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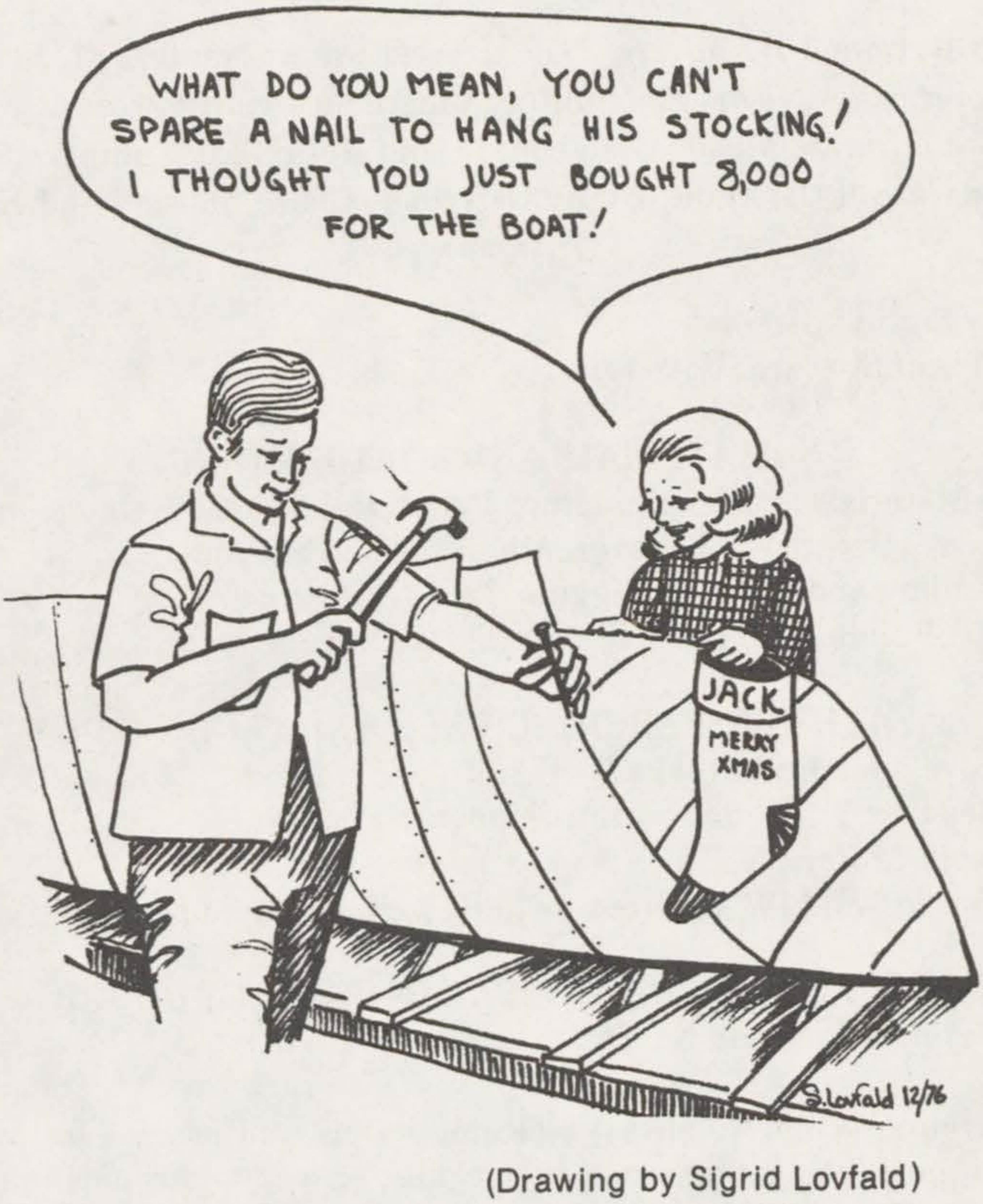
AYRS

BOATBUILDING AND MATERIALS '76

JOURNAL 85B
DECEMBER, 1976

Yacht Research, Design and Technology
Materials and Amateur Boatbuilding
Practical Cruising, Single-Handing, Self-Steering.
Sail Rigs, Spars & Rigging
Advanced Craft
AYRS Florida-Caribbean Contact Group



(Drawing by Sigrid Lovfald)

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Note to Authors: While we always welcome letters and articles for publication in any form, it helps the Editor when such can be sent in two copies, double-spaced *typing*. Units should be consistent with those used in AYRS publications. Photographs should be *black and white* glossy if at all possible. We are particularly short of articles on: boatbuilding, materials, self-steering and practical short-handed cruising. However, please remember that AYRS is concerned with YACHTS and RESEARCH and does not intend to be competitive with existing yachting magazines in any way.

AMATEUR YACHT RESEARCH SOCIETY

The AYRS is an international society for the amateur yachtsman, boat builder, yacht researcher, inventor, designer, sailor and experimenter. In 1976, six AYRS Journals were compiled, edited, published and mailed in the U.S.A. for members. Unfortunately, we have been very late in mailing these issues to members in Europe and the Far East, and I wish to apologize to them and to the AYRS Committee in England for this. We had three aims in publishing these Journals: to relieve England of this load for a time, give members in North and South America a better chance to have their ideas and experiments published and to build up membership here. We have to a certain extent accomplished these aims, but unfortunately we have probably antagonized members in Europe and the Far East due to mailing delays. We are returning the editing and publishing role to England, and this will be the last of the AYRS Journals. As of 31 December, 1976, *please address all correspondence* on memberships, book orders, manuscripts and substantive enquires to *Michael Ellison,* Amateur Yacht Research Society, Hermitage - Drayton Lodge, Newbury, Berkshire, England RG16 9RQ.

RENEWALS - Michael Ellison wishes to advise all recipients of this Journal that renewals are due for the 1976 to 1977 AYRS year - $15 U.S. and £5 England. *Please send renewals directly to England.*

The next AYRS publication will be AYRS 86: "Yacht Tenders." I understand that the book on materials and amateur boatbuilding has been delayed.

AMERICAN ORGANIZER - Michael is also seeking a new American Organizer to take my place, as I resigned from this job some time ago. Please write Michael if interested.

ACKNOWLEDGEMENTS - Many have donated long hours to AYRS, Americas and I am very grateful. These include every member of our Advisory Committee and staff and most notably: Terrence Barragy, Raymond Brown, Dick Kelting, Peer Lovfald, Harry Morss and Harry Stover.

WORLD MULTIHULL SYMPOSIUM PROCEEDINGS - Copies of the June, 1976 forum book may be obtained for $14.95 from; World Multihull Symposium; 91 Newbury Ave.; North Quincy, MA 02171 U.S.A. For foreign air mail add $3.50.

COTTON SAILS - AYRS Member Mary Dungan; 4, Aisha El Taymouriya; Garden City Cairo, Egypt, writes that there is a possibility of producing Egyptian cotton sail cloth to the highest possible specifications in Egypt. Anyone interested please write Mary.

WIND CHARGERS - Two firms are presently selling wind chargers for yachts: Winderator by Sun Water, Inc.; P.O. Box 732; Northridge, CA 91324 U.S.A. and AMPAIR Products; Aston House;Blackheath; Guildford, Surrey GU4 8RD, England. AMPAIR also has several U.S. importers including: IMTRA Corp.; 151 Mystic Ave.; Medford, MA 02155. The AMPAIR 50 is a 26 inch (.66 m.) diameter windmill and weighs only 18 lbs. (8.2 kg.) Charging rate varies from about one-half amp at 10 knots windspeed to 2.5 amps at 20 knots and 4.5 amps at 40 knots. U.S. Retail Price: $695. It has been used by Donald Street on his IOLAIRE yawl: and on CAP 33 and FT trimarans.

THE GREAT GREY HOPE - AYRS Member Mark Switzer; P.O. Box 728; San Francisco, CA 94101 has been publishing a newsletter outlining his project to:

"design, construct and utilize an approximately 250 foot sailing vessel, and to do so in the spirit of exuberance, adventure, and exploration. Among the goals is the creation of a sailing community aboard ship to be completely self-sufficient in energy, food and water. There will be an educational program and various projects having to do with marine research, exploration and salvage.

LITTLE AMERICA'S CUP RACE PLANS - For the first time since 1961, the Little America's Cup races will be held in American waters. First race will be on August 20, 1977 in southern California, with challenges from Australia and England. "C" Class racing catamarans compete in this event and are known to be among the fastest sailing craft in the world. Some have reached speeds of 25 miles per hour and they are able to sail faster than the wind on many courses.

Write: Charles Manning; 306 S. Vinedo Ave.; Pasadena, CA 91107; U.S.A.

MULTIHULL STUDY - A design study of catamarans, proas and trimarans has been proposed by AYRS Member J.M. Beckmann of Holland. He is collecting information on well-known designs of a technical nature which will be plotted in a series of curves to indicate trends, comparisons and technical characteristics. It is hoped that all multihull designers will cooperate with him in his search for information for later publication. Among the many curve plots he hopes to present are: rudder area vs. LWL and lateral plane area; freeboards vs. LWL; sail area vs. displacement and wetted surface; block, prismatic, midship and waterline coefficients and a host of other details which should permit the reader to examine the state of the art and make comparisons. J.M. Beckmann; Prof. Rutgersstraat 17; Den-Bosch; Holland.

ADVANCED MATERIALS AND BOATBUILDING

WEST System, Wood, Epoxy vs. Polyester Resins, C-Flex, Fiberglass Reinforced Plastics and Fiberglass Foam Sandwich

On May 15, 1976, a panel discussion was held at Sailing Meeting Number 3 at Fort Myers Beach, Florida on: Advanced Materials and Boatbuilding. The proceedings were taped, transcribed, edited and sent to the participants for further editing and amplification of obscure points, by Terrence Barragy. We have decided to publish the result in the symposium form in which it took place and include questions and answers. Panel members included:

Meade Gougeon (Meade) .... Gougeon Bros.
706 Martin St., Bay City, Michigan 48706

Bernard Rodriguez (Bernie) .... Rodriguez Yacht Building
Box 194 - Plattekill, NY 12568

Barrett Kennedy (Barry) .... Seeman Plastics Inc.
P.O. Box 13704 - New Orleans, LA. 70185

William P. Osterholt (Bill) .... Small Ship Systems & Designs
P.O. Box 38 - Placida, FL 33946

Robert Conover (Bob) .... Arrow Boat Building
Box 294 Alva, FL 33920

Capt. Edmund B. Mahinske (Ed) of: Sea-Quin Enterprises; 5515 Ivor Street, Springfield, VA 22151, made extensive contributions to the discussions as well. John Stoddart moderated the sessions (Jack), and your Editor's comments and questions are identified by: JWS. I am most grateful to all for their help.

JWS: For organizational purposes, perhaps Meade would like to lead off, since we have his article in AYRS 83B and can presume that some of the people present have read it.

MEADE GOUGEON: WEST SYSTEM: Wood plus Epoxy

MEADE: First of all I'd just like to make some comments about the AYRS. I've been a professional builder for the last nine years, and I have subscribed to the AYRS over the last 15 years. I've gotten a tremendous input of ideas and information from this magazine. As an individual member I can say that the seeds for my ideas have come from articles printed in the AYRS magazine. I think this is a tremendous organization because it has really helped a lot of people come up with fine boats. However, in my opinion, one area has been somewhat neglected, and that has been in the field of actual boat construction. Most AYRS publications have dealt with the design of rigs, hull shapes, the centerboard size and shape, and related items; not with actual construction. This type of information is really tough to come across. I think my article published in AYRS 83B is important in that it is a kind of gutsy thing that tells you about the various methods and techniques used in the actual construction of a boat. I believe that we, as an organization, might spend more time discussing engineering materials and the techniques of assembling these materials. The AYRS article concerns GOLDEN DAZY a monohull, built with the WEST system for the Canada's Cup competition, which she ultimately won. It was rather unique in that we were competing against just about every other available construction method. Dr Gerald Murphy came to us and said: "I heard about your WEST system. Do you guys think that you can build the strongest boat out there? Can you really build a winning boat?" "Sure, no problem." Then, I got to thinking about it and wondered if we could really do it.We had done it in multihulls and in some other areas but this would be a keel boat competing against others constructed with aluminum, kevlar and airex foam, and a sophisticated C & C yacht using balsa core and unidirectional E glass. Well, anyway, we signed the contract and started building the boat and doing our homework trying to come up with the best and strongest boat. The AYRS article mentions that GOLDEN DAZY was the strongest boat there. Well, that's not true. I used the wrong word. GOLDEN DAZY was not the strongest but was rather the *stiffest* boat, and there is a difference between the two. Stiffness is what is really important at this level of competition. What is happening, in effect, on a 40 foot boat like GOLDEN DAZY, is that she is pulling 9,000 lbs. (4100kg.) on the backstay just so the forestay will be as straight as possible. If a competing boat can only pull 7,000 lbs (3200 kg.) on his backstay, his foresail sags off a little; he can't point perhaps a half a degree as high and he doesn't get there as soon. Boats with tighter forestays win. Not by much, but, by just enough to win the race. So stiffness is a major consideration. A secondary problem stems from the fact that the rig is 58 feet (17.7m.) off the deck on a 40 foot (12.2m.) boat. The chain plates are placed roughly 32 inches from the mast, (81.3 cm.) and you have 10,000 lbs of lead bolted onto the bottom of the boat.

The moment arms are really pretty incredible especially when you get this hull tossing around in a seaway. So, the time for the Cup races arrived and Palmer Johnson, which is famous for building aluminum boats, had one in the series and, Spar Craft of California had another one. Hood had two boats, both with very sophisticated Kevlar, Airex - cored hulls. In each of these boats they used approximately $20,000 just in Kevlar. So they were really serious about what they were doing. Both of these boats were very strong competitors in the early part of the season. The Canadian boat, which was the ultimate challenger for Canada, was done in the time-honored method of normal C&C yacht construction, that has been successful over a long period of time. They used end grain balsa covered with unidirectional glass fiber laid on the double diagonal. This gave them quite a stiff hull. However, at season's end, it was the general consensus of all involved that pound for pound, we had the stiffest boat. You might be interested in our construction techniques.

You essentially have to deal with two problems in boat construction. The first, and most crucial, is that you have got to make the boat strong enough. There is no question that most boats built today are strong enough. However, related to that is the problem of stiffness. Stiffness is really important because you have got to keep the hull absolutely dimensionally stable over a long period of time and over a lot of difficult conditions. This means that the hull can't be allowed to bend in at all, and the decks can't wrinkle. The goal is no dimensional change in the boat. It is impossible to reach 100% in this area, but it might be possible some day. But the better you can maintain stiffness, the better off you are in a whole host of areas. This is really important in race boats, but it could be just as important in a cruising boat. So we want to choose the engineering material that has the greatest advantage in providing us with this degree of stiffness. It is difficult to effectively present this issue. I brought along some samples of different engineering materials in hopes that I could better display to you what the stiffness factor is and why we use wood to obtain it.

Fig. 1 - Meade Gougeon demonstrating carbon fiber sample.

These samples all have one thing in common i.e., they all weigh about 25 grams. They are also relatively the same width and thickness. I am going to do a simple bending test that will not be very scientific. I will hold one end of the material down on this platform and place a 200 gm weight on the other end. We are trying to determine the amount of flex in the various samples. The unidirectional E glass fiber exhibits the greatest degree of flexibility followed by kevlar and this sample of 6061 alloy aluminum. And this is the new miracle material - a piece of graphite fiber with a 70 million modulus. As you can see it is pretty spectacular as there is very little flex. Even with this 500 gm weight it is still extremely stiff. Graphite fiber, at this time, is the epitome of man's engineering knowledge. There is nothing for the weight that is stiffer. Graphite fiber is the best we have because it has almost no yield strength, only a breaking point. You have now seen the latest in technology. Thirty years ago we did not have E glass fibers, kevlar, or graphite fibers.

Now we go to that ancient material - wood. This is a piece of white ash, which is one of my favorite engineering materials. For its weight, it is the strongest and stiffest engineering material in the wood field and it has super engineering properties from just about every standpoint. We use it in our boat construction whenever we have high loads, as in laminated floors or in areas where we are going to try to distribute the loads over an area. Let's put our 500 gram weight on the ash which is the same weight, 25 grams, as the graphite fiber sample. The ash is almost as stiff as the graphite fibers and the price of ash is 23¢ a pound. Now we go to a piece of Sitka Spruce which is a pretty amazing material in its own right. This is our favorite engineering material after white ash. It is the same weight at 25 gms. but, the sample is thicker. There is no apparent deflection. The spruce at 48¢ a pound is stiffer than the graphite fibers.

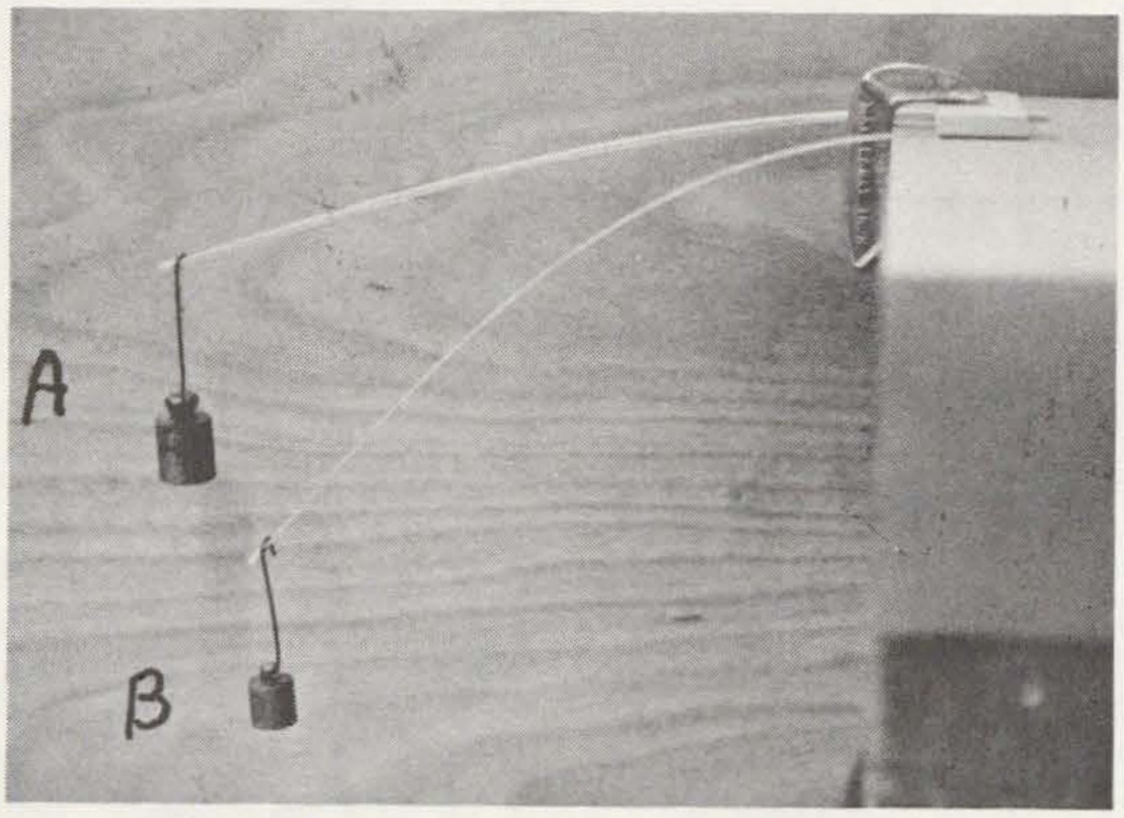


Fig. 2 - Bending Demonstration
A. 25 gm. sample of white ash supporting 500 gm. mass
B. 25 gm. sample of glass fiber supporting 200 gm. mass

There is an important lesson here, which is why I went to the trouble of this demonstration. All of these materials are stronger than the wood I've shown you. But this isn't our problem. Our problem is stiffness. Wood is obviously a very effective method of dealing with the problem of stiffness. So when we looked at GOLDEN DAZY and examined all the possibilities the vital questions were - how do we go about making the stiffest possible hull and, how do we get it dimensionally stable? In view of the hull shape, we concluded that there was only one way. We would make the bloody hull as thick as we could for a given weight. So, we picked Western Red Cedar which has a density of 22 to 24 lbs. per cubic foot (0.35 - 0.38 gm/cc) and we built a hull that was 1 1/8'' (28.6 mm) thick. It weighed 2.31 lbs./sq. ft., while the normal range in this area was 3 lbs.. So for a boat with a displacement of 18,000 lbs. (8165 kg.) we had a hull of only 1720 lbs. (780 kg.) This considerable savings in hull weight enabled us to put the weight somewhere else or at least keep it in the centers. We consider our engineering in multihulls much more sophisticated and difficult than the engineering that goes into keel boats. The load transfers involved in keel boats aren't nearly as difficult as those in multihulls where you have beams coming across, centerboards, mast etc. - it is an incredible problem. In multihulls, strength is just as big a problem as stiffness, but stiffness is still a problem.

