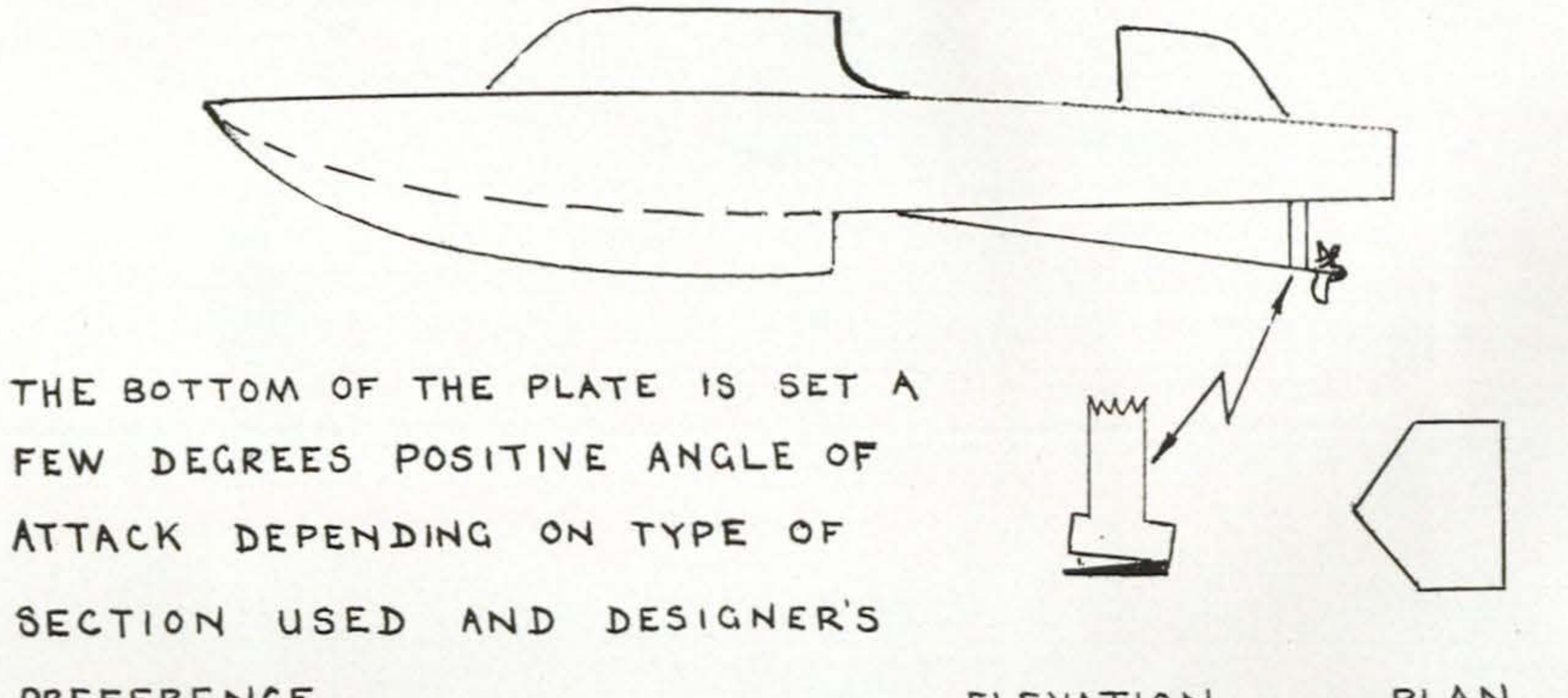
RODNEY GARRETT,
36a, Duke Street,
Brighton.

## FOIL MODIFICATION FOR A PROP-RIDING HYDROPLANE

**Devised by: J. Robert Williams** P.O. Box 84, Coconut Grove, Florida, 33133, U.S.A.

The summer has gone with no further sailing of the hydrofoil equipped catamaran as I have been building a house (See *A.Y.R.S. No.* 62).

Not being able to equal or duplicate a 75 knot test tank, I got some action in a 91 cubic inch hydroplane. I can hang devices from a sponson and observe from the driver's seat. The boat is a conventional Apel type three point hydro and prop rider. The business of using the prop for rear support (because of the shaft angle and air cushion) has never greatly appealed to



me, since if the throttle is closed rapidly, the tail drops, therefore the angle of attack of the hull becomes positive and the boat leaves the water.

To stabilize the desirable prop-riding attitude and eliminate this flying tendency I added a few square inches of supercavitating foil to the base of the strut. It is vented via the strut. At moderate speeds this plate serves as a foil after liftout and at high speeds it becomes a skid. Since the lift of supercavitating foil is largely from the lower surface, this is about equal to the same area planing surface.

When a small chop is encountered the foil just slashes through without bouncing the stern perceptably if the area and the angle of attack are close to optimum.

This boat is also used in closed course competition and the improvement in performance is startling. The speed improved by 30 per cent and cornering ability by an unknown or unmeasurable amount.

Naturally the balance of the boat is altered to stabilize this foil (or skid) riding condition by shifting the C of G aft a bit.

Work also proceeds on a water jet powered foil supported utility type chase boat. I have got to get a foil boat to be able to stay with the foil catamaran in a sea and get better photographs!

January 13, 1968.

Dear Doctor Morwood,

The enclosed photograph is of my 'A' *LION* fitted with all metal wings. These are of 3 ft. 0 in. chord and 24 ft. 0 in. span with $64_2015$ aerofoil. They have the same area as the conventional sail so comparison tests can and will be made.

I am using the '*A*' *LION* as a test bed for ideas of promise, which are in three areas at present:

a Improved sail power,

b Hydrofoils,

c Reduction of wind resistance of the whole craft.

As these ideas are tested and results obtained, these will be sent in to you to share with the A.Y.R.S. membership.

William Beuby,
Tulsa,
Oklahoma, U.S.A.

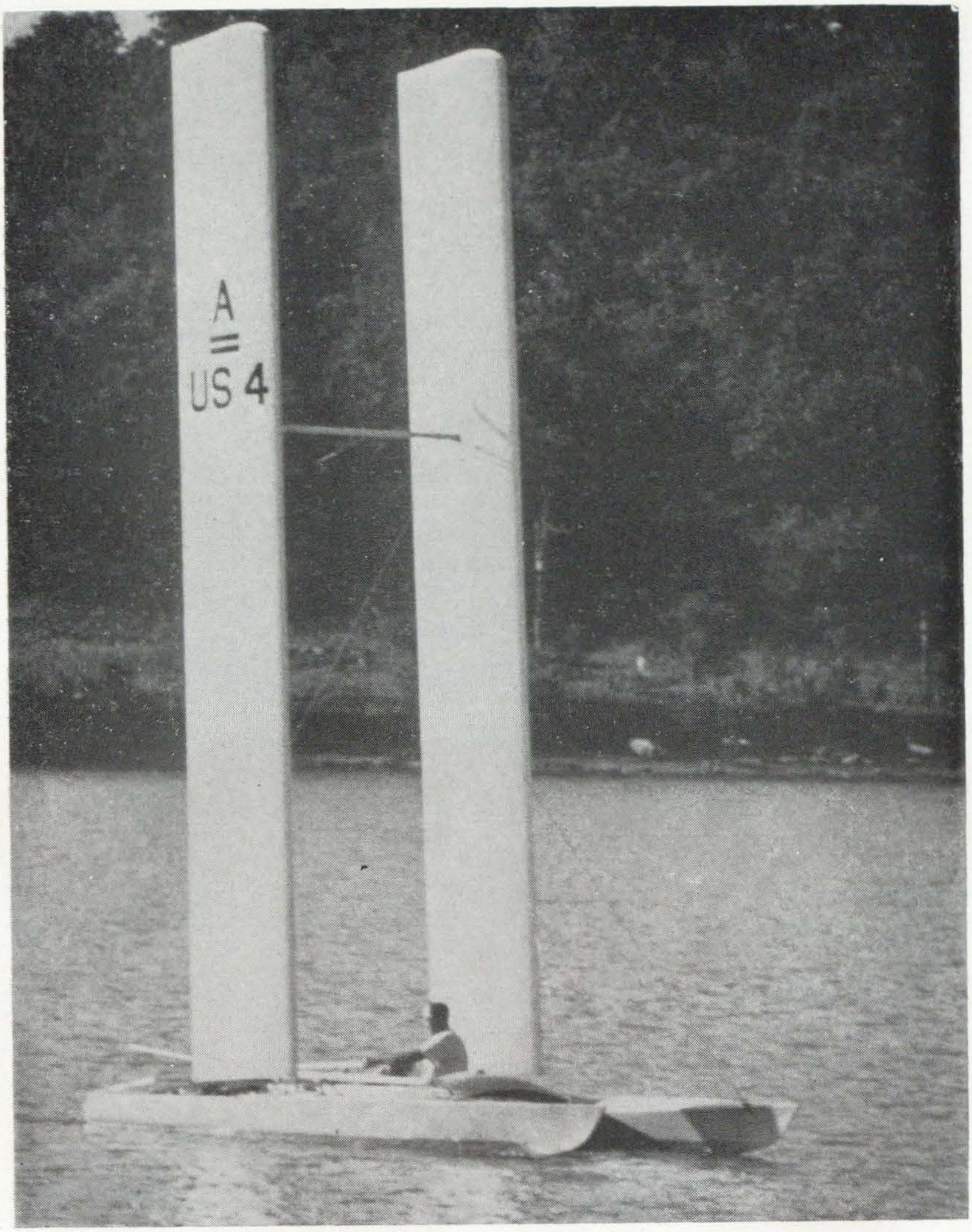
November 23, 1967.

Dear John,

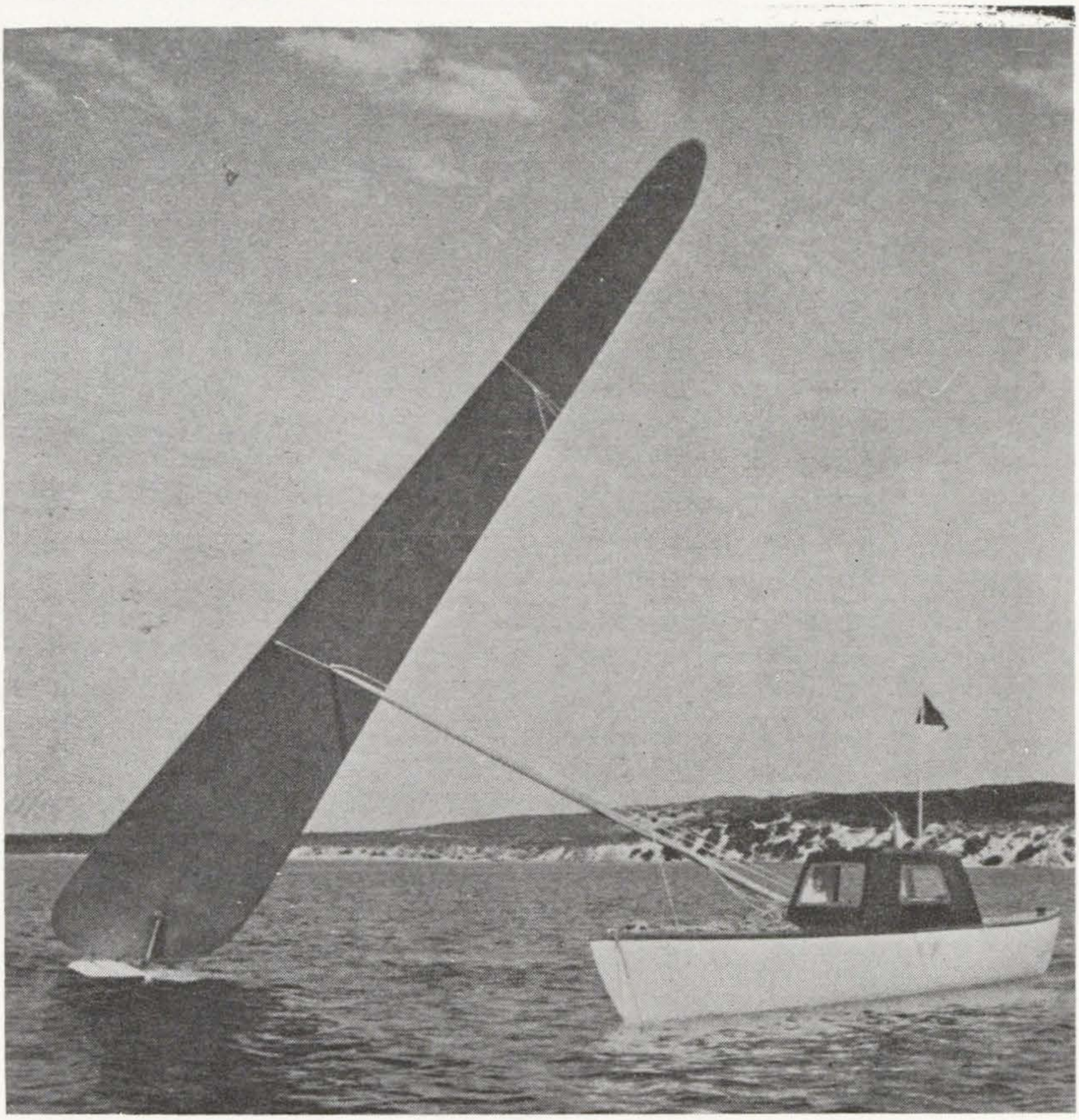
Enclosed a photograph of my 'Aerohydrohull' at Saldanha Bay. First results were promising, but after a few days sailing in light winds a violent gale sprang up and the airfoil was broken at moorings (See *A.Y.R.S. No.* 62 *page* 56).

The airfoil cannot reef and I am considering how best to overcome this fault, perhaps your members might have a solution to this?

John Goodwin,
Applegarth,
Hout Bay,
Cape, South Africa.




*William Beuby's 'A' LION with biplane rig*
(*see page* 65)



*John Goodwin's 'Aerohydrohull'*

(*see page* 65)

## PLANESAIL

**Designed by: John Walker**

Planesail Development, Sparkes Boatyard, Sandy Point, Hayling Island, Hampshire

The basic premise of the *PLANESAIL* design is based on Walker's idea that a boat should be as easy to sail as a motor car is to drive. There should be no special skills required and in addition the boat should be inherently safe under all reasonable conditions, including a gale on the open sea.

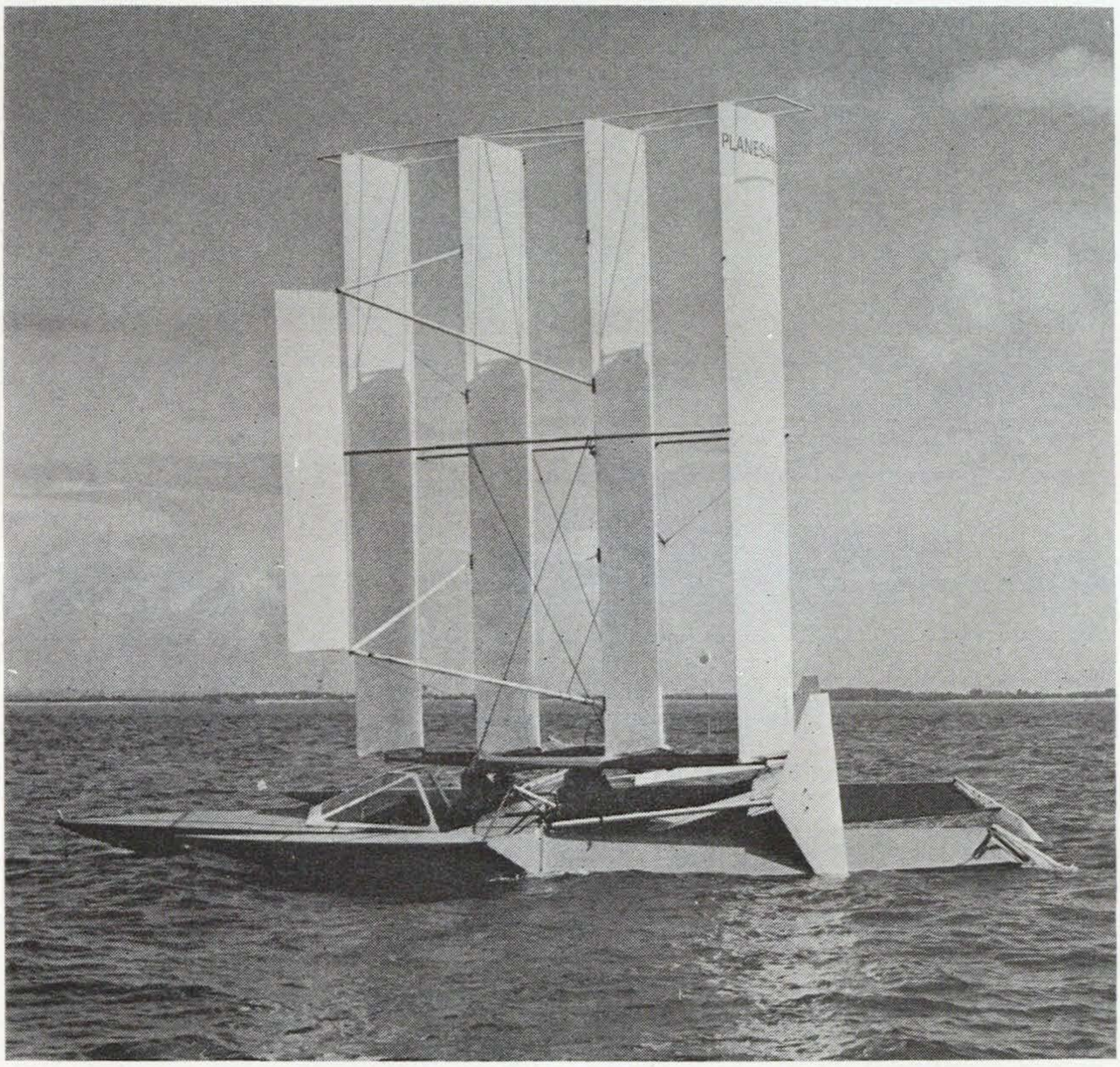
Speed also is a factor in the *PLANESAIL*, the design computations showing that under good conditions 30 knots in a 15 knot wind can be expected.

To arrive at this end he has designed a vessel that uses the trimaran type of hull combined with a remarkable type of sail which is rigid, non-fabric, and of very high efficiency.

The sail—from which the boat takes its name is built up of a number of aerofoils mounted vertically and pivoting about their axial centre lines. Total sail area 280 square feet.

The advantages of the rigid Planesail over the usual cloth one are aerodynamic. Modern synthetic fibre sails are highly efficient compared with the cotton sail of the past, but the lift-to-drag ratio is poor, power output from the sail cannot be satisfactorily reduced without arduous and skilled sail changing or reefing, and—perhaps most important—the whole sail system is rigidly connected to the boat and must move with the boat as it rolls, pitches, or oscillates with consequent variations in the angle of attack of the sail to the wind and variations of power output.

Conventional cloth sails are not very critical and will accept these variations to a degree, but the latest attempts to achieve high efficiency, such as wing sails where the mast is very wide and forms a rigid leading edge are very critical and require a great degree of skill from the crew. If the wing sail concept is followed to its logical conclusion and extended into a rigid aerofoil then it would be virtually unmanageable if used in the conventional manner with mast and sheets.




*John Walker's PLANESAIL, running*

The Planesail has gone to the extent of a rigid aerofoil, but the design has eliminated the use of mast and sheets entirely, freeing the sail from the influence of the boats' random lateral movements. Instead of sheets to control the angle of the sail to the wind there is a tail vane which is directly analogous to the elevator of an aircraft. The vane is connected to the 'power' lever in the cockpit, and also to a 'master' sail by an arm. Movement of the master sail is transmitted to the others by an interconnecting link. Under the normal conditions the airflow around the vane is equal both sides, but if more power is required then movement of the power control will deflect the vane relative to the wind and make it out of balance. It will try to move to restore the balance and in doing so will increase the angle of incidence of the sails to the wind and make them give more power. If the angle of the boat relative to the wind changes then the vane is deflected and as it returns to equilibrium it will correct the position of the sails, continuing the state of dynamic power setting relative to the wind.

If the driver should select more power than is safe, for the strength of the wind, then the sails will 'weathercock' under the influence of the vane and automatically reduce the power output by turning the boat off the wind, making it obligatory to reduce the power setting if the boat is to steer the required course. This safety factor also comes into play if the boat is sailing unattended—say at night—and it is struck by a gust., In such a condition as the wind increases it will turn off the wind and as gust dies away it will turn back on its set course.

The triple hulled layout is of course very stable, and provides a boat that is highly resistant to overturning forces. Steering is not by a conventional rudder but by two hydrofoils which produce a righting moment that balances the overturning moment at all times. Movement of the steering wheel alters the angle of the hydrofoils in the water, bringing the boat on to a new course and simultaneously adjusting the forces acting on the boat so that it remains upright, the sail vane will adjust the sails so that the power output remains constant during the course change.

Any tendency to 'pitch-pole' or turn end-over-end is resisted by end plates on the hydrofoils and the heavy sheer on the bow which gives a major increase in buoyancy if it tries to dig into a wave.

The sails are of glass fibre backed with expanded plastic foam and reinforced with plywood ribs. Plywood construction is used for the construction of the prototype hull, though it is expected that production models will be largely of glass fibre. The wide beam of the vessel, which is often a disadvantage in multi-hulled layouts, can be reduced for land transport or mooring by folding the outer hulls into the main hull on the hinged outriggers and folding down the sails.

# ICEBOAT AND CATAMARAN EFFICIENCIES

**by Greer Ellis** Box 77, 67, Lincoln Avenue, Pelham, N.Y. 10803

Under good conditions of medium breeze and smooth ice, skeeters can sail a broad reach at about 4 x true wind speed. DNs can do about 3 x. I believe that under ideal conditions, say a steady 12 mp..h. breeze, smooth ice made slick by the sun and 35°F. air temperature, a well tuned modern high rig skeeter can approach 60 m.p.h.—5 x true wind speed.

Dependable measurements are hard to get. A couple of years ago we set marks 440 ft. apart and timed a number of runs of several skeeters and DNs. The trouble, of course, was deciding what was the true wind speed. We used a hand held floating pill indicator and decided it was averaging about 15 m.p.h. Boat speeds ranged between 50 and 60 m.p.h. for the skeeters and 35 to 45 m.p.h. for the DNs.

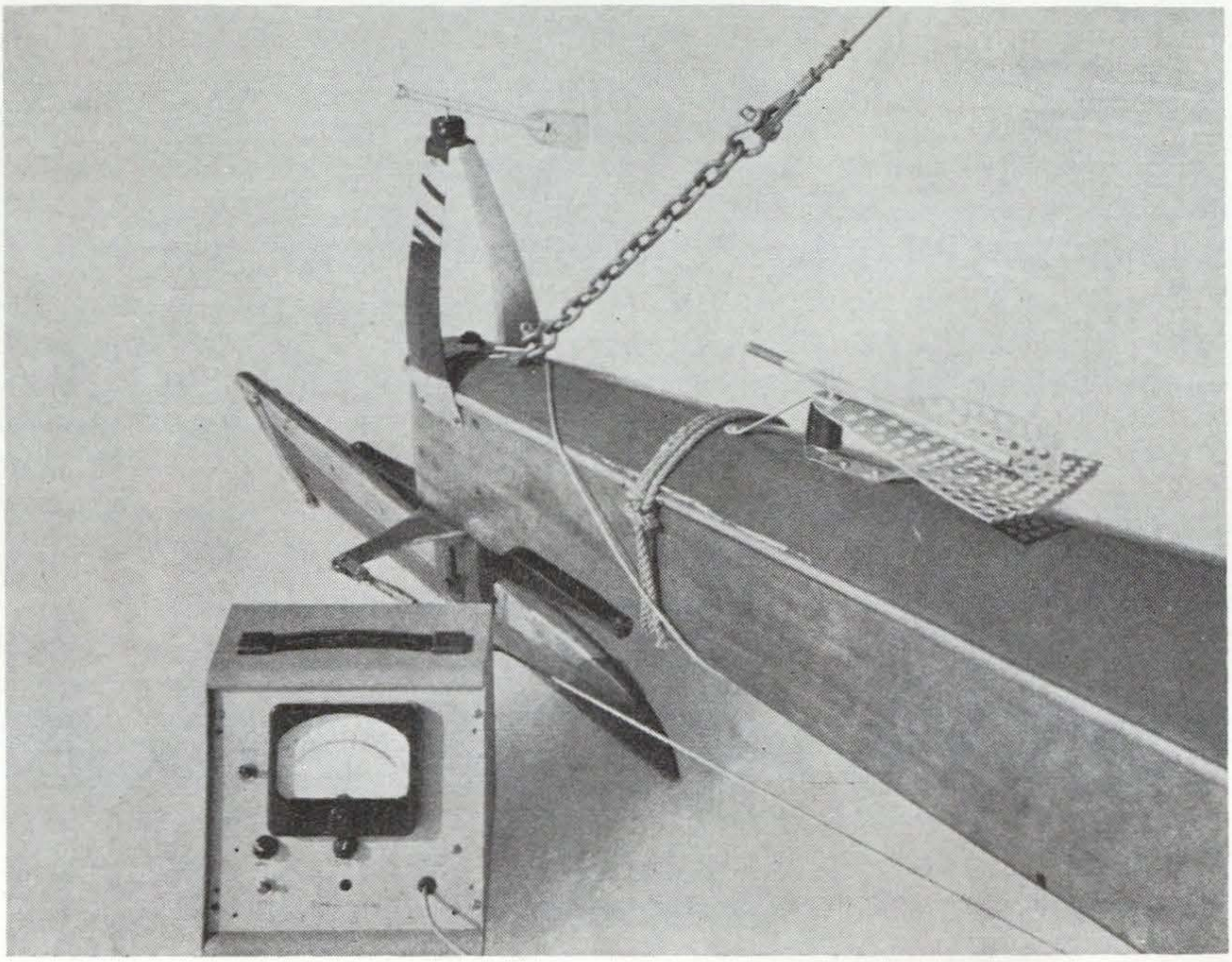


**Figure 1** Apparent wind angle indicators on author's skeeter iceboat. The electrical one up front was used to verify the reading of the permanently installed mechanical indicator

This winter I've been at it again from a different viewpoint—measuring the angle between course and apparent wind by calibrated indicators on my skeeter as you can see in fig. 1. The mechanical one which is quite low to the deck has marked points at 10°, 15°, and 20°. The second indicator mounted higher and further forward is electrical. It operates in freer air and was used temporarily to verify the readings on the mechanical one which has remained on the boat all season.

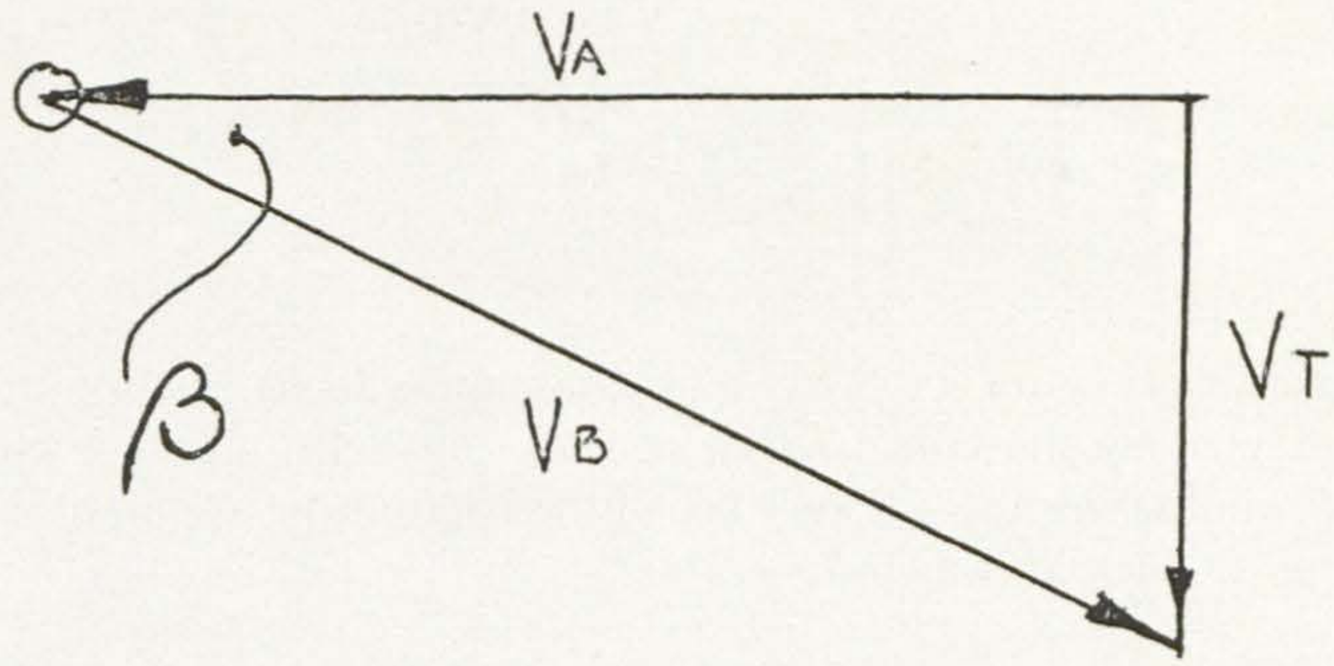



*Fig.* 1

Most interesting observation is that in moderate air on good ice, the angle to the apparent wind remains essentially constant while sailing all courses—upwing at 50° off the true, downwind at 140° from true and reaching across wind. In heavier air the wind would be too strong on a reach to get the sheet fully in before the boat wanted to flip so the angle increased. But both upwind and downwind maintained their angle or even decreased it while pinching a little with sheet full in. Again, the wiggles in the breeze never allowed a really constant reading. While racing I found the boat going well with the indicator in the range of 15°-20°. On occasion, when by myself on good ice, I was able to coax it to hold 15° while on a broad reach. This lines up well with the 4 x true wind speed previously measured as the following diagram shows:


*Greer Ellis' SKEETER*

| β | V boat/V true |
| --- | --- |
| 12° | 5 |
| 15° | 4 |
| 20° | 3 |
| 30° | 2 |

The course diagrams of ice boats and catamarans in fig. 2 show the drastic penalty exacted by the fluid friction of water on hulls. This is particularly true downwind where there is very little power left in the apparent wind when attempting to tack downwind:

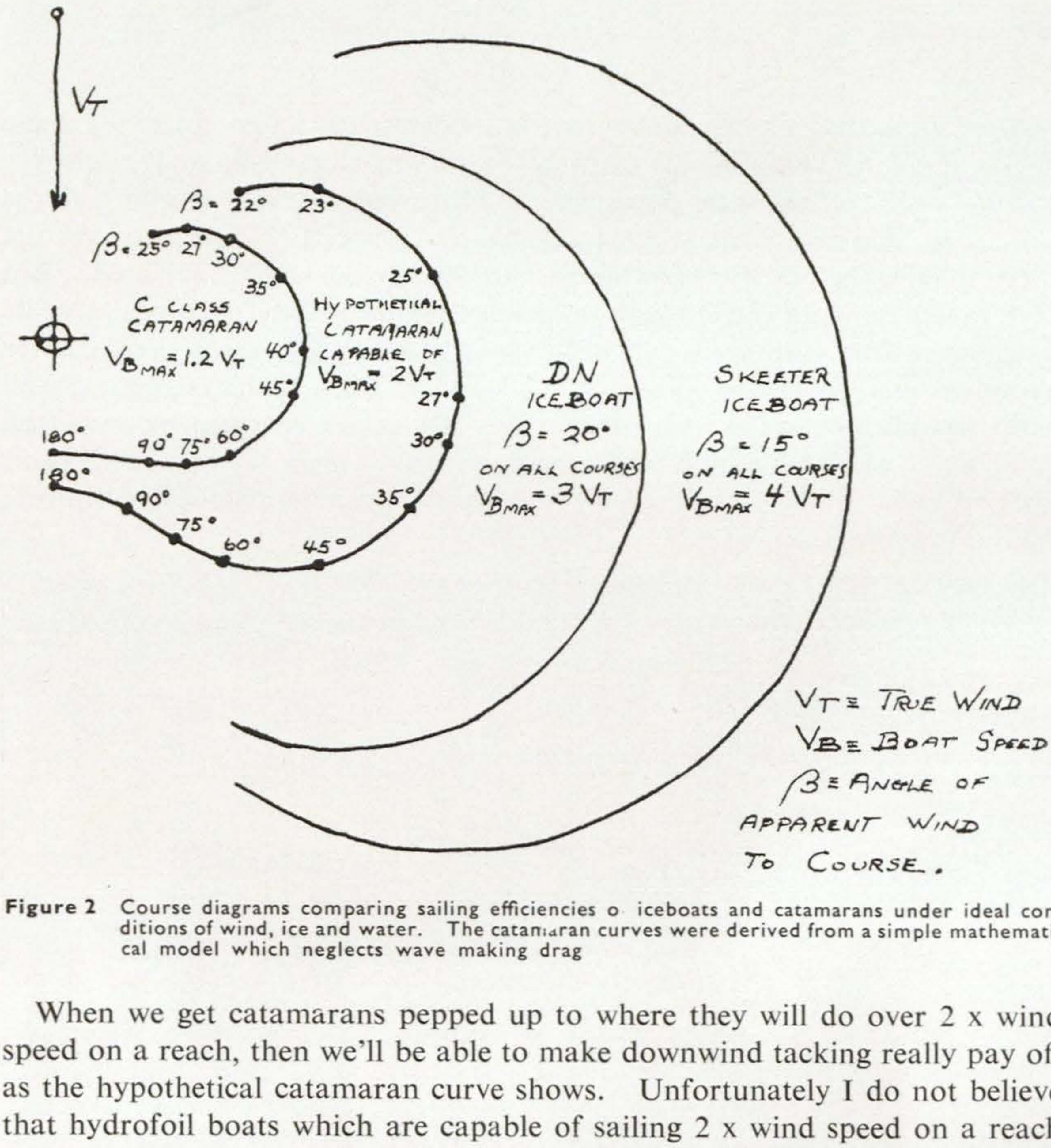



**Figure 2** Course diagrams comparing sailing efficiencies o iceboats and catamarans under ideal conditions of wind, ice and water. The catamaran curves were derived from a simple mathematical model which neglects wave making drag

When we get catamarans pepped up to where they will do over 2 x wind speed on a reach, then we'll be able to make downwind tacking really pay off as the hypothetical catamaran curve shows. Unfortunately I do not believe that hydrofoil boats which are capable of sailing 2 x wind speed on a reach will be able to do as well downwind as the hypothetical catamaran. Reason is the hydrofoils require a fairly large amount of wind power just to support the weight of the boat; so when wind power diminishes as the boat heads downwind, there is relatively little power left for extra forward drive.