STIFFNESS COMPARISON OF CANITLEVER BEAMS- COMPARING 8 DIFFERENT ENGINEERING MATERIALS

Test Conducted by: Gougeon Brothers-August, 1976

MATERIAL All Samples Weigh 25 Grams and Measure 24'' x ½''	Deflection In Inches With 200 Gram Weight	Deflection In Inches With 500 Gram Weight	Specific Gravity	Lbs. per Cubic Ft.	Cost per lb. In Dollars (August 1976)
Glass Fiber - Epoxy (50% Fiber Volume)	10''	Failed	1.52	104	.80
Aluminum Commercial Grade 6061	9½''	Failed	2.7	170	1.10
Kevlar - Epoxy (50% Fiber Volume)	6¼''	11½''	1.18	81	14.00
Graphite Fiber - Epoxy (50% Fiber Volume)	1-11/16''	4''	1.54	105	40.00
White Ash (Select)	1-11/16''	4''	.64	42	.22
Sitka Spruce (Select)	13/16''	1-13/16''	.38	26	.48
Western Red Cedar (Select)	11/16''	1-10/16''	.31	21	.52
Balsa Wood (Medium Density)	3/16''	3/8''	.13	11	1.14

Fig. 3

Anyway, with GOLDEN DAZY, we had a tremendous dimensionally stable boat that was strong enough and was constructed with a reasonable engineering material from the standpoint of maintenance and the related problems of normal boat owning. We did this with the WEST System which we developed to try and make wood a practical engineering material. We all know that the potential maintenance problems with wood are astronomical. We concluded that wood had great potential as an engineering material and so nine or ten years ago we began to develop the WEST System. We feel that it has reached a pretty sophisticated level in solving the problems and think that wood, as an engineering material, is now a practical way to build a boat, both in the areas of cruising and racing. My brothers and I have concentrated on the racing end of it as we prefer that area, however, as we get older I think we are going to tend more to the cruising. That will probably come more naturally to us.

At the present we are fascinated by the aspects which win races - the relationship of ultimate weight to strength and weight to stiffness. So we have built up a backlog of information that we try to rely on and it is now overflowing into other fields. We are talking to a lot of people in the cruising area now. One guy came in and said: "Gee one of my problems is I want to be able to hit a whale. These guys are hitting whales and they're sinking." So I hurried up and did the calculations on a two inch (51 mm) hull, and, it was within reason for a cruising boat. You can have a hull two inches thick on a 45 foot (13.7 m) boat and it is not too heavy. Now a two inch thick hull has a rather interesting side aspect. One is that it is really quiet down there. GOLDEN DAZY is tremendously quiet because of the sound insulation of it's hull. Secondly, it is a very good weather insulator. So you come up with two inches of hull that is super stiff and you can total off whales or hit an iceberg or two. It's not a bad way to go for a cruising boat.

We don't have time to discuss all aspects of the WEST System so let me answer any particular questions about it.

Q. Did you ever finish the 36 foot trimaran you were building a year ago?

A. Yes, it was launched last summer. It is a 36 foot (11.0 m) cruising trimaran (2,400 lbs.) (1089 kg) designed as trailable and, will be down in Florida next winter. It has an eleven inch (28 cm) draft; can be assembled on the trailer, and launched off the beach. It is a Jan Gougeon design and is an offshoot of the 25 foot (7.6 m) FUNKY. Since then we've built one other 30 footer which is not yet complete.

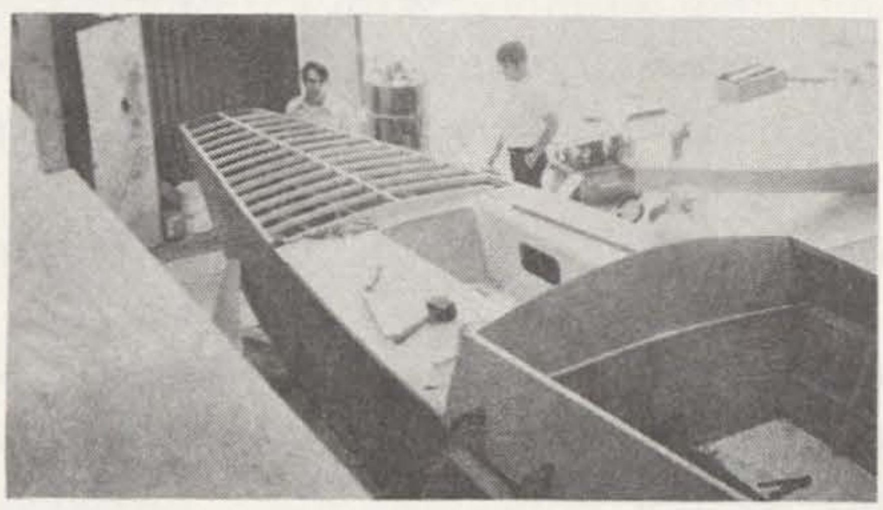


Fig. 4 - 36 ft. FUNKY

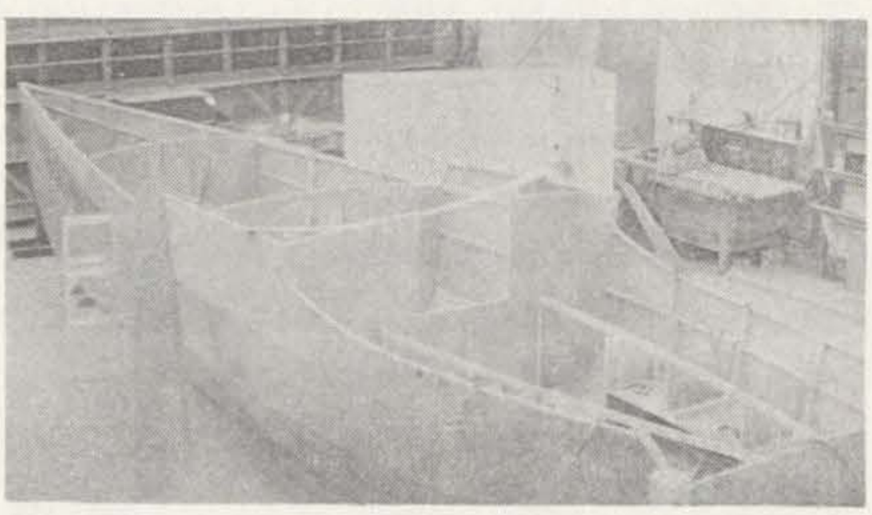


Fig. 5 - Jan Gougeon's new 30 ft. FUNKY of sheet plywood

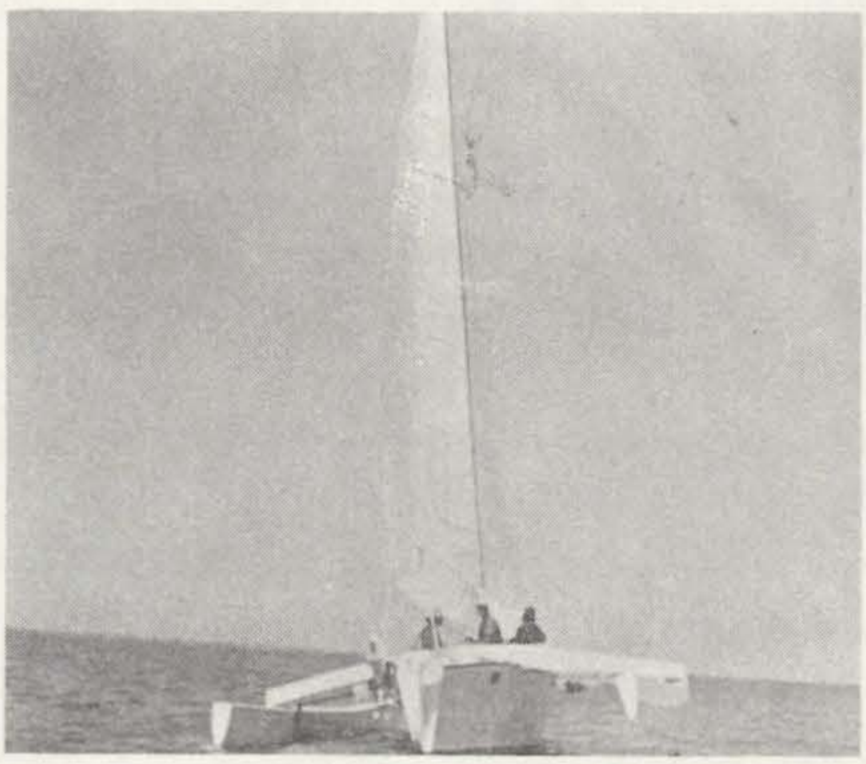


Fig. 6 - 36 ft. FUNKY

BERNARD RODRIGUEZ - AIREX FOAM SANDWICH

BERNIE: A discussion of super materials is very interesting, but the greatest development in yachting over the last few years has been the increase in the number of women yachting. That is getting down to basics and is hard to beat. For multihulls, I favor the Airex - sandwich method of construction. This is especially true for the modern multihull with its greater overall beam and increased sail area as compared with earlier designs. Sandwich construction offers the opportunity to achieve the required strength and light weight with minimal skill. I'm a designer and builder, and I am trying to take advantage of whatever materials seem to be best for the job. It is difficult to design a boat that will do everything. There may be no such thing as the perfect boat. A boat is designed to do a particular job for a particular person. Dick Newick has said that there are three things you can have in a boat: low cost, performance and accommodations or comfort. You can have any two but you can't have all three. So somewhere along the line you start making decisions on the kind of boat you ought to have and the kind of sailing you want to do. Then, it may well be that some of the materials, especially if you are building your own boat, may be more suitable to your particular needs. There are advantages and disadvantages to all materials. The strength of the new materials is fantastic and they open up new doors as Meade has pointed out. We are beginning to be able to do considerable things with design, especially with multihulls. This may be also true of monohulls, but I have sailed on them infrequently, so, anything I say must apply only to multihulls. With multihulls you are able to do things which were undreamed of not too long ago. It's now becoming possible to design a boat with a fair measure of speed and comfort at a reasonable cost.

QUESTION JWS: I think most of your experience with Rodriguez Yacht Building has been with foam sandwich. Is that right?

ANSWER: No we build plenty of wood boats. Wood is really a fine material, I like it. One of the advantages of wood is that you can, if building at home, work a few hours at a time in the evening. With fiberglass, you sometimes get involved in all-day projects. If you start fiberglassing something, you can't stop until you have finished that particular thing. That might be all day, four hours, or whatever. Normally with wooden construction, you can begin whenever you are ready.

QUESTION JWS: What method is this - cold moulded, sheet methods, or what?

ANSWER: At the moment, I like sandwich construction. It has all the advantages I'm looking for and you can supplement it with the new extra high strength materials. One of the things I am concerned about in multihulls is the old problem of payload. Everybody knows that if you build a multihull very light it is going to go very fast. The trick, if you are interested in cruising, is to build a multihull that will carry a bit of weight, and still perform well. Really adequate accommodations are not essential if you are racing or only intend to spend a week or two on the boat. However, for any greater length of time you need accommodations that you can really live in. If you are out for pleasure, you want to take the rest of your life with you or as much of it as is reasonable. There must be enough carrying capacity for things such as bookshelves, and a hobby or project.

QUESTION: I am particularly interested in the Low Cost Design.

ANSWER: Yes, it was intended to be a low cost boat, so I called it by that name.

QUESTION JWS: What kind of construction did you use with it?
ANSWER: I think it originally was tortured ply, and it was fairly easy to do. I think you can get a lighter boat with plastics.
QUESTION JWS: Would you kindly explain tortured ply?
ANSWER: Plywood will take compound curves. It doesn't want to, but, it will if you force it. So you can plank a suitable hull with plywood very easily. You can tack on sheets with no effort at all.
QUESTION: These would have to be moderate compound curves?
ANSWER: You can get quite severe curves, surprisingly severe. If you set a piece of plywood out on your lawn and just leave it alone for awhile, it tends to cup naturally. For severe curves, I wet it down and put it on the lawn with four cement blocks at the corners and one block in the center. Pretty soon it starts bending like mad.
QUESTION: You dish it out?
ANSWER: Yes. There are advantages to ply because it is easy to make the curves. However, as I said, one of the main things I'm looking for in my designs is payload and I think I get more payload with foam sandwich.
QUESTION: On your low cost design what is the length and carrying capacity?
ANSWER: Thirty-three feet (10.0 m.) and probably 2,500 lbs. (1134 kg.)
QUESTION: What kind of plywood were you using?
ANSWER: Marine ply ¼" (6mm)
QUESTION: What do you mean when you say foam construction? What is the foam and what is the overlay?
ANSWER: At the moment, I'm using Airex with 18 oz. boat cloth on each side. One of the things I like about this method is that you can tailor weights. As Meade said, strength and stiffness are two different things and, with sandwich construction, I find I can tailor the weights any way I want to. I can put in lots of fiberglass at the keel where you're going to be grounding and bumping into things. I can put in extra glass in the way of chain plates and the stem and things like that.
QUESTION: Excuse my ignorance, but is the Airex in the form of planks or sheeting?
ANSWER: It comes in sheets.
QUESTION: Airex is the most popular of these foams, isn't it?
ANSWER: It is going to stop being popular if the price keeps going up. It's pretty expensive.
QUESTION: What is its strength factor in comparison to two inches (5.1 cm) of red cedar?
ANSWER: It depends on how thick you are going to make it. That is one of the things Meade talked about.When you start building up thickness you get stiffness very quickly. Hull thickness and strength depends on what use you plan for the hull.
QUESTION. In a 33 ft.cruising tri, how thick would the total package be at the waterline?
ANSWER: Maybe you could use half inch foam and you would be applying as much fiberglass as you thought necessary for that particular boat. Thickness would be a little over 5/8" (16 mm.)
QUESTION: Would you compare rigidity with two inch WEST System?

ANSWER: It is not as rigid, but very strong.
QUESTION: (Arthur Peterson): What is wrong with styrofoam?
ANSWER: It's a pretty flaky material which tends to come apart. You can build a very nice small boat and knock around the harbor with it but for a cruising boat, I personally would not build in it.

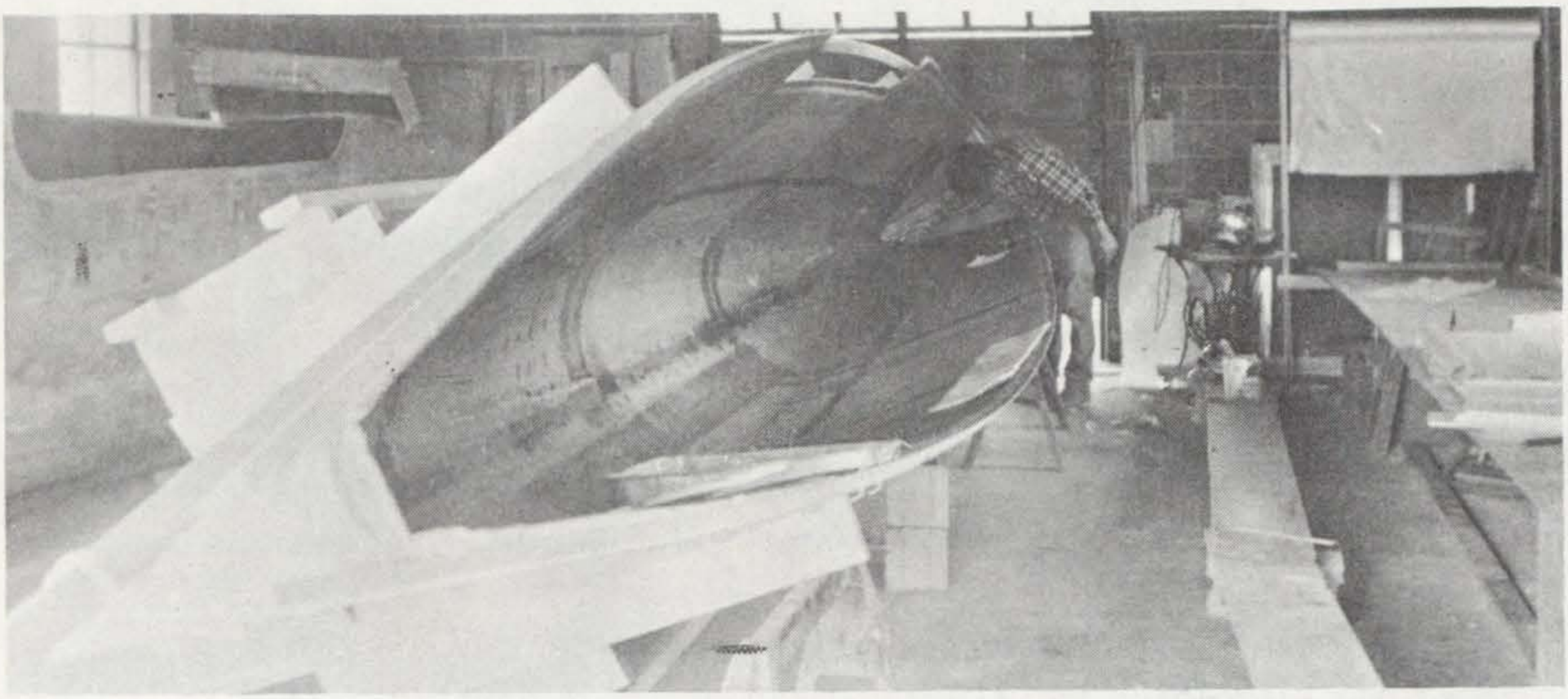


Fig. 7
Rodriguez Yacht Building: Inside of a 30 ft. (9.1 m.) catamaran being glassed. The core is ¼'' (6mm.) Airex, and the basic laminate is two layers of 18 oz. fiberglass cloth inside and out with three layers outside below the waterline. Average weight of this laminate is about 1.4 lbs./sq. ft.

ED : Can I answer that? The polyurethane and styrofoam materials are friable. Rub your hand over the surface and you'll find little granules or a grit coming off. That's an indication that you're not going to make a very good bond with any of your epoxies or polyesters to the material. If you punch the skin you'll get delamination between the polyurethane and whatever glass you are using.
QUESTION: What about adhesion (To Airex foam)?
ED: No problem. There is good adhesion. One of the things I like about it is the impact resistance. What you end up with, essentially, is a double-bottomed hull with a layer of fiberglass on the outside and another on the inside and that gives you a double bottom. If you pierce the outer hull, or skin, the foam absorbs the shock and it is very difficult to also pierce the inner skin. I have a sample at home from a 55 foot (16.8 m.) trimaran that turned out to be much too heavy. But it was amazingly puncture-proof. It is a layer of 5/8'' (16 mm) Airex covered on both sides with heavy 1/8'' (3mm) fiberglass cloth. I had a friend fire at it with a .38 caliber revolver and we have a bullet-proof boat, which in these days may not be a bad way to go! In addition to whales, we also have other things to worry about.
MIKE FIORENTINO: Will the foam absorb water if the outer skin is pierced?
ANSWER: They claim not Closed cell foam will not absorb water.
TOM BALDWIN: Have you or anyone else had experience using non-metallic honeycomb as a core material?
ANSWER: I haven't had any myself but it is interesting. Used in aircraft, it is the most advanced technology available.

MEADE: There is a considerable amount of it at the shop and we use it to make cockpit soles and cabin tops. We use several different kinds. One is Nomex and it's a phenolic fiber reinforced material and really tremendous success has been achieved with it. For instance, we normally build a cockpit first before we set it in the boat. One form is about an inch and a quarter (32mm) thick and it's very tight-celled. We can put a quarter inch (6mm) piece of ply on either side, and it is just incredibly stiff. With a very large cockpit bottom we put wood around the edges of it and can glue the side walls right on. So we completely build the cockpit with a cored base which makes it extremely rigid, and we then hoist it up with a crane and set it right in the boat. The system is really fast. We have also had great success with a paper kraft impregnated material. It's a phenolic resin impregnated kraft paper and inexpensive -- 7¢ a square foot. In the structural tests we performed on it, like jumping off a step ladder, that was the last thing to fail, the ply failed first.

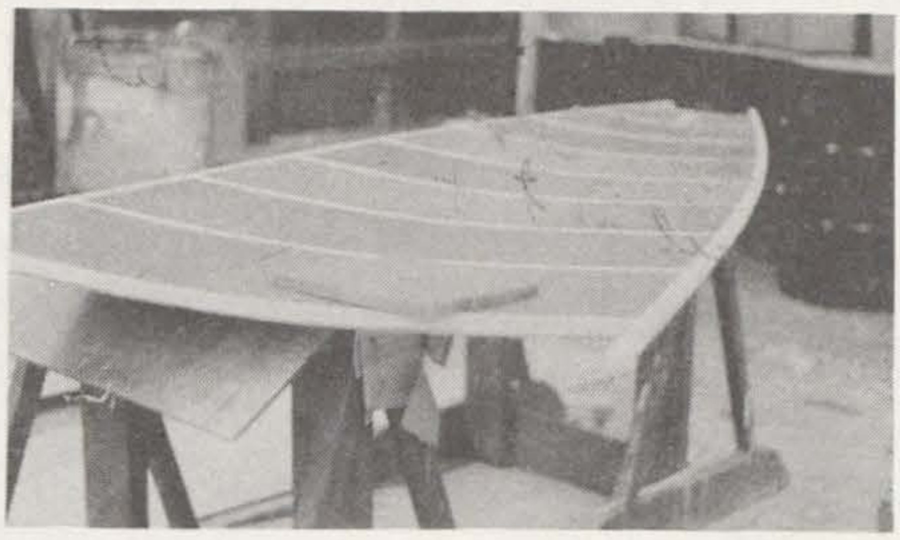


Fig. 8 - Curved cockpit floor/sole using honeycomb core material between 3/16" (5mm.) plywood.

QUESTION: I have been in the honeycomb manufacturing business and wonder why it hasn't been used in boats more. I was thinking of using a Nomex non-metallic honeycomb (nylon reinforced paper honeycomb) with a phenolic resin coating as a core and your WEST System as cured skins.

MEADE: There is a fellow named Gary Mull who has done this and I would advise you to get in contact with him. His only major problem was bonding this to the skin. He sat the skin in the mold and then placed the honeycomb in and, then vacuum bagged it down. He got that accomplished but with great grief. He put another skin inside. The cost was so high that he dropped it as a commercial project and only built this one boat. There's a fellow building a Stiletto catamaran using glass cloth impregnated with epoxy placed in a mold. He's vacuum bagging the Nomex down into the mold; putting it in an oven; heat curing it; bringing it back out; putting another several layers of cloth on the inside; vacuum bagging it; and putting it back in the mold-- just to make half a hull. I think that also is a very expensive method. I know that the materials are very expensive.

BILL: One of the problems is exactly what Meade says. I was in aircraft a few years back and we were experimenting with honeycomb a great deal at that time but when you look at the problems of getting that surface area, which means jacking up your inter-laminar area there with respect to high stress areas vs. the cost, it is just about prohibitive on a production basis.

MEADE: I think it can be licked. That is a viable way to look at it. I think it's a terrific method of construction.

BILL: Interesting enough, the solution finally came up but was never followed up, and that was an aluminum sandwich with a paper honeycomb and an aluminum skin.

QUESTION: Of course, an aluminum core could be used as well.

ANSWER: The aluminum core is now made in a non-corrosive surface.

MEADE: It is very tough to bond.

RAYMOND BROWN: How about using Airex foam with plywood, two or three layers perhaps and WEST? You get enough tensile strength in the skins. Would it be stiffer than with fiberglass?

BERNIE: A layer of foam with light ply on either side? When I was building wooden boats, I used 1/8" (3mm.) ply just about everywhere I could. I don't know how puncture-resistant it would be.

MEADE: One fellow has done what you say, but he only used end grain balsa. He put two laminates of cedar veneer then, ½ inch (12mm.) end-grain balsa, then two laminates of cedar veneer. There are apparently some problems. I personally think you ought to take the balsa and make a veneer out of it and make it work. The end grain balsa is not doing any work (load carrying) in there. It only acts as a core material, and you carry around this half inch of material that is only there for the ride, separating two skins. I say, let's slice up some balsa into veneers and put it right in there and let it do work. We calculated we could do GOLDEN DAZY over again at roughly the same strength figures with a one and three quarters inch (44mm) hull which would give it maybe 30% more stiffness, yet, with the same weight using balsa inside laminate veneers. The inner and outer layers would be red cedar.

JWS: What does the panel think about strip planking?

MEADE: It is a really good method and GOLDEN DAZY was built that way as you'll see. She was done first with 5/8" (16mm) strip planks, however, we didn't use nails but wooden 1/8" (3mm) dowels. It is cheaper, and if you go through the edge of the plank there is no problem as with metal nails. Also we don't use very many dowels. It is strong enough when the planking is edge-glued. One of the problems that all boats have is diagonal load transfer. One outstanding aspect of aluminum as an engineering material is that it has its modulus and its strength in all directions. No matter what direction the load comes from, it can handle it. As soon as we start talking of fibers such as wood, glass carbon or whatever, whatever direction loads are coming from, you'd better have a fiber going in that direction. You have diagonal loads on a wood boat that are really weird. In addition you have ribs going one way and planking the other, and that's a problem. We have a 35 foot (10.7 m) trimaran we built very light in 1969 of developed plywood. You can now see stress lines developing in the ply because diagonal loads are actually torquing the hull. We didn't take into account the diagonal loads.

JWS: Do you recall the conventional carvel method, the Herreshoff Nevins Scantlings where you actually put in diagonal metal straps?

ANSWER: Right. You can do the same thing with a series of veneers.

ROBERT CONOVER - AIREX FOAM SANDWICH

BOB: My experience with boatbuilding is pretty limited. I'm presently constructing a 40 ft. (12.2 m.) trimaran out of foam sandwich and using Meade's WEST System. If I can be of any help to any amateurs here, I'd be glad to, possibly save them a few broken finger nails. I use the WEST System on the ply bulkheads, deck, cabin tops, etc. The hull is Airex foam with ployester laminations on each side. I used a cheap wood mold, laid the Airex over the top of it, put the lamination on, flipped the thing over, knocked the mold out and laminated the inside. On the outside I used 3 oz. mat, 18 oz. WR, 3/4 oz. mat and inside ½ oz. mat, and 18 oz. WR.

QUESTION J.NORWOOD: Has anyone had experience fairing the last layer with glass balloons and doing away with the last layer of mat? That is the way I'm building mine, but with little experience.

BOB: No, I wish we could hear of someone doing this.

AUDIENCE: I wanted to build my boat of epoxy glass laminations, but could not find the technical information on it to give me the strength figures I wanted. So I gave it up and went to polyester.

DAN BISSELL: Is anybody doing work with epoxy and dynel or some other cloth and foam sandwich?

JWS: There is no reason why you couldn't, obviously. There is a price difference between epoxy and polyester resins which is about 2:1.

QUESTION: Did you trowel or brush on the gel coat?

BOB: I have not completely finished it yet. I wiped the hull up in a dry wall fashion and put microballoons on it to fair it completely with a screen. I'll grind the whole thing out and then probably put an epoxy primer and a polyurethane enamel over that for the finish.

BERNIE: There was a question here about using straight cloth over foam. I'm doing that and generally using very little mat. Mat doesn't do much for you except add weight to the boat. The claim is that you get a better bond between the layers of actual reinforcement and the Airex with the mat. Well that may well be true but it's got to be a very small difference, because the peel strength from tests I've made seems very good. My boats, both in Airex and fiberglass, are a hell of a lot stronger than the boats I was building out of plywood. So, how much better do you want to make it?

JOE NORWOOD: I made up a couple of tests. One panel is ¼" (6mm) Airex, and I laid it up according to the Airex manual using ¾ oz. mat in between the layers, but I did another one using the same amount of cloth, leaving the mat out. I ended up with a weight difference with a factor of two. The hulls I have are a half lb. per sq. foot as opposed to 1 lb. per sq. foot, from the Airex manual. I did some torture tests on them and except for puncture tests on impact they all seem the same.

BILL: This has been done for some time. The Navy has, in the past, never allowed a mat/roving layup in any of their fiberglass boats. It has always been only roving, and this has been going on for years. What Bernie suggests here is an argument that's been going on for years and years also. I think if you're going to a straight roving layup, you have to exert every bit of quality control in order to get the properties that you want. The biggest disadvantage of putting excess mat in it is that you jack up your resin content and thereby decrease your total laminate strength, notwithstanding the weight problem. But, it's not new. As a matter of fact, it is very difficult, without good quality control, to build up a good interlaminar bond in the normal production operation without using mat. You can do it with good quality control and come up with a fairly good laminate.

BERNIE: I'd go along with the point that when using a straight roving, you've really got to watch your laminate much more so than with mat. That's a disadvantage.

BARRY: We've done something to eliminate the mat and still get a good bond to the fairly irregular surface of the woven roving. We use milled fiber paste. It is milled glass fibers mixed in a polyester resin to make a paste which is brushed on the laminate surface.The roving goes down on top of it and, you squeegee your laminate to get rid of the excess resin. This effectively trowels the paste down into the voids -- into the skin. You do get a good bond.

BILL: In answer to the question from Dan Bissell about various materials. Yes, we use a lot of different materials. The problem is that each material has a specialized purpose as far as the laminate goes, and, dynel is used for different reasons, usually where impact is a prime design consideration. Vectra is being used all the time when the requirement is high peel strength. In general, with respect to cost and operation, the old polyester laminate with good design and engineering is a fairly good compromise because you don't have all the problems associated with cost, as Jack pointed out. You can get the strength you need in a straight polyester laminate with straight roving and cloth, or mat and roving if it's designed right.

EPOXY ALLERGY

JWS: Meade, I wonder if you could comment on this allergy problem. I returned your questionnaire. I notice you did try to do a survey of people who become allergic to epoxy resin.

MEADE: Well, you've got a definite hazard with any type of epoxy system and the hazards vary with the type of system you use. There are about ten different basic systems of epoxy. Epoxy is a bit of a misnomer in that it covers a wide range of chemical combinations. We deal with a system that is as low in toxic hazards as it can be and still maintain its physical properties and other requirements that we want. But, even with this we have a level of hazard. We found some very interesting things. First off, we know that blond, blue-eyed, light-skinned people are much more susceptible than are dark-skinned people. Really dark-skinned people can bathe in the stuff and it doesn't affect them in the least. It's almost unheard of for a black person to become sensitized to amines which is one of the ingredients that causes the problem. We know that our skin dries with age and you lose some of the protective oils that really help ward this thing off. Thus, you become a little more sensitive to it as you get older. We do know if you are not healthy, if your Vitamin C level is low and your health level generally is low, you are more susceptible to it. And, in fact, if you have a problem, taking lots of Vitamin C is one of the things to do. Take as much as possible because the epoxy is an invasion of the cell wall, much like you would have a germ invasion of your cell wall that causes a cold. It is much the same type of thing.

QUESTION: Do you use polyamide epoxy?

ANSWER:No. We use a basic amine. Anyway, we used to just bathe in the stuff. For ten years I personally bathed in it and I've never had any problems and neither has anyone in our shop. However, as we started marketing it to hundreds of people, all of a sudden a guy called with an allergy problem. I didn't know what to do, but I sure found out in a heck of a hurry what this whole thing was all about. Luckily, over at the Dow Chemical at Midland, there is one of the top epoxy allergy specialists in the world who is a consultant to Dow. He pretty well squared us away, so if anybody has a problem, we can pretty much tell them what to do. So far no one has had a serious problem but, potentially that could happen. Now there were some systems and some still exist that are sold on the open market that are really bad news. I don't want to mention names, but there's one system on the market which is a mean system -- really bad and I think they are negligent in marketing that type of system. In fact about ten years ago, there were some hardening systems that were so bad that they were actually caustic. They would immediately burn your skin. Epoxy got a real bad name at that point because a lot of people got hold of these things and got into trouble. Right away they said, "O boy, I'm not going to touch that at all."

QUESTION: We had the same problem when we were using cobalt accelerators.

ANSWER: Right. We are working on some curing systems that hopefully, on down the line, are going to be better and solve this problem.

JWS: Ed, didn't you have a sensitivity problem with epoxy?

ED: I work entirely in epoxy, and in this instance it was Shell Epon 813 and V 50. Of course, the instructions on my two 55 gallon drums said to stay away from prolonged contact with the epoxy. It's pretty hard to stay away from contact when using that amount to build a large boat. After a while I saw no effect from the epoxy and thought I was immune and played with it like a pig in mud. But after two months of this I woke up one morning and my two hands were meatballs. I got an extreme allergic condition to the epoxy but still had the two 55 gallon drums of the stuff and you just don't throw epoxy away. I then had to put on a cotton glove with a playtex glove over and a long sleeve shirt over this so that the epoxy would make no contact with my skin. Once you get this allergy it's extremely itchy and your first impulse is to scratch, and that's the very worst thing to do. The only thing I found that was useful in that condition -- itching -- was to put my hands under as hot a water as possible and rub lightly. That's good for about 12 hours and you can sleep comfortably. These materials are allergenic, and you have to be careful to follow the precautions that are prescribed. As was pointed out, the Nordic types, light skins, are the ones who are most likely to have trouble. I understand that Shell is working on a non-allergenic epoxy but they haven't advertised it as yet.

MEADE: 815 is pretty difficult because it's got a butyl glycidol ether in it-pretty tough.

ED : You might want to know why I used epoxy instead of polyester. Well, if you buy it by the 55 gallon drum the cost equates with polyester in the one gallon cans so that was one way of rationalizing it. Secondly, I was working on premises owned by other people, and they didn't want the fumes that are normally associated with polyester. Another reason why I used epoxy was that this was a one-man operation and I could only work four hours at a time -- a short while. I needed a plastic that had good bonding strength. Therefore I selected epoxy.

JWS: Would anyone have a comment on a letter I received from England recently? They tell me that over there they've had very poor results in bonding epoxy resin to polyester systems. I've experimented with this in my own shop and have had no difficulty whatsoever with proper preparation of the surfaces.

MEADE: It depends on the epoxy. Some systems won't work very well, and others are excellent. Ours works pretty well.

JULIAN WHITENER: I just want to say that if you eat mangoes, stay away from

polyester resin. You get the worst rash that you've ever had in your life.
BOB CONOVER: I'm using the WEST System and I have had no problem with the epoxy adhering to the polyester.
JWS: As long as I get the waxes off, I never have any trouble.
MEADE: You actually get a chemical bond between the two. There's really a nice linkup.
BILL O: Jack, from what I understand, we don't ordinarily recommend it. I'm not sure exactly what epoxy Meade is using but we have run into one problem. The most active of the epoxies make the best bond and as a result the allergenic reaction is pretty high as a general rule. So, therefore, we've stayed away from this although we realize you can get a good bond. We either go all the way usually with either epoxy or polyester.
JWS: There is one good application of this combination but it's not a boatbuilding application. If you leave a boat in the water too long, or if you use the wrong kind of bottom paint, the barnacles will eat off the gel coat. Epoxy resin is a very nice method of reskinning the boat. I found it works very, very well over a polyester system, where you can actually see some of the cloth, before treatment.
BILL: One of the dangers that we've run into using epoxy repair on a polyester boat is the difference in the modulus of elasticity of the two materials. The mechanical properties of the two have actually led to secondary failures. We have a case right now on a high speed power craft where a secondary failure occurred on an epoxy patch because of the difference in mechanical properties.