Iceboats fly on a downwind tack but only if they are first wound up on a broad reach and then gently peeled off to downwind. I can tell you it's about the most fascinating and delightful experience in the whole gamut of sailing.

April 14, 1968.

Dear Mr. Ellis,

Seldom in my experience as an Editor have I been sent such a well written article as yours. The wording is short, the material is exciting and it is packed with information not found elsewhere. I think we all appreciate the hours of work which has gone into its collection.

Naturally, with so much material, some questions arise:

1 What is your estimate of the leeway angle of an ice boat? One track in your photograph shows a breadth of some 6 to 12 ins., most of which will be ice particles. Though not making any significant difference to your figures, the leeway angle would have to be added to the course angle you took for the $\beta$ angle.

2 Using our wind tunnel, I found that the drag angle of a sloop rig on a 4 foot model dinghy was about 15°. Assuming that both the leeway angle and the hull drag angles are negligible, for an ice yacht, the course angle would also be the sail and hull windage drag angle which you have measured at 15° or more. In view of the 7° angle for a 12 meter, as stated by Edmond Bruce, and the high development of your sail, the boom losses and the hull windage must be high to give your figure. I should like your views on this, as well as on the two assumptions above.

3 In your highly developed sail, is any attempt made to reduce the twist in the sail by making the mast bend with the concavity to windward?

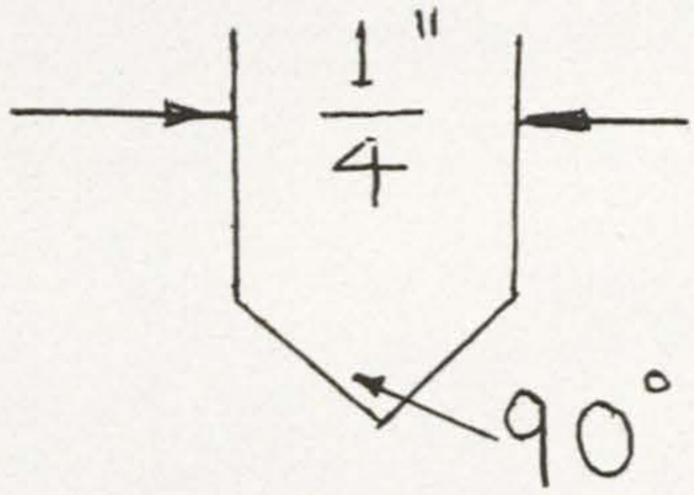
JOHN MORWOOD.

April 22, 1968.

Dear Dr. Morwood,

Thanks for your good letter of April 14. On to your questions.

1 Properly tuned, an iceboat sails with no skidding on a straight course; that is zero leeway angle. It's a question of runners. Most of us have




several sets of different lengths, widths and cuts. The basic cut is 90° included angle with fairly sharp bottom cutting edge. On hard ice, in a good breeze, the included angle may be reduced to 80° and the cutting edge left sharp. For light air the included angle may be increased to 100° and the sharpness of the cutting edge polished off lightly. For slushy ice the width may be increased to 1 in. or more and the length increased from the normal 42 in. for a skeeter up as high as 80 in. The included angle stays 90° and the sharpness of the cutting edge becomes unimportant. All runners seem to work best with no rocker along their length; but this is a disputed question.

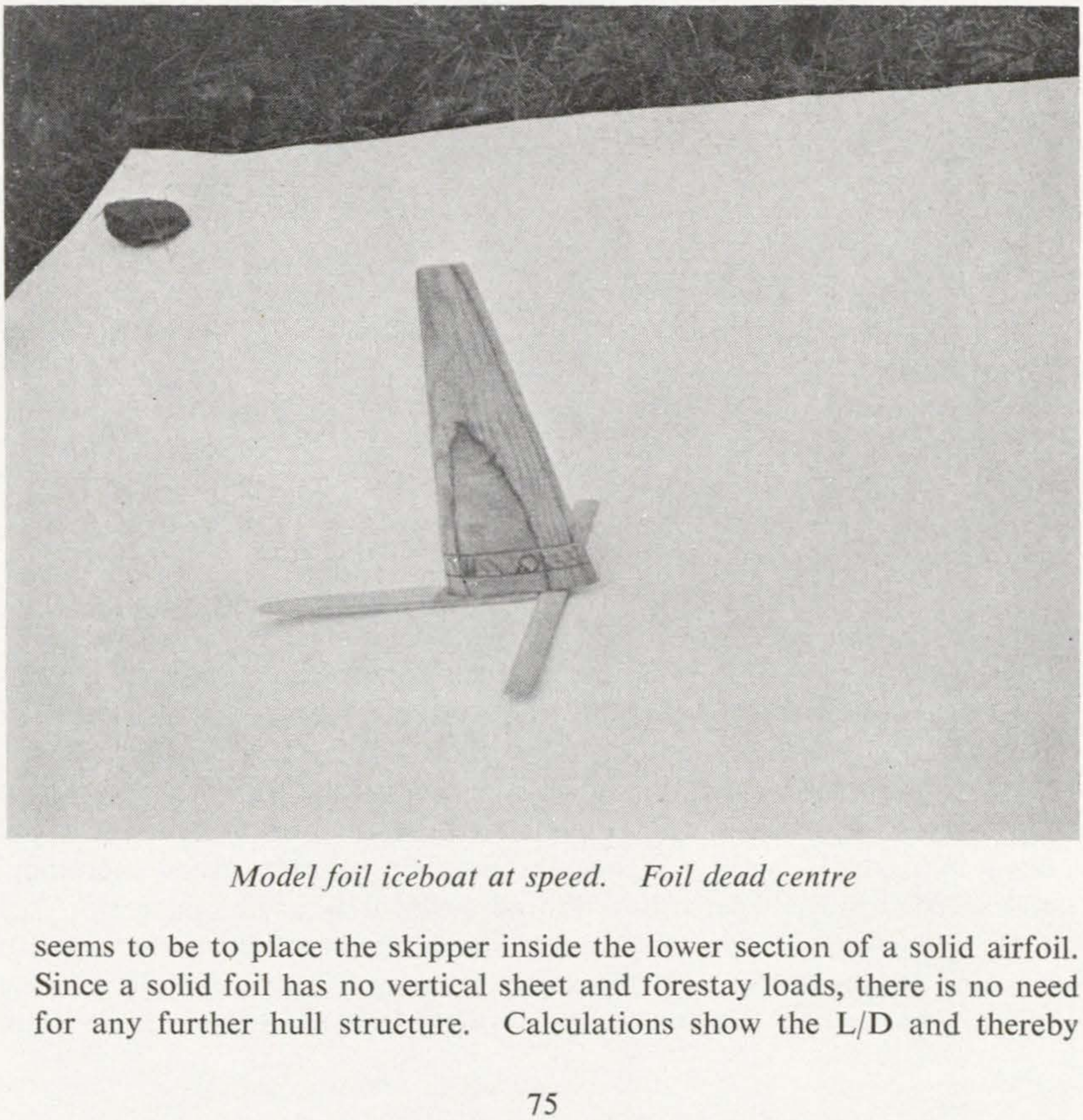

A modern skeeter in the foreground, a 30 year old skeeter in the background. Skeeters are a development class whose principal restriction is a sail area of 75 sl. ft in the head, clew, tack triangle

Some skippers use a rocker of 1/16 in. to $\frac{1}{4}$ in. along the length to allow easier turning with less scraping. Most hot sailors leave the runner flat, making up losses while chaging tacks by better speed on the straight drive.

Coefficients of friction are interesting. On hard, dry ice the pull at walking speed is about 1 per cent of the boat weight. On smooth, slick ice, say a sunny day with 35° air temperature, the film of water can reduce the pull to as low as $\frac{1}{4}$ per cent. Rough and soft ice increases pull up to 5 per cent and slush and snow go higher. Usually we don't race when conditions go above the 5 per cent level because downwind tacking suffers badly from the increased friction.

2 Tests on models and educated guesses lead me to the conclusion that sail drag angle including boom losses runs about 7° to 8° and hull, plank and appendages windage of the same order. Since runner friction can be neglected under good conditions, it comes out that on a reach VB/VT = L/D total. This makes the iceboat a close relative to the glider.

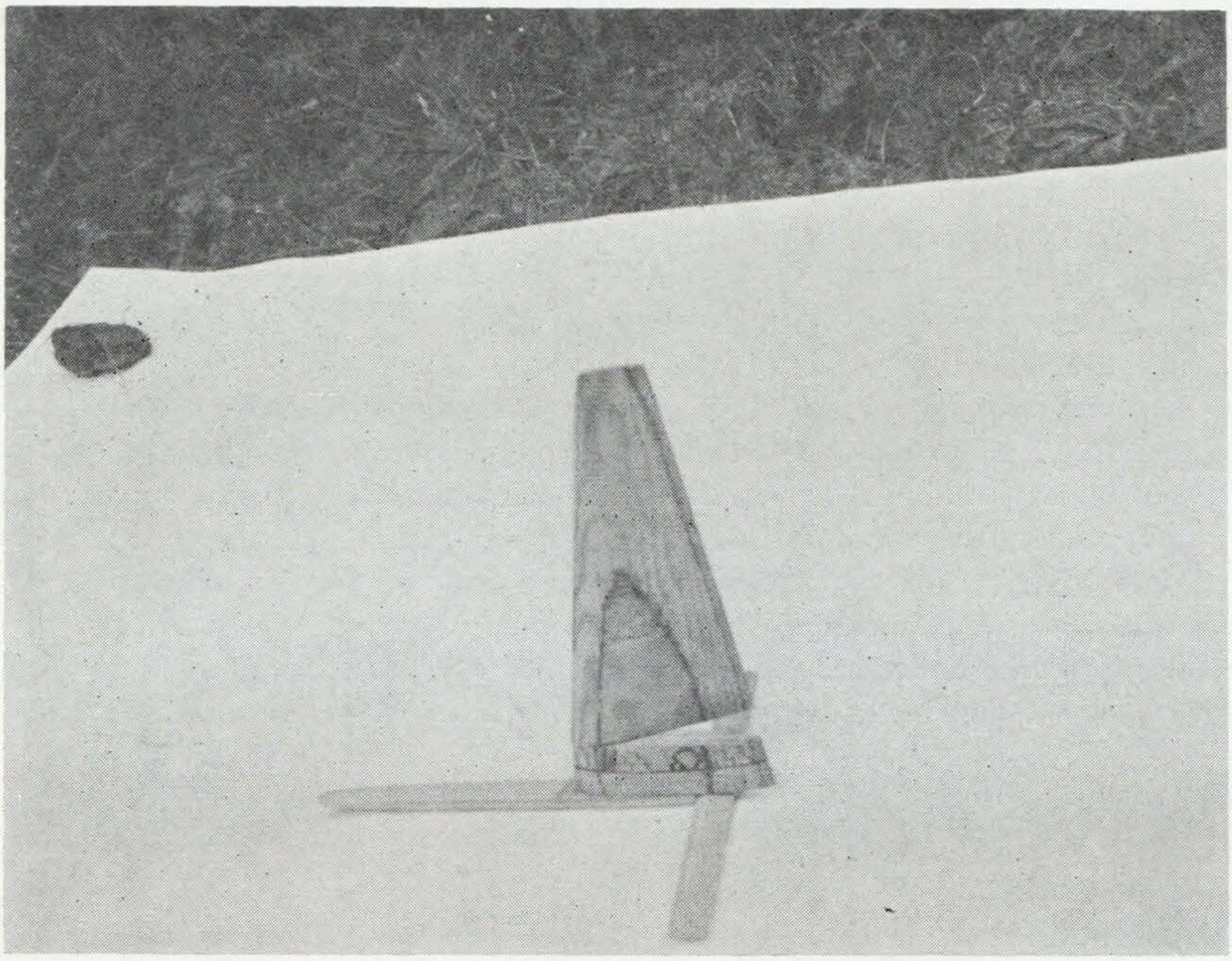
If gliders attain L/D = 25, why do iceboats have to stay down at a pokey 4? The main culprit is the hull being dragged sidewise through the wind. I have heard a rumour that the Germans, some years ago, tried pivoting the hull more nearly into the apparent wind. Theoretically the idea is good. Practically speaking I'm not enthusiastic about shifting tacks in such a swinging gadget while travelling 60 m.p.h. A better approach



*Model foil iceboat at speed. Foil dead centre*

seems to be to place the skipper inside the lower section of a solid airfoil. Since a solid foil has no vertical sheet and forestay loads, there is no need for any further hull structure. Calculations show the L/D and thereby

VB/VT ought to rise to around 8. Last fall we thought about building one as an experiment but only got as far as a non-sailing model. Now I see the Russians have done it. I notice they still have a fairly large hull



*Model foil iceboat without crew capsule. Upper section out while gaining speed*

structure—so they haven't yet gone all the way towards eliminating hull drag. On page 88 in the February, 1968 issue of *Yachting* there is a picture of 8 such solid foil iceboats with the men inside looking out through windows. It would be interesting to know what sailing efficiencies they have actually attained. An editor of *Yachting* stated that the man to contact for further information is: H. Kuivjogi, c/o Experimental Boat Yard, Tallin, Estonia, U.S.S.R. I haven't written him. Perhaps you might like to.

Incidentally, calculations show that a symmetrical solid airfoil put in place of the sail on a skeeter will not perform as well as the regular sail. Reason is the parasitic drag of the hull requires a rather high lift coefficient up around 1.0 for best overall efficiency and unfortunately that's where a symmetrical foil gets fouled up with stalling. A conventional sail, as we know, goes higher than $C_L = 1.0$ without fuss. The picture changes when the parasitic drag of the hull is eliminated. The foil can relax and drop down to maybe $C_L = .5$ as its equilibrium point for max. overall efficiency and speed. $\beta$ would be around 7° and airfoil drag angle about $3\frac{1}{2}°$.

On sail efficiency modern skeeters are developing higher aspect ratio rigs and getting better sail efficiency. Since my thirty year old skeeter (photo enclosed) has a lower aspect ratio rig, I have to work harder to keep up with the modern boys. By careful tuning it runs with the pack of modern high rigs. Towards the end of the season I was experimenting with a horizontal end plate boom under a loose footed sail with adjustable camber and also a vertical deck sweeper plate below the boom to reduce circulation under the boom. Results were encouraging enough to plan further work next season.

3 For over thirty years skeeters have had over-rotated airfoil shapemasts with a single set of stays. This naturally bends the mast with concavity to windward. Some masts bend sidewise as much as 10 in. in twenty feet. Most skeeter masts bend perhaps a couple of inches. The concavity is recognized as worthwhile in reducing sail twist. Full length battens with full leech roach and very heavy sheet loads help take out sail twist. Cut of the sail is important. It's enough different from water boat sails so that only a few specialized sailmakers account for most of the successful iceboat sails. Incidentally, there's quite a difference in the cut of DN and Skeeter sails. DNs with their almost round bendy masts, use a 3 in. roach in their 14 ft. luff while Skeeter sails on stiffer masts normally have no more than 1 in. in their 22 ft. luff.

I like concave mast bend but on my A Lion catamaran with two sets of stays and a very bendy mast, I have found it necessary to restrict mast bend to less than what originally looked good in order to bring the effective angle of attack of the centre section into balance with the upper and lower sections of the sail.

If you have any other thoughts on this, I would enjoy discussing them with you.

GREER ELLIS.

# THE SUPREME SAILING MACHINE

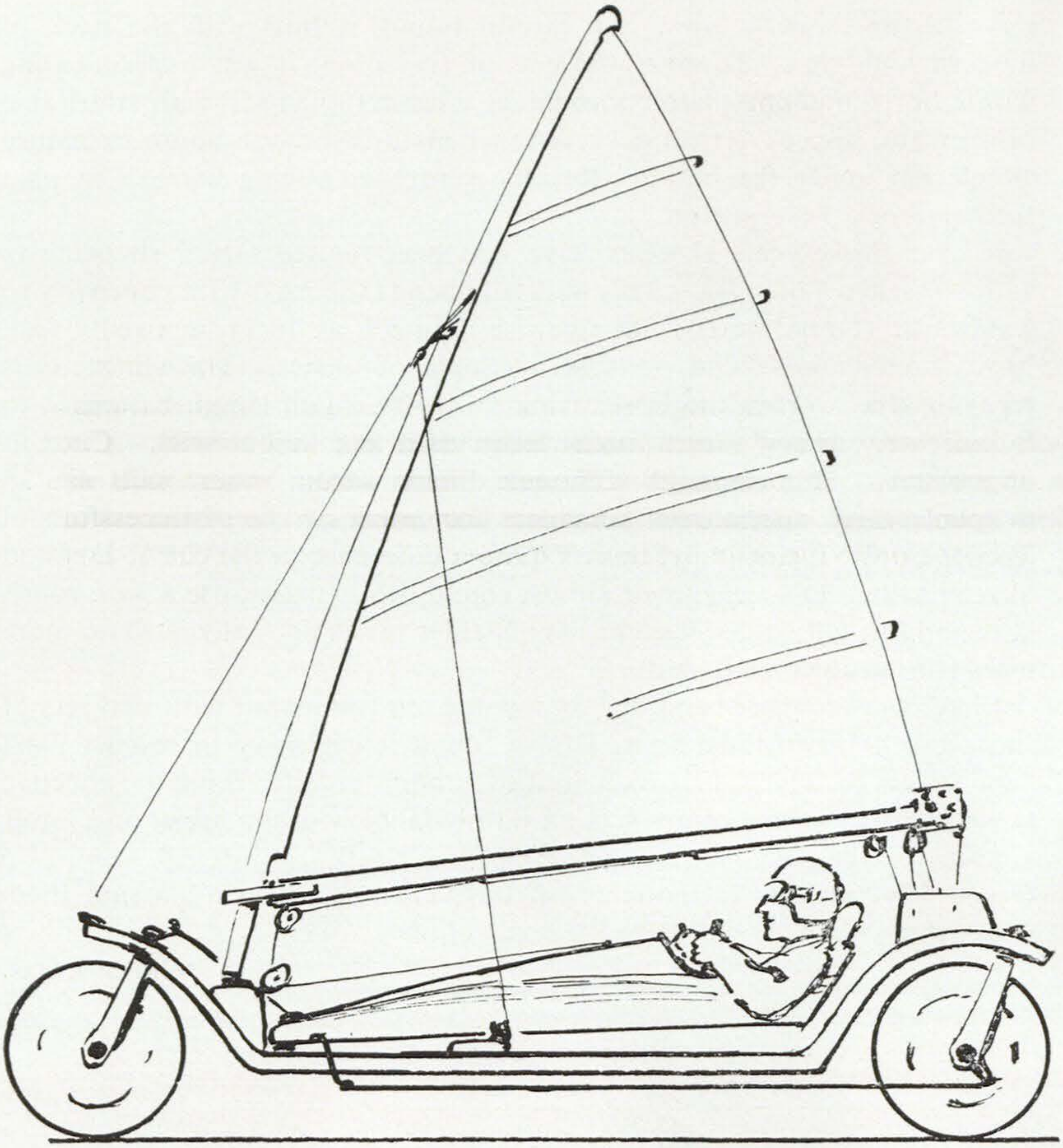
## by John Morwood

Illustrations by Dick Andrews

This is, quite simply, a sailing bicycle, though instead of wheels one could use two ice runners or two hydrofoils for a water craft. It is not quite the simple bicycle we know, however, but the development from it is not very sophisticated.

### The dynamics of the pedal bicycle

I rather doubt if more than one person in a thousand knows how he can manage to stay on a bicycle. Or he doesn't bother to think it out. The proportion will be much higher amongst our members, possibly 100 per cent, but the matter needs to be stated to appreciate fully our machine.



*The Supreme Sailing Machine?*

When riding a bicycle, if one begins to fall to one side, the machine is steered to that side and centrifugal force throws one up to the vertical again. If one wants to turn a corner, the bicycle is first of all steered AWAY from the corner, i.e., to the outside of the curve, so that one begins to fall to the INSIDE of the bend. Then, by steering around the corner, the centrifugal force is exactly balanced against the slope of the rider from the vertical so that he is held by gravity and the centrifugal force with the resultant force acting downwards along the line of his sloping bicycle. If a bicycle rider simply turned his front wheel to negotiate a corner, without previously beginning to fall to the inside of the turn, he would fall off.

## The sailing bicycle

Obviously, ever since the invention of the early bicycles, inventors have tried putting sails on them and doubtedless a search through the back numbers of *The Illustrated London News* would reveal some of these. One can imagine such a machine, leaning slightly into the wind, making a great rate of knots over the ground. However, it would have the great fault that, when a stronger puff of wind hit it, steering the machine into the wind to spill the wind would capsize it to leeward owing to centrifugal force. This would also hold for a stern-steerer, if any inventor ever got around to such a thing.

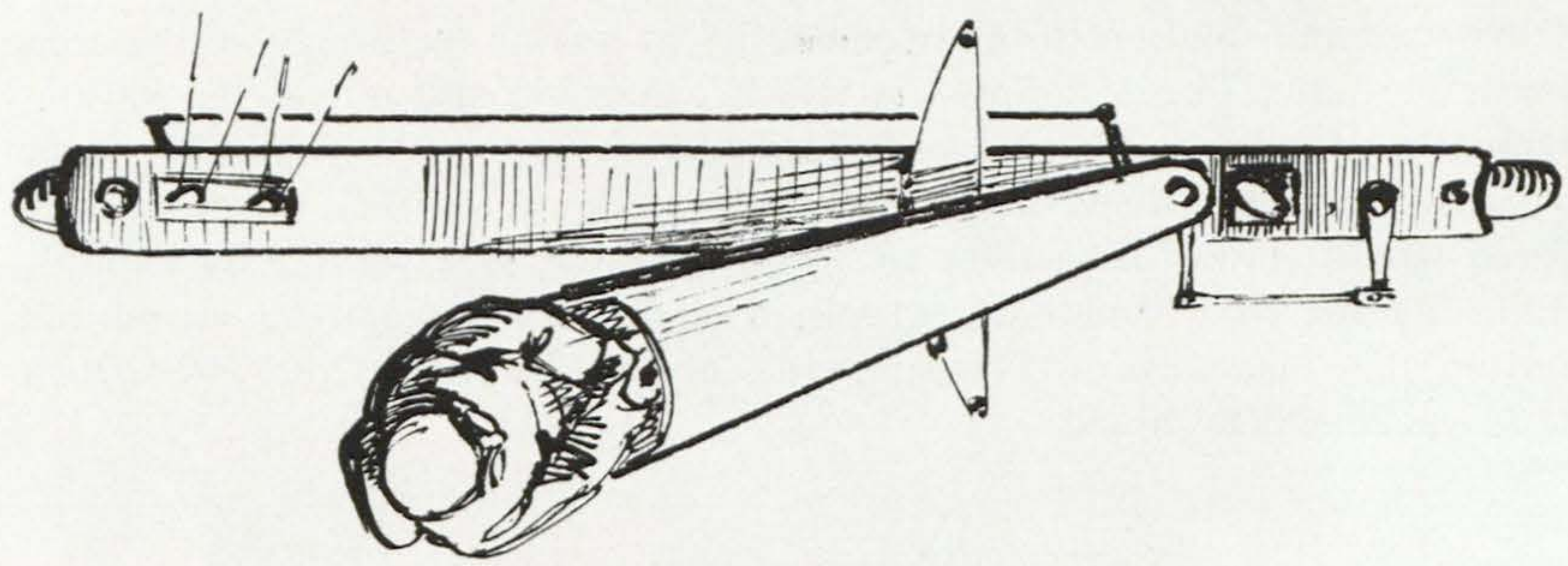
## The necessary stability

Obviously, the solution to the problem lies in having the weight of the crew on some device like a sliding seat which can go in and out in the various strengths of wind and having both fore and aft wheels steering in the same sense so that, when they both were steered to leeward together, the centrifugal force would throw the weight to windward, and vice versa. By suitably adjusting the front and back wheels, a slight luffing could be introduced during this manoeuvre. The similarity of this bicycle to the *CRABBER* land yacht will be noted.


*The Supreme Sailing Machine?*

## The supreme sailing machine

The drawings by Dick Andrews shows the set-up, as I see it. On a longitudinal chassis, two steering wheels are mounted at either end. A DN sail is set on a mast with stays, the aft two of which come down to a cross bar. Instead of a sliding seat, the crew sits in a capsule at the end of a beam which is pivoted forward just behind the mast but has two wheels which run on a rail on the cross beam to which the aft stays are attached. These wheels transfer the righting moment exerted by the capsule to the weather shroud.



*Steering and balancing mechanisms*

The two road wheels have links to the capsule support beam and from there to the hand controls which can be two sticks moving fore and aft. The crew can thus steer the forward wheel with his right hand and the stern wheel with his left. The steering of each wheel is therefore quite independent of the other and both wheels can be steered to leeward when a puff strikes and a correct adjustment of forward and aft steering achieved at all times.

### Overall beam

The DN has a beam of 8 ft. This machine need only have a beam of 2-3 ft. when the capsule is fully out on one side.

### Sailing with this machine

A small wheel with castor action is mounted on the bottom of the capsule which is pulled out to windward. The crew gets aboard and is shoved off. The wind fills the sail, he gets going and either the wind lifts the capsule or, in light winds, he steers both wheels beneath it until it is off the ground, and he is sailing.

If the wind gusts stronger, a quick flick of both wheels to leeward will shoot the capsule to windward a bit and balance the craft so that it is always upright. A sudden loss of wind behind another yacht or building would need a quick flick of both wheels to windward to bring the capsule in. The sheet is controlled by foot pressure and, should the strength of a gust exceed what the stability will control, easing of the sheet is possible. At the moment, I can see no reason why there should be any control of the capsules position other than the skill of the pilot. The sudden lurch to leeward in a gust will greatly reduce the apparent wind speed which will ease the heeling moment, even though its angle of attack on the sail will increase.

**Summary**
A sailing machine is conjectured with the object of reducing the wheels of a land yacht, the runners of an ice yacht or the hydrofoils of a water yacht to two. I believe the saving in weight and rolling, sliding or water resistance will be beneficial and, as a sailing vehicle with only one support is not possible without control of fore and aft speed by a brake of some kind, I have no hesitation in calling this *The Supreme Sailing Machine*.

## LETTER FROM WILLIAM GARNET TO JOHN MORWOOD

January 2, 1968.

Dear John,

Thank you for your letter and article on the sailing-crab-bicycle idea.

A winter or two ago I was skating near here in a bitter wind and found that by holding out my coat and leaning back against the wind I could sail pretty well on a reaching course, and even working up to windward a bit. My weather skate was leading the other, and I went about proa-fashion. After a few tacks I had to resort to ordinary skating to restore the circulation. But there are some differences between this and your machine.