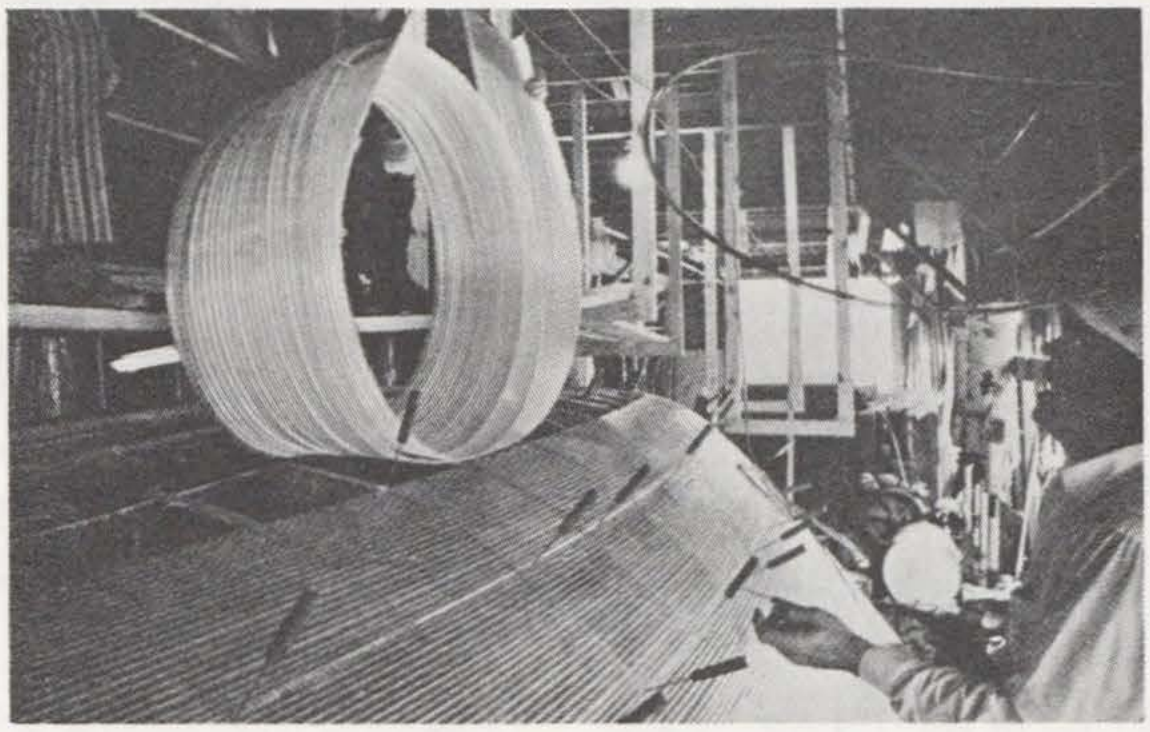


Fig. 9: C-Flex fiberglass planks being applied over framework.

ROSS CARTER: I just wanted to mention my experience with the WEST System. My only concern was using asbestos. I helped build a 47 ft. cat, not yet completed, using end grain balsa. At times we were building with six layers of cedar and at others using balsa core and two layers of cedar on either side. When working with the asbestos, we would use a mask. After learning from Walter Cronkite one night that even a small amount may be fatal, I became concerned about it. The inside of the hull is red cedar and when finished it's gorgeous. The wood is $250 per thousand sq. ft. so in the boat that Bob Conover is building (Buccaneer 40) the cost of the wood is very reasonable at just over $1,000. In addition, you are going to use seven coats of epoxy at 11¢ per sq. ft. I think it becomes quite economical and it certainly is strong. You can drive a car on it.

BARNETT KENNEDY and WILLIAM OSTERHOLT: C-FLEX

BARRY: Bill Seemann sends his regrets that he can't be here. He would have liked to come but is out of the country.

JWS: Barry is Vice President of Seemann Plastics which manufactures C-Flex materials.

BARRY: Bill Osterholt and I are going to do a little song and dance here. I'm going to talk primarily about construction procedures and the nature of the material itself. Bill is going to go into the engineering aspects in more detail so we're going to alternate basically between the two as we talk about C-Flex. This sample is a survivor of the Miami boat show. This is the light-weight C-Flex material. It is primarily a unidirectional material and its uniqueness lies in the fact that it supports itself over a long span. With the light-weight material we recommend a maximum of 14" (35.6 cm) unsupported in the level plane to avoid sagging. On the heavy material we recommend 18".(45.7 cm) The light-weight material is about ⅓ lb. per sq. ft. and uses about ⅓ lb. of resin per sq. ft. The heavy material is about ½ lb. and uses ½ lb. resin per sq. ft. so you get a 50/50 glass to resin ratio. C-Flex is all fiberglass. The rods are GRP-pultruded fiberglass rods 1/16"(1.6mm) in diameter for the CF-39. You can see the extreme shapes this sample will take. I've got a compound curve here over my knee so it's obviously very flexible and will conform to compound curves in a hull. This is due to the bias in the material. The fill strands between the rods make it flexible and pliable so that it can handle the difficult shapes that you find in all types of boat hulls or other structures. Boats aren't the only application of the material.

BILL O: I might mention that as a result of the basic stability of the material, its inventor, Seeman Plastics, was originally looking at this purely as a means of making one off production. It is now being used in the production shop for the construction of plugs and for prototypes, etc. It is much cheaper than a cavity mold for one-off, since you don't have to build a plug and so forth and as a result of that, it has broadened out to encompass a number of applications in which it's showing its advantages with respect to strength and other engineering properties.

JACK STODDART: Do you have to put it on in several layers? With all the fibers running in one direction, you only have strength in one direction.

BILL : We will answer your question next in our discussion of structure. Basically it's very rewarding to hear these other gentlemen up here. We all started out many years ago when we went through an evolution in thinking where we all reached a point of realization that (particularly in ocean racing,) strength to weight ratios were so important and stiffness was the key to the whole operation, not just strength. And then we digressed to our own preferences with respect to building methods and now we have two very efficient construction systems in which we provide stiffness in a boat hull for a reasonable weight. I think the common denominator here is the plastics industry because in one case we are using resin and fiberglass material and in the other wood and epoxy. The plastic is both a molding agent, and an actual structural component. In any structure you have two situations. You have the basic material properties and you've got the basic structural properties of the vessel, the framing systems and so forth. You can look at it from the standpoint of the material properties and you can look at it basically in the sense of the whole structure itself. When you get into bigger vessels, it is a "hull girder" and it acts as a beam. For certain types of smaller vessels, and as a result of the high backstay loadings Meade is talking about, and some of the seaway conditions that these boats are being pushed into, you also get this "Hull Girder" beam action. So, as a result, your basic hull is one part of a beam, your deck is another part of the beam, and they all work together. If one part separates, then obviously you don't have the beam anymore - you have failure.

C-Flex is very much directional because of its character (rods, etc.) as are most materials in boatbuilding except aluminum and steel. Glass reinforced plastics are all orthotropic, i.e. the properties such as strength vary according to direction. As Meade pointed out, we have tremendous headstay and backstay loads; therefore, longitudinal stiffness is a very important factor, and this longitudinal strength characteristic of C-Flex can be utilized for maximum stiffness. Torsional stiffness is also important and we build for it. C-Flex with the rods running in one direction, obviously will provide this longitudinal stiffness as far as the character of the overall hull goes.

BARRY: In the framing of a C-Flex boat, you can either build over an entirely temporary framing system over permanent bulkheads and stringers. In building over permanent framing, when you have completed your entire laminate, there is no chance of distorting your hull. You have all your structural components bonded into the skin from that initial layer of C-Flex. Temporary framing is especially good for smaller boats which do not require a lot of structural stiffness. In this technique you tape the edges of the frames so you can pop the hull off the frames without the resin bonding to the wood and then reuse that framework to build another boat. There is an advantage for a limited production shop or a backyard builder who gets his neighbor in to help him build the framework, which both then use for two boats. With the permanent framing system we generally recommend that you build over it instead of having a bunch of temporary station molds. You build over your permanent bulkheads and then run fairing battens fore and aft longitudinally across your bulkheads. Assuming the bulkheads are on six foot centers the C-Flex needs support every 18 or 14 inches. So you run your fairing battens across the bulkheads and then use stock wood lathing, the same material that you use to build lattice work, for your 18 or 14 inch on center supports. In this sample laminate (example shown) there is a permanent longitudinal stiffener that would be included in the initial framing and across it we have run these wooden laths on 16 inch (41 cm.) centers.

QUESTION: Is your stringer itself fabricated of C-Flex?

ANSWER: Right. It is molded over a couple of shaped 2 x4"s to shape covered with waxed paper so you can pop it right out. A one oz. mat and 18 oz. roving are placed on top of the C-Flex. C-Flex is a good material to use here as well because of its high unidirectional strength. The rods increase the stiffness and strength of this stringer considerably, much more that a woven roving laminate over the section.

BILL: With respect to that stringer section, and structures in general, these designs are a result of high impact pressure loading experienced on high speed planing boats during the Vietnam War. Longitudinally framed vessels with a floating transverse framing system became at that point a very important means of maintaining strength and stiffness in the hull. This has been commonly extended into the naval architecture of high performance sailing boats of today. The conventional system of building, in a cavity mold, has one drawback. It becomes very expensive to insert a longitudinal framing system into a hull that is already built. So either with the WEST System or with C-Flex you can go ahead and build up your transverse bulkheads and then run these longitudinals, which are also prefabricated, the full length of the hull. You can do all this before any of the hull laminate is started, so as a result this C-Flex, as with the WEST System, lends itself very much to a longitudinally strengthened vessel which is so important because of the stiffness and light weight requirements of modern ocean racing craft. All these things can be applied to cruising boats. It costs you money to drive an extra pound around in the water, so why do it? The other factor is that one of our considerations in the layup procedure is primary and secondary bonding. When the heavy material is wetted out from the outside it does leave a little bit of the white cloth showing through on the inside. So when you turn your hull over and start your layup on the inside you can tie the whole thing together very effectively with a primary bond to the free cloth that is showing on the inside of the hull.

JWS: It sounds almost as though you're going to a Lloyd's system of scantlings, fiberglass boats with longitudinals.

BILL: Yes, only as far as our resin contents and quality control, we far exceed Lloyd's.

JWS: I mean in terms of longitudinals which you don't see in American boats.

BILL: That's right. We will certainly see a lot more, and in our more expensive light-weight, extremely high performance boats, we are now seeing them longitudinally framed with floating transverse bulkheads or floating transverse framing systems or just water-tight bulkheads.

QUESTION: The battens that you show adhering to the inside of that form; at this point how do they contribute to the strength of the structure? Are they for the forming purpose?

BARRY: They are temporary framing.

QUESTION: Once it's been impregnated do you require any support on 14 and 18 inch centers?

BARRY: No, once the skin has been completed, it's a matter of structural design. On the C-Flex itself, we recommend that you use it in the fore and aft direction due to its (unidirectional) reinforcement of those critical stress areas of the hull. Another advantage of this is the material itself which acts like a bunch of long fairing battens because of the rods. When using a full length piece to cover your hull, you can quickly distinguish unfair sections of your framework. It's important to make sure that you get your frames as fair as possible instead of leaving the fairing for the final stage. There is a considerable savings both in time and cost, if you keep an eye on fairness throughout the whole construction. In applying the C-Flex to a hull, you use one layer of the material (one foot wide), and lay it over the transverse battens. You butt the end rods of the two planks instead of overlapping. They're butted in side to side and attached with 3/8 inch narrow crown monel staples. Usually only a minimal number of staples are needed; one over the outside rods of each plank; however, at the stem and transom and in areas of concavity, you use more staples.

JWS: To clarify that a little, do you mean you staple from the end of one rod to

another with a leg of each staple in adjacent rods?
ANSWER: No, you staple over a single rod. C-Flex comes in 250 ft. lengths. When you apply the material you do so with no overlap. This would create an unfair area which would have to be sanded down. The staples which are an eighth of an inch wide straddle the rod so that the rod is the same width. When the material is on the hull of a round-bottom boat we usually start at the sheer or at the keel or center-line and work in one direction. On a hard chine boat, you start at the chine and work to the centerline and down to the sheer. When the material is applied, we recommend a marble casting resin on the C-Flex itself. It has a relatively low styrene content, and when the resin cures, there is minimal shrinkage. It's a resin used to fabricate artificial marble bathroom fixtures and moldings. We found in round bottom hulls that, between frames and battens supporting the material in this round section, with a general purpose laminating resin, you get shrinkage and a flat spot betweeen these two frames. The frames will hold it out fair, but the area in between will sag. With casting resin, you maintain a fair surface on the hull.
BILL: Now, as a result of what Barry has been talking about, we have basically a hull formed up and, to the lofted dimensions, on top of the bulkheads and longitudinals. Because of the unidirectional strength of C-Flex, most of the time you lay the warp of your woven roving 90 degrees to the unidirectional cloth. That means that with your standard woven roving in the direction of the fill you've got about 84% of the strength in a test laminate. In the longer thread direction you have, of course, 100% of the strength. By laying the cloth transversely to the direction of the C-Flex you build up transverse strength along with your longitudinal strength.

One problem we have at present is that of diagonal stresses which is what Meade has been talking about. These stresses are more predominate in multihulls and therefore using C-Flex in a multihull system is very simple but be sure you get the right engineering. We do get diagonal stresses as a result of torsion in the bigger boats, particularly in big cutters where all the chain plate loads are further forward than in two-masted vessels and you get a tremendous amount of torsion going into a hull as a result of these shroud loads. In those cases you have to get into the engineering aspect and in the most extreme case you would lay the cloth at an angle which is very similar to Meade's work with wood.

Another important factor is how do you use the C-Flex in composite construction and what are its advantages?

The C-Flex laminates that have been tested have about 50-75% more modulus than the standard laminate, which means that if you are going into a composite construction with aluminum or some other higher modulus material, you can go ahead and possibly get away a little better with C-Flex construction than you can, let's say, with straight layup or wood construction. As you all know, when you get into composite construction, you have to carefully watch your design. The basic characteristics of the materials have to be married together so you have a hull that will not fall apart. It's easier to do with C-Flex.

What we're really saying is that we are now designing the beam, the panels, and the entire hull to take the greatest advantage of the properties of the material.
BARRY: I would like to emphasize the importance of using a squeegee. We use long metal squeegees to help fair each layer of laminate as it goes on - each mat roving as it goes down (or each milled fiber/roving or a mat/cloth or a milled

fiber /cloth(. This gives you not only added fairness but also a better glass to resin ratio. In a boat built by this technique you get rid of a lot of excess resin and get a much stronger hull for its weight.

BILL: This is very difficult to do in any other type of fiberglass layup. High resin contents are extremely damaging to the total strength of the laminate.

JWS: You might just as well hammer an obvious point for everybody's benefit, that the resin doesn't do any good at all.

BILL: It has very little strength and resin contents should be about 40% of the total laminate. Isn't that right Meade?

MEADE: It helps a little bit. It depends on what kind of resin you've got. We use resin with some flex in it and this reduces the strength. We realize that a boat is not a totally rigid structure and you had better have it a little bit flexible so consequently you have to give up some physical properties. But you can get epoxies which have some pretty high qualities.

BILL: I think Jack's referring to polyesters. Some people are unaware that there are several types of resins both flexible and laminating. You have to be very careful where you use your flexible and where your laminating. There are sometimes problems in production boats where laminating resins get into the gel coat and you end up with crazing all over the hull.

JWS: Two things. One, because of a common misapprehension, I would like to repeat a point briefly mentioned earlier about decks. The deck itself is just as important a part of the structure as the hull. It has to be there. And yet, I've seen published articles by people who ignore this or ignore the center of gravity problem. My second question is that you mention multihulls and C-Flex. I do worry about the weight. At about what minimum size, roughly speaking, does C-Flex become applicable to multihulls?

BARRY: In comparison, for instance, with a canoe, where weight is fairly critical, I have built several C-Flex canoes and found the weight is comparable with standard fiberglass laminated white water canoes and lighter than aluminum. A 16-½ foot (5.0m.) canoe had the light-weight C-Flex, milled fiber paste, and 7-½ oz. cloth on each side of the C-Flex. Its hull weight was right around 56 lbs. (25.4 kg).

JWS: What would that be per square foot?

BARRY: This was about0.8 lbs./sq. ft. I might mention that in the canoe the only structural framework it had was a gunwale. I did not have any thwarts, so that the hull shell itself was rigid enough that it did not need any other framing - no keel.

BILL: You cannot ignore the deck. I think one of the reasons is that naval architects in the past have considered 60 ft. as a break-off point. What I mean is that with anything over that you consider the hull as a girder. Under 60 ft. you do not have much bending of the hull as a beam. So, from a design standpoint, as Meade so aptly pointed out, we're putting tremendous loads on these hulls.

It's just like a bow, and as a result, you can no longer consider a small hull as having only sea loads. They have hydrodynamic loads and also static loads that are fantastic. As a result, the hydraulic backstay manufacturers are issuing backstay values for certain types of boats because some people have either driven the mast right through the boat or busted the hull. They just go out and start cranking that backstay up and that's it. You can only design up to a certain point.

You can't cover all contingencies. Obviously we do now have a bending moment situation. We have a 56 footer (17.1 m.) on the board with end grain balsa decking tied into a box girder on each side. So we can't get away from wood.

QUESTION: You touched on one point, and that is where you gain the most strength when it comes to stepping the mast. Did you assume purely in terms of stepping on deck?

BILL: No, what I was really referring to was considering the whole hull as a unit, beam. Considering the deck, sides and bottom as a square tube. The deck would be the top of the tube, topsides the sides and bottom, the bottom of the tube. What we were referring to was the total load imposed on that whole system, so what we're looking at is a system reaction, not just a deck or hull reaction.

BARRY: On the laminate, again as I say, for fairing purposes, we squeegee the laminate then move on into the final fairing procedures. In most cases we finish the laminate with a fairing mat except where weight is critical and then use glass microspheres as the fairing compound mixed in resin followed by a high build polyester. This laminate is a section from a typical 30 ft. (9.1 m.) sailboat. It has 3 one oz. mats and 18 ox. rovings as the exterior laminate. The interior laminate has one mat roving laminate on it with no fairing mat on the finish. For a 34 footer (10.4 m.) this would be about 2.4 lbs./sq. ft. as a light-weight layup. On the fairing procedures, the glass microspheres are slightly different from the phenolic microballoons. We found that the microspheres troweled easier and sagged less with a good mixture and sand easier and did not clog the paper as much as microballoons. Instead of using sanding machines, we use foam glass which is actually a rigid insulation material. We take blocks of this and abrade the microsphere surface. The foam glass is porous, like pumice, and it actually cuts down the high spots in the hull without digging into the low spots. A grinder would be indiscriminate. It would take the valleys as well as the high spots. Foam glass goes across the microspheres and takes a fair shape across it. It is done by hand at the rate of 4 or 5 sq. ft. per man hour. On a hull like this which is about 300 sq. ft., (28 sq. M.) a good commercial finish can be achieved at 10 - 12 sq. ft. per man hour. This includes application of the polyurethane paint. Now on a plug finish which is a virtually perfect finish, you'd expect to spend more time, say 1 sq. ft. per manhour, which means with a 34 foot hull you'd spend about 380 man hours on the plug. Another helpful tip is that after troweling on the microspheres we spray the surface with a dye mixed in acetone. As you use the foamglass blocks to bring it down to a fair surface, the dye remains in the low spots in the hull. You see where your dye is and can go back and do localized filling. Thus, you avoid the time-consuming use of fairing battens on the hull. We then use a high build polyester spray paint to fill the scratches and remaining low spots in the hull, and we go over that with a slow speed sanding maching with very fine grit paper. Finally we spray on polyurethane paint which gives a very good finish on a hull.

BILL: You'll notice that there is not a gel coat on the C-Flex sample. You could have gone ahead and put a gel coat on, but now most hulls I am involved with are simply painted with ALLGRIP or IMRON or any of the polyurethanes. They do have a toxicity problem which you must be careful about. Fairing the hull is the most tedious part of the whole construction. To give you an example, I just built a 24 footer (7.3M.) with a very experienced man. We set up the frames and put the laminate on the whole boat in two and a half days. Fairing was another 3-4 days.

So what I'm saying is that with good people it is very, very quick. But the work involved in fairing the hull has been one of the biggest criticisms about C-Flex. The WEST System may take longer to lay up but less to fair, so you probably come out about the same in the end.

BARRY: I might mention that the 24 footer was a commercial fishing boat built in New Orleans. The ¾ ton SOLENT SARACEN which was the World Cup winner in 1975 is an interesting example. Her owner wanted the boat built and delivered in six weeks. When no one would take on the job he decided to do it himself. He was a house builder and he finished the hull structure in eight days, and the entire boat in six weeks. It obviously did not turn out too bad because he won the championship. Since then he's built three one tonners.

The 1974 winner, SWAMPFIRE, was also built of C-Flex. Her displacement was 9,250 lbs. (4196 kg.) Of this, 5,000 lbs. (2268 kg.) was ballast, so you had a better than 54% ballast ratio. The people that sailed on her were impressed in rough weather with the quality of the laminate. SWAMPFIRE had a completely different sound when she fell off a wave. It pinged a little, like metal rather than the dull thud of the conventionally built glass goat. There was a very high glass content in her and she had very good strength and stiffness. The hull weight was right around 880 or so lbs. (400 kg.)

QUESTION: What did you do about diagonal stresses, if anything?

BILL: We're at that point right now with respect to development. Over in England they've been using C-Flex quite a bit. Diagonal stresses in high speed planing craft have been measured by using strain gauges in the hulls and, as Meade has pointed out, there are tremendous diagonal stresses that go into a hull which have been over looked in the past. Fortunately, most of the overdesigning that has gone on in small boats has been enough to counteract this. There are several proposals. Number one, is to use unidirectional on a 45°, or some pre-determined angle.

QUESTION:

If it was laminated on the inside of the hull at 45°, it would solve your problem, wouldn't it?

BILL: Not necessarily. The only reason that worked before, like with Herreshoff's scantlings is that for diagonal strappings he used steel. With its high modulus if there was any deflection the steel would take the load. Another solution as previously mentioned, is to lay C-Flex at 45 degrees. With one high speed power boat there was talk about running this at 90 degrees. The basic unevenness of C-Flex can give you bonding problems, so you have to use a heavier mat. In addition, you get into hard bilges and high shape areas which represent another problem. So far we have not had that type of diagonal stress failure with C-Flex , as far as I know.

JWS: Would you feel like commenting on recent articles on building with C-Flex ?

BARRY: Proven fairing procedures are most important. You must keep an eye on fairing through the whole construction procedure from the initial framing through the placing of C-Flex on the hulls, to the squeegeeing of the laminate and on through the final fairing of applying a relatively thin coating of fairing compound on the hull. You can control this by using a notched trowel like a mortar trowel and screeding the coat on with that notched effect and then getting yourself a ¼ inch (6 mm) thickness of the compound, and then going over it with a straight edge trowel and smoothing out the notched application. In this way you don't get serious buildup of your fairing compound. You then finish using the foam glass. We have gotten a good yacht finish on a 36 footer (11.0 m.) with 18 square feet (1.7 sq.m) of foam glass which costs $24.

BILL: One further comment on this diagonal stress business, because there obviously is some concern. Suffice it to say that there is no fiberglass boat out that doesn't have the same problem, nor any boat. The warp of the cloth is the long direction of your woven roving. If that is considered 100% strength and you go 90 degrees to it, it is something like 84% if you go about 45 degrees to it, it is down to about 54%, so what I'm basically saying is you still have a certain amount of diagonal strength along with the C-Flex when used in a longitudinal direction.

JWS: There is another point which interests many of the people in the AYRS particularly and that is cost. Of the three basic systems we have talked about today: WEST, Foam Sandwich, C-Flex. I don't think anyone would argue that AIREX foam sandwich is a very expensive method. Western Red Cedar plus WEST is a rather inexpensive way to go compared to foam. My question is where would you estimate roughly C-Flex fits in?

BARRY: I think C-Flex is competitive with all the other systems and in most cases I would say it is better than competitive. What we have to consider is that in terms of the overall cost of your project, you're talking about a relatively small percentage of that cost.

JWS: You mean the shell of a boat?

BILL Using polyurethane finishing techniques, the cost of the materials runs around $2.30 a sq. ft. for about 2.4 lbs. per sq. ft.

JWS:Very reasonable. I don't know if Bernie has any figures just off the cuff, but the last estimates I made for foam sandwich for this size boat ran approximately double that.

BERNIE: I don't have any accurate calculations. I was sort of thinking here but, I could be wrong. I came up with about $1.75 per sq. ft.

JWS: Of course, that's for a multihull layup - light-weight. I'm talking about a 34 foot (10.4 m.) keel boat.

BILL: It is hard to say that, Jack, because we figure everything on a pound basis.

BARRY: Figure a dollar a pound average.

JWS: Yes, but the average amateur in the AYRS who is thinking about building a boat, and I think we have a number of them here in this room, should know that of course his shell cost is at most one-third of the boat, perhaps only 20% but still he worries about this and he should. And he says to himself, shall I use foam sandwich? Shall I use C-Flex? Shall I use the WEST System? And he must make his evaluation on a square footage basis.

BARRY: There may be another way to evaluate it. Lots of boats are built in lots of different ways and lots of ways work, and it may have to do with what kind of advice you can get on it. In other words, if you have someone nearby you who knows all about the WEST System, has built a boat in this method, that might be a good way to go. If you have someone nearby who knows all about AIREX Foam sandwich, that might be a point to consider. If you have someone who has used C-FLEX or can get good information some way or other, that would be a good reason too.

BOB: I think that is an excellent point.

BILL: It takes skill and engineering for any of this stuff we're talking about. I think if you throw it in the hands of somebody that doesn't know what he is doing, obviously he is going to come out heavy, expensive, and poorly designed.
JWS: However, we do have the case where many laymen go to firms that supply plans and designs for the amateur builder in any medium - every boat - and the poor guy - here he is, he has to make a choice.
BILL: Hopefully, the industry is doing something. I think Barry can answer that as he is from Seemann Plastics. I know that a good part of the Seemann Plastics, (and I imagine a good part of Gougeon's) problems are to educate some of these designers to make sure they put out the right layup, because some of them are pretty bad.
BARRY: Not only the designers but we like to keep track of where the material goes and how it's being used. We want to be available to make sure that this guy's dream, which is what it is, is as successful as possible. We like feedback but unfortunately this is something we don't get very often. When things go good, people don't want to go back to the company that sold them the material or the people who sold them the plans - they're out sailing. When a guy has a problem it is generally the result of a lack of communication. I think it is the basic problem with any of these systems. You have to have the communication.
JWS: I wonder if I may ask Meade a question? You made an effort to get feedback which I was very happy to see. Has it been reasonably successful?
MEADE: Well, one of our problems was, as Barry said, everyone would buy the epoxy and start building their boat and never tell us what they were doing. Some guys would talk to us on the phone. We'd say, well, what are you building and how is it coming along? And they'd give us a "Can't talk to you long. It's long distance and got to get back to my boat." We felt that we really had lost touch. We hadn't. First off, we just got to the point where we had so many customers. In our early days with the WEST System, I could personally keep track of a lot of different projects and kind of know what was going on. Sometimes I would just go out and actually see some of these jobs. I had no idea what problems could arise. I did not really know how well some people were going to build their boats. I used to lie awake nights saying, "Geez. These guys are going to build a boat with the WEST System, and it's going to fall apart and it's going to look bad for us." So we sent out the questionnaire. We sent off 1,400 of them and got 860 back. Boy did we get information. We really got a pile. Although everyone was pretty happy with the epoxy, there were a lot of problems. A lot of people went into great detail about these problems which we then immediately began to try to solve. For instance, we found out that people were complaining that their epoxy would not cure. And the guy would tell me: "Gee, I'm mixing it perfect. It's warm. Everything is right." We'd go back and check our batches to see if there was any quality control problem. We could not figure out why it wasn't curing, until we found out that if you used the Salamander type heater the carbon monoxide from the Salamander got in with the system and completely shut it down. We had a whole bunch of people get in trouble with that. We found that out because eight people had batches of epoxy that wouldn't cure and all used the Salamander heater, in a tent. Aha! We immediately sent out a newsletter informing people that you can't use Salamander heaters. You have got to have a ventilated system. We solved a number of other problems that people wrote in about. Now a new

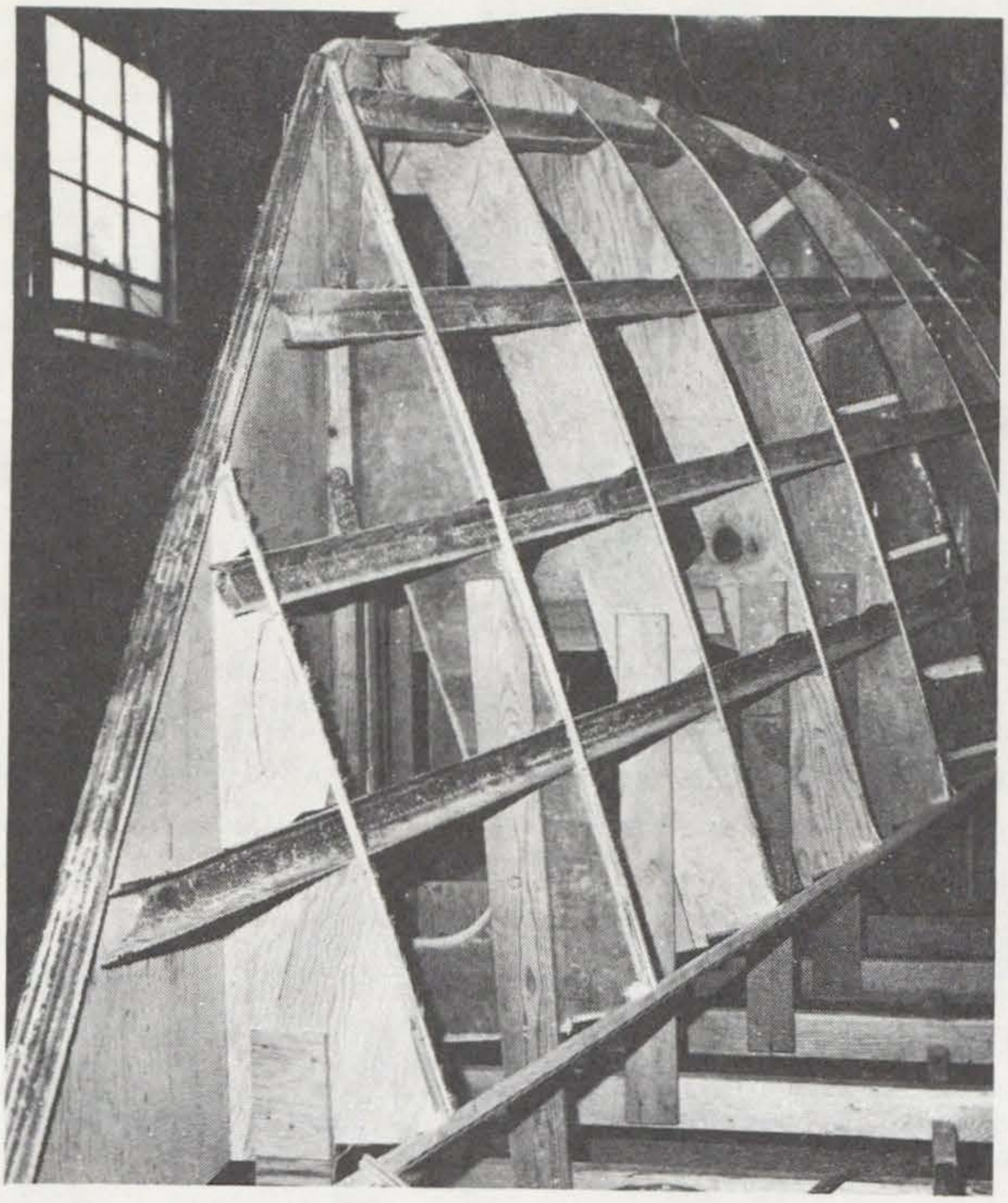


Fig. 10 Framing Ready for "Planking"

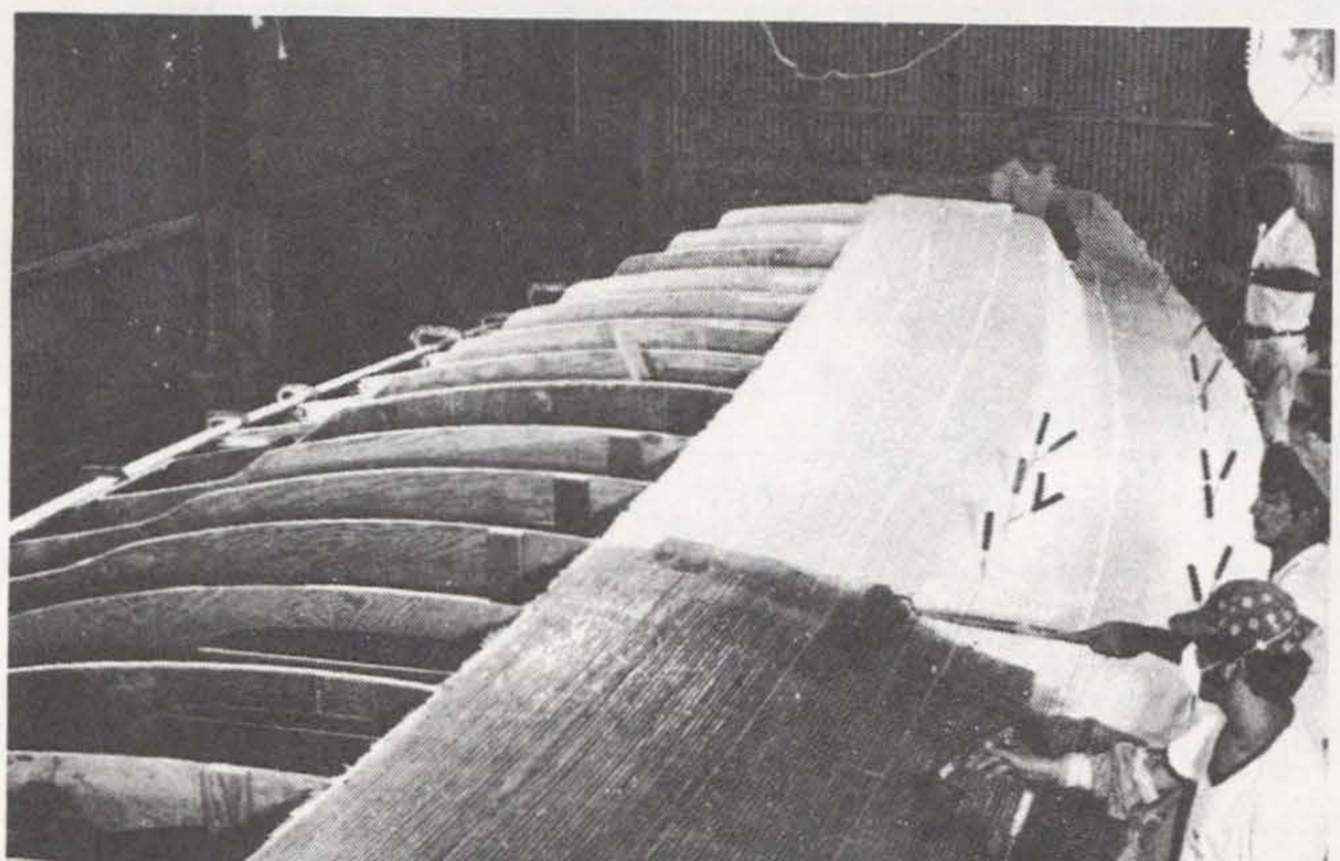


Fig. 11 The Start of a Balsa Core Deck
After the C-Flex is in place, it is wet down with resin.