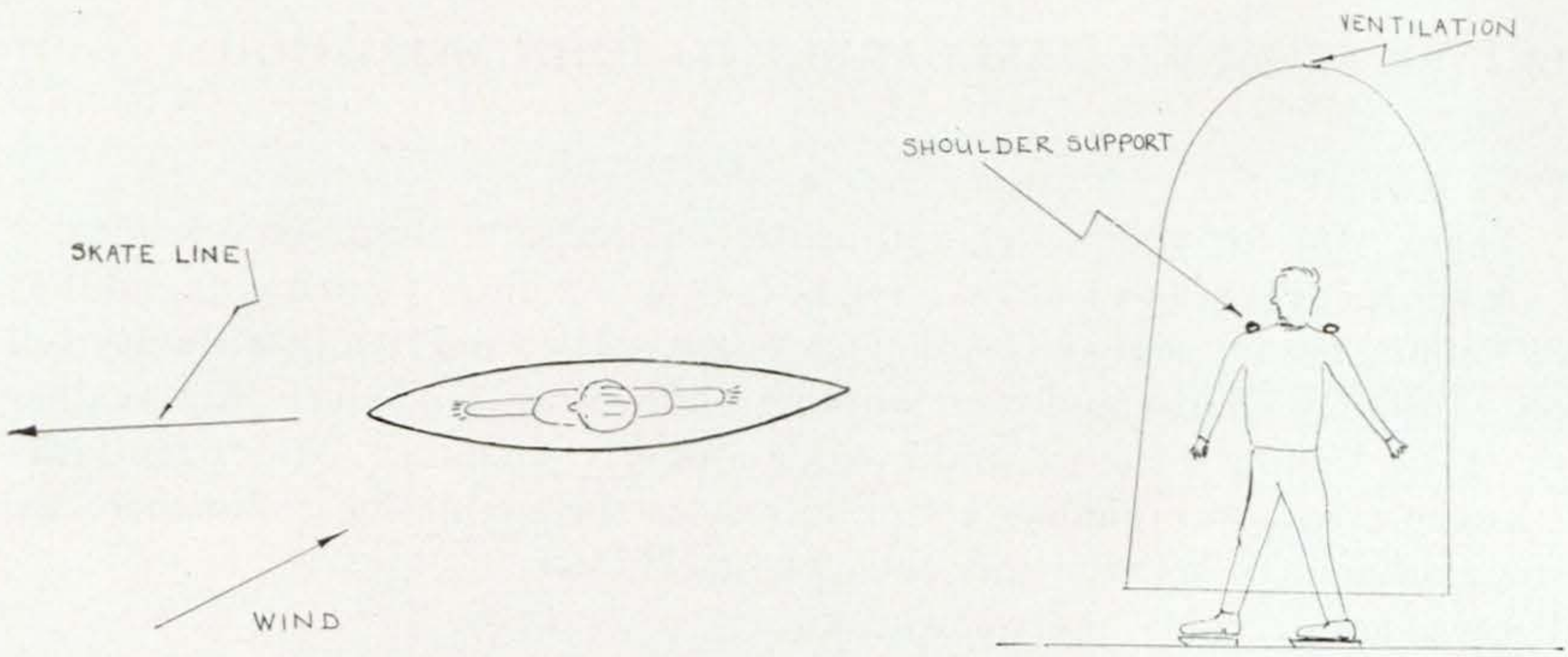
1 I was considerably under-canvassed.
2 My centre of gravity was considerably higher, relative to the skate-base, than yours. This makes for easy balancing, since the longer the period of the inverted pendulum the quicker any toppling can be counteracted. It is this relation between wheelbase and centre of gravity height which makes it possible to ride a bike without toppling at any speed except the slowest. In this respect the dynamics of the pedal cycle differ diametrically from those of all types of sailing craft, where the weight is kept as low down as possible.
3 I had a direct and precise control of all variable factors. Of these variables you have too many on your bicycle, and it is absolutely essential to have direct control of the angle at which the capsule swings out; the slightest gust of wind would blow your capsule across to lee, capsizing the craft and landing the pilot with such a wallop that he would be lucky to crawl out in one piece.

Three-wheel yachts are by contrast extremely safe, since in the event of a collision it is only the extremities of the yacht that actuallv hit anything; the pilot, sitting in the middle, is untouched and can jump clear if necessary.

My chief criticism of your bicycle is that, even if it were drastically simplified, it could only sail as a tricycle in light winds, and in strong winds would be suicidally dangerous.

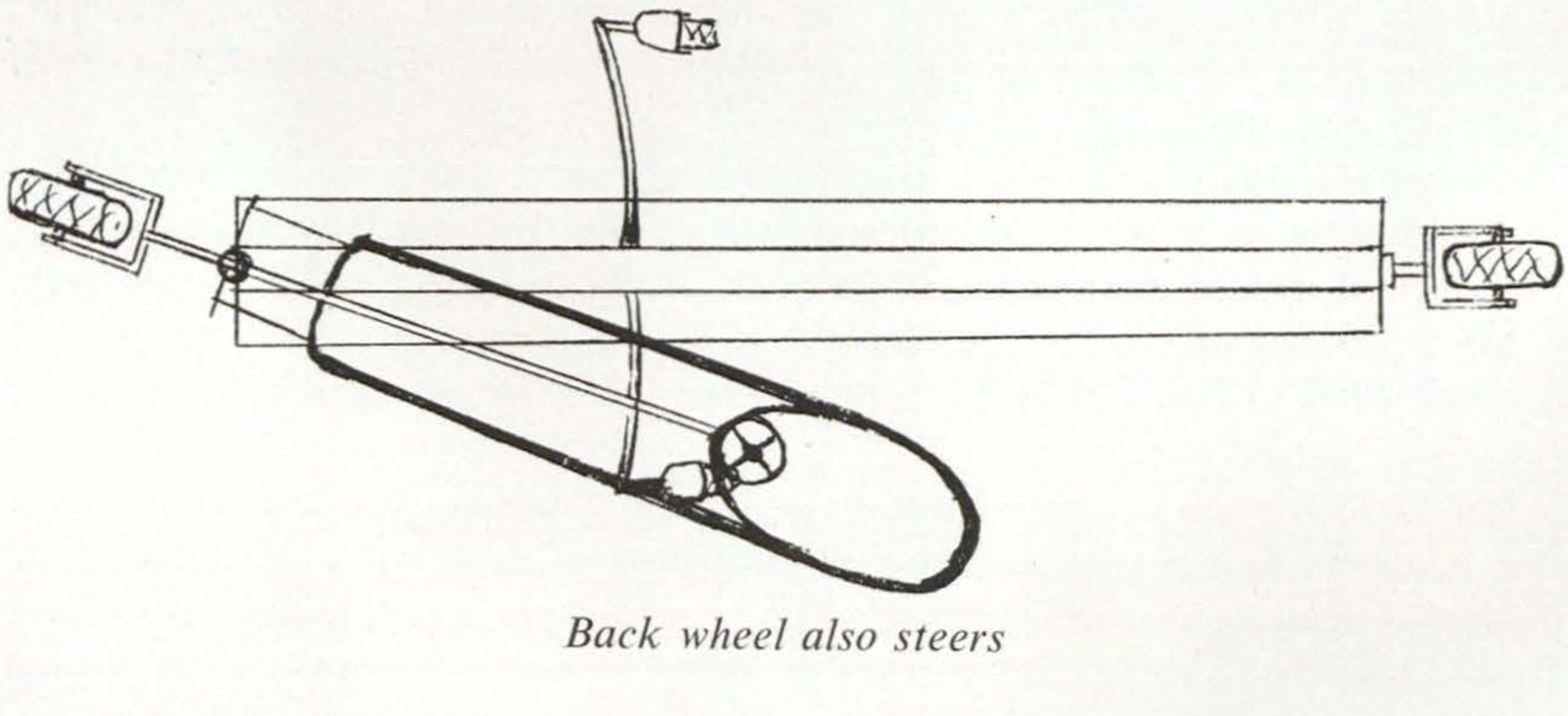
Ian Forbes once suggested this swinging capsule idea for a three-wheeler. But it seems to me that all the complications of crossbar and capsule bar must add dead weight and extra windage; the capsule is designed to swing out almost broadside to the relative wind, whereas the pilot normally sits in a neutral fore-and-aft position.

To take my first point about canvas, that is a big difference between a yacht and a bike. I feel that, apart from safety, efficiency and manoeuvrability are bound to be compromised in the interests of maintaining the craft in a precrarious state of unstable equilibrium. It is easy enough to balance a broom handle on your hand, but have you tried doing the same with a thin piece of board in a strong wind? The wind is always buffeting and veering, and the slightest alteration in the angle of the board will double or treble the force (apart from gravity) which you are trying to keep in balance. I would nevertheless like to try an improvement on my skate-sailer in the form of a plywood and perspex aerofoil made to fit over the body almost down to the knees and internally supported on the shoulders (see sketch below).




Your objective is to reduce wheel friction. But this is not reduced in direct proportion to the number of wheels unless there is a corresponding reduction in weight. One cannot halve the friction of a bearing simply by halving the number of balls or rollers in the cage.

I think the version of your idea which would be most workable would be a four-wheeler, with two side wheels raised so that they would touch down if the craft heeled 30° either way. The front wheel would be mounted on a forward extension of the capsule arm, so that both are controlled by a single



*Back wheel also steers*

wheel for the hands. The feet would control the rear wheel in such a way that it would normally remain parallel to the front wheel when that is steered. Sketch above. No sheet, of course, because this is a genuine 'crab' yacht, with sails fixed to the chassis.

I have just been discussing your article with Peter Shelton, who probably knows more about land yacht engineering than anybody alive, and he agrees with my comments although admitting that he once considered the idea but came to the conclusion that the pilot would have to be placed in a capsule on the masthead! He says that the nearest practicable thing to two wheel sailing is a yacht with two large wheels at the ends of the main crossbeam, and smaller, very lightly sprung wheels for and aft which with careful balancing by the pilot take very little weight or downthrust, and with which he steers. In fact, a four-wheel yacht. He thinks it might be possible to sail a fore-and-aft bicycle yacht in ideal conditions, but not to race it against other yachts.

William Garnett,
Hilton Hall,
Hilton,
Huntingdonshire.

## LETTER FROM JOHN MORWOOD TO WILLIAM GARNETT

January 4, 1968.

Dear William,

Many thanks for your consideration of the sailing bicycle and comments thereon which I find very stimulating.

1 I see the point about the centre of gravity being well above the ground. If one begins to fall to one side, there is more time to bring the wheels under you. However, what really matters is the rate of angular capsize which would depend on the inertia of the system. With a low C of G, the rate of angular capsize would be slower surely and the wheels could be shot under it even MORE easily than with a high C of G?

Possibly the point where we are at variance lies in whether only the front wheel steers or whether BOTH wheels steer in the same sense. Surely, if a gust hits you, if BOTH wheels are steered to lee, not only will it take the blow out of the gust but smartly (through inertia) heel the bicycle to windward?

2 I think I disagree with your argument that it is necessary to have direct control of the angle of the capsule from the middle line. I believe (for the moment) that if a gust of wind hits the capsule and tried to send it to leeward, a quick flick of the wheels to lee would shoot the bicycle to lee, leaving the capsule even farther out through its inertia. And vice versa, of course. In other words, the side to side position of the capsule is decreed by the steering. I did design a capsule control at first but now think it unnecessary.

3 In view of all the above, I don't feel that I see Peter Shelton's point about having the capsule at the masthead. All that is required surely is an instantaneous adjustment of the righting moment which steering by BOTH wheels in the same sense would give (with the capsule free on either a rotating arm or on a track athwartships). This righting moment adjustment must, of course, overpower the sail in gusts—the sail area must therefore be limited in area but this need not necessarily be smaller than the DN sail.

**Your suggestion**

This seemed fine to me as a method of capsule control but I guess that in practice, it would need a lot of power to force the capsule out against its inertia. Then, steering such as I envisage would be needed to get it out. I agree most whole-heartedly, of course, in the side wheels which would obviously be needed with any two wheeled arrangement, making it a four-wheeled craft.

**Ian Forbe's suggestion**

As the DN only has a beam of 8 ft., the capsule need only travel 2 ft out on either side. If one objected to the angular swing of a capsule, having it on a track across the vehicle would stop this. With a 3 wheeled land yacht, the DN seems to have ample stability at most times and a capsule would be almost useless but it would make a good trial for a bicycle.

**Your plywood and perspex wing**

This looks like great fun and I hope you try it sometime. I should think it would go like a bomb.

JOHN MORWOOD.

**LETTER FROM WILLIAM GARNETT TO JOHN MORWOOD**

January, 1968.

Dear John,

Thanks for your letter about the bicycle idea. It is news to me that you would have brakes on the machine, a most unusual feature on land-yachts. I don't in any case see how you could brake without doing a forward capsize. Since the craft is a crab why not use the sail to stop you? All you have to do is swing past the luffing angle so that the wind is on the wrong side of the sail, the danger then will be a backward capsize which is perhaps slightly preferable. Braking the wheels would also tend to lift whichever wheel is behind thus converting you temporarily into a monocycle.

In abolishing the windward wheel, which at times takes little more weight than is needed to balance the yacht, you have introduced a new factor into the already complicated balance of forces. I suggest the use of a kite rig to solve this problem.

I think you should do some practical land-yachting, if you haven't already, to get to know what you are theorising about, and just what it is you are trying to save with two wheels instead of three.

**High v low c.g/**

There is a danger with a low centre of gravity of overshooting in your attempt at balancing. Try balancing a hammer on your finger head-up and then head-down; the former system is far more inert.

But I wouldn't rely on inertia for control of the capsule position. You know how easily things can jam on a yacht. I would suspect, anyway, that the inertia of the capsule would tend to be a little delayed behind that of the yacht as a whole, so that if the yacht heels one way it is a moment or two before the capsule follows suit. Thus, having weaved to lee to keep balance you find yourself all at once thrown off balance again by the capsule swinging across. Hence the need for direct control of the capsule, and my suggestion is one way of doing this while at the same time keeping two-wheel steering.

What do you hope to save by all this? Weather wheel friction. But on a properly designed yacht, as Peter Shelton points out, the flexing of the rear axle plank under wind pressure tilts the two wheels outwards, which has the same effect as toeing-in. Thus the lee wheel, which provides virtually all the lateral resistance, can do so without the wheel having to skitter unevenly over the track to maintain the same leeway angle. In lighter winds the axle plank is fairly straight and the wheels run more or less upright with little or no simulated toe-in; and that is what is required in conditions where lateral resistance is shared. The practical point about the lee wheel under pressure is that there is an even rate of side slip as one tyre tread twists across the path of the next; the wheel scrubs evenly over the runway so there is no needless friction here. And with simulated toe-in the weather wheel just follows freely where it wants to go; again the friction is minimal.

So where do you expect to make a saving with your bicycle?

This winter does not look like offering any scope for trying out my wing-on-skates. The snow has all gone this morning but there is no sign of any hard frosts on the way. If there is a cold spell I shall certainly do something about building one.

WILLIAM GARNETT.

## EXTRACTS FROM LETTER FROM DICK ANDREWS TO JOHN MORWOOD

February, 1968.

Dear John,

The problem I see in the sailing bicycle design is control. A man must fly it—by quick reflexes. It is an added complication that he is handling a sail. I do not believe that a 'DN' sail can be controlled by any foot apparatus as one must get it in and out so fast—and there is a block train adding to sheet travel. We steer our 'DN's' by a knee-grip on the tiller, this leaves both hands for the sheet.

I suggest that control of the craft be simplified by:

1 Using a sail of smaller area than the DN (do you need 60 sq. ft.?), and so reducing the block train, say 35 sq. ft. or a lateen giving some balance.

2 Instead of independent wheel steering (which might cause wedging and is a control complication) have the wheels turn in opposition as linked by cables to a common steering arm. This arrangement could give pedal steering in a natural way—as it also braces the rider in swinging his seat out. I do not favour crabbing off if avoidable—it is bound to cause collisions if these things are raced—or hitting objects otherwise.

   The wheels turning in opposition will make a quick swing helping to put the seat arm out to windward.

3 Various 'joystick' arrangements might be used. The Craig ice boat with 35 sq. ft. sail area uses a for-aft stick to move the sheet (there is no block train).

4 I favour a cross-arm of 4 or 5 feet length to stay the mast and carry a small wheel at either end so that the machine has static balance—then the pilot can run with it to get started. This is a must (at least he must be able to start unaided and he must run and push off in most winds.

Dick Andrews,
25, Audubon Drive,
Ossining,
N.Y. 10562.

**LETTER FROM EDMOND BRUCE TO JOHN MORWOOD**

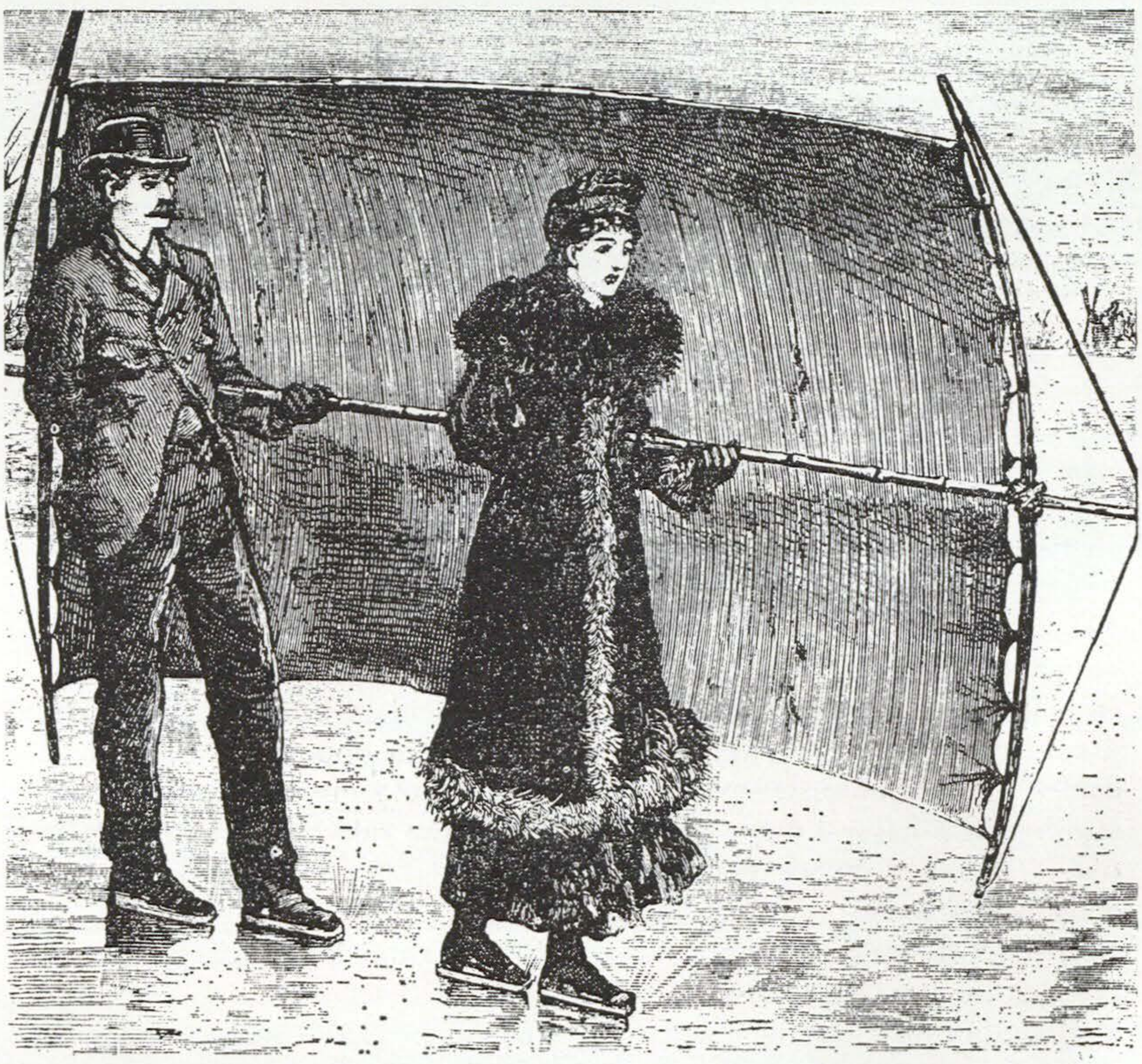
January, 1968.

Dear John,

In regard to your article 'The Supreme Sailing Machine', first let me make some minor comments on your fine thought-provoking article and then suggest what possibly may be a further evolution.

On a conventional bicycle, rather than first 'steering away from a corner' before turning, does not one usually shift his body weight by leaning toward

(Sailing on Skates. From 'Illustrated London News', 31st January, 1880.)



*From Illustrated London News, 31st January*, 1880 the inside of the turn to avoid an erratic course? However, the steering that you describe is appropriate to the 'Machine' where it is used to cause a weight shift.

On a 'hard-water' ice-boat, the most difficult thing for a 'soft-water' sailor to learn is that he must not luff into the wind to avoid a hike resulting from a puff. One must bear off. Therefore this manoeuvre, which you describe, is presently well established. (See page 88 of *A.Y.R.S. No.* 62).

Is not an ice-skate sailor already the 'Supreme Sailing Machine'? Your proposal permits larger sizes.

As described, the pivoting capsule is positioned, during sailing, by inertia alone without manual assistance other than steering. I can imagine situations during acceleration or deceleration that will cause trouble. For example, braking the wheels would not brake the capsule.

In drawing the three-dimensional vector forces, it becomes apparent that the capsule might benefit by being rigidly attached to the boom and perpendicular to it. This would continuously counteract the sail force which is always more or less perpendicular to the boom. One steerable wheel could be under the mast and the other under the capsule. An appropriate castor could take care of stability when stationary.

Your elliptical square-sail would be attractive with this scheme. The jibe would completely disappear. It is a good riddance. A full tack should be made quickly so as not to lose too much speed, when the sail momentarily opposes progress. It would be possible to sail to windward with the capsule temporarily to leeward until it was convenient to turn it 180° further.

EDMOND BRUCE,
Lewis Cove,
Hance Road,
Fair Haven,
New Jersey, 07701.

**LETTER FROM JOHN MORWOOD TO EDMOND BRUCE**

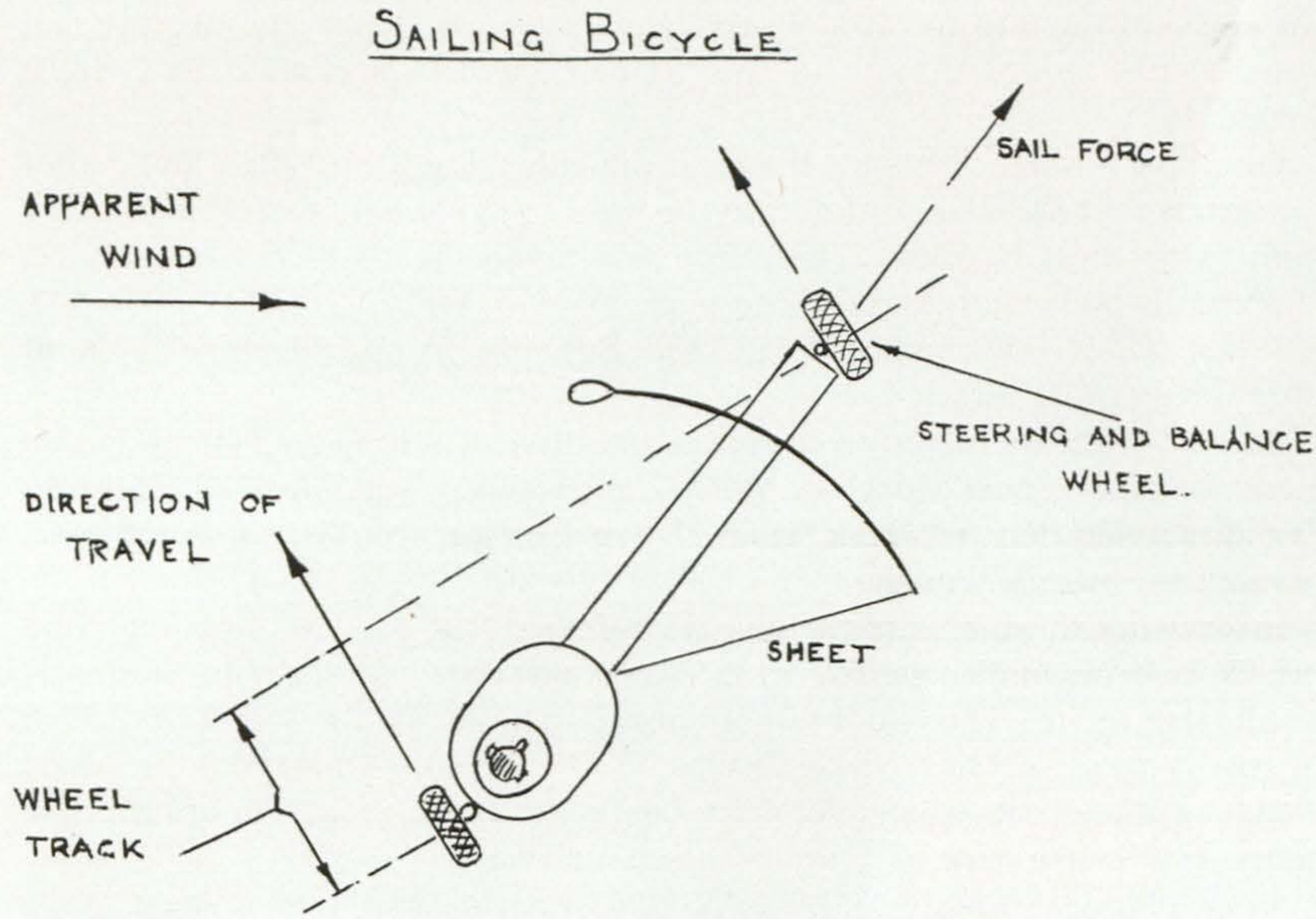
February, 1968.

Dear Edmond,

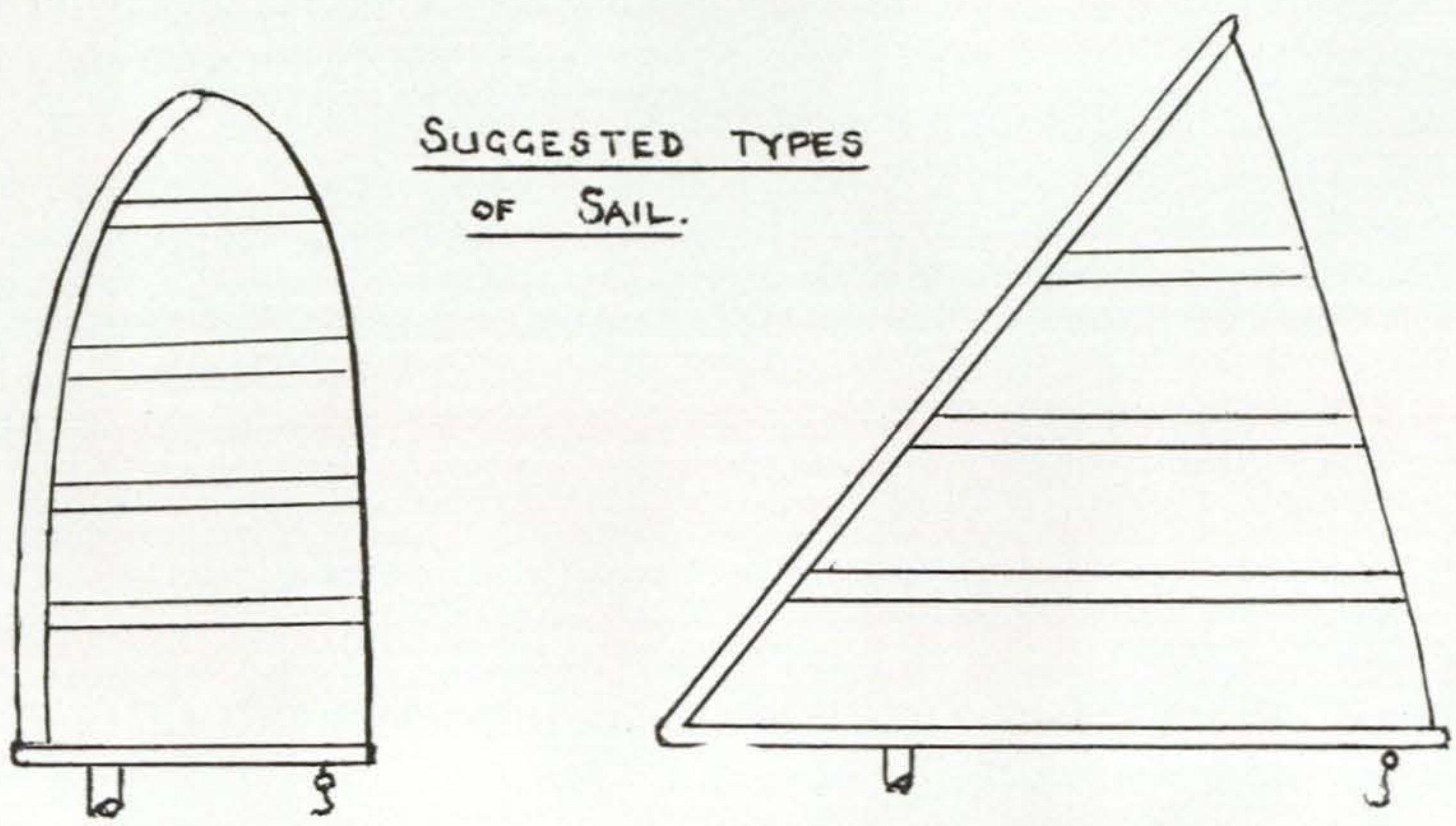
I drew out your suggestion for a sailing bicycle as enclosed. At first, I doubted its stability as it appeared to be a two wheeled chariot. Then I realised that the lee wheel must lead the weather wheel by enough to steer and balance and this would increase by reason of the rolling friction.

I rather doubt if a semi-elliptical squaresail would be of much use with this and show both a lateen and semi-elliptical fore and aft sail.

I quite agree that an ice-skate sailer is already the 'Supreme Sailing Machine' but having never sailed thus, it didn't make an impact. One of my friends has wondered why one should try to reduce the wheels of a land yacht to two when three are so much easier and probably have no more resistance. I suppose the answer is that the principle 'lies' to be invented so we must invent it, even if it is no better than a three wheeled craft.









I think one does shift one's weight onto the inside of a turn on an ordinary bicycle but, as one is balanced on a fore and aft fulcrum, surely this can only be done by displacing the fulcrum to the outside of the turn, i.e., by steering momentarily to the outside of the turn—a fact which makes cyclists appear to wobble.

**My sailing bicycle**

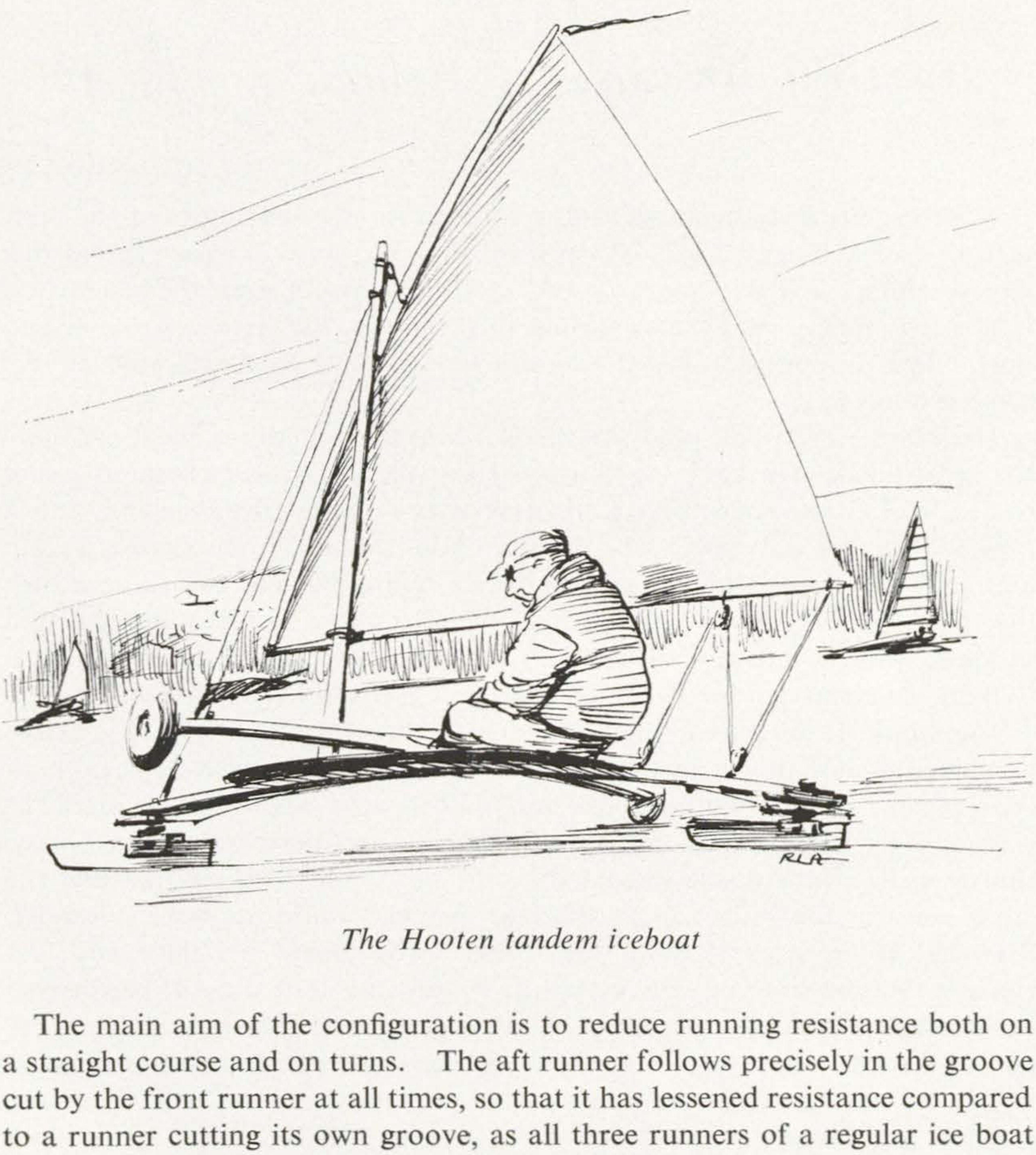
I am pleased that you found the main concept possible. As you say, acceleration and braking might give trouble. One could, however, control the capsule by the feet or have the brakes acting on the capsule bar before acting on the wheels.

JOHN MORWOOD.

# THE HOOTEN TANDEM RUNNER ICEBOATS

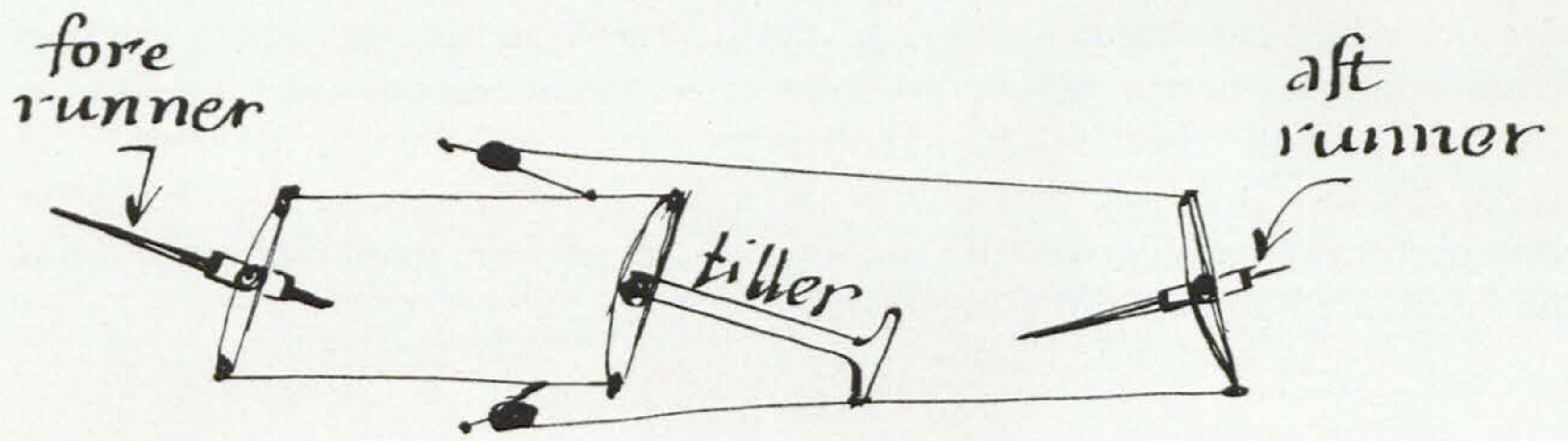
**by Dick Andrews** 25, Audubon Drive, Ossining, N.Y. 10562

A designer and builder of high performance ice boats is Art Hooten of Danbury, Connecticut, who also likes to venture into experiments with new concepts and configurations. For some time now, Art has been working on the concept of a tandem runner—or bicycle—ice boat. Briefly, the craft rides mainly on just two runners, one forward and one aft, both of which are steered. A simple cable linkage, as illustrated, steers the runners together from a single tiller or wheel. A light cross plank provides staying for the rig and a small wheel at either end gives lateral stability as required. To date, Art has built two versions of the craft, of which the first and smaller one performed very well while the new and larger one promises success but has presented a few tuning problems.



*The Hooten tandem iceboat*

The main aim of the configuration is to reduce running resistance both on a straight course and on turns. The aft runner follows precisely in the groove cut by the front runner at all times, so that it has lessened resistance compared to a runner cutting its own groove, as all three runners of a regular ice boat must. As the crew shifts weight to keep both side wheels off the surface, this is again less resistance than for three runners. And in turns the tandem craft never drags a rigid runner through a circle, as both runners are riding along the line of the arc of the turn. These features enable the tandem runner craft to go well in light airs and to maintain drive through a turn such as can stop a normal three runner ice boat due to the resistance to turning of its two rigid and parallel side runners.

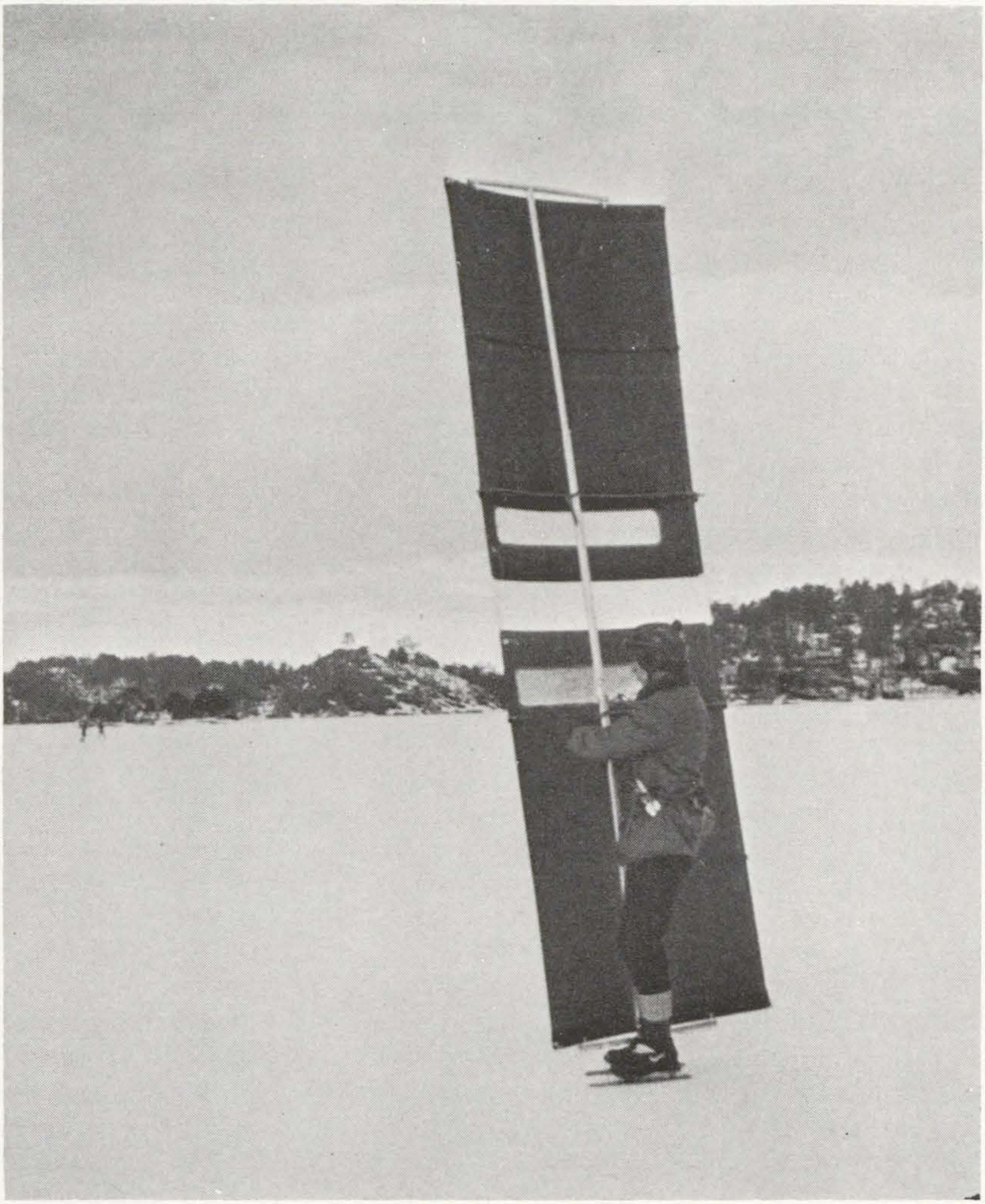



steering linkage of Hooten ice boat

A further marked advantage to the configuration is the ability of the craft to turn and manoeuvre very sharply and quickly, as this writer found one day in sailing the Mark I version. As the helm was put over, she just swung in a smart circle. As the bow swung to starboard, the stern was moving to port. The turning radius is thus much less than for standard craft of the same runner base.

The Mark I craft consisted simply of a heavy longitudinal plank (actually the cross plank of a large ice boat) given a steering runner chock at either end, a light cross arm athwartships with a small wheel at either end, and a plywood tray for the crew. The rig was a boomed lateen sail borrowed from a Sailfish and thus entirely adequate for ice sailing but not competitive with the 'DN'. In the view of this writer, such a craft with efficient rig would in many ways be superior to the 'DN' for sailing on confined surfaces as it is more manoeuvrable and controllable and probably non-capsizeable.

The Mark II craft is a much larger and heavier affair with a massive laminated arched timber as main structural member, an enclosed cockpit or crew capsule mounted on it, and a long limber cross plank. A standard 'E' class sail rig is used. In one trial using a powerful rotating plank mast, shorter cross arm and side wheels, the craft went well but it was felt that the cross arm was too short to stay the mast properly and tests were cut short, the wind being strong. With the longer cross plank, a lighter and less efficient rig, and side runners instead of wheels, the craft did not perform so well in lighter wind on soft ice. Art Hooten plans to try her with a more powerful stick, and also to try wheels on the cross plank and then runners with a rounded section and considerable rocker to remove any alignment problem and drag on turns.



*John Hamilton's skate-sail*

April 21, 1968.

Dear Mr. Lamble,

Just for fun I send you a picture of my skate-sail, an entirely new conception and based mainly on what I have learnt as being a member of A.Y.R.S. The last two winters have been rather unfavourable for skate-sailing, so I have only preliminary results so far, these are however promising.

JOHN F. HAMILTON,
Bergviksvägen 58,
161 38 Bromma.
Sweden.

# ICEBOAT ACCIDENTS

**by Richard Andrews** 25, Audubon Drive, Ossining, N.Y. 10562

Sailing at high speeds has its risks, and if we get foil craft on water going at mile per minute rates we will have to undertake a new and much less relaxed view of the subject of safety.

One hazard on ice that should be easy to avoid for high speed water sailing is, simply, rear steering. I went as crew on one old time rear steerer in a sentimental regatta and, gentlemen, the 'flicker' of flat spin out when the rear steering runner loses its grip—is no joke. It comes without warning and it is quite violent. I nearly fell under the main spar of our craft with minus clearance for me and rough ice—at speed. These old time rear steerers also capsize. I sailed along parallel with a big one which gradually lifted higher and higher despite all efforts to control her, when she punched her lee runner through a soft spot and slammed to a sudden stop. Control is the essence of safety at speed—rear steering has not got it.

With the front steering craft, whose control is essentially good, a major risk is collision. Consider the closing speeds of two craft both doing 60 per. Consider that high speed sailing means that in a race the whole fleet is constantly tacking, upwind and downwind, and soon the downwind and upwind tacking boats meet each other. In road racing everyone is presumably going the same direction as everyone else. This is also true in speed boat racing—but it cannot be true in high speed sailing races. I recommend a study of the racing rules used by iceboats under the National Iceboat Authority of America, which are the result of long experience. The five man body which drew the rules have, to a man, been champion sailors on ice for decades.

In a collision between a 'DN' and an 'E' boat this winter, the 'E' hit the side of the 'DN' with her weather runner, which knocked the 'DN' skipper out of his boat, right through a heavy double side rail. The boat sailed on and left him. The 'E' boat almost disintegrated. Her side runners ripped loose from the cross plank, which in turn tore loose from the hull or 'fuselage', and took out the aft section of the latter. The rig of course crashed down. Her skipper was badly shaken up and bent a leg, putting him in the hospital for some time. He had come to rest under the fuselage, which was upside-down.

Another 'E' boat being driven hard in a race, broke a stay and somehow the jolt broke the castings holding the plank to the fuselage. She came all apart and her skipper travelled some distance on his head—fortunately with a good helmet on it.

A large 'E' boat was making a pass for a photographer, and was not doing more than about 20 m.p.h. when she hooked one runner under a boat dock. The plank and half the fuselage still attached went under the dock; the other half and the rig went over it. Fortunately her skipper was in the half that went over. He took a violent whiplash and broke a rib.

All these craft are far, far stronger and more substantially built than the flimsy catamarans being raced today.

# HOW TO MAKE AN ACCURATE DIRECT READING SPEED LOG

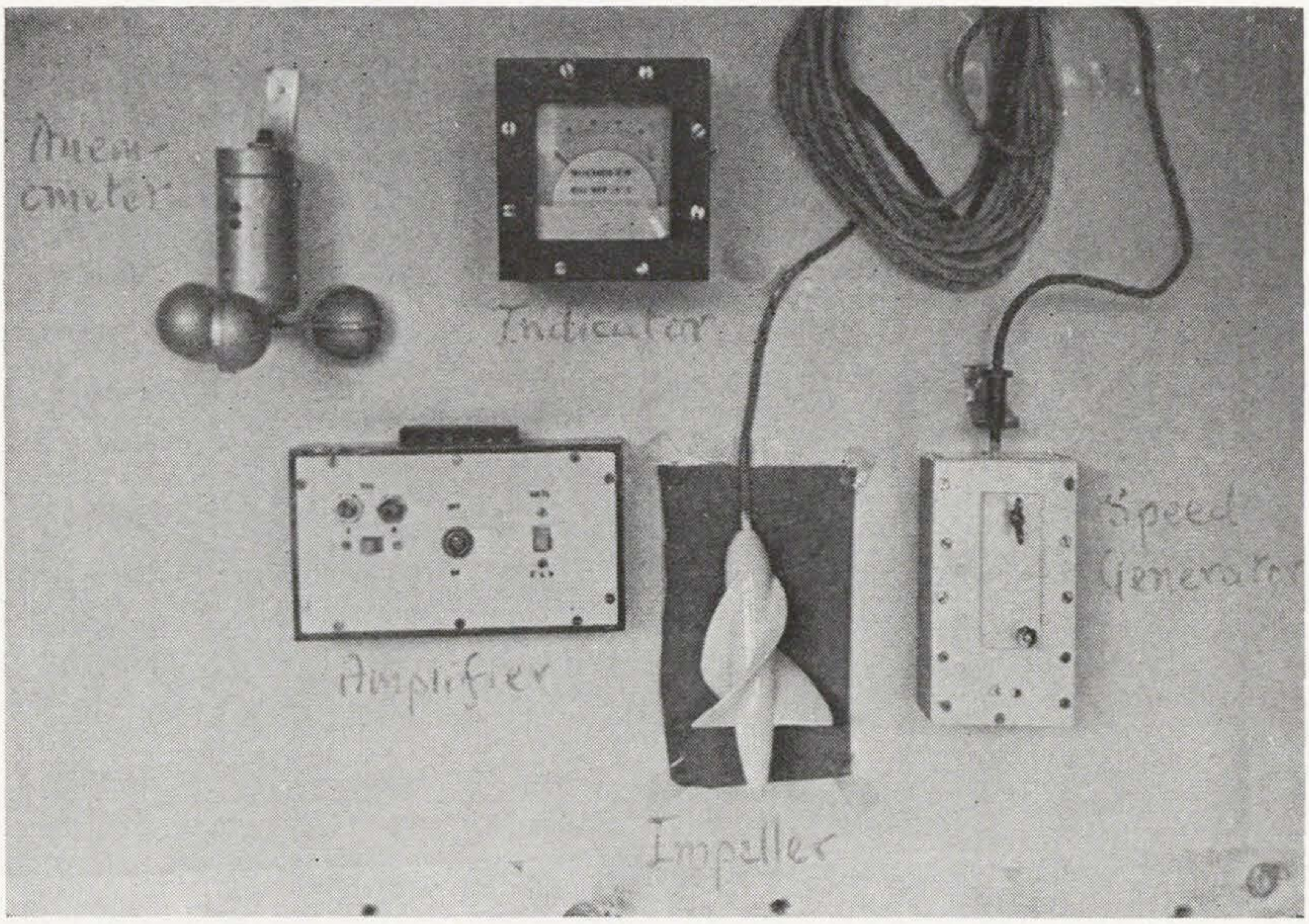
by J. H. Gill 5, Chelmerton Avenue, Chelmsford, Essex

## General

The instrument to be described can be made, using hand tools, by any reasonably skilled amateur, and is capable of measuring speeed through the water to an accuracy of better than +5 per cent. It is instantly responsive to changes of speed.

There are four main components, consisting of an impeller, a low level generator, an amplifier and an indicator. Of course it is possible to make a generator read directly on an indicator, but such is outside the scope of the amateur without special tools, and even more difficult to make such a generator without significant magnetic drag. But a relatively crude low level generator can be made to give the same overall result as a high grade direct output generator with the aid of simple electronics, and with very low magnetic drag. Low magnetic drag means that there is negligible load on the impeller, so that rotation of the latter is almost entirely governed by its designed pitch.

The impeller is trailed some distance behind the boat, so that the generator is not immersed and there should be no position error. On the line just ahead of the impeller a few beads of lead are fitted so that it runs just below the surface. I use a line of about 20 ft. With this length in choppy seas there is some swing on the indicator. This is not of too much concern as the maximum and minimum of the swings can be averaged, but the amount of swing can be reduced by using a longer line if required.




*J. H. Gill's speed log and anerometer*

The author's complete system is shown in the photograph. It will be noticed that included is an anemometer. This is mast head mounted but works on an identical principle to the speed log to be described, wind and water speed being presented on the same indicator using a changeover switch to read one or the other alternatively.

Before arriving at this basic system a number of methods were tried. For minimum friction (particularly applicable to the anemometer) a lamp interrupted by a perforated disc and a photocell has much to commend it, but suffers from high battery consumption for the lamp. Greatly simplified electronics (although working on the same basic principles as described below) are possible using the new magnetic reed relays. This is an attractive alternative as the magnetic drag is exceedingly low, but the author has some reservations as the reeds have finite life and a failure in mid season could be a nuisance. Hence the decision to go for the low power generator system, where the rugged construction is such that it should last forever with virtually no attention except to fit a new battery at infrequent intervals (in the author's case about once in a season).

## The impeller (3 bladed)

It is hoped that the method of construction shown in fig. 1 is practically self explanatory. Steel wire (about 18 s.w.g.) is inserted into the wooden cylinder,

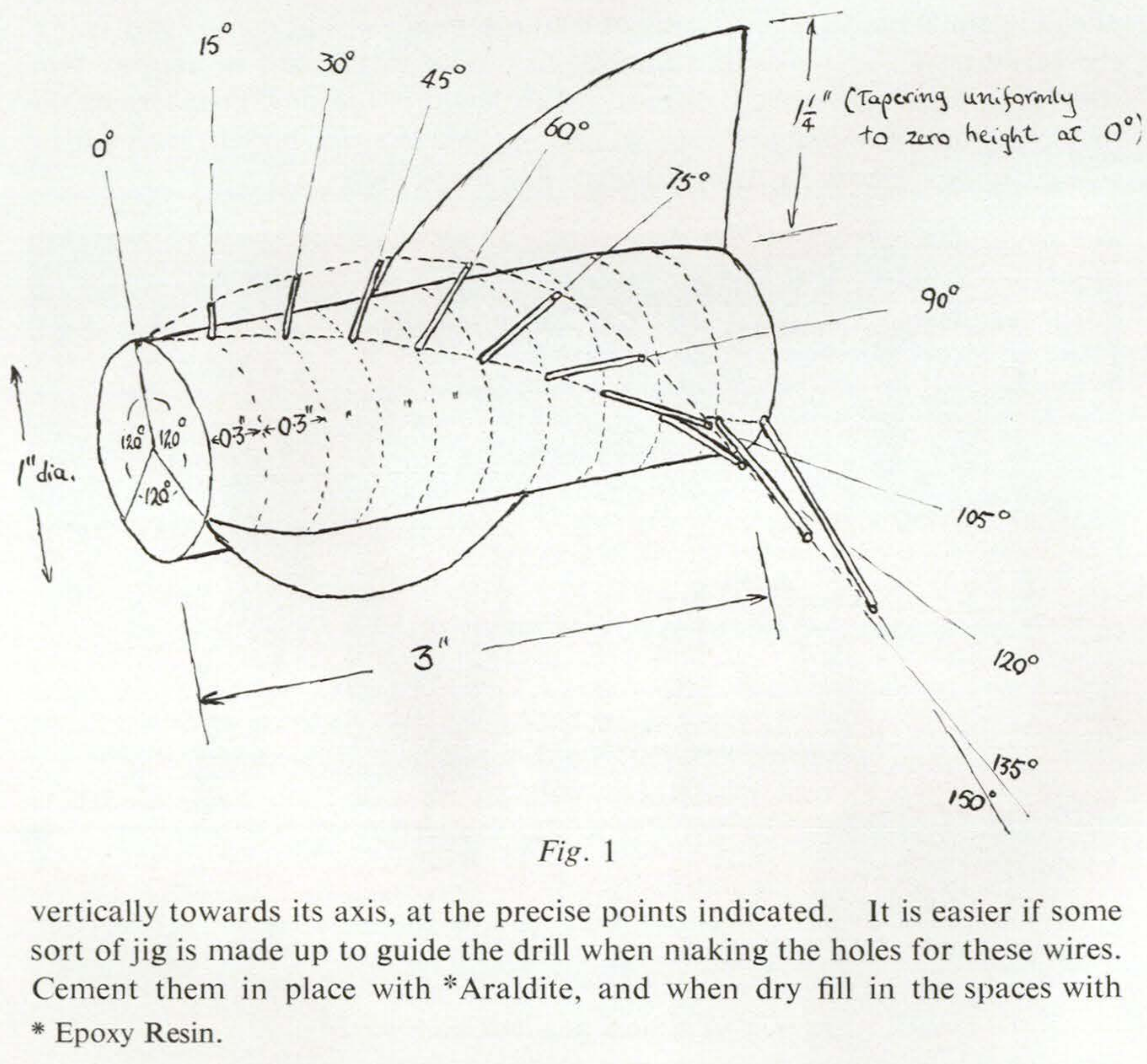



*Fig.* 1

vertically towards its axis, at the precise points indicated. It is easier if some sort of jig is made up to guide the drill when making the holes for these wires. Cement them in place with *Araldite, and when dry fill in the spaces with

* Epoxy Resin.

fibreglass, and cover the wires overall. Sandpaper to leave uniformly smooth thin blades. Finally add a nose piece (with one end of the line cemented in), a fairing tail piece, and paint. Provided the dimensions are followed carefully the impeller will revolve at 675 r.p.m. at 4 knots.

## The generator

An 'exploded' view of the basic components of the generator are shown in fig. 2. Although a generator can be built literally in this form, the physical

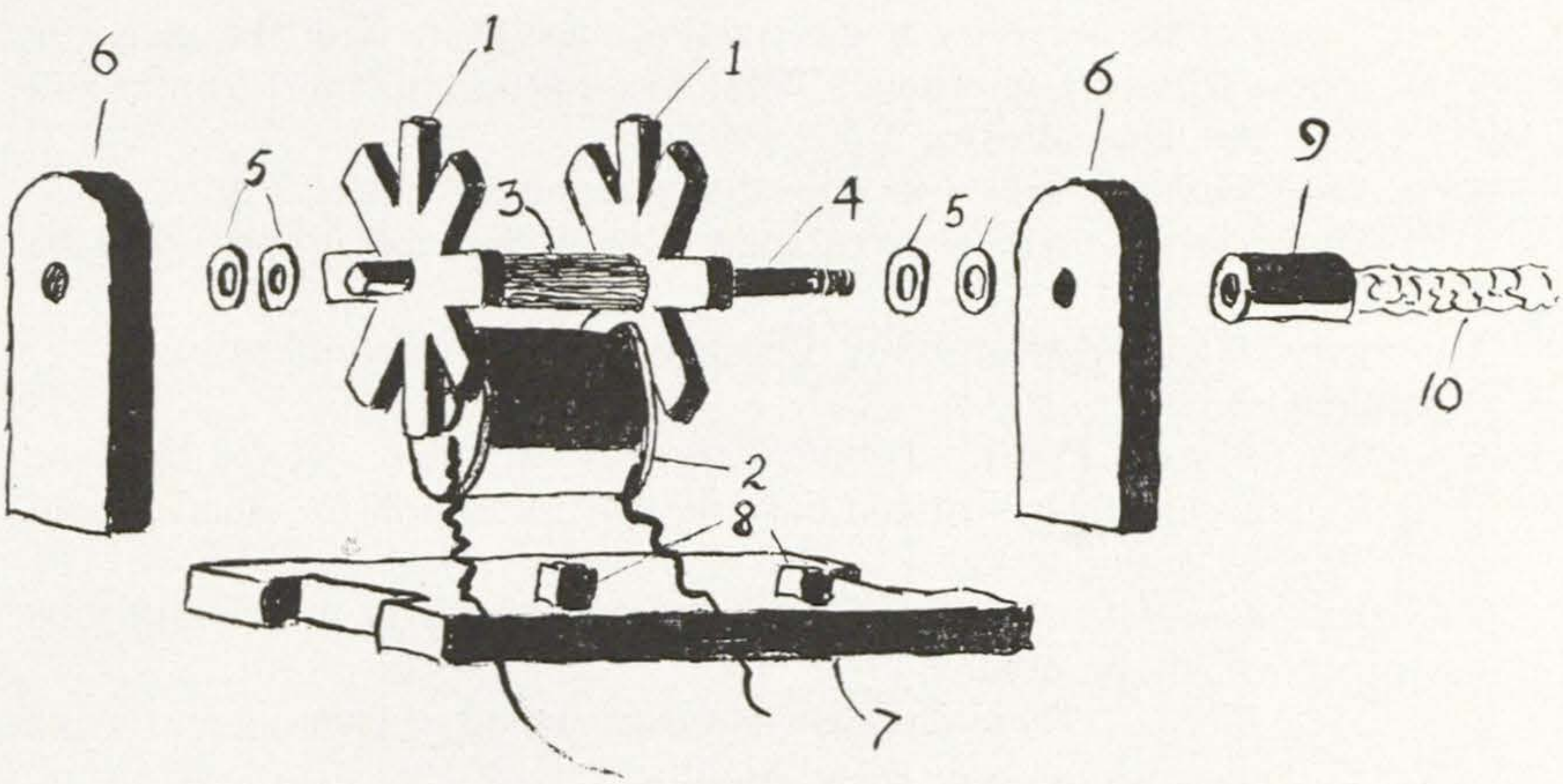



*Fig.* 2

arrangement will probably vary quite a bit depending on the builder's whims. For example, the whole assembly could be contained within a few inches of $1\frac{3}{4}$ in. I.D. tubing, using Tufnol discs as end cheeks and bearings.

Referring again to fig. 2 the components are as follows:

| Item | Qty. | Description |
|---|---|---|
| 1 | 2 | *Rotors.* Each is formed from a $1\frac{1}{2}$ in. disc cut out from $\frac{1}{8}$ in. sheet of mild steel. Each arm, weight in all, is formed by cutting 'V' slots in disc, leaving arms of 3/16 in. width. Form these rotors as carefully as possible, some fine sawing and filing work here. Drill spindle holes accurately too. |
| 2 | 1 | *Pick-up Coil.* The core of this is a small bar magnet (obtainable from ironmongers, made by Eclipse—20 mm. long, 6 mm. diameter approximately) to which two $\frac{1}{2}$ in. diameter cheeks of paxolin are attached with Araldite glue. This makes a former for the coil. Temporarily attach a length of $\frac{1}{4}$ in. rod to one end of the magnet, using Araldite again, so that former can be held in hand drill chuck.<br>The winding uses 44 s.w.g. enamel covered copper wire. First solder on a flexible 'tail' wire of practical size, to use as terminal, passing this through hole in former cheek near the centre. Magnet is covered with PVC tape, which can also be used to fix the 'tail' and beginning of winding. |

| | | |
|---|---|---|
| | | Having determined the hand drill ratio wind on until there are 4500 turns. Wind these on as evenly as possible and keep a careful score as you go! Be careful too that the wire runs out smoothly from its spool, as it is most provoking to have it break when the final turns are almost there. When completed lock up with PVC tape, attaching another 'tail' to the end of the winding. It will help to protect this coil by soaking it in varnish. |
| 3 | as required | *Soft Iron Wire*. This is simply stuck around the spindle to a depth of about 1/16 in. to complete the magnetic circuit. It may not be necessary if the stainless steel shaft is of the magnetic variety. Use ordinary floral wire cut up into short lengths and Araldite adhesive. |
| 4 | 1 | *Shaft*. Ideally use $\frac{1}{8}$ in. diameter stainless steel. Brass could also be used, or even mild steel if the rust problem can be tolerated. |
| 5 | as required | *Shim Washers*—brass, phosphor bronze, or stainless steel. |
| 6 | 2 | *Bearing Plates*. Tufnol 3/16 or $\frac{1}{4}$ in. thick. Holes must be accurately drilled and burnished by metal polish. Shaft should be a sloppy fit. |
| 7 | 1 | *Baseplate*. Tufnol $\frac{1}{4}$ in., aluminium, brass or aluminium tube might be used. |
| 8 | 2 | *Blocks*. These represent but one method of locating and fixing the pick-up coil, using Araldite. |
| 9 | 1 | *Line and Coupling*. Instead of screwing coupling to shaft a safety pin could be used. |

Many dimensions have been left purposely vague, and reference is made only in the more critical areas. Thus, the rotors have to be 'Araldited' dead square to the shaft, and spaced so as to give a total clearance of about 1/40 in. between the magnet poles and rotor arms (1/80 in. on each side when finally assembled).

The pick-up coil must be located such that the end of the arms just cover the magnet when opposite, leaving the magnet exposed when the 'V' slots come in line.

The two rotors must be accurately aligned with each other.

Bearing plates must be assembled, with the aid of shim washers, so as to leave the rotor perfectly free, but not with so much play that either rotor can touch the pick-up coil magnet poles. These shims should be adjusted so that, when tension is applied to the line end of the shaft, the coil is perfectly centred between the two rotors.

## The amplifier and indicator

The wiring and layout diagram of the amplifier is shown in fig. 3. There is nothing very critical in the layout, but one simple method is to take a piece of well dried and varnished plywood, with brass or copper pins stuck in to correspond approximately to the position of the black 'blobs' shown in the diagram. The list of components, which have to be soldered together as indicated, is detailed on next page.