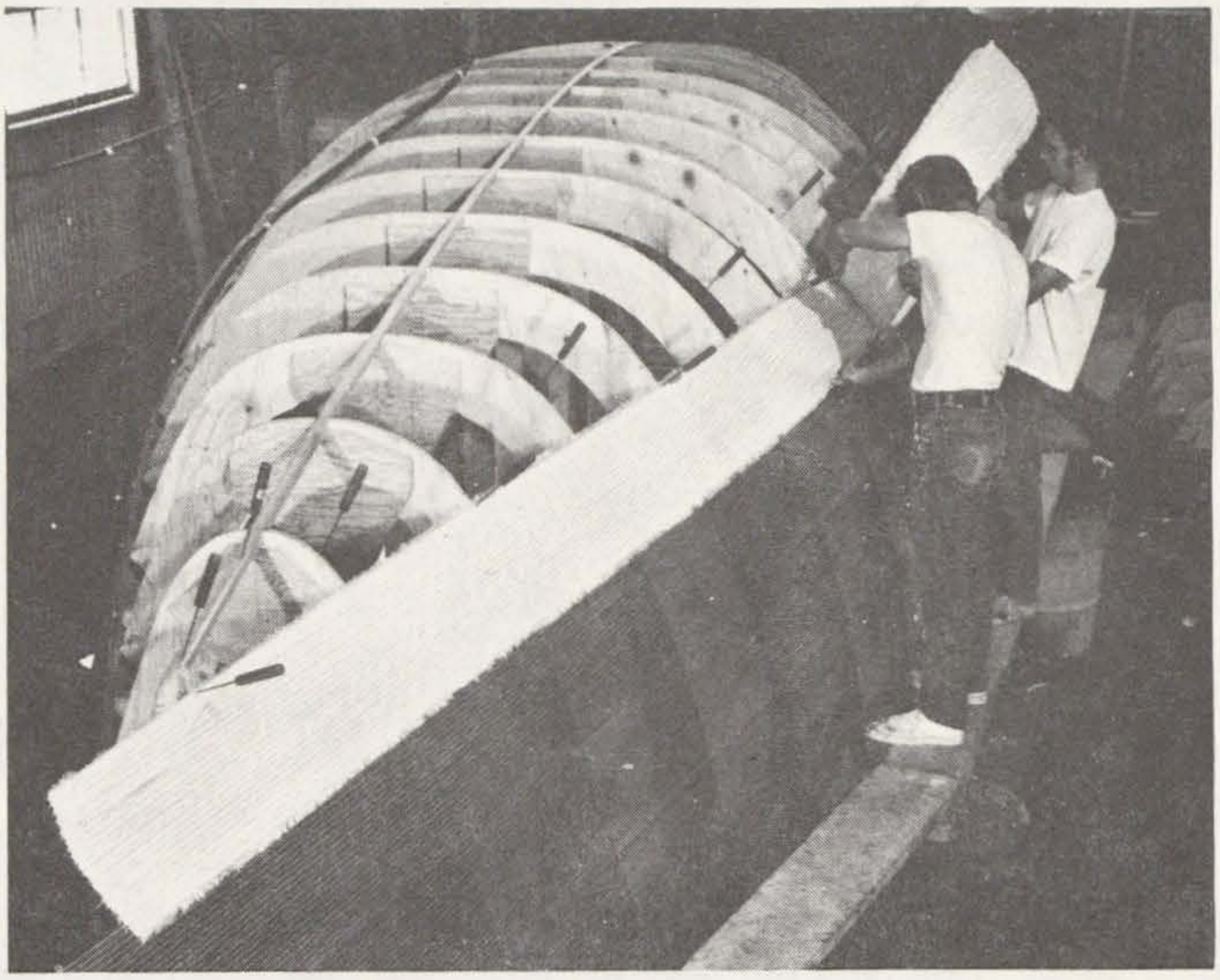


Fig. 12

Building a Plug with C-Flex

This is the first step in building a Fiberglass Production Mold. The plug is not destroyed but is finished and sold as a boat or used as a prototype.

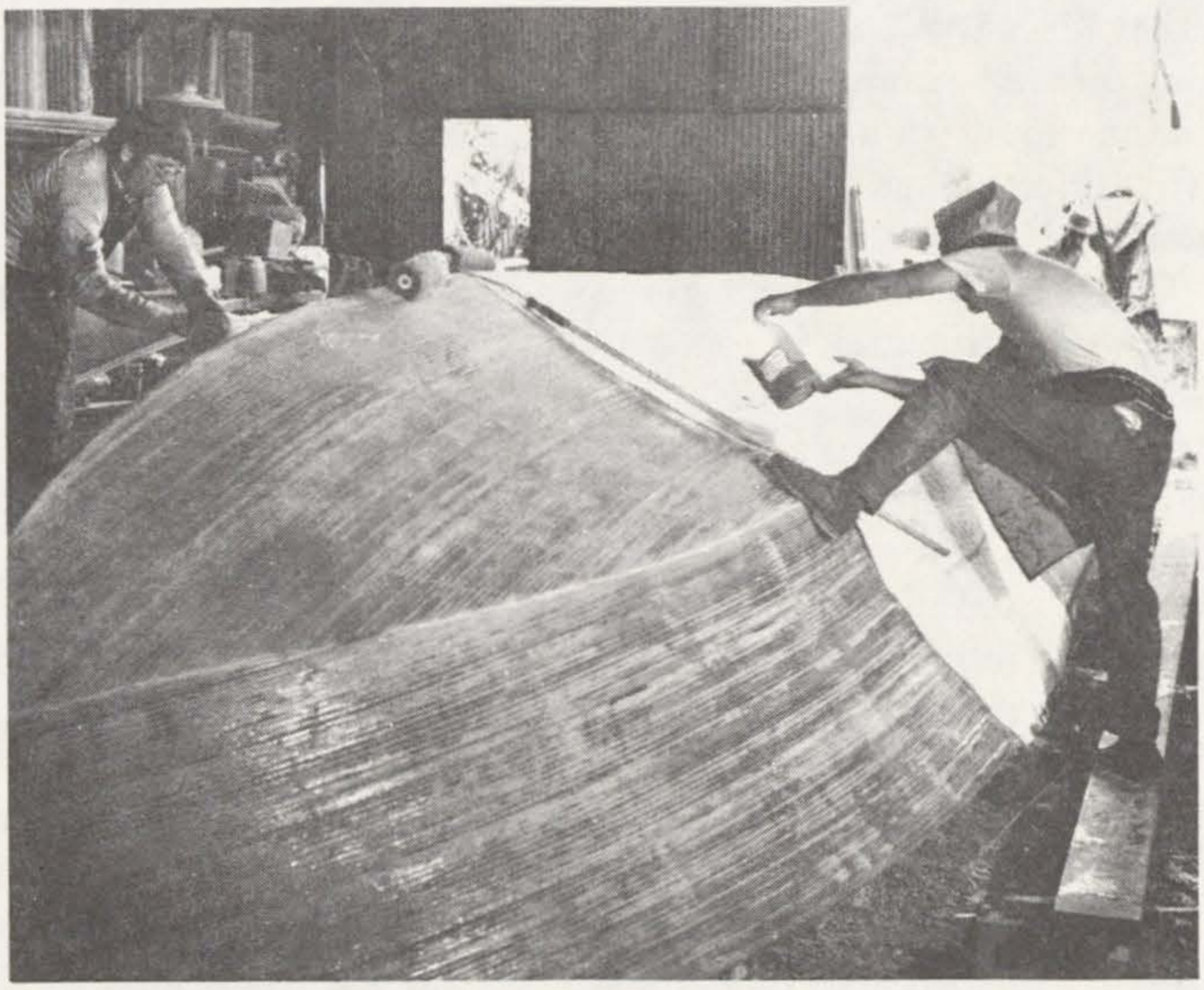


Fig. 13

29 ft. high Speed Fishing Boat

Additional laminations of fiberglass and resin are added over the C-Flex to build up the required hull thickness.

WEST manual is coming out and it's going to have all this information in it. But there's a certain time lag there and you know some people can get into trouble.
JWS: I think that is a remarkable response. Weren't you very encouraged by this? Have you thought of applying that to C-Flex?
BILL: I can speak of Small Ship Systems, a design office. In all honesty, it is just hard, in the South Florida area, with the number of people using C-Flex to follow up on everything. It is just a matter of physical time.
JWS: It was just a little questionnaire, a simple questionnaire really.
BILL: Well, it is just like anything else. It takes time and a lot of us travel around all the time. It makes it pretty tough, even to sit down and evaluate them once they come in.
BARRY: The evaluation is important. If you go to all the trouble to send this thing out, you want to read it when you get it back.
JWS: Ed Mahinske made a very good comment, if I may quote him, about all these things about the designers and the manufacturers of materials for the amateur builder. They may take all the time in the world and many of us do, really. We knock ourselves out to get something designed just right. You calculate your stresses and everything else and the one thing over which none of us have any control is the man actually building the boat. Will he build that boat that way? Very often the answer is no, and there is a failure, and this is poor.
MEADE: I have got to comment on the fact that I am absolutely impressed and totally amazed at the quality of workmanship that about 70-80% of the people are doing. I've gone out and seen some of these jobs, and I mean I've seen a couple of jobs, then I go back and look at the stuff we're doing in our shop and I feel like calling up the guy and hiring him. Now I know that he probably spent three times the hours that we can. We've got $11 a labor hour, and we can't go lavishing love on this thing forever without going bankrupt, but I've seen incredible work. Free labor is the one thing an amateur has going for him. He has a lot going against him. The first thing he has a problem with is lack of information. And I think most people try to solve that,but he's also operating with a zero experience level in a lot of areas. The next problem he's got is a physical facility to work in. This is probably the most difficult. Without having a good shop which is well-ventilated and well-heated and good tools to go with it, you're working at a serious disadvantage. Another one is a combination of not understanding the plans or the engineering or the materials. He has a problem just solving all these little questions that continue to come up. There are literally thousands of them. Boatbuilding is assembling maybe ten to fifteen thousand parts and it's really an incredibly difficult job to assemble all these parts into a boat and make everything work. But the only thing the amateur has going for him is that it is his fanny on the line. It's his macho on the line. It's his creation, and by God, he'll kill himself if it takes that to get this thing done right. It is because of his sheer determination,pure raw guts, and a knockdown drag-out fight approach that he wins. Just because he's got that tremendous desire to do it, and if you don't have that desire, my advice to anybody, if you don't have that real winning spirit, boy, just stay out of boatbuilding because that's the only thing that's going to carry you through.
BILL: If the job is big enough Seemann Plastics will send a man out no matter where it is in the world.
BARRY: We do ask that our expenses are paid, if the guy has to fly in, but we

have worked with amateurs before. We don't have that many requests frankly. But we have gone and helped apply the C-Flex with amateur builders who had no glass experience and who only planned to build one boat.

ROSS CARTER: This is for Meade and Bernie. What would be the cost of the hulls on a 40 ft. (12.2m) 10,000 lb. (4536 kg.) trimaran if built with the WEST System or AIREX?

MEADE: Ten thousand pounds? I don't know roughly what the surface area would be. On a per square foot basis, I think you'd probably be looking at a 4-ply laminate on the main hull and 3 ply elsewhere of 1/8'' (3mm) veneers. It probably would come out roughly somewhere about $1.50 - $2.00 per square foot. It would be between seven and nine thousand dollars just for the boards and epoxy. Now that's a pretty small part of the cost of that boat, but that would be my rough estimate.

JWS: Would that be roughly 1/4 or 1/5 the cost of the finished boat?

MEADE: Yes. All the boards and epoxy for GOLDEN DAZY, which ended up costing $120,000, cost $7,000.

JWS: A lot of this cost information is in Meade's article in the March issue of the AYRS Journal. AYRS 83B.

BERNIE: Like Meade, I'm guessing without knowing what the laminate is. I would say, around $2.00 to $2.25 per square foot for Airex Foam sandwich. I can't give you a plus or a minus on that or how accurate that might be, but that is as close as I can come off the top of my head.

QUESTION: How does that compare with C-Flex?

BILL: I think we're in approximately the same ballpark. I'll be honest with you. I think it might be a few cents more per square foot with respect to some of the numbers they come up with. It is awfully hard to transpose all this because we don't deal in square feet.

QUESTION (TO MEADE): Are you talking about strip plank and epoxy construction?

JWS: Combination of strip and cold-moulded.

MEADE: Did you say a Piver designed 40 tri? You would go with frames and stringers.

CARTER: I would prefer to have an interior similar to that of an AIREX main hull.

MEADE: Well, you could build a simple lath mold and build up, say, to a half inch (13 m) using four laminates of the eight inch (3mm) cedar. This would give you a very rigid hull, at about 1.2 lbs per sq. ft. You might want to build a fairly good sheer clamp and maybe one or two longitudinal stringers. The only problem would be the bow area with its large flat area. I think you've still got to go to some sort of frame work up there. However, you would not need any framework in the rounded turn of the bilge. You would have all the stiffness you'd ever want.

BOB: This particular design uses foam ribs up forward.

QUESTION: Is this diagonal strip plank?

MEADE: Yes. You'd want to run the diagonals approximately at 60°. We've got a chart worked out to where 45° laminates give you 50% strength thwartships and 50% longitudinally if you average out the strength figures of the two. But with GOLDEN DAZY we had some veneers running at 60°, some at 50° and some at 30° because we anticipated that these diagonal loads are not right on the 45° line. Right now we're building Tornado cats and we're running the veneers at 27-½°

up from this angle because their longitudinal problem is much greater than the thwartship strength factor so we adjust the veneers to pick up whatever the anticipated loads are.

DAN BISSELL: Jim Brown, in his Searunner series, uses the WEST System. Would that cost per square foot or pound fall a little lower than what you've been estimating?

MEADE: It depends on the local cost of plywood. That's the whole name of the game. I've got a source for Finland plywood that I'm going to try to make available to everybody, and am shipping it in now. My cost is like $11 for 5 ply ¼" (6mm) with Gaboon outer layers and spruce inner cores, and $13.50 for 3/8" (9.5 mm.) 7 ply gaboon outer layers. It is beautiful stuff, really nice.

JWS: Is this the BSS 1088 or equivalent?

MEADE: It's the SS veneers with the Type 2 bond. They have a funny rating system over there, not the British or ours, their own. It's equivalent to our type 2 bond. It is not sold as marine plywood. It is what they call their type 2 veneers which on outer plies are type 1; which are gaboon and they allow knots that are 3/4 inch diameter which is something like 19mm. on the inner plies. We use the material and you can hardly ever find a knot and there are no voids at all. I just received my latest price list from Harbor and I was really disturbed to see that 3/8" ply was going for about 85¢ a sq. ft. However, that isn't too bad when compared with the cost of veneers. We can buy cedar veneers for 20¢ and the top grade veneers at 25¢. So three laminates of cedar would still be 75¢ plus the cost of the glue involved, so plywood is still cheaper, even buying it from Harbor.

QUESTION: How do you feel about using the lower grade of plywood with the WEST System?

MEADE: I can't justify it. I think it's really dumb and here's why. Let's assume you've got a multihull and you're going to pay $20 a sheet for plywood - pretty good stuff. In a Brown 37, I think it takes 100 sheets roughly, and so we have $2,000. Then you're going to go and buy A-C plywood fir production grade for $10 per sheet. So you've saved $1,000. Now you've got this Brown 37, that if you came to us and we were to build it, you're looking at a $70,000 bill minimum, because that is what the boat is worth when it is professionally built. There's no way you can get us to build that for less than $70,000. So what's a thousand bucks? It's just dumb. It doesn't make any sense at all.

JWS: And you have something you really can't trust if you're out in extreme conditions.

MEADE: Through the questionnaire we found out that people were having problems with fir plywood and the WEST System. As a result I really began to get into this and I called up everybody I knew who was making plywood or who knew anything about it. I found out the difference between marine plywood and A-C plywood. The first thing is just the quality of veneer. Now with good marine ply they select a better log. Then they soak that log to 100% moisture in a soaking pit so that when the veneers are peeled off they aren't cracked. With A-C you buy precracked plywood. It's already cracked and has checks all over it when you get it. These cracks run all the way through and there's no glue or anything in those crack voids.

JWS: I've measured voids in AC which run the entire 4 ft. width of the sheet in one of the plies up to 3/8" wide. There's no way you're going to plug that.

MEADE: You can buy some good exterior. Once in a while someone goofs up and you can buy some good stuff. They happened to have some good logs that day and the guy is feeling good who is putting the veneers in there and so on. I've seen some beautiful stuff but you can't count on it.
JWS: Would anyone care to comment on a phenomenon that started a few years ago - of using door skins as a veneer for hulls? I had a Weyerhauser man come out a few years ago and we talked about this. He told me at that time that all of the door skin wood made in this country used non-waterproof glue and in fact two boats in our area using these for the hulls fell apart. However, I know that perhaps 20 or 30 boats have been built in the past few years using very cheap door skin wood, and perhaps some domestic door skins now use water proof glue.
BILL: Years ago, in 1955, a fellow built the first cold moulded boat I'd ever seen. It was very similar to the WEST System, but he used resorcinol glue. He laid it up on the diagonal using doorskin and he was getting failures because the grain selection is not what it is in plywood. You have a random grain in doorskin, and obviously you don't have the strength, because of the very directional type of strength wood has. So, as a result he started having failures in the wood.
JWS: That is my feeling, too, but there is a widespread use among amateur builders primarily in California, but some here in Florida, too.
MEADE: Some time ago lumberyards stopped stocking interior plywood. They found out that the cost difference in the glue between interior and exterior was not as much as the cost of stocking two types of plywood. So most plywood made in the U.S. now is made all of exterior glue, which is type 2 bond, which is pretty good.
LELAND HARDY: I'd like to ask Meade a question about plywood sheets. Is there any company that makes impregnated plastic ply under pressure?
MEADE: The best thing you've got is the MSO or HDO, a medium density overlay which is a phenolic film in kraft paper. They put it on with heat and pressure. MDO has been used for years in your better-built boats such as Chris Craft and Owens. It's pretty successful except for the end grain which is unprotected against water damage. But it has a very stable surface on the plywood and it was the thing to use. Harbor still sells it. It is used as a cement form material primarily so that the conrete won't stick to it. We are seriously looking into the potential of manufacturing plywood and we're looking at it from the standpoint of many things. I think that the whole marine plywood industry has a tremendous hole in it; from the standpoint that the volume is there but nobody's marketing for it properly. There is a tremendous demand for good wood and it's set up for a killing. If anybody wants to get into the marine plywood industry they can do very well. Weldwood and all of the big guys are not interested in this small volume stuff. It is going to take a small tight-run company. Marine plywood is not difficult or expensive to make. Sanding it is the most costly part of the production process. If all you guys wanted to sand your own plywood, you could buy it really cheap.

EDITOR'S NOTE:

I have been asked to comment on the problem of sheathing hulls in synthetic fabrics. I have personally done about 2,000 sq. ft. (186 sq. m.) of sheathing using fiberglass cloth and tape and both polyester and epoxy resins, over fir marine plywood and Utile mahogany type marine plywood. I have never had any difficulty with the glass peeling from the wood for the portions where polyester resin was used after some four years or so, but it should be emphasized that *surface preparation is all-important*. All wood surfaces should be roughened by sanding to remove all waxes and the sealed condition in which plywood surfaces are usually found. Next, the plywood is soaked with a coating of polyester bonding resin thinned way down with styrene. Then and only then is the actual fiberglassing process begun.

Clearly, epoxy has far better adhesion than polyester, and rather simple shop tests will show that the latter is a poor glue. However, polyester resin presently enjoys about a 2:1 cost advantage, and if *finish resin* is used as the last coat, sanding is not difficult. However, epoxy enjoys clear advantages in: adhesion, strength and flexibility. I would urge the amateur and professional builder to be very certain that the epoxy he uses is suited to a marine environment - there are many formulations around. I do not know of any simple tests and think probably it is better to go with proven brands than to take a chance on a local product. In Europe, I understand that Ciba has produced a good epoxy resin-hardener system, but I have as yet had no opportunity to test it, in the elementary ways I employ.

In the U.S.A., there are four common systems of sheathing wooden hulls known to me, while an English firm produces a nylon material used in the so-called Cascover process: epoxy only in three or more coats as in the WEST System, fiberglass plus epoxy or polyester resin, dynel with either resin, and polypropylene (Vectra) with either resin. Fiberglass is rather brittle. As Bill has said, if impact is a prime design consideration, dynel would be a good choice, and where peeling might be a problem, polypropylene should be best. The approximate relative peel strengths to pine wood of: fiberglass reinforced plastic: dynel: polypropylene are approximately in the ratios of: 1 : 3.7 : 4.2. Dynel has excellent abrasion resistance, polypropylene is good, and fiberglass reinforced plastic is fair.