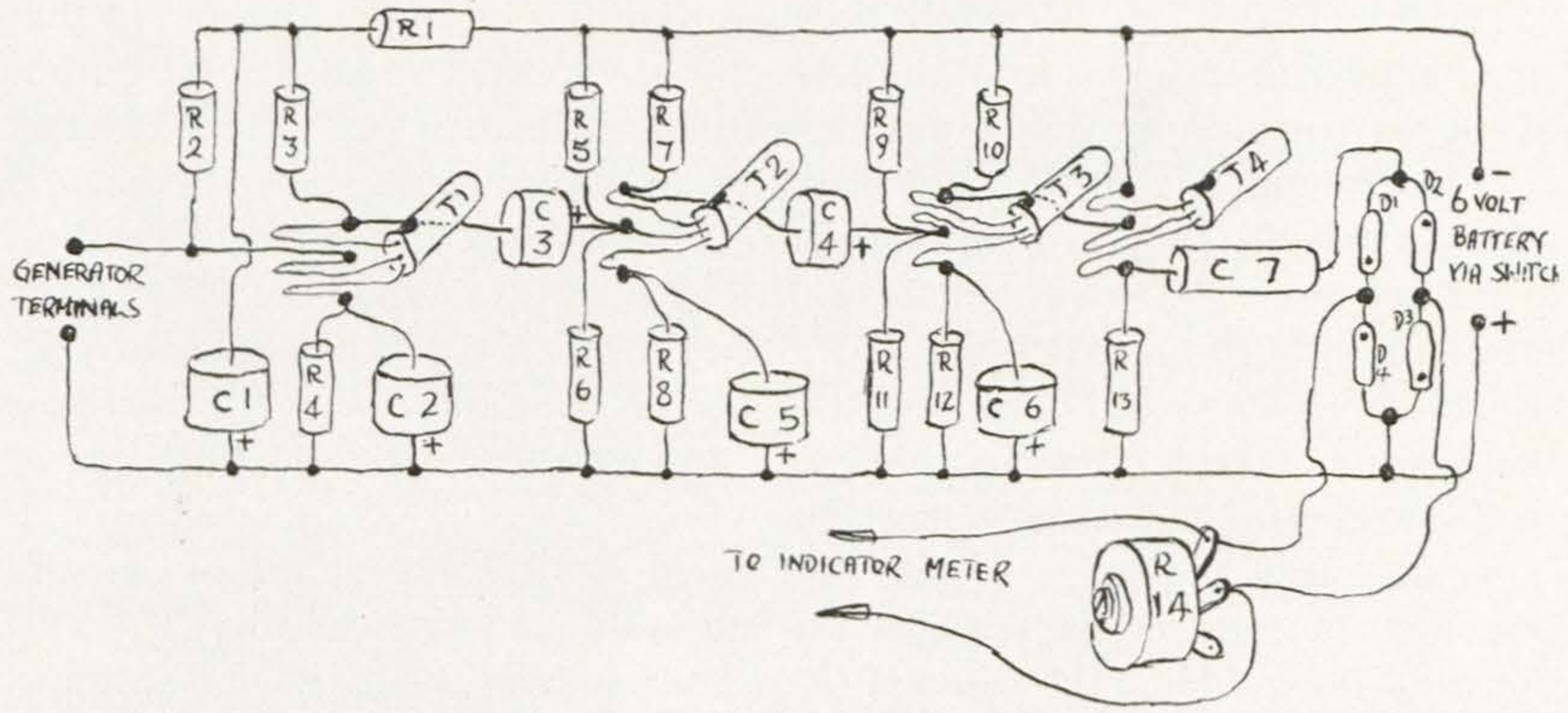



*Fig.* 3

| Component Reference | Description | |
|---|---|---|
| R1 | Resistor 10,000 ohms | |
| R2 | ,, 10,000 ,, | |
| R3 | ,, 4,700 ,, | |
| R4 | ,, 680 ,, | |
| R5 | ,, 12,000 ,, | |
| R6 | ,, 2,400 ,, | All these resistors except R14 |
| R7 | ,, 4,700 ,, | are composition types of the |
| R8 | ,, 680 ,, | smallest readily available and |
| R9 | ,, 12,000 ,, | should cost a few pence each. |
| R10 | ,, 5,800 ,, | (R14 about 2/6d.). |
| R11 | ,, 6,800 ,, | |
| R12 | ,, 680 ,, | |
| R13 | ,, 5,000 ,, | |
| R14 | ,, 5,000 ,, variable | |
| C1-6 | 100 microfarad electolytic capacitor, 10 volt working. (6d. to 1/- each). | |
| C7 | 0.1 microfarad paper dielectric capacitor (about 1/-). | |
| T1-T3 | Transistors, Mullard type OC71. | |
| T4 | ,, ,, ,, OC72. | |
| D1-4 | Diodes. Almost any small type, such as Mullard OA 70, will do. (Transistors and diodes, say about 15/- the lot). | |
| Meter (The Indicator) | 0-200 microamps full scale deflection, with scale marked 0-10 preferably, but 0-100 lends itself to easy mental conversion. Size depends on eyesight. (Japanese meters can be got for about £2. A first grade British meter might cost £5 but surplus ones can be got for £1 or less). | |

Any of the large radio component shops in London would quickly sort out all the above items. If the reader is not himself familiar with electronic techniques maybe his son is (lots of schoolboys seem to play with electronics these days) or perhaps he has a friend who would help.

The principle of this electronic circuit is that of a limiting amplifier, in that small but variable signals from the generator are boosted up until at the output of T4 the signal is sensibly constant, entirely dependent on battery voltage, and the combination of C7/D1-4 produces an output to the meter (indicator) which is directly proportional to frequency, and hence the speed of rotation of the generator. The variable resistor R14 is used to adjust the scale of the meter to an accurate reading. The author uses an old grindstone for this, which conveniently has a ratio of 10 : 1. As mentioned above, at 4 knots the impeller rotates at 675 r.p.m., and the instrument should be adjusted to this speed on the bench if possible.

As described the range of the instrument is 10 knots at full scale. By doubling the pitch of the impeller the full scale reading would be 20 knots. Similarly, by doubling the value of C7 in the amplifier the maximum readings would be 5 and 10 knots respectively. Obviously the components can be adjusted to suit individual requirements.

For those wishing to apply these methods for an anemometer, it may be noted that half table-tennis balls make excellent cups. If mounted so as to give an overall diameter of 5 in. (i.e. radius of $2\frac{1}{2}$ in. from centre of rotor head to outer edge of each of the three cups, the cup diameter being about $1\frac{1}{4}$ in.) then 1000 r.p.m. corresponds to approximately 40 statute miles per hour. It is usually necessary to have separate variable resistors for each system (R14 in fig. 3) so that the changeover switch has to operate these as well as changing over the two generators when a combined indicator is used. To get the most sensitive readings with an anemometer it is desirable to use ball bearings.

## Checking the calibration

If the instrument has already been calibrated on the bench as described above it is probably that a check at sea will merely confirm the accuracy of the reading. Alternatively, it may be calibrated direct by the following method. Use a 'chip' log, consisting of a 4 in. quadrant of wood, weighted so as to float with the apex of the quadrant uppermost, with three short lines attached so that the chip stays vertical as the line pulls out. After the line has been allowed to clear the boat knots are tied at intervals of exactly 10 ft. The number of 'knots' that run out in 6 seconds is the speed in knots. With the boat preferably under motor, proceed at any constant R14, check, adjust R14 again if necessary, until consistent agreement is reached. This need only be done at one speed, preferably near the middle of the range.

The simplest way to check the anemometer is to fix a pole to the roof of a car, with the generator well forward of the car to reduce position error. Check the accuracy of your car speedometer against its milometer (the latter are usually more accurate than the former), then pick a calm day and proceed at constant speed, say 30 m.p.h., and adjust R14 to give that speed on the indicator. In case there is any residual wind make several runs both ways and average the results. With the value of C7 in the amplifier shown a convenient range is 0-50 m.p.h.

## Application

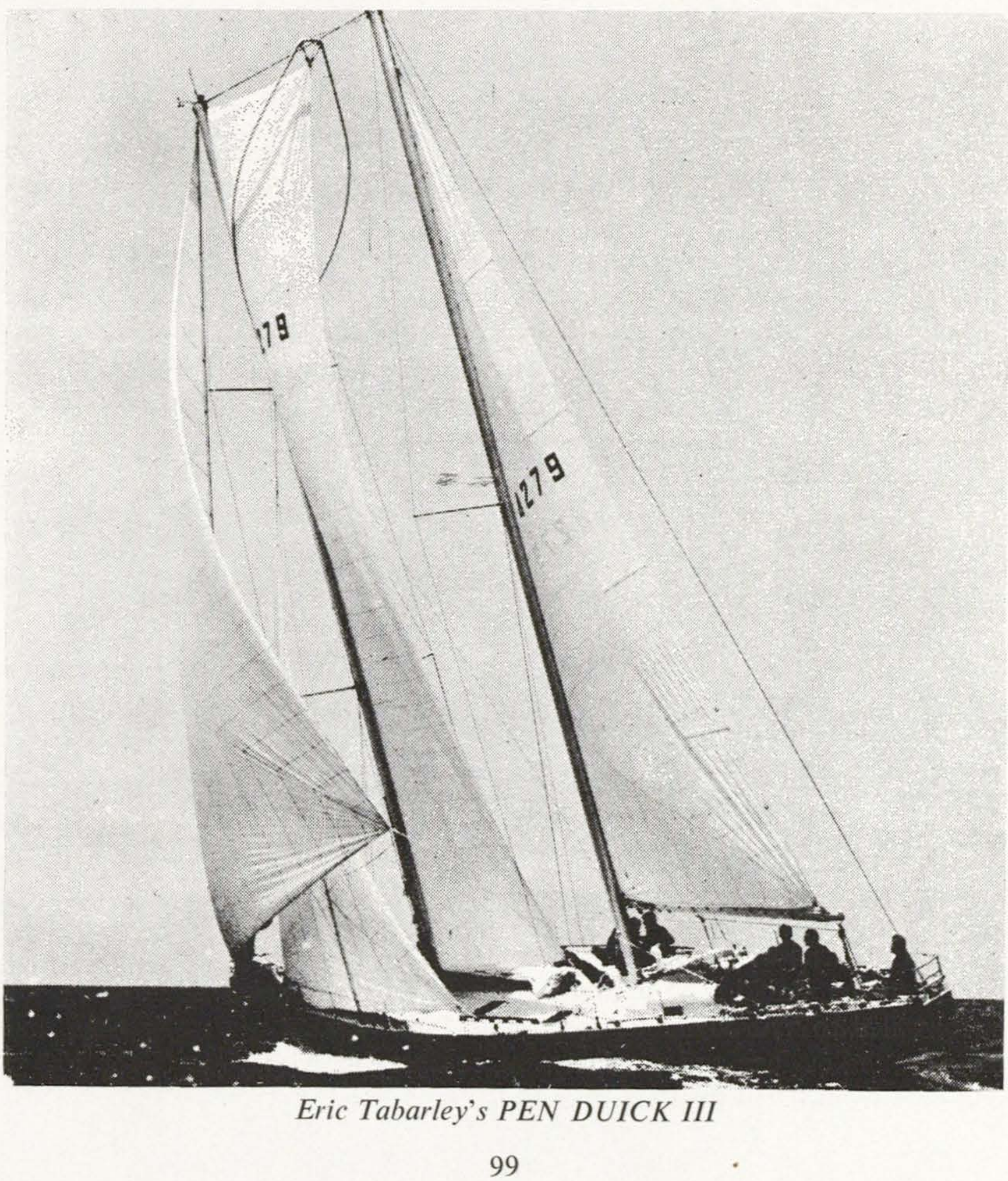
In use the speed log reveals surprising information about the effects of sail adjustment. Perhaps the author is just a bad helmsman, but the first time the log was used during racing, from a position consistently half way down the fleet or worse the boat came in with the leaders, second in two successive races in fact. It has particular value in sailing to windward, when it was proved that in a condition which was previously considered as 'pinching' the boat was in fact sailing closer and faster. It also demonstrates the uselessness of trying to sail with too much canvas for the conditions, and the increase in speed when the boat is reefed to suit.

The particular value of the anemometer is as a reefing guide, both when sailing and at moorings beforehand. It is also comforting at night in harbour. In a small boat a slight moaning in the rigging gets amplified inside to the extent that the apprehensive ones imagine a gale is raging. It is most consoling to switch the indicator on to find a mere 10 m.p.h. or so in fact!

## TANK TESTS OF KEEL FOR PEN DUICK III

**by E. Ravilly** **Translated by Charles Potter**

(*By courtesy of Editor of the French magazine 'Bateaux'*).




*Eric Tabarley's PEN DUICK III*

The hull of *PEN DUICK III* is of the long, light displacement type. The first keel tested was as in plate 1 and needed a large radius joint to fair into the planking.

First trials with the model showed loss of speed out of all proportion to the wetted surface. For a model speed of 1 metre/sec. the resistance of the bare hull was 67.5 grammes and that of the hull with keel, 113 grammes. The maximum speeds obtained were 1.127 m./s. with the bare hull and 0.95 m./s. with the keel, a loss of 18.6 per cent.

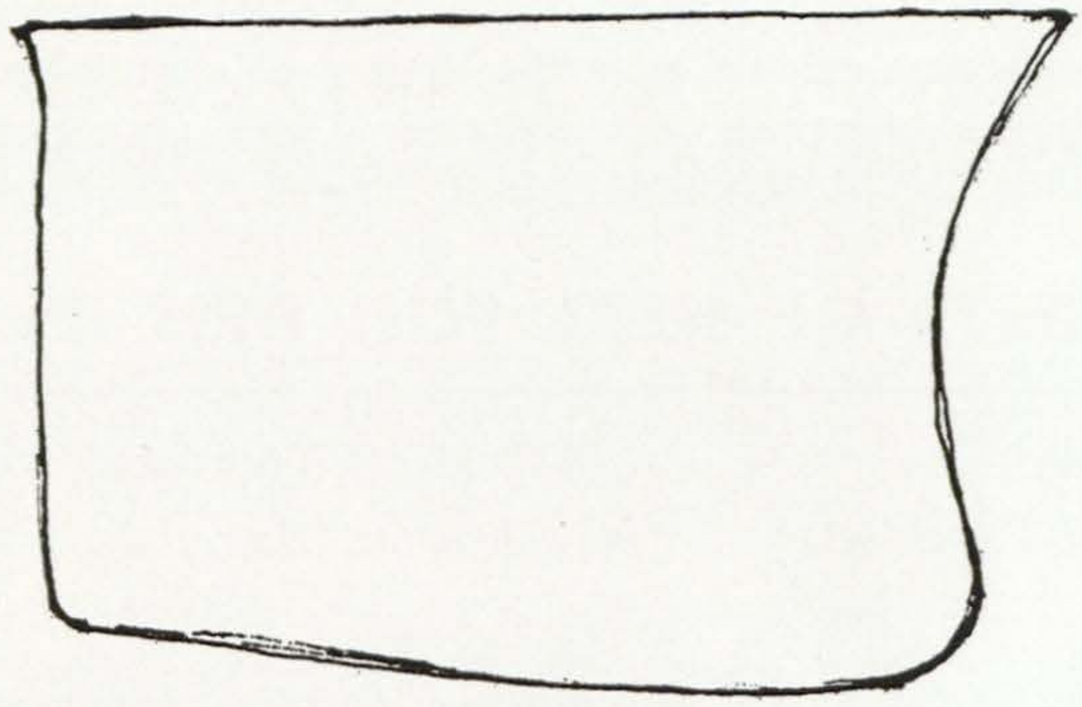


*Fig.* 1

A keel with thinner section and lengthened ballast (plate 2) and the same keel/planking joint confirmed the above result. This protruding ballast was rejected because in practice it would catch seaweed.

If the shape of the ballast at the base of the fin has only a slight effect on the resistance of the keel, then it follows that the joint between the keel and the hull causes the greater resistance due to the water flow round the hull and keel surfaces. A trial with a modified hull without the fin showed this to be true.

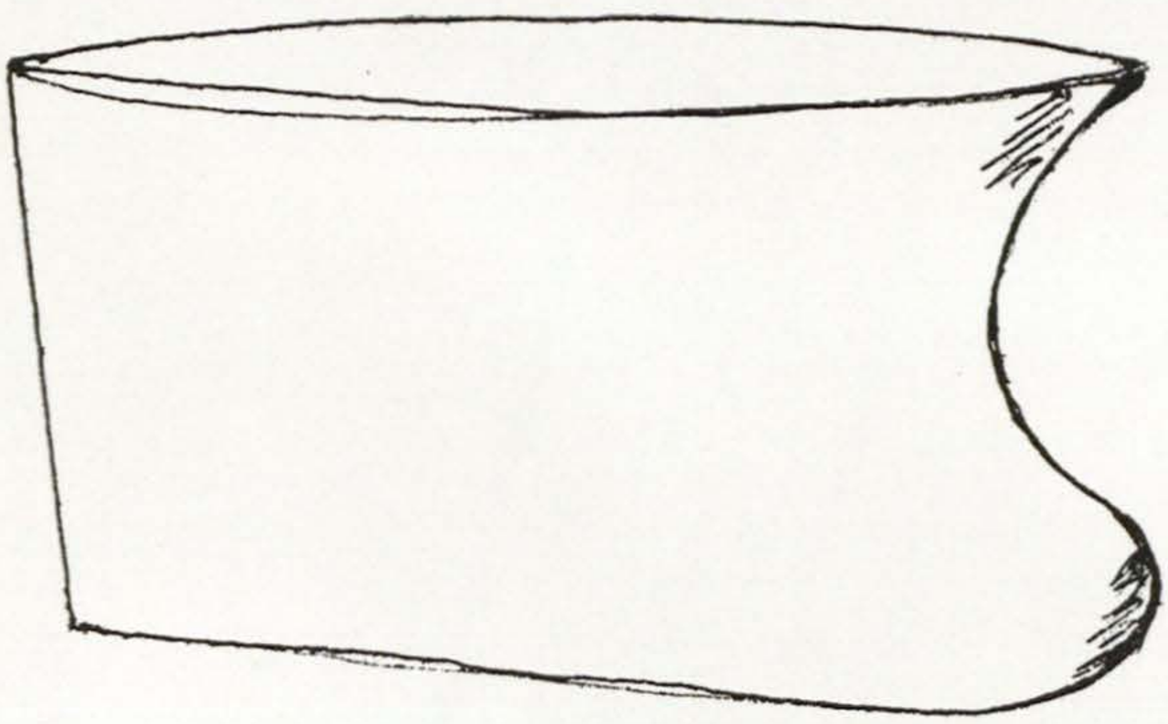


*Fig.* 2

The first modification which was tried was that of reducing the fairing between the keel and the hull. Plate 3 satisfies this requirement by joining the fin to the planking at a sharp angle. The fin remains thick in section but profiled to hydrodynamic contours. Improvement was noticeable, and for a wetted surface and displacement comparable with plate 1, for 100 g. one goes from 0.950 to 0.988 m./s.

For comparison a fin keel made from thin aluminium sheet, of similar profile to the keels, was fixed to the model and gave these figures: for 100 g. pull the speed increases to 1.022 m./s., which gives an improvement of 7.2 cm./sec. in performance over plates 1 or 2.

Thus the thin fin gives the least resistance; but if the thick suitably profiled fin does not appear to offer more resistance than the thin plane equivalent, at least the joint between the hull and the keel needs careful consideration.

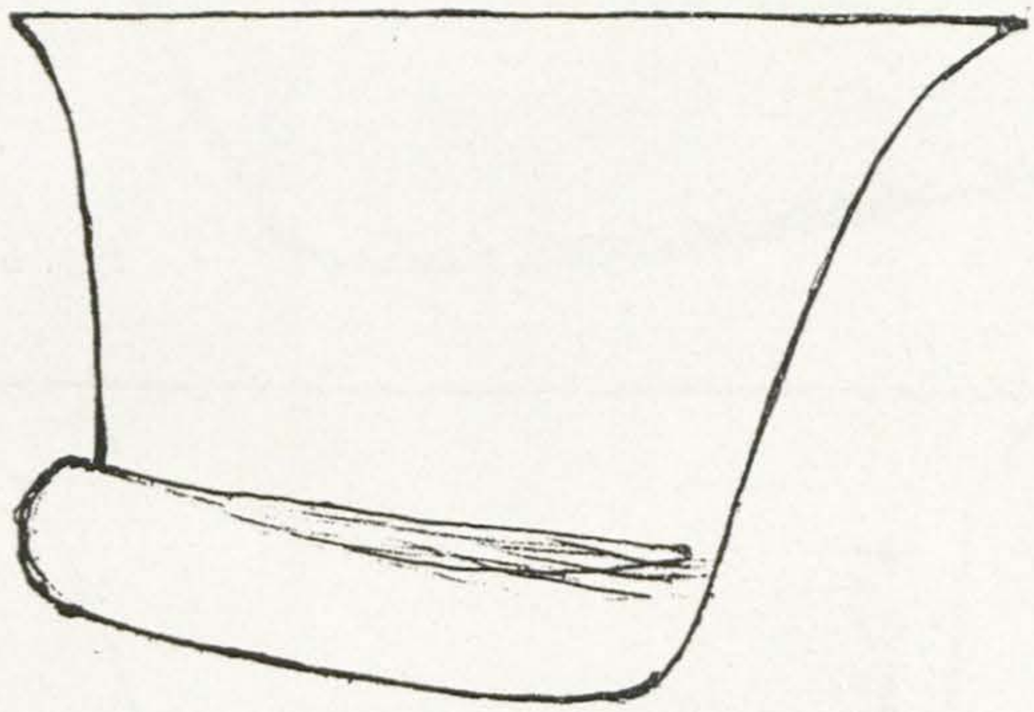


*Fig.* 3

The keel in plate 4 confirms that an important fraction of the resistance is in the waterflow under the hull and round the keel. Some experiments making visible the lines of flow have shown this distortion at the level of the keel/hull joint.

By concentrating the ballast in a streamlined shape at the extremity of a thin plane we automatically cut out this factor. Hence the trials with models 4 and 5.

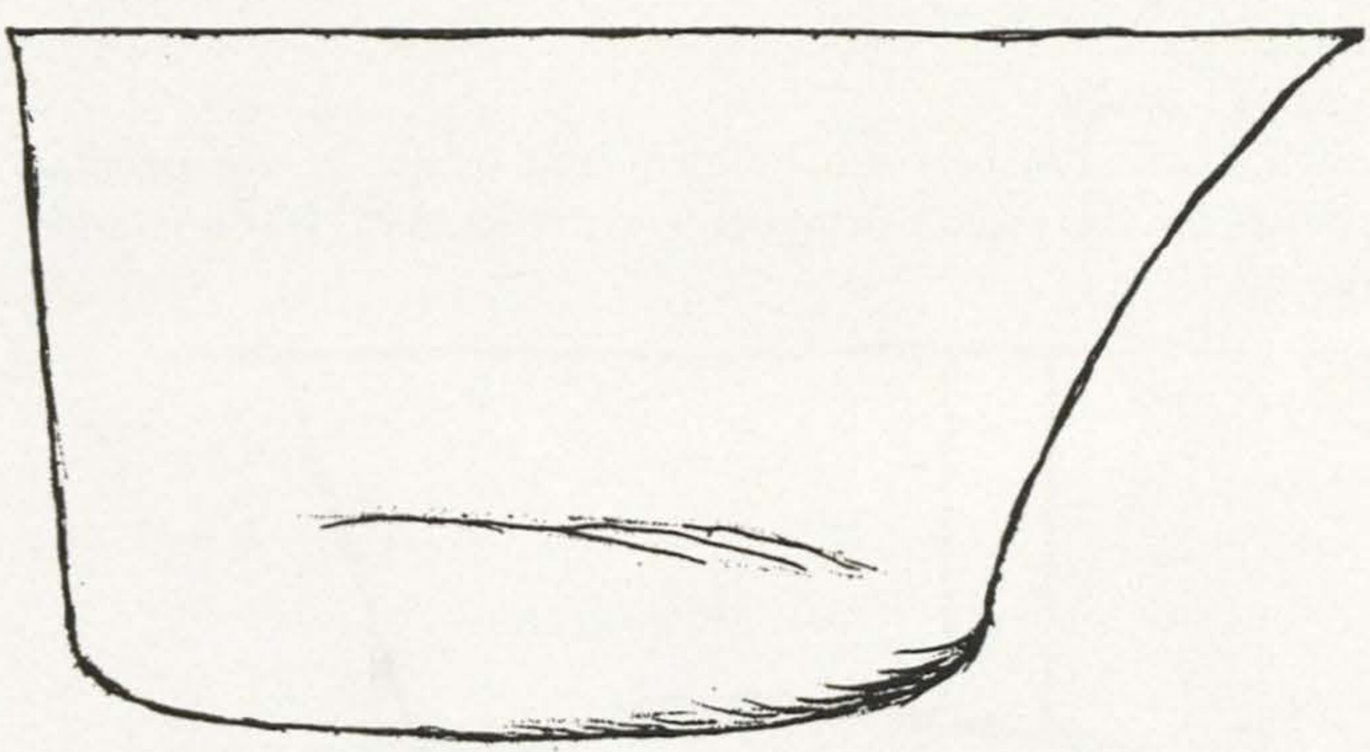


*Fig.* 4

Plate 5; this marks a very clear advance, for with 100 g. the model exceeded 1 m./s. The ballast being a streamlined circular shape.

With a hull of design like *PEN DUICK III* the advantage of the thin plane stands out clearly as a result of this systematic research.

The builders proposed studying a keel as in plate 6 consisting of a thin plate with a flat base to facilitate grounding. No results are available for this configuration.

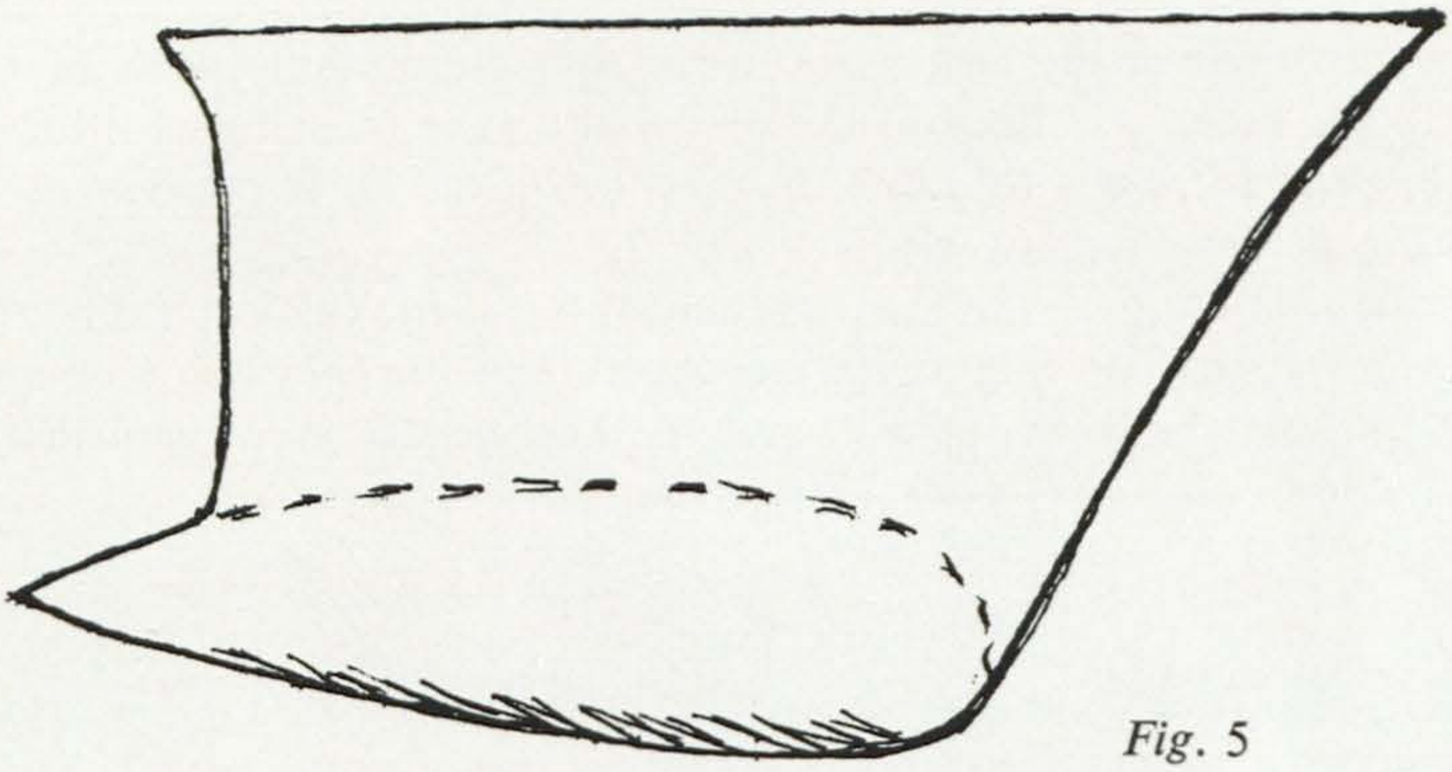


*Fig.* 5

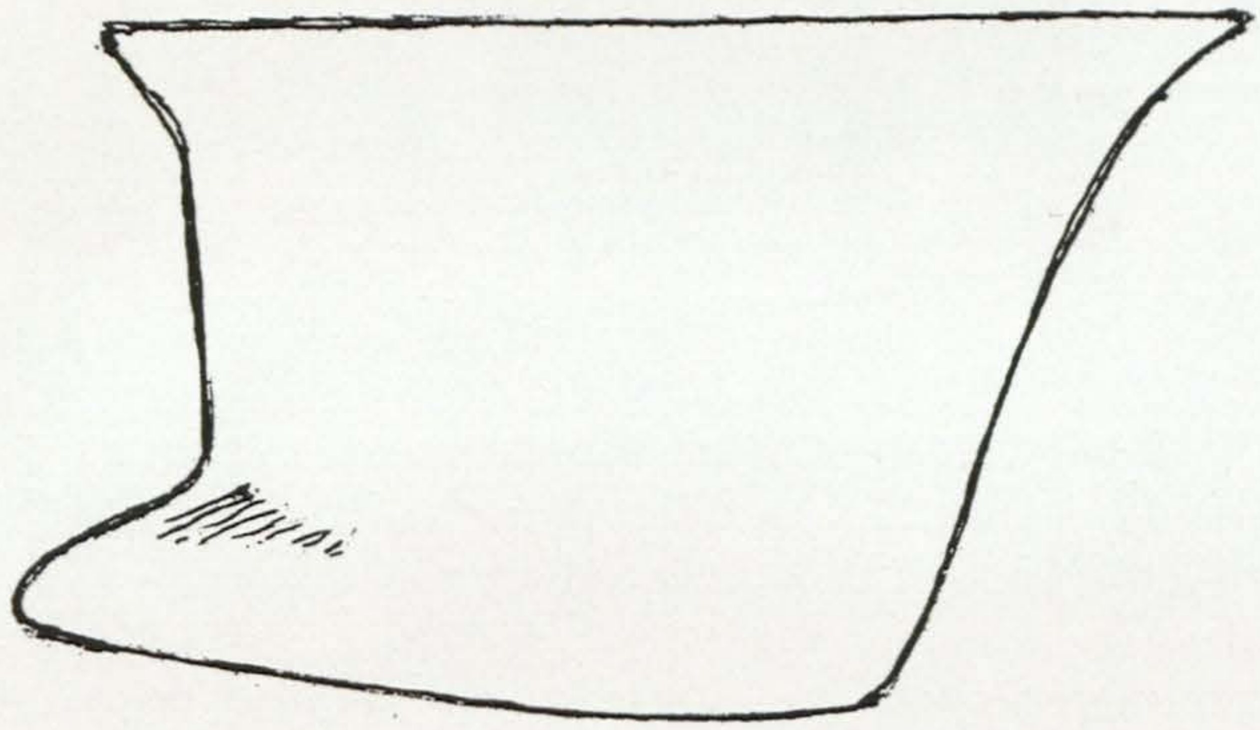


*Fig.* 6

Then fin No. 7; its performance was slightly less than that of No. 5 because of the shape of the ballast. Under 100 g. it attains 0.9976 m./s., thus losing 0.45 per cent of speed.

After much discussion between builders and owner it was decided to use the keel shown on the model in plate 5, with straight leading and trailing edges to the fin.

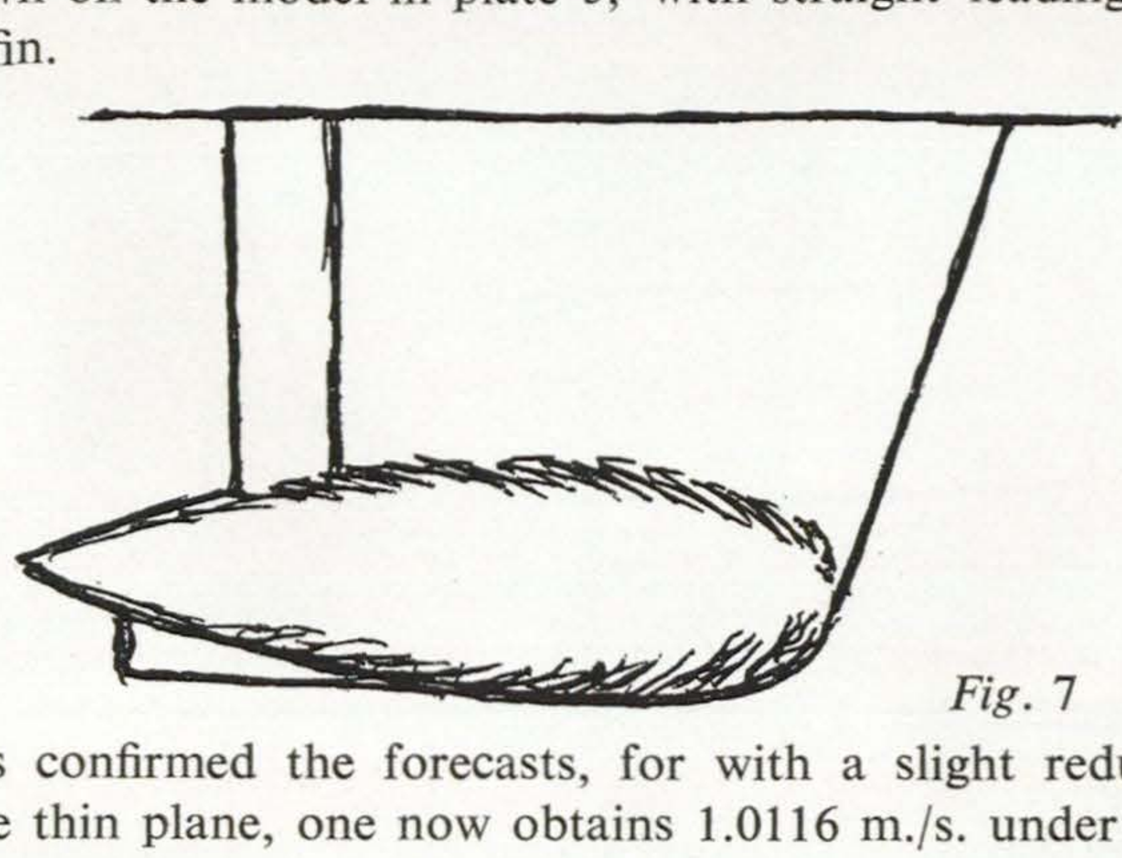


*Fig.* 7

Final trials confirmed the forecasts, for with a slight reduction of the surface of the thin plane, one now obtains 1.0116 m./s. under 100 g. which is only 3 g. more than that for the thin plane at the same speed.

It should be noted that both Nos. 7 and 8 are equipped with a trim tab to improve lift without perceptible change of drag.

January 2, 1968.

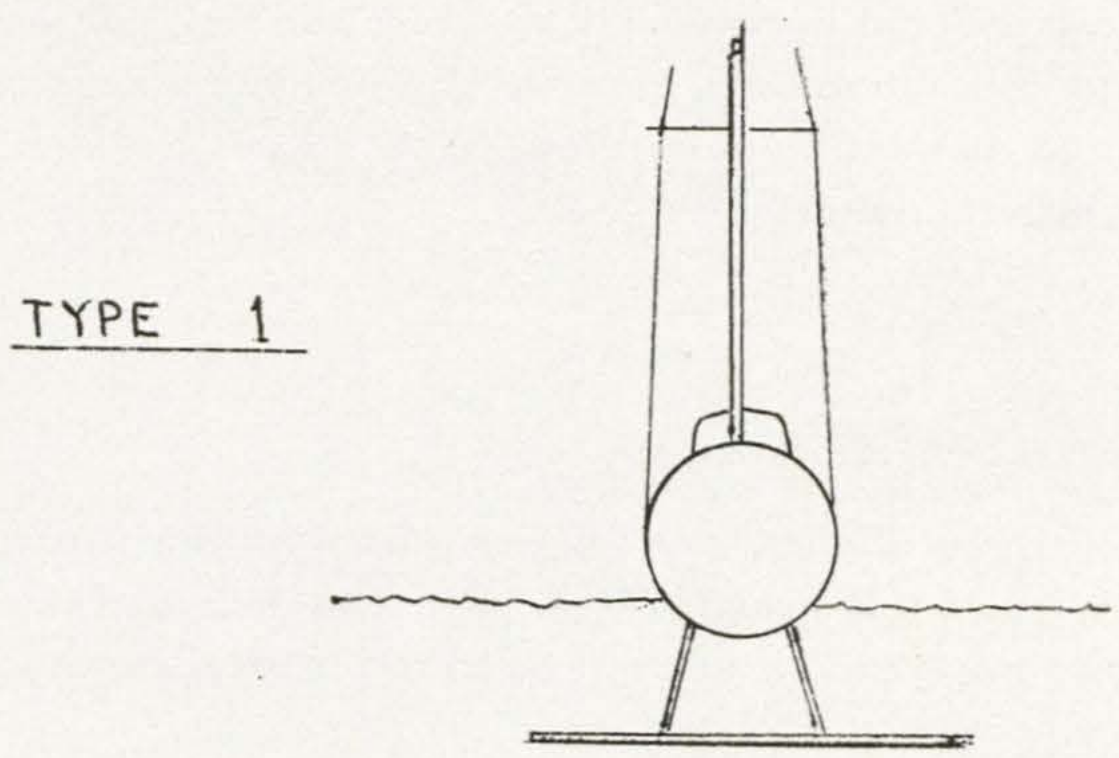
Dear Dr. Morwood,

In response to your questionnaire, I am interested in all aspects, theory—design—racing—etc.

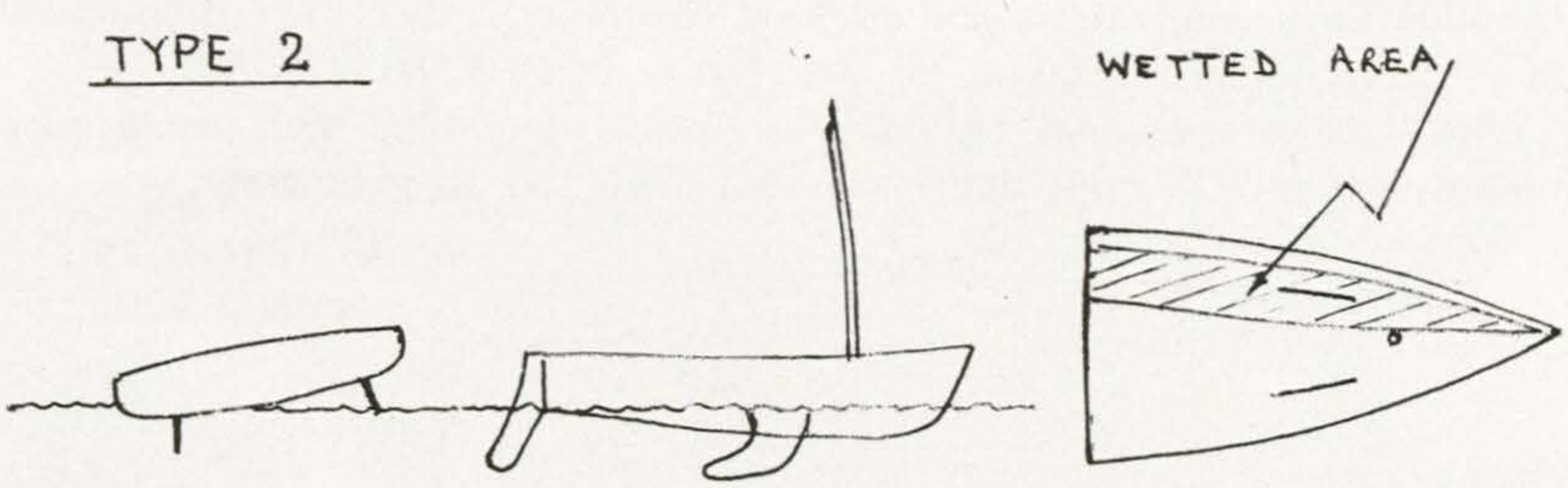
I own a monohull but am nevertheless very interested in multihulls. I would like to meet other members in the Boston, U.S.A., area. In fact I would comment that there is a notable disparity between membership in this area, which is reasonably high, and boats which are anything other than traditional.

My profession is aerospace engineering and I prefer publications which are more technical, if there is a choice. However, as you have pointed out, the experimenters are not often technically orientated.

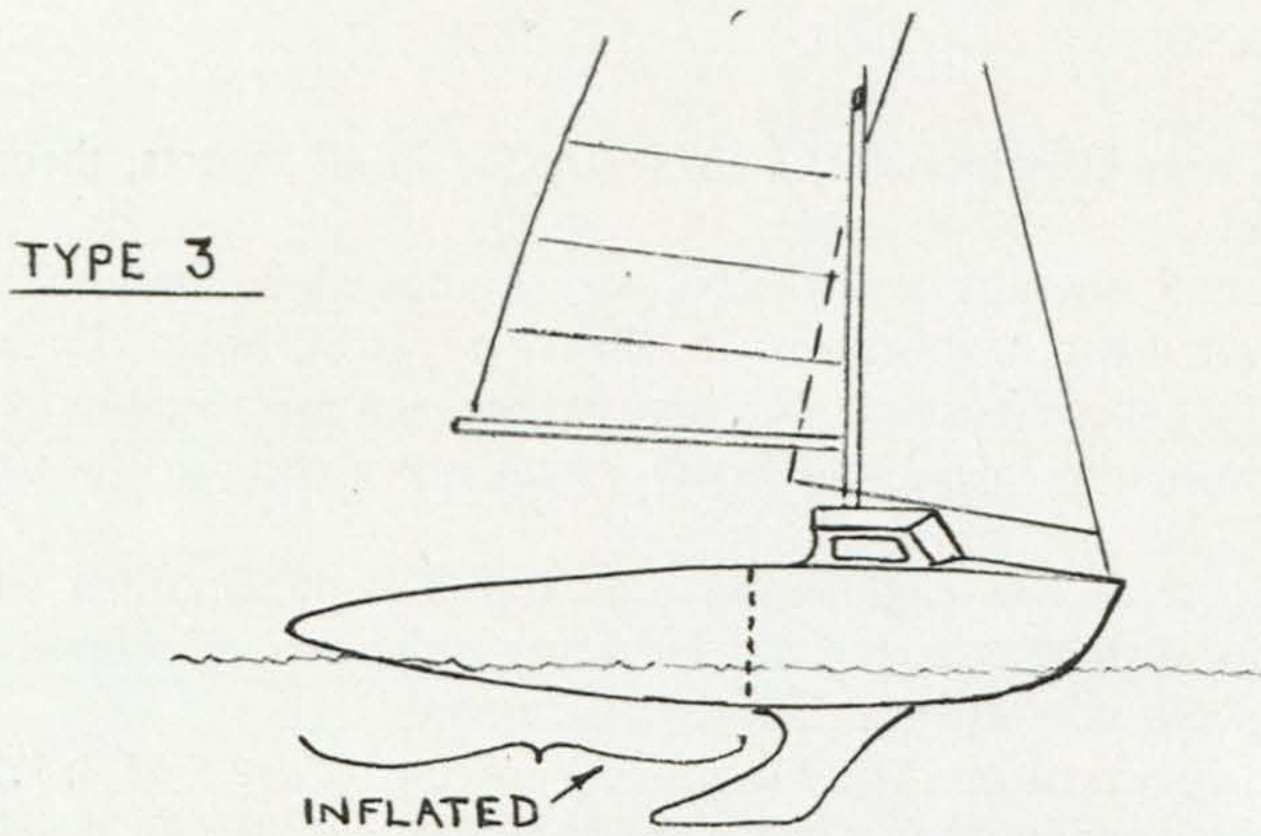
I would like to comment on 'The Future of Yachting' (*Page* 5 *of A.Y.R.S.* No. 60) wherein it is stated that, 'There are only two craft left to develop'. I have conceived of three more, which are:




1 The lightly ballasted monohull which is stabilized by hydrofoils which extend outwards from the central keel and are mechanically angled by a small heel of the boat. These foils would be totally immersed at all times and thus would not be chopping roughly in and out of the waves nor cavitating.




2 The wedge-shaped monohull which has an increasing radius of curvature of the wetted surface progressively aft; with two keels which are toed-in, so that only one is used on a tack; the keel inclined to 'climb' rather than oppose the run of the boat as normally. This type would not have the structural problems of the multihull.




3 The monohull which has an aft half which is pneumatic. Amidst all the controversy there seems to be one common point of agreement: that speed and light displacement go hand in hand. The pneumatic hull (aft section) can be lighter than any other method of construction and can absorb turbulence like a porpoise to maintain laminar flow.

(*Ed.*—See Rodney Garrett's letter—this issue.)

As you may note, all three of these types are a monohull derivative, and are a reflection on my belief that when we all have switched to some new type of yacht in ten or twenty years, it will not be to tris or cats, because they are *too heavily ballasted.*

Their current deficiencies, such as swing space needed to moor, or anchor, and inability to fit on marine railways or marina slips, can all be overcome as facilities are changed with the times. But no matter how one constructs a catamaran, half (when heeled) is ballast, and a third more or less of the trimaran is ballast. Pretty high ballast to weight ratios.

Clearly the multihull has no monopoly on light weight and I would suspect the odds for speed, safety, and parking capability; other than running up on a beach, is more in favour of a derivative of *PEN DUICK II.*

With greatest personal regards for your stimulating and provocative publications and the hope that I have not made too many enemies.

W. A. Antrim, Jr.,
287, Nahant Road,
Nahant,
Mass., U.S.A.

April 9, 1968.

Dear Mr. Morwood,

On p. 71 of your note on Norfolk Wherries in *A.Y.R.S. No.* 62 you mentioned the use of the interaction of the bow wave and the lee bank, and queried the dynamics of this trick. I know very little about the Wherries, but I recalled something called *canal effect* from my naval college days.

This effect is produced by large displacement craft in a narrow seaway. Forward of the bow and aft of the stern there are two relatively high pressure areas, and from the bows aft there is an area of comparatively low pressure, both due to the wave making of the hull. In motor driven ships, failure to keep to the centre of a canal can result in violent sheering and unpleasant accidents. If anyone doubts the pressures involved, they might be interested to know that excess speed in the Manchester Ship Canal has resulted in mooring warps breaking about 3 miles away from the offender of the speed limit.

Probably, low speeds in Wherries will have minimised the effect, but it is the only explanation I can think of.

Another interesting phenomenon is that of *smelling the ground.* This happens when a ship rounding a bend on the outside bank is helped to turn by the bow pressure zone.

I hope members will be interested in these points.

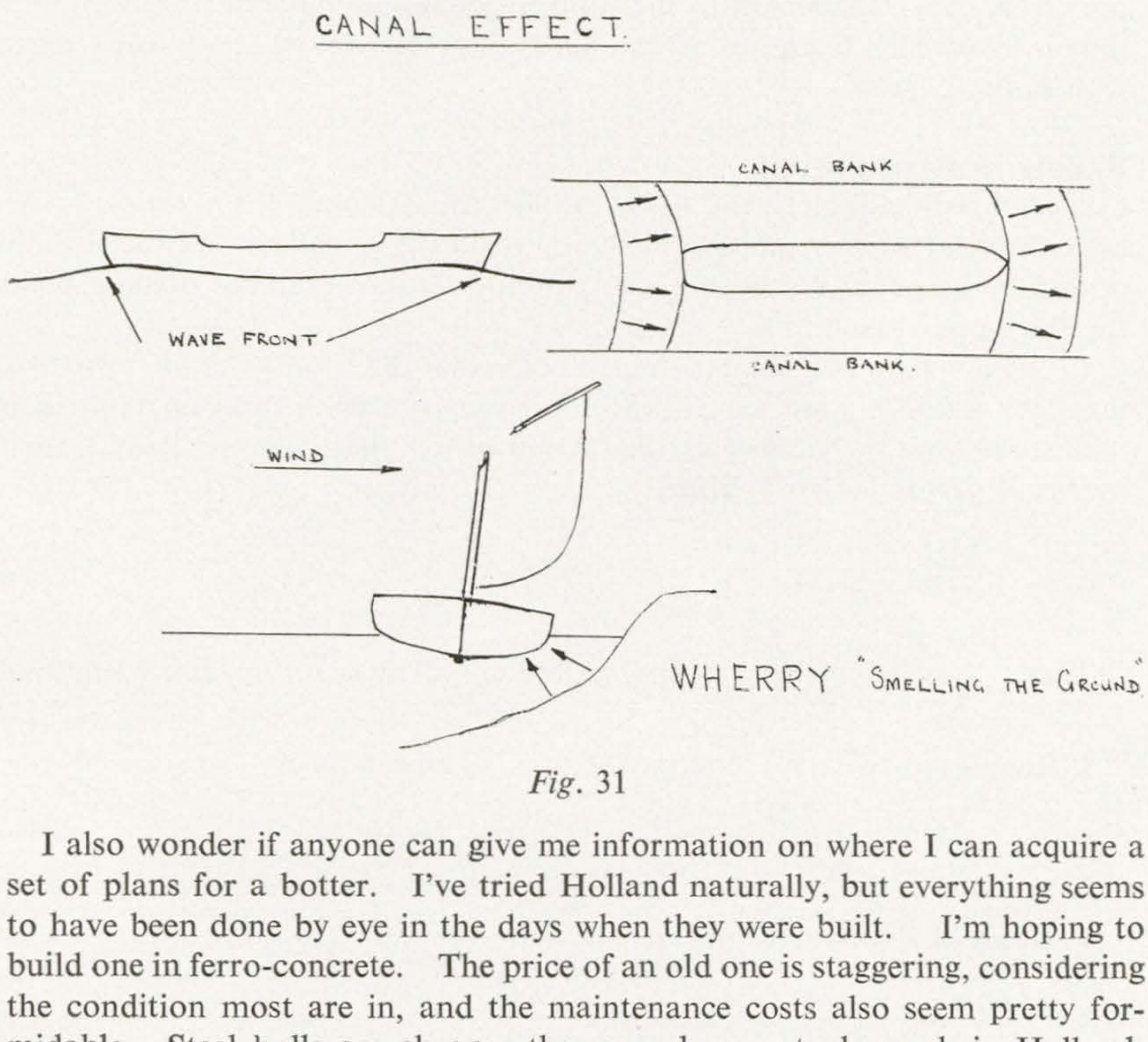



*Fig.* 31

I also wonder if anyone can give me information on where I can acquire a set of plans for a botter. I've tried Holland naturally, but everything seems to have been done by eye in the days when they were built. I'm hoping to build one in ferro-concrete. The price of an old one is staggering, considering the condition most are in, and the maintenance costs also seem pretty formidable. Steel hulls are cheaper than wood, except plywood, in Holland, but designs are for what they call *schouws*, which are hard chined. A new 12 meter would cost about fl.60,000 or £6,900. Believe it or not, fitting up an old one would cost about fl.40-45,000. A bit of a deterrent to romantics!

IAN WILLIAMS,
8, Moorland Road,
Fulford,
York.

# HANDICAPPING SAILING RACES

by Edmond Bruce Lewis Cove, Hance Road, Fair Haven, N.J., U.S.A.

## Purpose

For a long time, the writer has been distressed by the lack of a solid mathematical foundation in any present sailing handicap system with which he is familiar. Many of us have witnessed how small boats often defeat large boats in light wind handicap races. In strong winds, the reverse is usually true. This is the subject of this article.

Among existing rules, the so-called 'Time on Distance' is a poor method, in my opinion. It gives a time allowance per mile. This has little mathematical foundation as it is correct only for one speed. A *ratio* system for speed or elapsed time, such as the 'Portsmouth Yardstick', is much to be preferred. Also, the length of the course becomes immaterial if only elapsed time is involved. Even this system needs improvement to more nearly agree with natural laws.

## Racing in strong winds

Consider only displacement boats of the usual length-beam ratios. This excludes most narrow multi-hulls which avoid the so-called 'hull speed limit' caused by its generated water-wave pattern. It also excludes planing boats for the same reason.

Let us compare two similar shaped boats that differ only in size. Assume that they are in a wind which is strong enough to drive both boats at their 'hull speed limit'. Numbering the smaller boat 1 and the larger boat 2, their speeds V versus length L are:

$$V_1 = 1.34 \sqrt{L_1}.$$
$$V_2 = 1.34 \sqrt{L_2}.$$

Thus, $\dfrac{V_2}{V_1} = \sqrt{\dfrac{L_2}{L_1}}$ is the desired speed ratio for specified lengths.

If Boat 2 has twice the length of Boat 1, as an example,

$$\frac{V_2}{V_1} = \sqrt{\frac{2L_1}{L_1}} = \sqrt{2} = 1.414.$$

In terms of the elapsed time T,

$$\frac{V_2}{V_1} = \frac{T_1}{T_2} = 1.414.$$

Thus, $T_2 = \dfrac{T_1}{1.414}$

Regardless of the length of the course, Boat 1 should be allowed to divide its elapsed time by 1.414 under a fair handicapping system *when the winds are strong.*

### Racing in light winds

In light winds, a 'hull speed' ratio has no meaning whatever. The above reasoning no longer applies. Wave-making is so low that frictional resistance dominates the situation. This resistance is approximately proportional to Vn where n may be between 1.8 and 2.0. The exact value of n does not matter as we shall see.

Compare the two boats, as discussed above, when both are in the same light wind. The larger Boat 2 would have 4 times the sail area of the smaller but similar shaped Boat 1 since it has twice the length. This means that Boat 2 has 4 times the driving force F and therefore 4 times the hull resistance R. It also has 4 times the wetted area and 4 times the hull cross-sectional area of Boat 1. Writing all this in the form of equations and assuming n as the exponent of V,

For Boat 2, $F_2 = R_2 = kA_2V_2^n$ where A is any hull area and k is a proportionality.

But $F_2 = 4F_1$ and $R_2 = 4R_1$.

Substituting $4R_1 = k4A_1V_2^n$ and $R_1 = kA_1V_2^n$.

For Boat 1, $F_1 = R_1 = kA_1V_1^n$.

Equating, $kA_1V_2^n = kA_1V_1^n$.

Therefore, $V_2^n = V_1^n$ or $V_2 = V_1$.

Thus the value of the exponent n does not matter. We discover that similar shaped boats travel *at the same speed* in the same light wind regardless of size.

The above demonstrates that in light winds, when $\dfrac{V}{\sqrt{L}} <$ about 0.4 for both boats, the larger boat should *not be handicapped.* Any fair rule should reflect this situation.

### Summary

The writer's principal objections to existing handicap sailing rules have been outlined. No rule will ever be closely accurate unless, in some way, a variable factor is provided which is a function of the average strength of the wind, encountered over the course, in relation to the boat's size. This can be determined in a relative manner by calculating the average achieved $V/\sqrt{L}$ for each boat. Of course, if this is used, the course distance must be known.

The writer has devised one handicapping method for the above accomplishments. It will be with-held for the present. It is suggested A.Y.R.S. readers let the Editor know how they would solve this problem. A collective judgment is necessary since acceptability, as well as simplicity, is most important to its success. In final form, it might be called 'The A.Y.R.S. Handicapping System'.

# THE DESIGN OF THE SQUARE RIG

## by John Morwood

The design of the square rig is far more complicated than it appears at first sight. It is not really enough merely to have the sails on each mast continuous and, by the use of curved yards, have 'built-in' flow to the canvas. One must make the rig free of vices in handling as well as positioning it on the yacht or ship so that it has the fewest losses.

### Ease of handling

The main fault of the square rig when set upon a single mast is that the centre of effort is forward of the pivoting axis. This means that the sail will not weathercock to the windflow if the sheets (or braces) are eased but will do the reverse, i.e., will come more fore and aft, thus increasing the capsizing moment. This lack of the 'fail-safe' property of the conventional squaresail was the reason why our A.Y.R.S. members felt that the most ingenious square rig made by George Dibb for his trimaran was not acceptable, though it was otherwise efficient and might have been more so than a conventional sail plan.

Many years ago, having noted the theoretical fact that when the braces of the square rig were let fly, the sail would come more fore and aft, I asked an old sea captain about this. His reply was that when the lee braces were eased off the yards swung more athwartships, which surprised me at the time.

The explanation of the anomaly between theory and performance lies in the 'advance wind' of the aft part of the rig bringing the centre of effort of the front sail AFT of the pivot axis. Naturally, this will not apply to the mizzen mast of any square rigger and to overcome this, the fore and aft 'Spanker' was set on the mizzen. Ships of the time of Elizabeth I, used lateens aft. Medieval single master square-rigged ships and 16th Century herring 'Busses', even with three masts, didn't have fore and aft canvas on them and are the only exceptions to this rule I can find.

If therefore anyone wants to put square rig on his yacht, he should consider using two masts at least and have some arrangement to bring the centre of effort aft of the pivot axis of the aftermost one. This could be a 'Spanker' or alternatively the square canvas ahead of the aftermost mast could be brailed into it in its lower part.

### Square rig efficiency

Square sails were remarkably efficient to windward, the single-masted Humber keel being alleged to look a point closer to the wind than the fore and aft rigged barges. However, when there were enough hands to work a ship, a foremast was set and the sail on it was sheeted down to the lee gunwale so that the wind flow on the lee side was far 'cleaner' than on the mainsail placed about amidships. The topsides of the bow then became part of the driving force on the ship. The modern Genoa uses the same principle when it is sheeted down to the deck, especially with a short-ended yacht with little or no overhangs.

### The mizzen mast

The Romans used a square mainsail and a fairly high aspect ratio square foresail set in the bows (the 'Artemon') but knowledge of this had probably been lost when the Medieval shipwrights began to use a foremast. We would expect that the foremast was first used for manoeuvring as the Romans used their 'Artemon' but the increased drive would have been noted and the sail increased in size until sail balance had to be restored by the use of extra sail aft. The aft sail was a small square mizzen in the herring Buss but was soon replaced by the lateen—eventually to become the Spanker on the mizzen mast of the clippers.

### The brig rig

This is a two-masted square rigged ship noted for its windward ability which was greater than that of the three masters. It appeared as late as the 18th century when jibs came into general use. By this time, ships had started to be 'designed' rather than evolved and designers had seen that the masts could be moved aft and the sail balance restored by long jibooms and jibs placed out ahead of the ship. I am not sure if the principle of sheeting the foresail to the lee gunwale got lost in this process because of the lack of interest in the brig owing to its humble use of bringing coal to London and the South of England. The Royal Navy also used brigs as dispatch carriers which was hardly as impressive an employment as that of ships of the Line.

### Modernising the square rig

I think that George Dibb and all those who have thought about this believe that in modernising the square rig, two masts should be used. Nobody that I know of appears to want any jibs at all, being content with two semi-elliptical squaresails, the relative sizes being a function of the underwater profile of the yacht.

The foremast would have the 'yards' or battens running up it and have a partially streamlined section so that they would twist with it. The sail would be continuous, of course, but I would like to suggest that it be loose footed so that it could be sheeted to the lee gunwale which, in turn, could leave the midline of the boat at an angle of about 12° forward. This mast could be stayed from the gunwale on each side up to the level of the lowest 'yard' and a strut at that point could stay the mast up to its full height, the strut and stays revolving with the mast. A short bowsprit might be necessary to keep the forestay clear of the sail, though I doubt it.

The mainmast—the after mast on a brig—would have the same type of near-streamlined section as the foremast with the 'yards' hoisting up it similarly. However, in order to make the sail 'fail safe', i.e., for the yards to weathercock if the braces are eased, some canvas forward of the mast should be removed on each tack which could be done by brailing in that part of the lowest 'course'. Alternatively, the lowest part of the sail could be only of half width and be hoisted up a luff groove on the forward side of the mast to the level of the lowest yard. On each tack, this sail could then be sheeted to the end of the lowest yard which is to lee, and of course to the deck or lee gunwale.

### Summary

Some factors are examined of the square rig which contribute to ease of handling and efficiency. The other main benefits of this rig which are (a) the absence of twist; (b) the absence of the mast at the leading edge of the sail; (c) the semi-elliptical plan form; (d) clean and predetermined shape of the lee side of the sail and (e) the ease with which relatively large sail areas can be worked have already been considered by the A.Y.R.S.