I concur that there is not much point in trying to save a few dollars by using exterior grades of plywood vs. marine. In addition to much-relaxed void tolerances, the wood species used in the interior veneers in exterior plywood are often of relatively weak and rot-prone woods. Surely it is poor economy to purchase such for hulls and decks and other high stress areas for boats that may go offshore.

There was some discussion at the panel meeting on how the individual could test unknown plywood as doorskins himself to ensure that they would not delaminate in time from use of cheap adhesives between the veneers. According to PS 1-74, the National Bureau of Standards Boiling Test consists of boiling specimens prepared in a prescribed way for four hours, dried for 20 hours in an oven at a temperature of 145° F to lower the moisture content to a maximum 8.0% by weight. It is boiled again for four hours, cooled in water, and tested while wet by tension for loading to failure. Other tests include: vacuum pressure, vacuum soaking, heat durability, scarf strength etc. Some have complained that they have purchased marine plywood which subsequently delaminated. It is important to be certain that what is sold as marine plywood actually is of that grade. In the U.S.A., fir plywood is usually edge branded: BOAT HULL A-A and has a red painted stripe as additional identification.

Write: American Plywood Association; 1119 A Street; Tacoma, WA 98401 and request copies of their booklets: "U.S. Product Standard PS 1-74," (latest edition) "Guide to Plywood Grades," "Plywood Properties and Grades," and "Plywood Design Specification."

KEVLAR STANDING AND RUNNING RIGGING

Until the stayless mast is a routine reality for high performance ocean-going yachts, perhaps kevlar (tm) rigging will be an intermediate step. Phillystran (r) is a non-metallic rope and cable which is a composite of kevlar-aramid and polyurethane (to improve chafe resistance). Advantages are:

1. Strength to weight ratio is five times higher than steel in air and 30 times higher in water. (Tensile strength - 300,000 psi.)
2. Equal diameter Phillystran is stronger than steel but has a higher breaking strength and is flexible as rope.
3. High modulus of elasticity (9.5 x 10^6 psi) and low elongation (3.4% elongation at break) gives very low snap-back when cable breaks.
4. Low weight. (Sp. gr. = 1.3)
5. Temperature-resistant for continuous operation - 70° - +165° F.
6. No corrosion by salt water, fuels, lubricants and most solvents.
7. Electrical insulator (dielectric constant = 3.5 at 1 khz and 68°F.).
8. No painting, lubrication or maintenance.
9. Outperforms steel and other organic fiber cables working over sheaves and winches and will not fray.
10. Cyclic fatigue resistant tests have shown Phillystran to have a lower fatigue life than comparable steel rope.
11. Very low creep rate (about 0.1% per year when loaded to 50% of breaking strength).
12. Terminals as nicopress, spliced eyes, pre-formed steel wraps and epoxy-potted end fittings now are used. A program is being completed to modify standard steel cable end fittings for use with Phillystran.

PROPERTIES

	Phillystran			Stainless Steel Wire Rope		
OD	Break Strength Pounds	Weight lbs./1000'	Price/ 1000'	Break Strength Pounds	Weight lbs./1000'	Price/ 1000'
5/64"	1200	3	$90	---	---	---
3/32"	---	---	---	1200	20	$43.92
1/8"	3000	7	$200	---	---	---
5/32"	---	---	---	3300	55	$128
3/16"	5500	12.5	$360	4700	77	$151.20
7/32"	9000	20	$520	---	---	---
¼"	---	---	---	8200	135	$272.00
5/16"	15000	33	$960	12500	210	$364.80
13/32"	23000	50	$1360	---	---	---
7/16"	---	---	---	15600	345	$926.00
9/16"	40000	90	$2520	26600	550	$1160.00

For more information write: Philadelphia Resins Corp.; David R. Kollock, Vice President; Box 454; 20 Commerce Drive; Montgomeryville, PA 18936

Another type of kevlar (tm) standing rigging is now available commercially combining stainless steel cable with a kevlar core. It is claimed to be "30% lighter, 20% stronger and 10% cheaper." Standard swaged marine and aircraft fittings can be used, but a specially-developed bonding agent is required to reach the extra 20% breaking strength at $10 per half pint for 50-100 swages. Write: Loos & Co.; 328 Cable Road; Pomfret, CT 06258.

Anything which will allow us to reduce weight and windage aloft is to the good and increases the safety of our craft.

KAUAMEA BUILDING PROGRESS (Part 3)

(34' Wharram Catamaran)

George Snyder - P.O. Box 66538 Seattle, WA 98166

Unemployment makes for fast progress building *Kauamea*. I am now ready to install bulwarks and connect the hulls together. After that it is just inside detail and rigging.

The rigging on the model has been changed four times. Originally I was going with a Chinese lug ketch. But no single expert in the field provided a complete package I liked. And I studied them all; the Chinese in *Junks and Sampans of the Yangtze*, Tom Colvin, Jannik Cortsen for *Jesper,* Hasler and McLeod, Donald Riddler for *Erik the Red,* even Wharram's method. What I ended up with -- on the model at least -- is a mixing of each with a lot of ideas of my own. So, for now it looks like *Kauamea* will be a Chinese lug sloop. But rigging can be discussed at a later date.

The other day I was in a friendly tavern lifting a few beers with a fellow Wharram cat builder. Our conversation moved from discussing the fine form of the barmaid's legs to other nicely shaped forms, which eventually brought us to boats.

This man was living aboard his 45' (13.7 m.) Wharram cat with his wife and two children. It was his third multihull, the first two being thirty foot (9.1m.) trimarans. His first trimaran was built using fiberglass-covered plywood. The second one was of foam sandwich construction which he found very strong but it took a tremendous amount of work. They were both built and sailed around Santa Cruz, California. Eventually he wanted a bigger boat to widen his horizon a little. He noticed a large number of plain plywood boats working the fishing trade off Northern California. Some of them were more than ten years old and still looked strong.

So he built the cat. He used exterior plywood, plastic resin glue, galvanized nails, and plain alkyd enamel on the hulls. The decks were covered with a mixture of linseed oil, pine tar, and turpentine. Inside, the hulls were treated with just linseed oil. He declared her ready for sea after one year of construction.

With family aboard the cat made a trouble-free voyage across the Pacific to Hawaii. From there they sailed northeast to catch the westerlies and had a downwind slide to Alaska. After a leisurely gunkhole cruise south they stopped for a while in Seattle.

When I asked about maintenance, he said it was constant. But he called it mindless, dum-dum maintenance; two coffee cans with the deck mixture,, and two kids each with a rag. In one afternoon with the kids working the deck, he could paint another coat of enamel on the hulls. That would last about eight months.

The family has since sailed further south and as far as I know they are sailing still. The point is maybe we are being spoiled by the plastic industry to where we close our eyes on other methods. Realistically, it is possible that within our lifetime there will no longer *be* a plastics industry. Then what?

Kauamea has her bilges painted up to the waterline with epoxy resin. This is in each hull from bow to stern. The same protection could have been had cheaper using a polyester resin. Cheaper still I could have used roofing tar. All the metal hardware on *Kauamea* is ¼"(6mm)316 low-carbon stainless steel. I now wonder how ¼" mild steel, heated, dipped in oil, then painted with Rustoleum would have worked.

Expensive is good, cheap is bad are the watchwords today. But down at Fisherman Terminal there are a lot of empty Sears Weatherbeater cans. And those long voyaging heroes of ours seem to have done their sailing in good cheap boats.

Today there are great varieties of adhesives and coatings in the roofing industry.The recreation vehicle and trailer industry has many good things the boat owner can use, and cheaper.

My last trip to the boat show convinced me that a great deal of so-called marine hardware is grossly overpriced and pathetically undersized. But boat shows remind me of supermarkets; most of what's on display I can't afford anyway.

In one way or another I have had exposure to most of the present popular boat construction methods and I've formed some brief opinions, the value of which you can decide for yourself. Here they are:

WEST SYSTEM: I used this system on a 99¢ ice chest. It holds up very well but on a boat there would seem to be a lot of sanding required. I judge the efficiency of a boat construction method by how many times it requires me to move from one end of the boat to the other. Probably one-third of the time spend boat building is sanding anyway. This system would add a great deal to that. Since the ice chest was polystyrene I called this the Polystyrene Epoxy Saturation Technique -- or the Pest System.

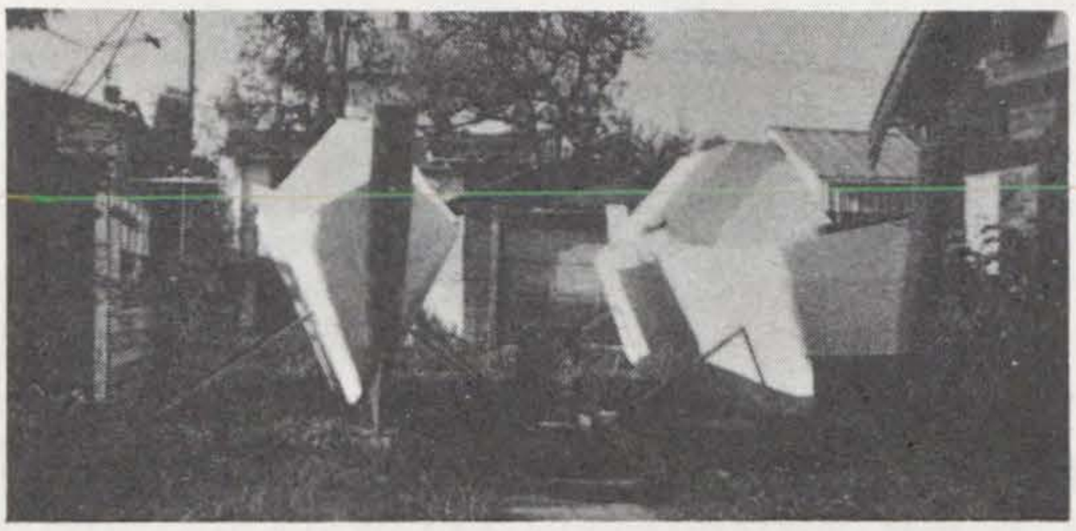
C-FLEX: A national boating magazine ran a series of articles on the building of a boat with this method. At the end of the project the builder said he would not use C-Flex again, partly because of cost, partly because he felt the stuff required too much support to keep it from sagging.

FOAM SANDWICH: A fellow Northwest Multihull Association member built his boat with this method and showed us slides of the construction process. It seemed like a tremendous amount of labor. I was worn out just watching the slides. Another member had his foam sandwich centerboard snap in half on him during one of our frequent heavy breezes.

FIBERGLASS: Although I intend for *Kauamea* and I to be together for many, many years if I were building another boat hand lay-up fiberglass would seriously be considered. There are a lot of fiberglass boats in this world. Still, I think this would be my number two choice.

CONCRETE AND STEEL: I am a certified welder, but I would not build a steel boat. I often picture myself someday sailing into an unknown port broke and hungry with tattered sails and peeling paint. Steel maintenance is not conducive to the one man alone program. It requires expensive machinery and more expensive help and I could never afford it. Now a *stainless* steel boat is something I'd love to build, if I could steal the material. Concrete is beyond my skill level, and it would mean hiring too many outside experts to help me finish it. Besides, the idea of floating in cement affects me like fingernails across the chalk board. WOOD PLANK: Here again more knowledge than my two-year self-study level would be required. Mistakes with expensive, exotic hardwood which must then be thrown away chills my blood. But I know me.

Many boats could and have been built using any one of these methods. My opinions are based on one man standing alone in his back yard, inexperienced, clutching to his battered, meager tool box, getting ready to build his dream ship. For him it would be hard to beat plain, good, strong plywood. Fiberglass on the seams and below the waterline is the only addition I would make. If chance and circumstance ever have me building another boat, this is how it would be.



This ground level shot shows the narrow beam/length ratio. There is a skeg in front of the rudder but otherwise no centerboards or low aspect ratio keels, which Wharram feels are just something to trip over. While there is validity in his argument these vessels *will* skid sideways when hard on the wind. This might concern a sailor in sheltered water, but I've been told that out at sea it is much easier to fall off a little for comfort. It must be kept in mind that these are cruising vessels, not racers.

This is pretty much where I am now. The ports have to be cut in the main cabins. Under the cover is the opening for the sliding hatches. Although the ends seem to be sticking up like afterthoughts, there will eventually be bulwarks sweeping from bow to stern. Final paint is now on the hulls. As an experiment the hatch covers have been painted with Sears Weatherbeater. I am toying with other experiments in fasteners, adhesives, and paint.

Here can be seen the model of Kauamea before rig experimentation began. Never mind the legality of how an impoverished boat builder can afford ¼" 316 low carbon stainless steel material to fabricate his rudder pintles. It is enough to say that even these days there is an underground black market for almost everything.

YACHT RESEARCH, SCIENCE & TECHNOLOGY

ICE BOAT DEVELOPMENT
Part II

Dick Andrews; 25 Audubon Drive; Ossining, NY 10562

During the nineteenth century the great ice yachts of the Hudson River were the fastest moving creations of man. A famous print by Currier & Ives shows one of these large craft, rigged as a gaff sloop, sailing up the frozen river past a train on the bank. The craft is a massive T-frame assembly, and a man stands at each end of the great cross plank forward, hanging onto a stay, while the helmsman sits aft right over the runner he steers with a heavy tiller. And they are whizzing along - and hoping that it doesn't "flicker"!

When one of these craft flickers, or goes into an abrupt flat spin, the crew are tossed out in all directions, unless they have an excellent grip on a stay or handrail. This spin is caused when the steering runner is lifted off of the ice by the forward pressure on the mast. Heavy construction and hefty crews helped some. But control - rather than speed - remained a problem.

Then in early 1931, the Joys brothers, sailmakers at Milwaukee, Wisconsin, appeared on the ice on a tiny triangular sailing platform steering in front. The tiny craft scuttled along - and never a flicker! The mast moment was holding the front steering runner firmly on. The word was quickly out, and ice boating entered an intensive period of development.

Other configurations were tried, and one was a craft with two cross planks fixed to the backboneor longitudinal member, and running on two pairs of runners as shown here. The front set of runners was fixed to steer by an automobile type of linkage. Control was good and trials continued for some time, but a persistent problem remained runner alignment and the weight of the steering linkages. (The least misalignment of paired runners will seriously degrade ice boat performance.)

Another configuration tried somewhat later also used four runners, with one forward and one aft linked to steer together, and a pair of runners at either end of one cross plank. A small version of this design with rubber wheels instead of the side runners sailed well and was very manoeuverable, but a larger version with regular ice boat plate runners on the plank did not do well, possibly again due to the alignment problem.

Quite large front steerers were built, often with jib and mainsail rigs, and it was then found that whereas the old "flicker" had been cured, there was a new problem. The rear steering three-runner ice boat capsizes very gently as it falls backwards across the line from the lee front runner to the rear runner, and parachutes nicely down at slow speed. But the front steering three runner craft capsizes forward across the line between the front runner and the lee side runner, and it comes down fast and hard. There were some heavy smashes and the big boats were retired.

The front steering three-runner craft remains controllable at high speed in a hard breeze and thus can be light. The weight of the skipper sitting on the aft plank holds the boat down on a "hike" as heeling is called in ice boating. The mast moment holds the steering runner on. The longitudinal member now became a streamlined monocoque "fuselage" and it very much resembled an open cockpit plane fuselage of the 1920's, traveling backwards. Jibs disappeared and masts were raked sharply aft to keep the center of effort of sails just ahead of the rear runners. Rotating plank masts and full-length battens appeared. The modern high speed one-man ice yacht was on hand.

Various small one-design types appeared, of which the best known is the tiny "DN". It is actively raced across America and Europe, but in design remains a charming archaism of the 1930's when its form was fixed.

The old time rear steering ice boats were various in specific dimensions and still are so today. They were raced in sail area limit divisions, and so were the early front steerers. However the larger sizes of front steerers are seldom seen, and the smallest sail area class - class "E" - with 75 square feet (7.0 sq. m.) maximum sail area permitted - is the class still very active in front steering racing. It is a development class, and the changes from the early 1930's to this day are interesting.

The "E" boat of 1932 carried its 75 sq. ft. of sail on an 18 ft. (5.5 m.) stick. Its "fuselage has" was 14 ft. (4.3 m.) long, and its cross plank, was 9 ft. (2.7 m.).

The "E" boat of 1976 carries its 75 sq ft. of sail on a 24 to 26 ft. (7.3 - 7.9 m.) stick and the fuselage has grown to 22 ft. (6.7 m.) and more in length, and is extended by a "half plank" forward (called the "spring board") placing the front runner well ahead, for a total length of almost 30 ft. (9.1 m.)! The cross planks are 18 to 20 ft. long. These modern boats don't always accelerate as quickly as the older ones, but once they are "cranked up" they really go, and are clearly faster than any other form.

The advent of heavy dacrons permitted the higher and narrower sails to stand, and higher speeds resulted from the reduction of induced drag. Some owners of older "E" boats switched to the taller rigs - increasing mast heights four feet (1.2 m.) or so - and promptly broke their fuselages in half when they sheeted in with a hard breeze! The few extra feet add so much force and compression that the fuselage has to be heavily reinforced to withstand the load!

Presently another new development is occuring. A fellow turned up at the national regatta in the mid-west last year with an "E" boat modified so as to bring the boom right down on the deck when sheeted in hard - and in a very fast race on good ice in a hard breeze, he managed to lap the whole large fleet! It is estimated that he was getting 20% and more extra speed.