# THE WISHBONE RIG

## by H. Newton Scott

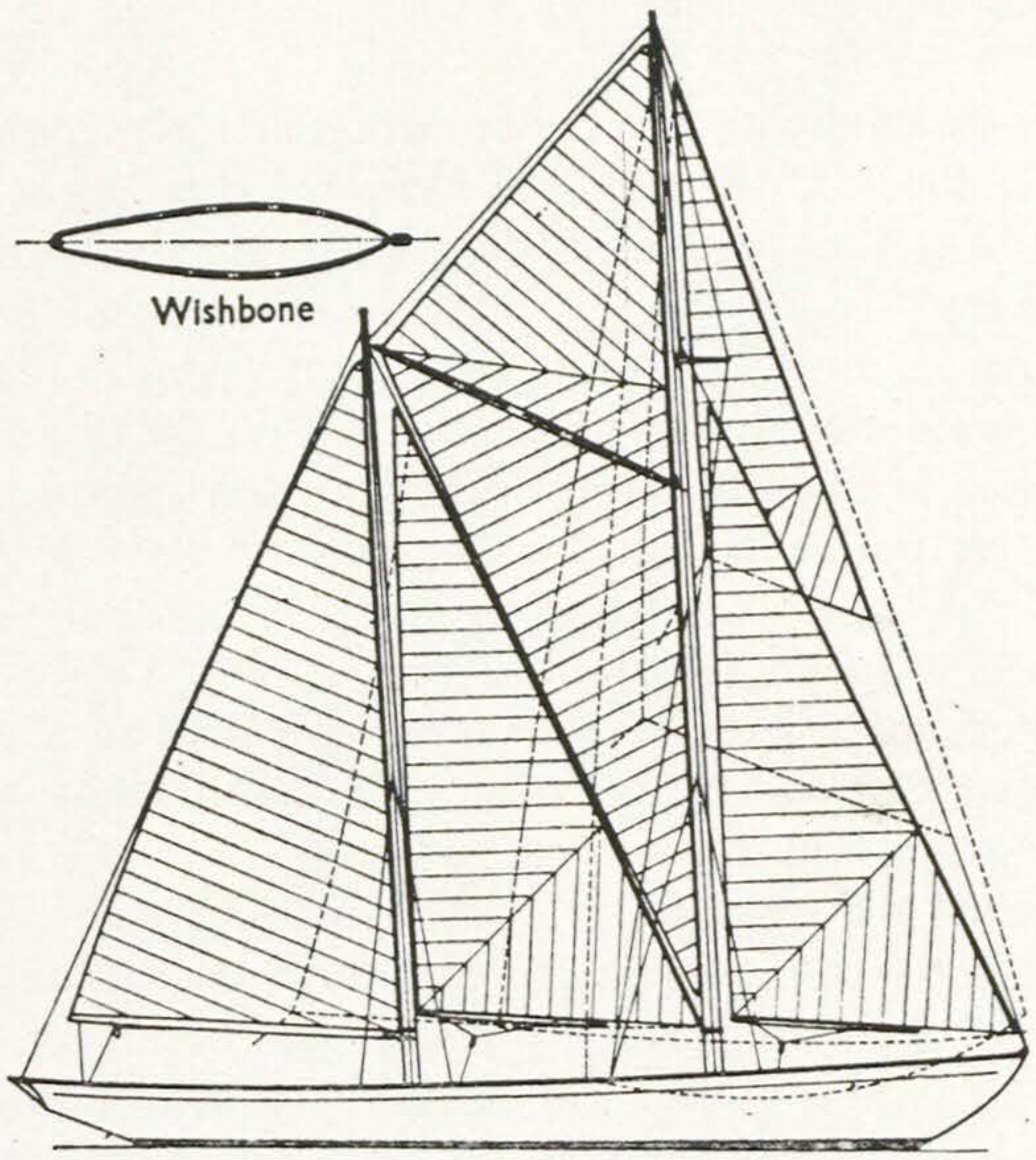
Many have requested me to write an article on the Wishbone Rig. Seeing that I have now been shipmates with it for 27 years and cruised under it for over 44,000 miles I should consequently know something about its peculiarities and advantages over the conventional rigs.

One has a hard row to hoe in endeavouring to convince those who have not sailed under the rig of its advantages and it is hard to change and introduce something new to the confirmed 'stick in the mud' and I am generally claimed as a crank, for one yachtsman remarked, 'Don't wish that rig on me Scotty'.

Having spent many years doing the hard forward work on the conventional gaff rigged yachts, schooners, sloops, cutters and ketches for over 20,000 miles of deep sea cruising, not including all the racing when topsails were the vogue, I endeavoured when designing my own ship to design the sail plan

*H. Newton Scott's NEW SILVER GULL*

that would eliminate most of the hard work and I came to the conclusion that it must be a bermudian ketch. I wanted a ship that I could be independent of a crew, a ship that one man could handle. One day I saw the picture on the cover of Rudder Magazine of a yacht with a divided sail plan. It happened to be that of the 72 ft. *VAMARIE.* The possibilities of that




*Sail plan of VAMARIE*

rig hit me, it was just what I had been endeavouring to find, so I adopted it and for 6 years experimented with it till I finally contacted the original designer of the rig. A letter to Fenger soon put me on the right track and I now have the pleasure of stating that I sail under the easisest, most efficient rig ever designed, with no big booms swishing about, no heavy blocks and tackle to heave on, I had become lazy in my old age.

I have always been led to believe by those authorities—that should know—that a sail—no matter what size—has only one driving line. In other words, there is just one part of the sail that the winds enforce their strength upon and act as a driving medium. Well if such is the case, it stands to reason that the more narrow sails one can hoist, the faster the ship should go. This surmise has evidently been accepted as one sees today elongated narrow sails which is in adverse ratio with those of 40 years ago.

It was then the custom to extend the huge mainsails far over the stern of the yachts. Therefore I maintain if such is the case, five driving lines in a ketch should be better than a sloop with two driving lines. The proof of the pudding is in the eating and I would like to see the result of two similar hull boats, one fitted as a sloop or cutter and the other with the wishbone rig, contesting with one another on a long ocean race.

Now to get the maximum efficiency from a sail—no matter what shape—it must be boomed out with a spar of some sort to ensure it from collapsing with wind pressure. The common orthodox way is to fit a boom to the foot of the sail, which is then controlled by a sheet to the deck. When close hauled on the wind, this boom lies practically along the midship line of the ship or very close to it and the sail is as flat as a board. The upper portion of the sail curves in a nice flow and is the only portion of the sail that is working efficiently.

If the sheet is eased slightly the boom merely lifts perpendiculariy and the top of the sail balloons further and the more the sheet is eased the more it balloons out till it is foul of the rigging. Therefore the boom can never be eased out more than about 45°. This is where the wishbone boom has it all over the ordinary booms, for as it is set at right angles to the luff of the sail to the clew or approximately along the mitre. Thus the lower portion of the sail from the boom to the foot is a restraining action against the clew lifting. In other words the foot of the sail acts as a holding down rope and prevents the clew from skying when the sheet it eased. Thus the sail retains the same flow no matter how much the sheet is payed out. This also means that when close hauled, the sails need not be so hard held as with the ordinary boom and thus give more drive, for the freer the sheet the less heeling moment and the faster the ship will sail. When running free the boom can be payed out till it is against the shrouds—which is close to a right angle—and thus exposes more sail area to the wind. Even though the sail might rest against the shroud, no chafe takes place as there is no movement in the canvas. If one sails a gaff rigged ship they will notice that when beating to windward, while the boom is hard held, the gaff—at the head of the sail—is away out to leeward and drawing well.

Now this is so in the main-trysail with its boom up aloft. It is getting the true wind and this sail is never sheeted in closer than at least 8 ft. off the top of the mizzen mast. It acts as a gaff does and draws and drives like a team of horses. It is not pressing the ship to any great extent and I maintain it is equal to the drive of at least three lower sails. Once the main-trysail is set you immediately feel the ship jump ahead.

Another great advantage of this rig is that one can obtain the maximum of canvas and driving lines without going outboard and without having very tall masts. The simplicity of rigging does away with those awful runners that keep the crew on their toes when going about or anticipating a gybe.

Talking of gybes. It is almost impossible to gybe accidently. I have sailed on the open ocean with the wind on the quarter and the sails set out on the same quarter and they would not gybe until I hauled the booms almost amidship when they would quietly swing across. We have never any fear in allowing any rank amateur to take the helm in a running sea and stern wind.

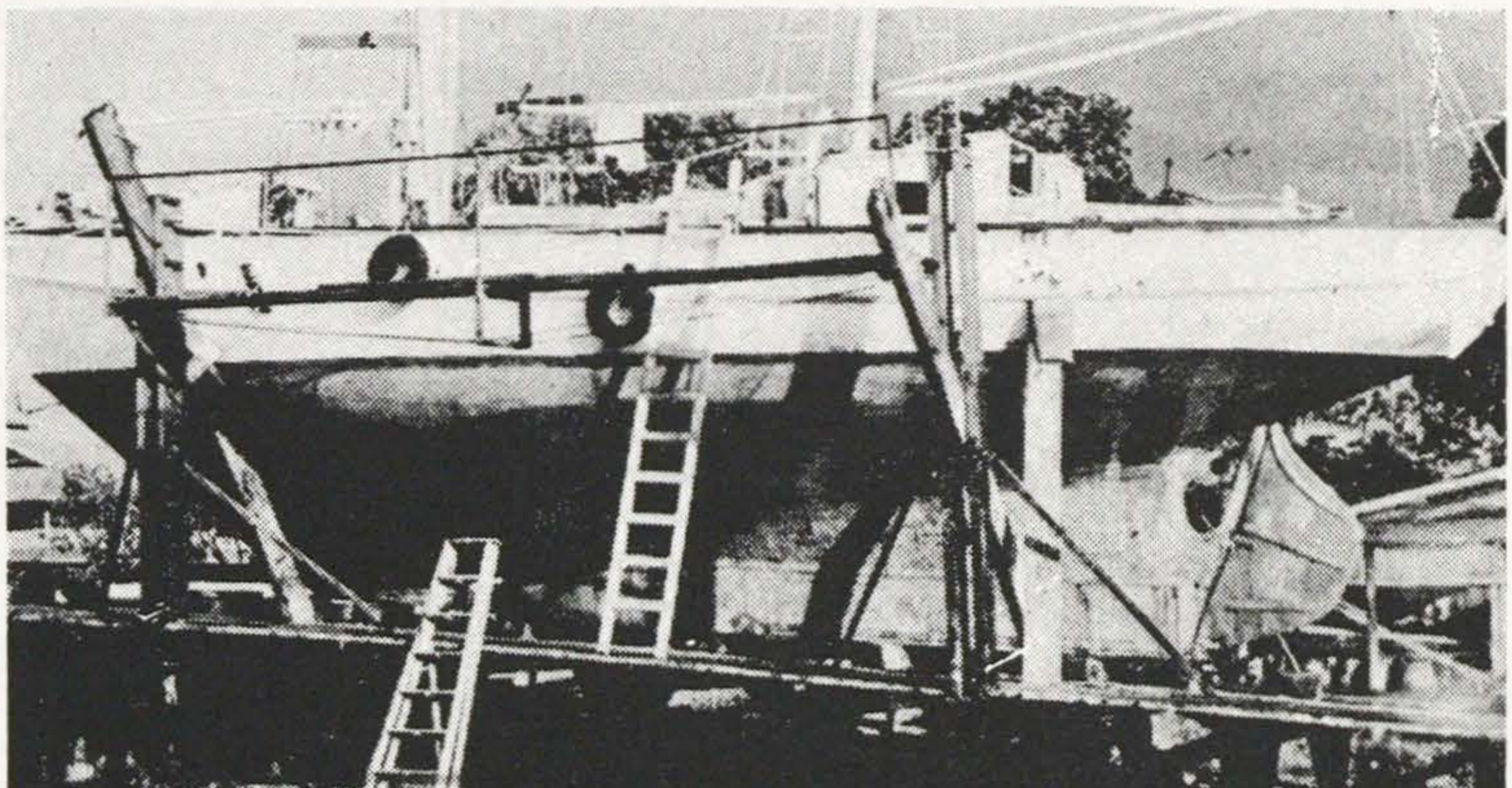
Wishbone booms for ordinary staysails we maintain are a must. We have induced several yachts to instal them and they have been definitely sold to them as the most efficient they have ever had. With the wind on the beam or quarter we pay out the staysail like spinnaker and ease it out till it is about 45° forward of amidships. With an ordinary boom the sail would sky and wrap itself around the forestay.

So ordinary booms to us are pre-historic and completely out of date and inefficient and why the wishbone boom has not been more universally adopted has completely mystified us especially on small craft. The sheets of the staysail, main-trysail and mizzen staysail are only single sheets leading direct to the cockpit and need no purchases. The jib sheet has a single purchase from the pennant that leads through a block on the deck and the mizzen sheet is a four purchase tackle so that the sheet can be handed from either side of the cockpit. There are no winches necessary. It is not necessary to bring the ship into the wind to lower any of the sails, for rounding up in a gale can be a hazardous undertaking and generally a wet one at that.

Occasions do arise when one is running and it becomes advisable to reduce canvas. The first sail to come off of course is the main-trysail. To the head of the sail is spliced a light line that leads down the luff to the tack. On the spar at the clew is attached another rope—a vang—that leads down the leech to the club boom. This vang was installed for the purpose of keeping the sail and spar from slatting in a light wind and rolling sea.

When lowering the main-trysail on the run, the sail is hauled in close amidships and the vang handed to the man in the cockpit. The forward hand lets the halliard fly, at the same time the sheet is cast off. The peak of the sail is hauled down with the downhaul light line and the vang kept taut till the spar is down to the tripping position. When it is let go, the boom then swings into the mast, housing the sail against the mast. A couple of ties around it and it is snug till it is convenient to make a decent stow. There is no reefing necessary in this rig, for as the wind increaess the main-trysail is housed, if it further increases, the jib is rolled with the Wykham-Martyn roller and if it is too hard for the three lower sails, it is time to heave-to. So the staysail and mizzen are housed and the ship hove-to under the mizzen staysail.

One of the worries I had when deciding to adopt this rig was that of one sail blanketing another. This can happen on the dead run, but it is obviated by goose-winging the sails. On light days and nights I had a 480 sq. ft. flat



*NEW SILVER GULL has Fritz Fenger's DHOW hull*

cut spinnaker which I could also use as a genoa. In fact on the run between Tahiti and Samoa I went to bed and left her all night with the spinnaker drawing to the south east trade wind. Adjustment of the sails to work one against the other makes the tedious work of sitting at the helm practically non existent but I will stipulate this: No matter what rig one adopts, the lines of the ship should be designed to suit that particular rig and vice-versa. So it is with the wishbone rig. It must be designed to suit the hull lines of the ship to be 100 per cent efficient.
*Ed.:—A.Y.R.S. publication No.* 11, 'The Wishbone Rig' gives most details of this rig.

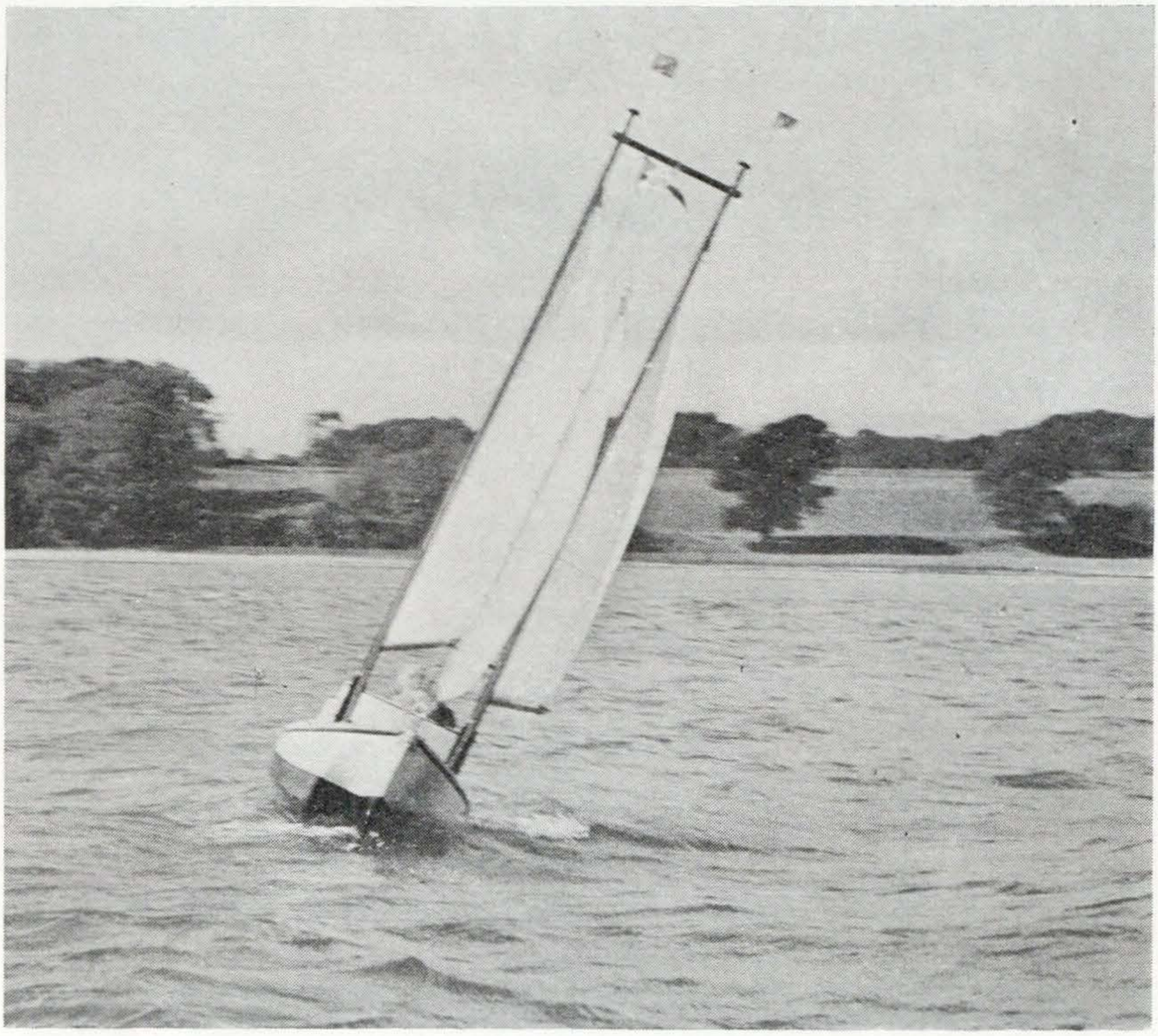
# TWIN-MAINSAILS

## by Cdr. Guy Bagot

194 Conway Road, Colwyn Bay, N. Wales

Within recent years, a few people have been experimenting with 'Twin-mainsails' (Mainsails set athwartships).

The illustrations produced with this article are those of a prototype hull of 'streamlined' design to reduce the retarding effect of wind and water. Of shallow draught and fitted with a drop-keel centreboard. The



*Cdr. Bagot's biplane rig, close hauled*

Sails could all be manipulated from the cockpit, where the Coxswain sat upon a sliding seat to remain upright at any angle of heel. (Photos of *OCEAN PIGEON* taken during trials in the Menai Straits, 1962).

The advantages of 'twin-mainsails may be categorised as follows:

*The centre of Effort*

It is lowered by reason of setting the *Mainsail Area* upon two masts. Thereby reducing the risk of capsizing the craft. Very important with vessels of shallow draught.

*Effort of Reefing*

Reduction of the sail-area is a simple matter as *half* the total area can be reduced by lowering *one* mainsail, which in itself, has already been reduced in size.

*Going about*

Close hauled, or on a reach, the Lee-mainsail has the effect of being a Genoa. Unnecessary therefore to take it around the mast when going about.

*Twin Masts*

Strengthen the structure of the mast. Avoids fitting additional shrouds. Thus enables the 'booms' to be eased off at right angles, without interference from Shrouds or Backstays.

*Running free*

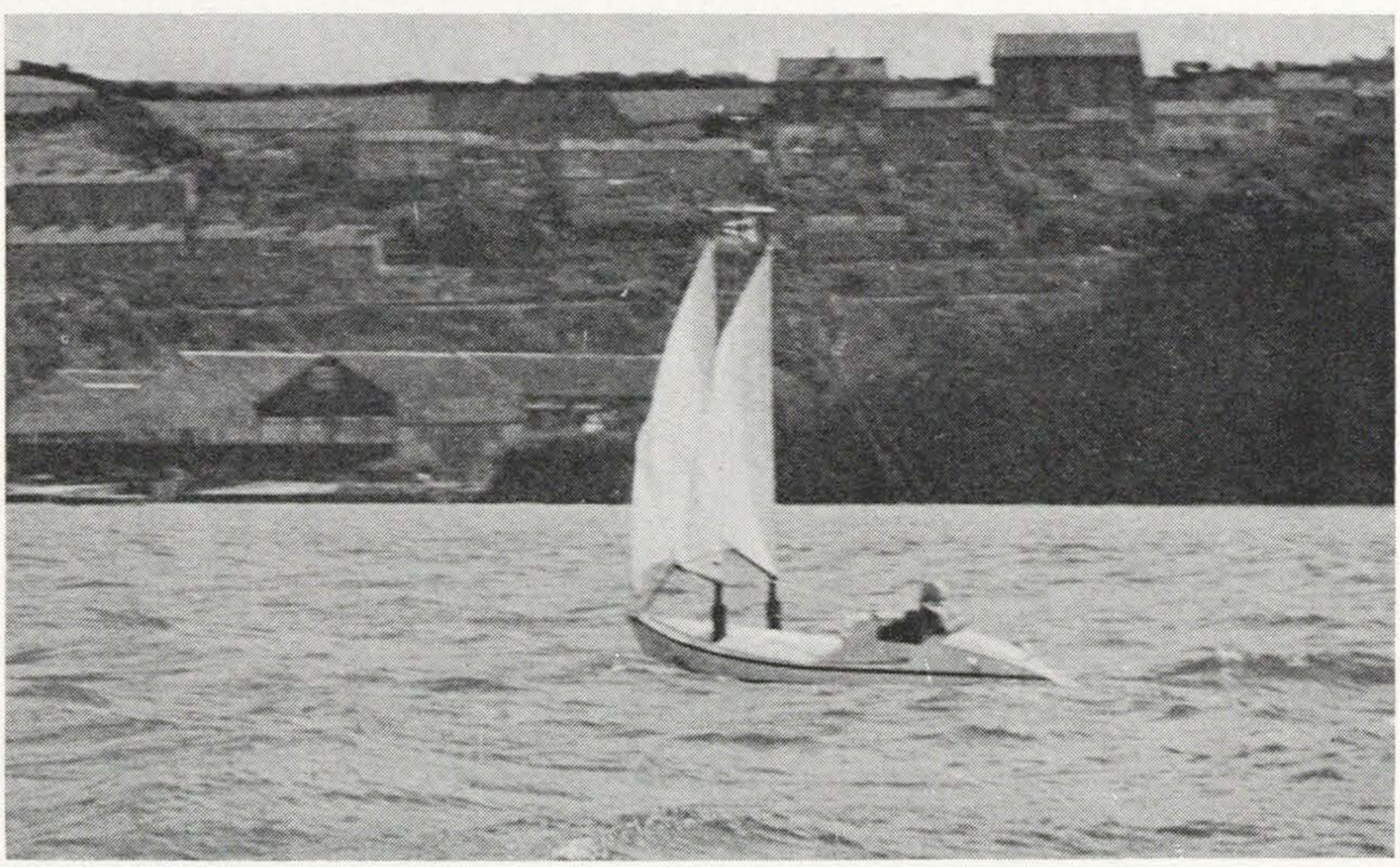
The front mainsail acts as a Spinnaker. Sudden alterations or course, coming up into the wind causes no trouble.

*Close hauled*

Points to the wind as close as any other rig.

*On a Reach*

Manipulation of the sheets, or slight alteration of course has to be adjusted to maintain best results, as is customary with any rig.



*Broad-reaching*

*Gybing*

The Gybing action is less severe than with a single mainsail. A cushion or sandwich of air is brought over with the twin mainsails. Easing off/ setting up backstays is unnecessary.

More recently, thanks to my friend James Wharram, Designer and Builder of Polynesian Catamarans, further trials have been carried out with these Twin-Mainsails fitted onto a catamaran.

The wider platform (or deck space) upon which to erect Twin-Masts is immediately appreciated, and also, the greater stability resulting from the lower 'centre of effort' which is so much to be desired with shallow draught vessels.

The necessity for further trials, to determine the optimum distance apart between sails, and to ensure both sails being filled on all directions of course or wind, is a matter for further experimentation.

Likewise, modification or alterations in the design of the sails themselves, continues to make an interesting study of this Rig.

The many advantages to be achieved, especially for 'single-handed' sailing, makes it all worth while.

August 23, 1968.

Gentlemen,

I have moved from California and your renewal notice just arrived.

I would renew again if I thought the forthcoming issues were not so heavily weighted towards multihulls. I believe more issues should be built around the theory and design (in detail) of the Trans Atlantic boats *and* an issue on Schooners. It seems all the English and current U.S. Sailors always deride the schooner—as Eric Hiscock says 'an indifferent sailor' yet they have never sailed on one. Last week I sailed the Schooner *SADIE* (SydneyMisser's boat) out of Sausalito and she was one of the most beautifully handling boats I have sailed—and would point with the plastic boats upwind. It was a revealing experience—and, of course, on a reach she was a flyer. This experience makes me more aware of what Peter Tangvald is doing right by building a schooner for cruising.

Anyway, are there any more plans to balance out the contents of the years offerings where more variety—and depth—is possible? Then, if this is done, I will renew. But, like others over here, I believe you are going overboard on multi-hulls.

WILLIAM R. HOLMAN,
3412, Foothill Terrace,
Austin,
Texas, 78731.

September 11, 1968.

Dear Mr. Holman,

I agree most wholeheartedly with your criticism of the A.Y.R.S. being too heavily weighted in favour of Multihulls. This has been a worry of mine for years, from two points of view.

Firstly, I frankly am bored with Multihulls myself and, secondly, I think the progress we are showing is one of reversion back to single hulls, but with the lead ballast replaced by out-rigged hydrofoils, which are much more elegant than sheer weight.

I have just had delivery of a new boat, which you may be interested to learn is a single hulled craft—a four berth cruiser, long and narrow, which should cost $1500.

I myself am romantically inclined towards a schooner or a fully rigged ship for yachtsmen, and believe either to be highly efficient if properly rigged. Indeed, having carried out experiments with a new type of sail on my present yacht, I think I would put a square rig on her and hope it would be just as good as the sloop.

All single hull sailors can derive enormous benefit from an insight into multihull design and multihull sailors should study hull design in equal depth. I cannot seem to get these two propositions over to many people, and it is amazing how often multihull sailors fail to derive information from advances in single hull design.

JOHN MORWOOD.

# HYDROFOIL SPEEDBOAT

## by Don Tempest

*by Courtesy of the Editor of the New Zealand magazine SEA SPRAY.*

The project is a new type of foil-borne craft known as the Walker hydro-ski-plane and the man behind it is Hamilton Walker a Kiwi inventor who recently set the engineering world back on its heels with rotary engine designs, that in one stroke, overcome most of the problems of contemporary rotary engines. Walker engines are being developed in Canada and the U.S.A. while Australian and English engineering firms are negotiating for rights.

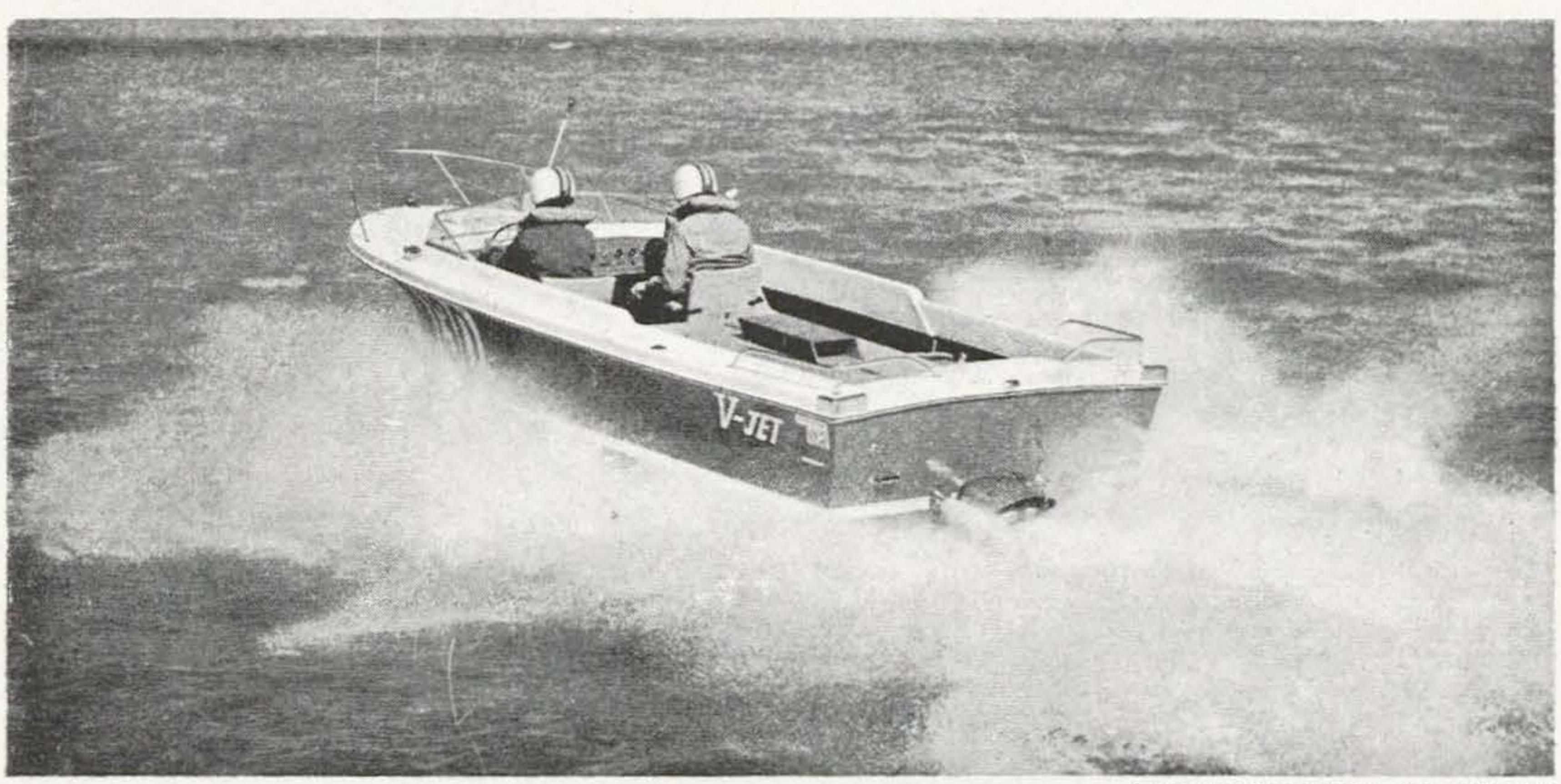
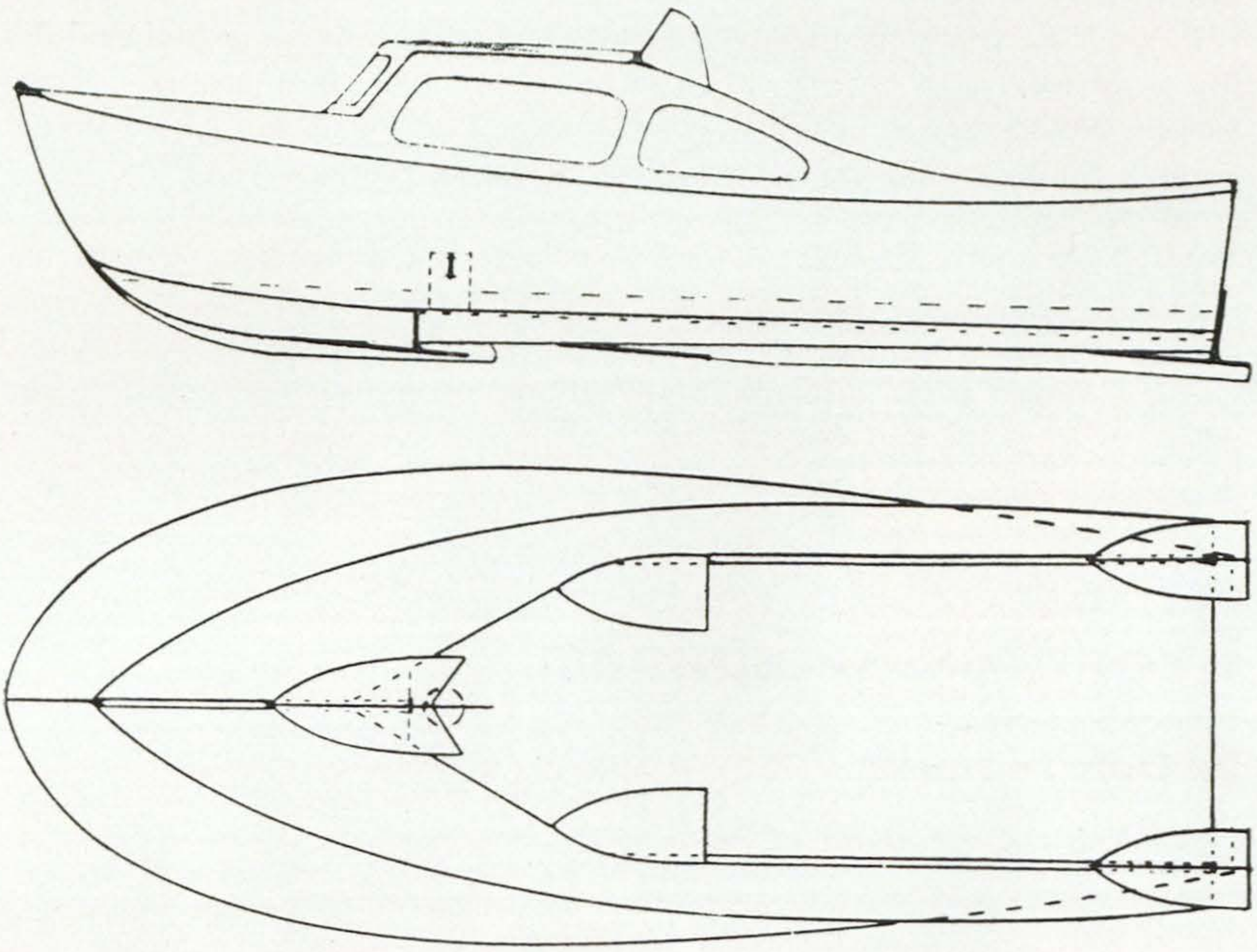



Photo by Mannering & Associates Ltd

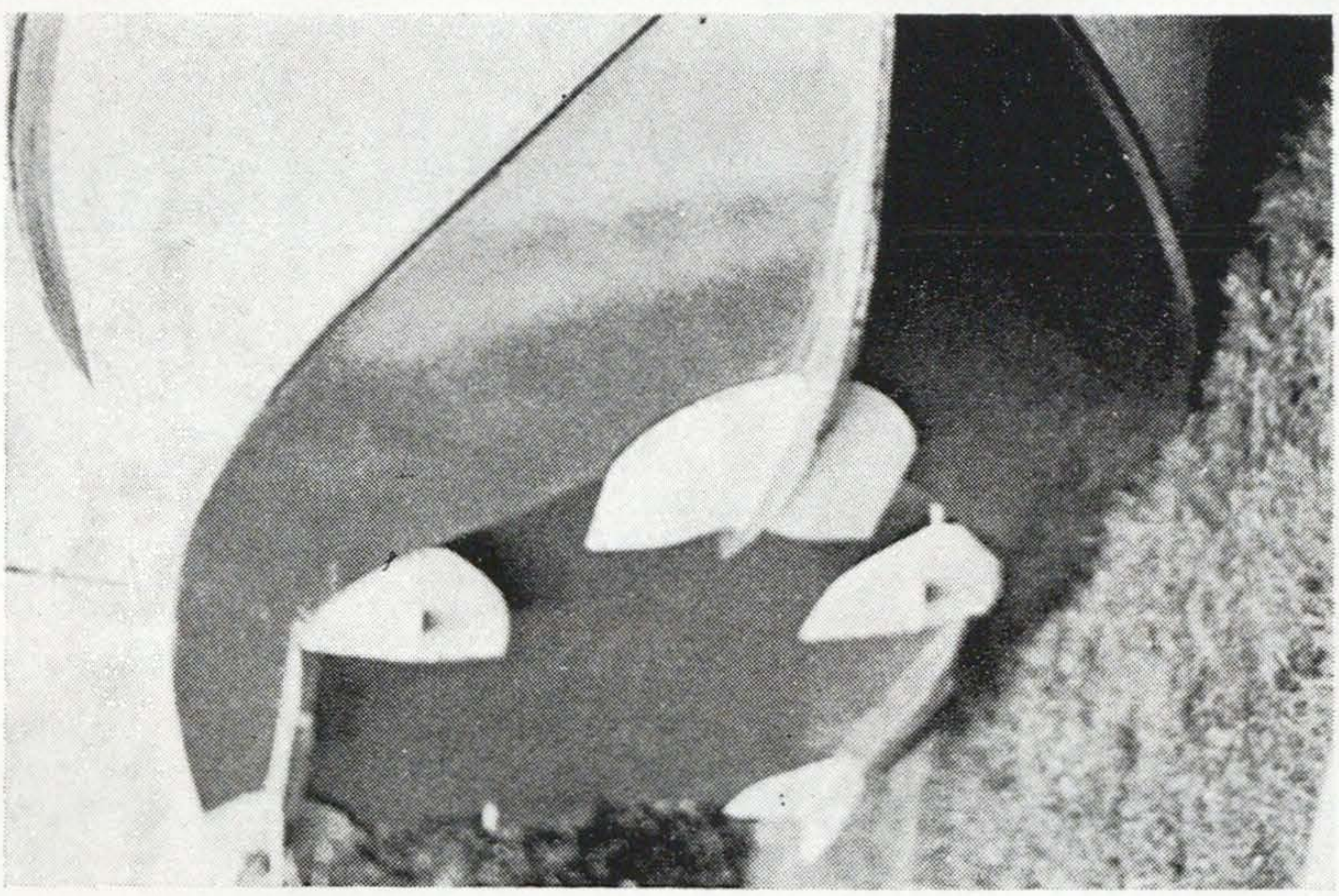
George Davison from Hamilton Marine driving the 7-litre Ford powered Vee Jet to victory in the Southern Lakes marathon

Basically Mr. Walker has taken a Peter Willetts designed 16 ft. runabout and converted it to a type of tunnel boat. Five delta-shaped foils have been fitted and are inset into the keels. Finally an air valve has been fitted to control the amount of air into the tunnel.

The end result is to give a remarkably smooth, stable ride and in early trials the boat has achieved speeds far in excess of what she had ever achieved

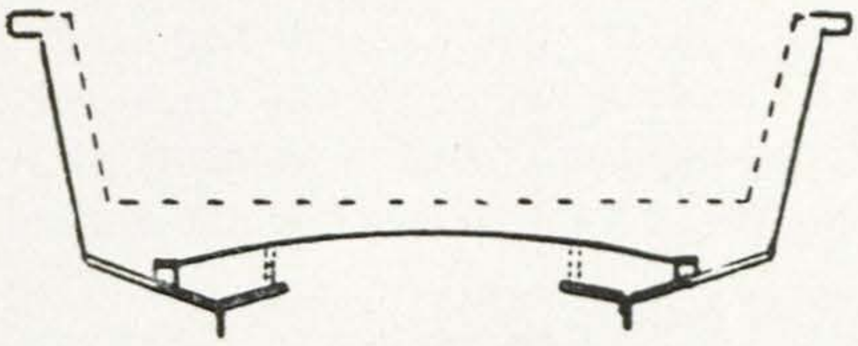


Drawings showing the location of the foils and the depth and shape of the tunnel in the bottom

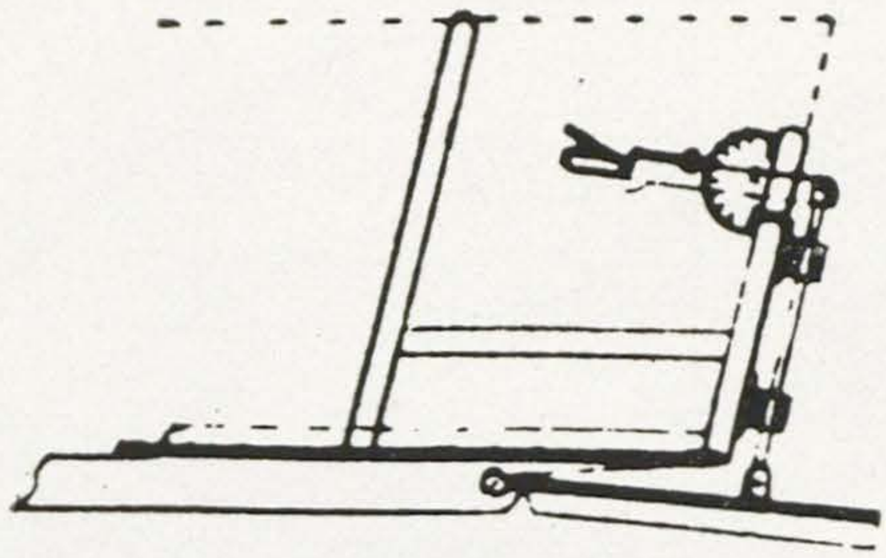


before with the same power unit. The designer is predicting a maximum speed of 44 m.p.h. with a 35 h.p. Johnson. Economy is expected to be about 10 miles to the gallon. Now you can understand why he has applied for provisional patents.

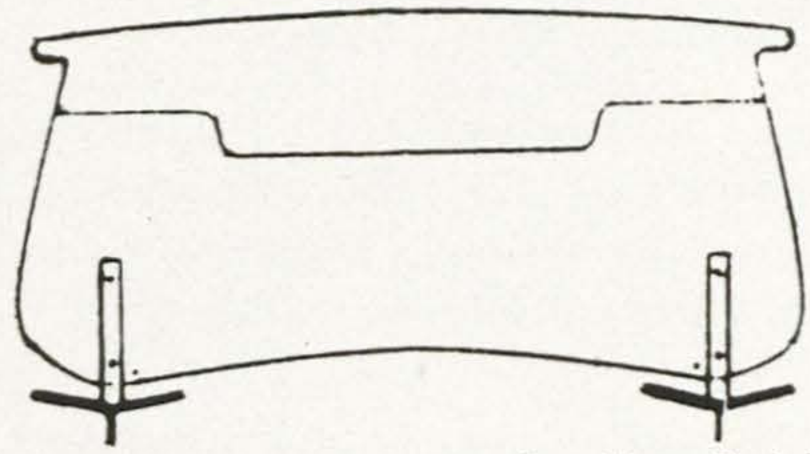
Let's go over each of these features. The original bow has been maintained on the hull but now she has a tunnel starting one third back from the bow, from where it broadens out between two diagonal steps to run between twin keels to the transom. This tunnel is designed to give an angle of attack



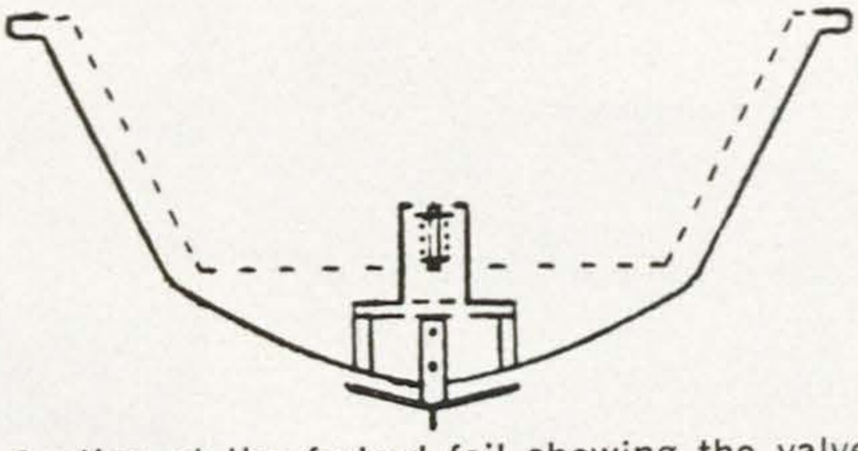
Section at the centre pair of foils



Side view of the stern foil installation showing how their angle of attack can be adjusted



Section at the stern showing the aft foils

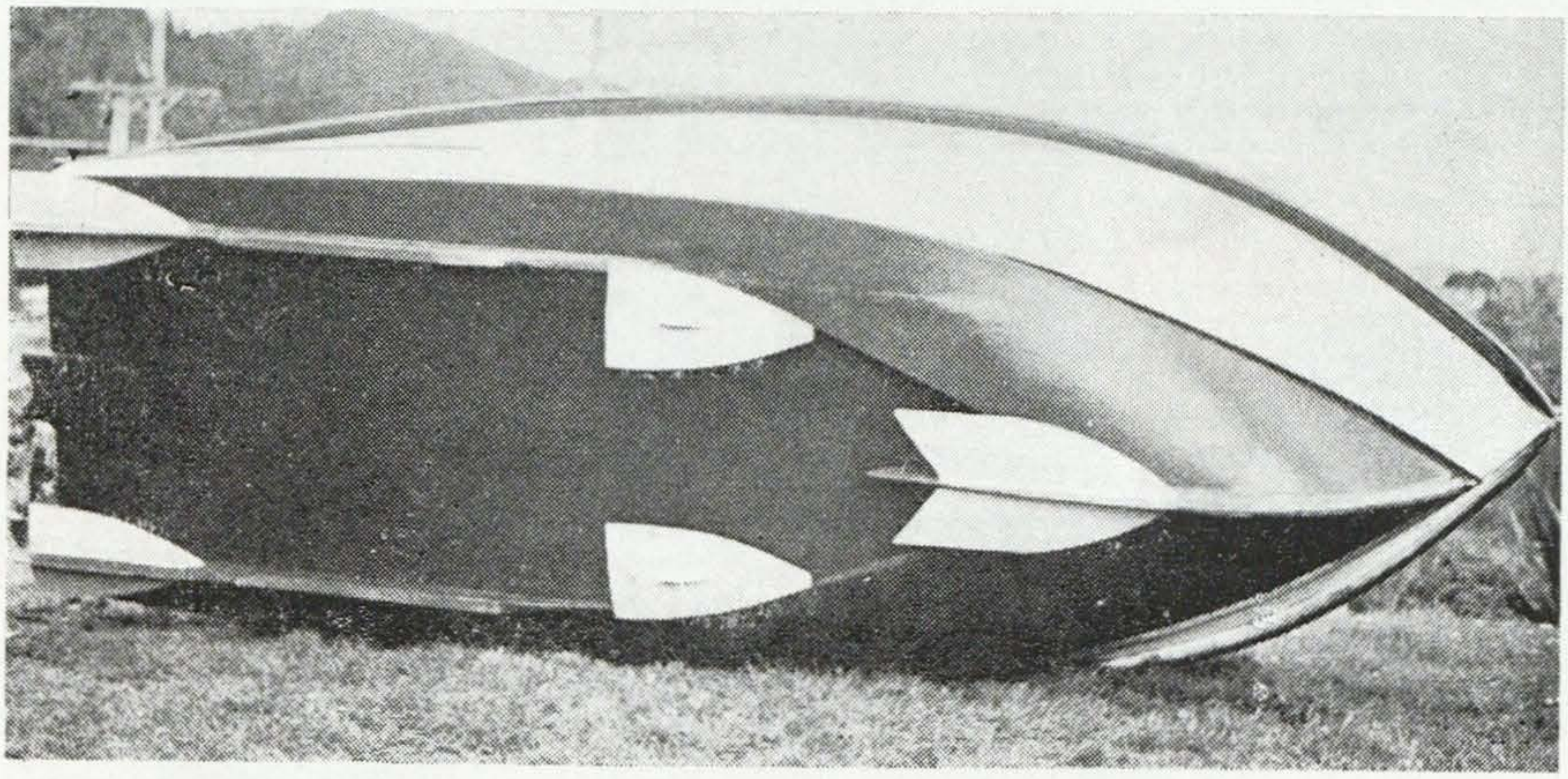


Section at the for'ard foil showing the valve which lets air under the boat

approximately 3° while the arch of the tunnel provides a vee at each keel. Mr. Walker says that besides adding strength the diagonal steps give the following water a spin so that it can mix with a large volume of air creating free flowing aerated water and reducing drag.

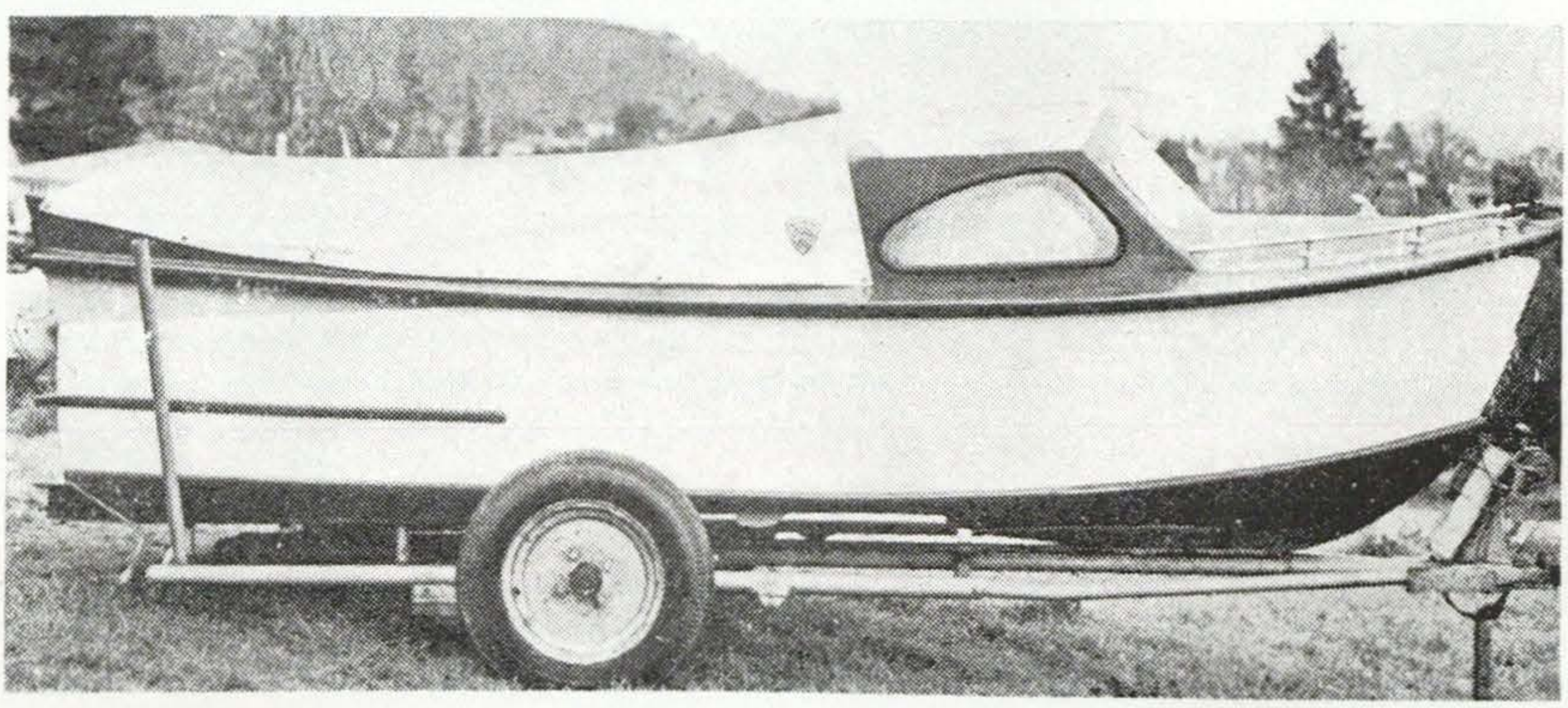
The foils are arrow shaped and total five in all. According to Mr. Walker they overcome all the disadvantages of present hydrofoils. As they are inset into the keels they do not add to the draught and can easily skid over submerged objects. Their brackets are concealed and are adjustable and because of their shape they do not get fouled with seaweed or other rubbish. One obvious advantage is that they do not add to the beam or draught of the craft at rest, thus they are ideally suited for small trailered craft. They are extremely simple in construction and would be very easy to mass produce.

The central foil is double veed in shape and is called a wave splitter. The next pair of foils are stabilizing foils and these are situated at the junction of the diagonal steps and the twin keels. These have proved extremely sensitive in tests and movements of as little as $\frac{1}{4}$ in. in tests have caused the boat to become over stable and difficult to turn. The rear foils of course are



used to give the hull horizontal alignment. In other words they operate virtually as trim tabs. At present they are pre-set but Mr. Walker says it would be a simple matter to hydraulically or mechanically control all the foils from inside the cockpit.

The air valve consists of a tufnol disc with a 3 oz. spring set in a 6 in. tube connected to the tunnel just above the rear of the leading foil. 'At low



Although fitted with foils the 16ft hull sits easily on an ordinary trailer speed it allows air to flow down the tunnel breaking the suction behind the steps and above the front foils,' said Mr. Walker.

'At medium speeds it supplies a continuous flow of air to mix with the turbulent water that has just passed over the diagonal steps thus increasing the free flowing bubbly water in the tunnel. At high speeds there is a full flow of air into the tunnel giving an air-cushioned ride. In really rough waves the valve snaps shut and the air in the tunnel is compressed to give an unbelievable soft ride', he says. 'In the ten square feet at the front of the tunnel of the 16-footer a 1 lb. per sq. in. compression gives a feather soft lift of 1440 lb. Five lb. gives 7200 lb. and 10 lb. gives 14400 lb. This takes care of the hull hitting a really rough wave at speed".

**COPY OF LETTER FROM BERNARD RHODES. YACHT *KLIS* OF BARROW**

May 20, 1968.

Dear John,

At last I've got around to writing! I'd have written sooner, but I was experimenting with self-steering gears till the day before I left St. Croix, so thought I'd wait till I had some conclusions to give you.

My time in St. Croix helping Dick Newick with his new proa (*CHEERS*) was very pleasant and instructive. I feel that *CHEERS* is a very bold step forward in multihull design, and could be the start of a whole new line of development.

Also, sailing on *TRICE* was quite an experience; once we crossed to St. Thomas, a 40 mile passage in 3 hours 10 minutes—approaching the harbour, an extra puff hit and we were making a steady 18 knots, reaching, in open sea conditions. She gave an incredibly smooth ride and was finger-light on the helm.

After *CHEERS* was launched I hauled *KLIS* out on the beach and went to work to practically rebuild her—10 months hard sailing and 5 months swinging round her anchor had reduced her to a sorry state. I stripped off all the old paint, glassed the crossbeams into the hulls heavily, joined the floats to the cabin sides, fitted some extra stringers in the main hull, rebuilt the float hatches and coamings to make them watertight, then covered all the topsides, wings and decks with polypropylene/epoxy resin. I also altered the mast, sawing $\frac{3}{4}$ in. off the leading edge and fitting a lower forestay, and scrapping the two sets of diamond shrouds in favour of lower shrouds to the cabin side. After 3 months hard labour she was re-launched, better than new. She's about 200 lbs heavier now, but so much stronger that this is more than compensated. By developing a ruthless policy of throwing overboard all doubtedly useful junk, I find I can still keep her floating on her marks (which are about $1\frac{1}{2}$ in. higher than shown on the published drawing). (*Ed.:—*See *A.Y.R.S. No.* 60, *page* 83).

Over the Easter period *KLIS* earned her living by day chartering with Dick Newick's Sea Rover fleet, taking his surplus bookings. She proved a great success, taking four people each day out to nearly Buck Island—sailing, swimming and snorkelling. A fair proportion of the people were sailors already; for many it was their first experience of trimaran sailing, and they were all delighted with her lively performance.

However, by this time I had a severe dose of 'Tahiti fever' from yarning with people who'd been there, so as the tourist trade slacked off I started playing with self-steering gears.

The gear I used on the Atlantic crossing, a simple vane mounted directly atop the trim tab, was unsatisfactory because of its tendency to over-steer, necessitating check lines on the tiller. It was also difficult to disengage in a hurry.

A friend on another yacht had given me the working parts (made from an old bicycle) of a simplified servo-pendulum gear which he'd invented but never tried out. I christened it the 'Drunken Servo-Pendulum' because the vane sways from side to side, coupled directly to the pendulum. The system had tremendous power, but I couldn't tame it, it would slam over to 'full lock' one way or the other, or else the blade would oscillate violently as it travelled through the water. I tried raking the blade aft, and moving the point of attachment of the tiller-lines on the blade, but it has me completely baffled. Can you suggest any reason in theory why it shouldn't work?

I eventually settled on the simplest form of running-line gear, copied from a little 17 ft. fibreglass twin keeler called *EVE* with a German boy aboard, that had sailed out from England and was passing through St. Croix.

The vane is fairly large, about 5 sq. ft., and the ratio of the radius of the pulley wheel to the distance of the tiller-cleat from the pintles is about 1 : 2.

The gear works fine since the rudder is balanced-out so there is practically no weight on the helm; however, above 6 knots, when we start surfing, it no longer holds a steady course, the waves throwing the stern about too much. I want to try the horizontal vane someday, but it will be rather difficult to build with my facilities.

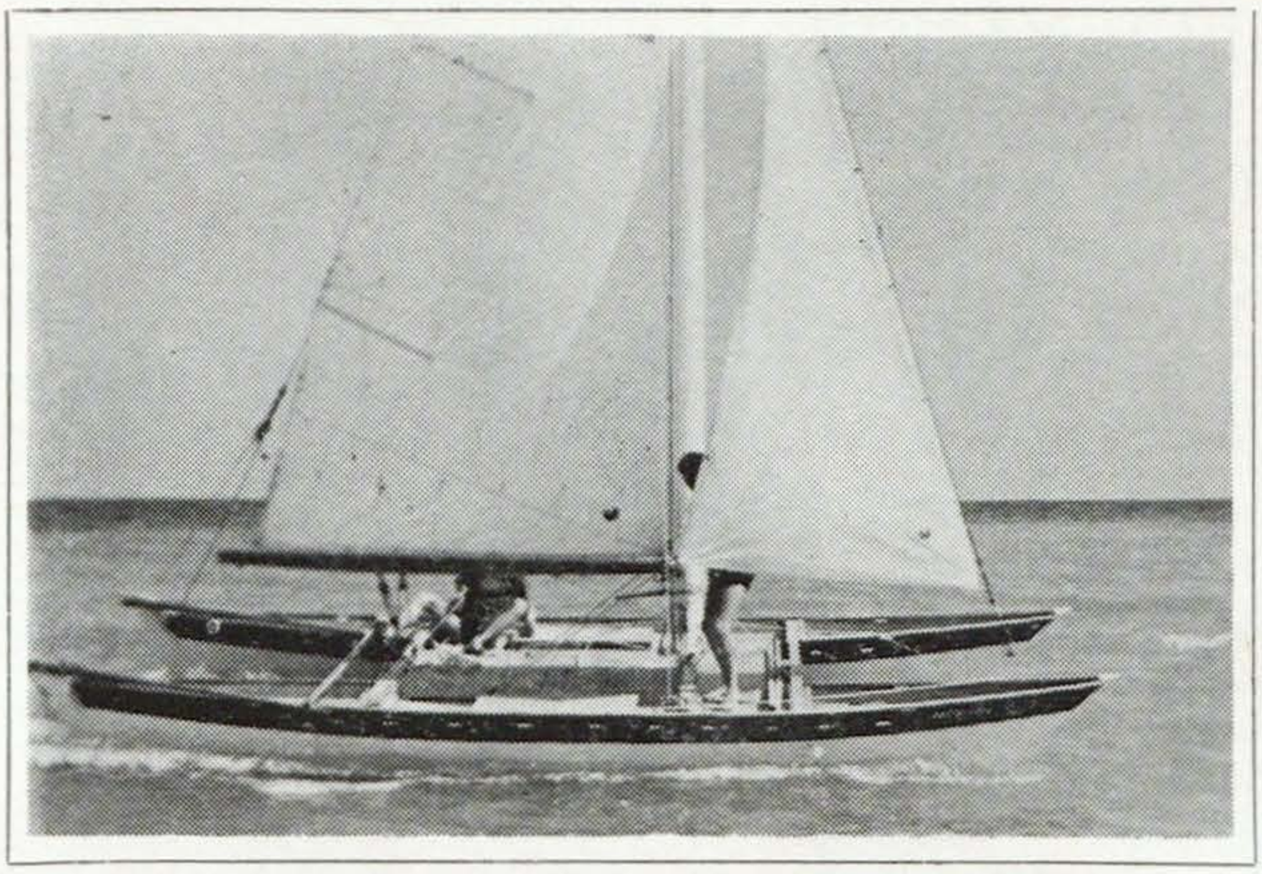
On the rundown from St. Croix to Panama I had a crew, and whenever we felt like it we would take over from FRED (his full title is Faithfull Fredrick IV) haul in the twin sheets and go charging down the waves like crazy, sometimes hitting 14 knots. However, while playing this game one day I felt the helm go still, and looking over the stern found the rudder blade ($\frac{3}{8}$ in. aluminium) bent about 30 in. sideways! The strain on it must have been terrific. We unbolted the blade and took it aboard, sawed the top off and re-fitted it 9 in. shorter. She still steers fine though requiring slightly more helm to achieve the same effect. I always wondered if the rudder was too big—now I know! Its present dimensions are 1 ft. 9 in. deep x 1 ft. 2 in. fore and aft.

Just off Cristobal we were becalmed for a while in a horrible cross-sea and in all the banging about the mainsheet caught Fred and knocked him out.

After 4 days in Cristobal we came through the Canal using a borrowed 5 h.p. Johnson outboard. On this side there is a 17 ft. tidal range, so yesterday we dried out on the beach, antifouled the bottom and fixed Fred back on the stern where he belongs. In about a week I hope to be leaving for Galapagos —Marqueseas—Tahiti, probably single-handed again. I'll let you know how I get on. Next address is Poste Restant, Papeete, Tahiti.

All the best,

Bernard Rhodes, Balbao
Panama Canal Zone, U.S.A.



# a WHARRAM POLYNESIAN CATAMARAN

**The 22 ft. HINA, built for £190.**
Demountable for easy trailing.

Sleeps 2 adults, 2 children in special harbour deck cabin.

*Over 200 being built.*

Owners reporting offshore cruising speeds averaging 9 knots.

Top speeds of 15 knots without the aid of trapezes.

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The Basic Principles of the Ancient Polynesian Catamarans were:

★ Narrow beam-length ratio hulls.
★ "Veed" cross-section.
★ Flexibly mounted beams joining the hulls together.
★ No permanent deck cabin between hulls.

The narrow beamed hulls give speeds above the square root of the Waterline Length, due to minimum water disturbance, (Without the necessity of planing with large sail areas, so avoiding the multihull leap).

The shallow draft Veed hulls require no centreboards or fin keels, for good windward performance. (The absence of projecting centre-boards or fin keels has been shown to increase stability on catamarans.)

The hulls joined flexibly together decreases capsizing possibility, as both boat and masts give like trees to wind gusts.

Having no deck cabin lowers centre of hull gravity, which again increases stability.

WHARRAM POLYNESIAN DESIGN PRINCIPLES = MAXIMUM CATAMARAN STABILITY.

Using modern material and building methods, Wharram 'Polynesian Caramarans' require no building stocks, or level floor to build on. The simple Veed cross-section is the easiest known method of boat construction. Demountable, complete boats are easy to transport, for quick assembly on the sea shore.

This design philosophy and construction has been tested in 4 Atlantic pioneering voyages, the first being in 1955-56, Britain-West Indies.

**Plans:** from 22 ft.-51 ft. available from James Wharram, Poste Restante, Deganwy, N. Wales. Send 2/-. (3/-. overseas) for details.

Addresses of Franchised builders also available for: Australia, U.S.A. S.E. Asia, Spain, France and French speaking countries, Britain.

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# PIVER

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* Designer's Experience

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