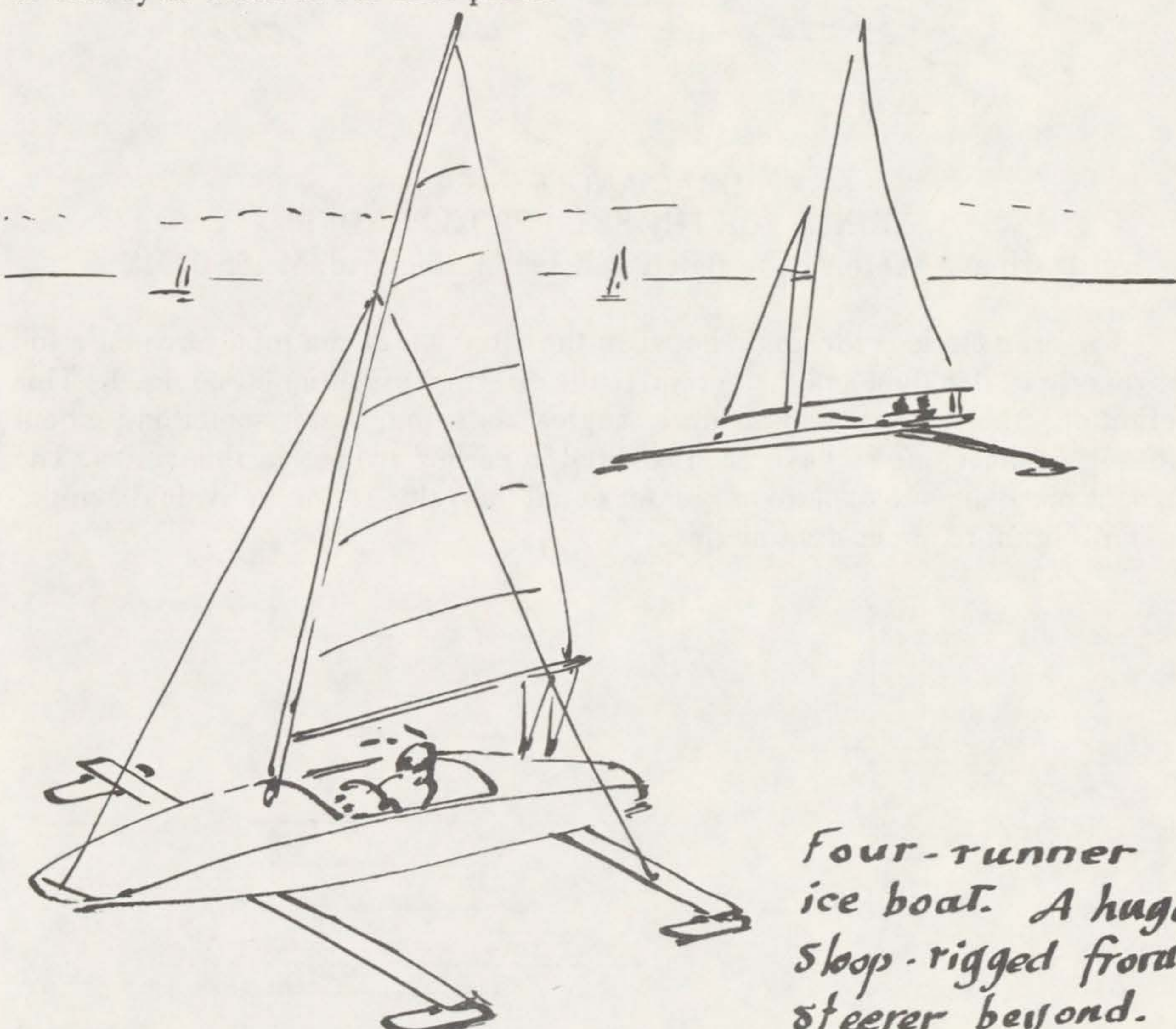
A lot of new craft are under construction or old boats are being modified, and skippers are scratching their heads over such problems as what to do with the twelve part block trains - not to mention the question of where the skipper himself fits in!

In our next installment, we will describe the techniques and the sensations of sailing one of these incredible machines which easily glide along at several times the speed of the wind. We will also discuss aspects of ice boat sailing techniques which can enhance watercraft performance - with particular reference to faster sailing in very light air!

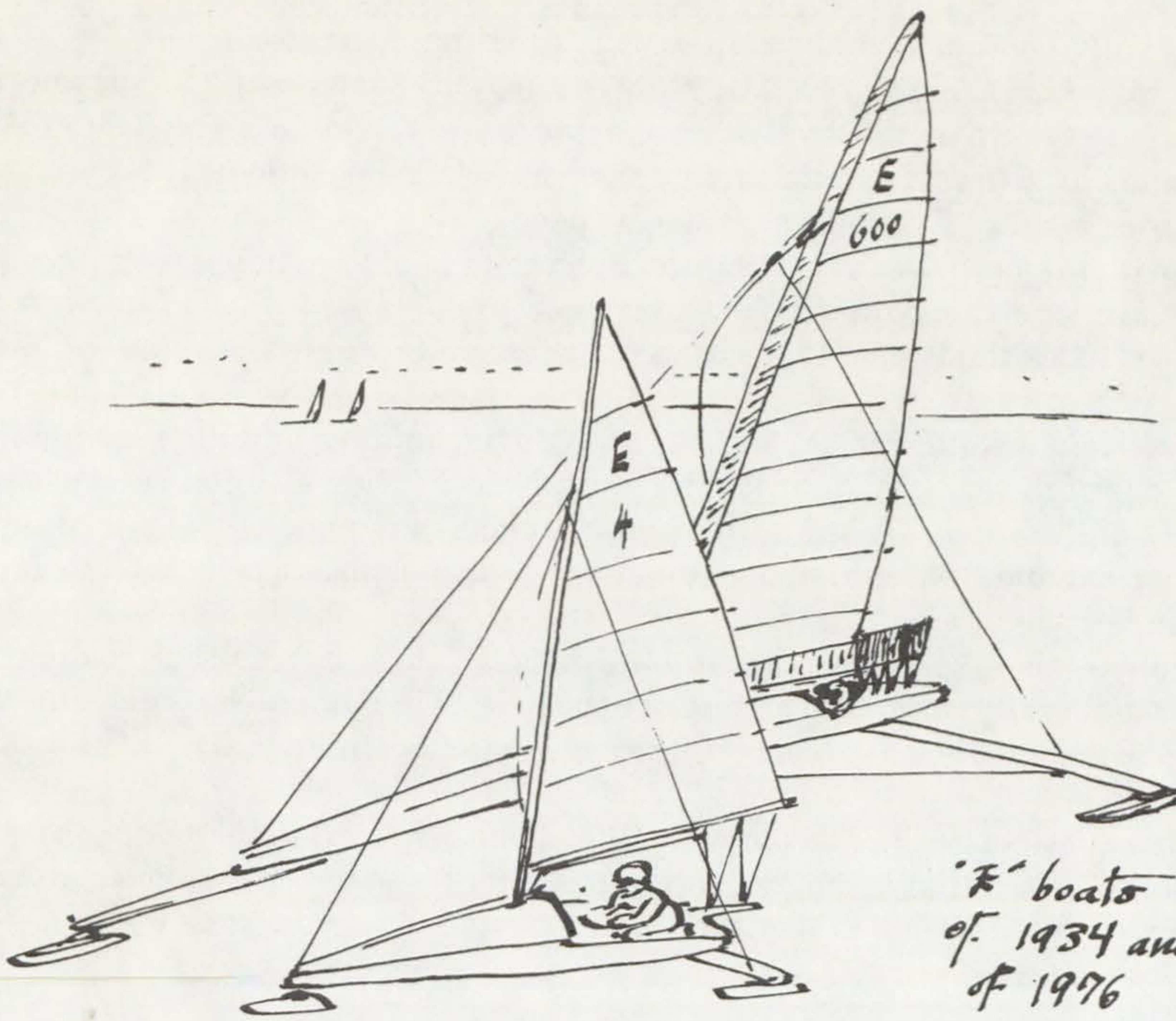
Finally: - the question everyone always asks... how fast do they really go?

It is generally accepted among ice boaters without much argument that speeds above 100 miles per hour (161 km/hr.) have been made by "E" boats on occasion.

But that is not really the fun of it. It is sailing several times faster than the speed of the wind - that is the amazing sensation of it -- and that is what we hope to convey in detail in our next piece.



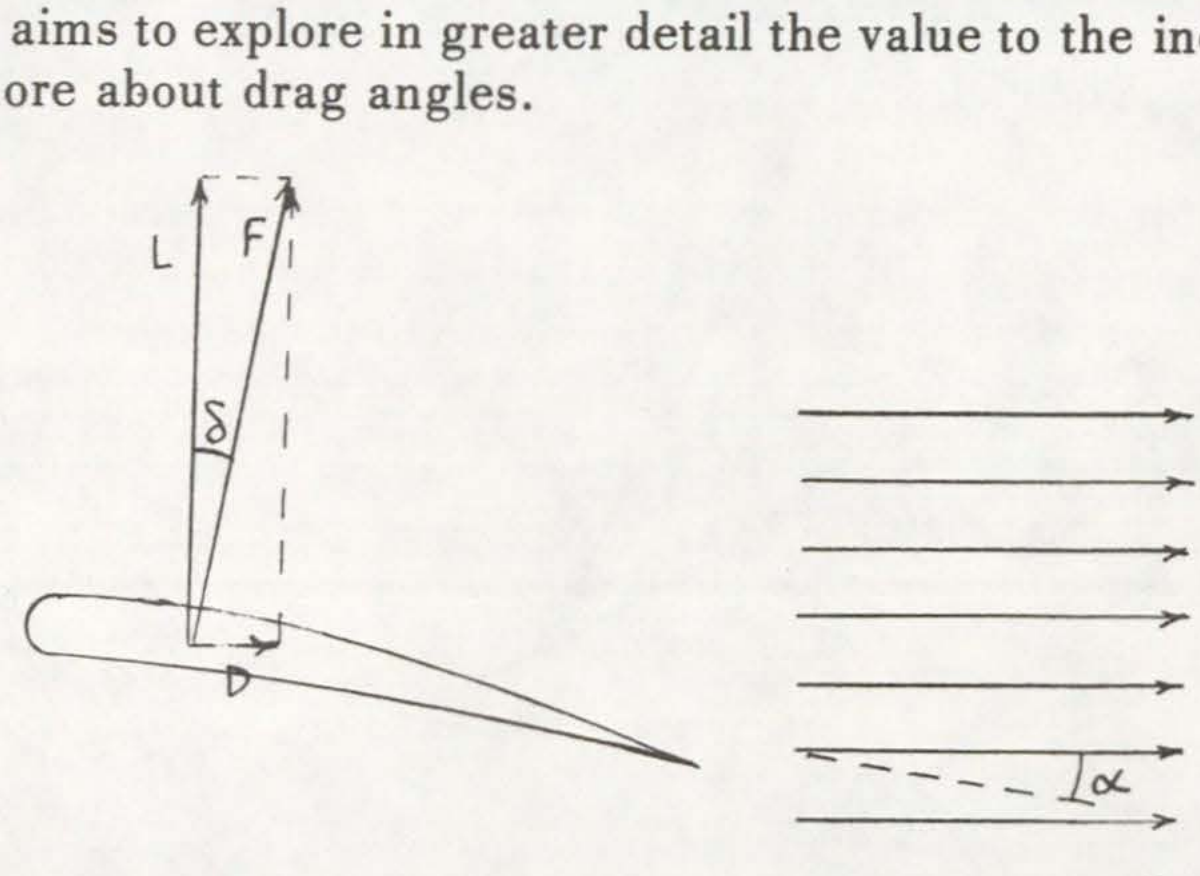
Four-runner ice boat. A huge sloop-rigged front steerer beyond.



DRAG ANGLES -- V
THINGS FOR THE SKIPPER TO PONDER

By Henry A. Morss, Jr.; 6 Ballast Lane; Marblehead, MASS 01945

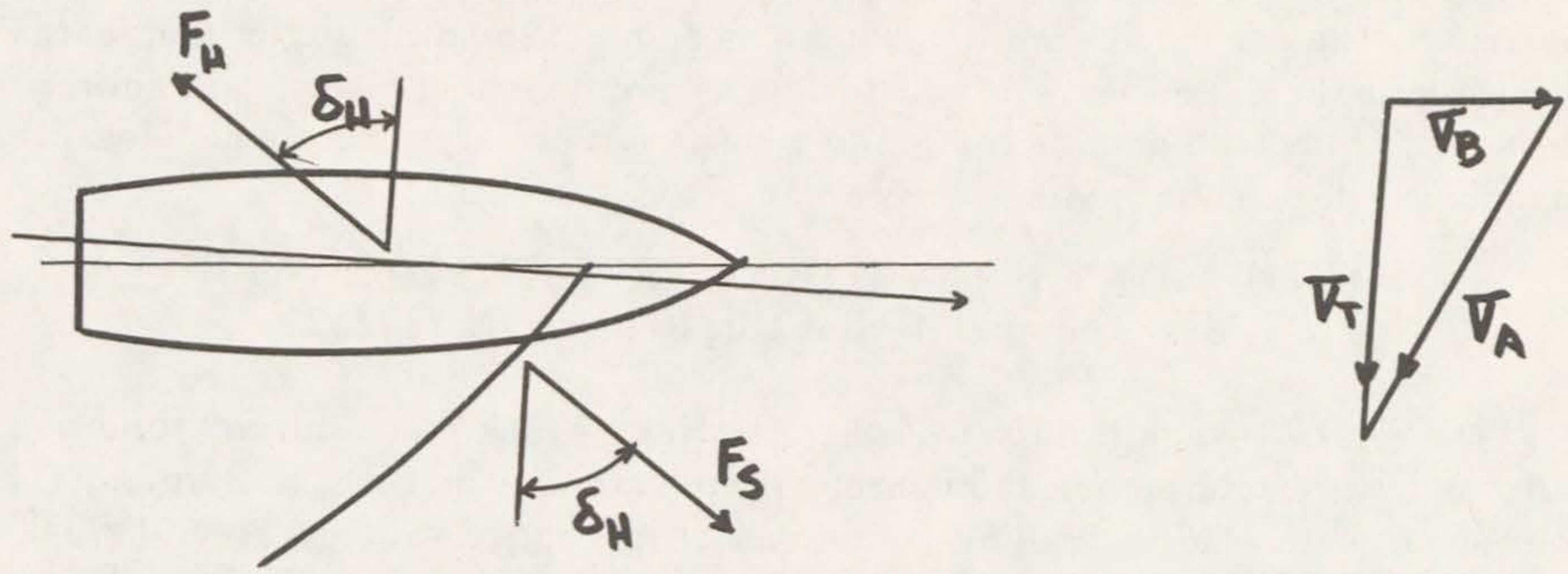
The drag angle is the angle between the direction of the total force on a foil moving through a fluid and the normal to the direction of motion. (See fig. 1.) This definition, the importance of drag angles to sailing and something about measuring those angles have been covered in earlier articles in this series. The present piece aims to explore in greater detail the value to the individual skipper of knowing more about drag angles.



The Course Theorem, telling us that the angle beta between the boat's course and the apparent wind is equal to the sum of the two drag angles, has been mentioned previously. In itself, it says valuable things about sailing.

Before the wind, both drag angles are right angles, 90°, and $\beta = 180°$. The apparent wind lines up with the true wind. (In the typical case of sailing before the wind, the speed of the apparent wind is equal to the speed of the true wind minus the speed of the boat.)

As one heads up from this course, at least one of the drag angles must decrease. What can be said about this? A force diagram, fig. 2, for sailing with the true wind abeam shows the direction of the sail force to lie forward of abeam (abeam of course, not centerline) by an angle which is the hull drag angle. The larger the hull drag angle is, the more nearly the sail force points in the direction of motion and the larger will be its driving or thrust component. Obviously maximum driving force is desired. That means that the hull drag angle should be as large as it can be. In turn, the sail drag angle should be small, since the sum of the two is the same as the angle beta between course and apparent wind.



Indeed, if in this situation of reaching, the sail drag angle can be reduced and the hull drag angle increased, the more favorable direction of the total sail force could cause an increase in boat speed. This, in fixed true wind, will reduce beta a bit and so accentuate the usefulness of decreasing the sail drag angle.

Still another effect there is that as the direction of the sail force comes closer to the direction of motion, its side force component will be reduced. This should reduce the induced drag and with it the total drag. Again, this should increase the speed.

As the boat is headed up to the angle best for beating to windward, one may be tempted to think that both drag angles should be brought to a minimum to reduce beta, which means sailing at the closest possible angle to the wind. This reasoning contains two faults. One is that it is the formula for pinching. Clearly pinching is going too far in reducing the drag angles.

The other is more subtle. It is true that any reduction in sail drag angle, if it can be accomplished without hurting the total sail force, will improve windward performance and reaching speed. Nothing of comparable simplicity and directness can be said about the hull drag angle. The optimum for windward speed, and of course also for reaching speed, is often larger than the imaginable minimum.

This contradicts the simple logic which goes as follows: For best windward performance (and, to a lesser extent, reaching speed also), one would suppose that the effort would be to design a craft to provide the side force needed to counter the side force of the sails *at a minimum resistance to forward motion* that is, at a minimum hull drag angle. Plausible as that sounds, however (and most people probably accept it today), it is apparently not a reliable rule. Best windward and reaching speeds seem to be realized in fact at values of hull drag angle larger than the practical minimum. (This is spelled out in some detail in the author's paper "Forces and Angles in Sailboat Performance" presented on Jan. 24, 1976 before the New England Sailing Yacht Symposium.(The mathematical basis for the analysis has been sketched earlier in this series.)

"*Cleaning Up*." In effect, the drag angle is a measure of the "cleanness" of the sail, rig, and all parasitic windage resistance or of the underbody, whichever is the concern of the moment. (At least, the minimum value of the appropriate drag angle is such a measure.) If the skipper is prepared to make some direct measurements, he can compare the effects of variations. For instance, if he will perform the "tethered boat test," to measure the sail drag angle, he should be able to learn something about the possible benefits of a boom vang or of bringing the foot of the genoa down very close to the deck to prevent the formation of an eddy under it, with the consequent inefficiency.

Summary. Thus as the skipper digests the meaning of the drag angles and learns to work with them, he should be able to develop improvements which will improve the speed of his craft and his compotitive position if he races. Surely his pleasure in sailing will be enhanced.

HYDROFOIL YACHT "WILLIWAW" RETURNS TO HAWAII

David A. Keiper - P.O. Box 181, Honeoye, N.Y. 14471

The return voyage from New Zealand to Hawaii took place during June and July, and was via Rarotonga and Penrhyn islands. On the first leg, to Rarotonga, I met some of the hairiest sailing conditions of my entire sailing career (30,000 miles). (48,000 km.) I had one crew member. We left with a disturbed Southwest air stream that was generating squalls up to Force 8, (34-40 kts.) at any time of day or night. Sails were reefed, unreefed, furled and unfurled more times than I've ever had to do it before. Even then, we usually had the wrong amount of sail us. We would get caught by squalls carrying full sail wing-and-wing or quartering, and find ourselves screaming along at speeds 20 to 25 knots .This was great when the seas were reasonable, but when we started slamming into walls of water, we chickened out and reduced sail. Other times, we found ourselves with too little sail, the boat acting logy and being tossed about by waves. In the first six days out of New Zealand, we made 1000 miles. That is about 7 knots average, or averaging ⅓ foilborne. The sixth day, when the winds steadied out and the seas became more reasonable, we averaged 9 knots, which is slightly better than a ½ foilborne average. If we had had a third crew member, and decent foul weather gear, we could have driven the boat appreciably faster. Because of later headwinds, variable winds and calms, we didn't reach Rarotonga until 14 days out of New Zealand.

About 500 miles (800 km.) off the New Zealand coast, we met a freak wave of the sort that pitchpoles yachts, whether mono - or multihull. (The average sea conditions were not so bad that any yacht would have had a drogue out.) The wave was 35 to 40 feet high, (11-12 m.) had a slope greater than 45 degrees and a flat bottomed trough with no rounding between the slope and the trough. I happened to be at the helm at the time. We were half-foilborne coming over the crest. I think my hair must have stood on end as "Williwaw" nosed down into the yawning chasm and started accelerating like wild down the slope. We hit the trough at about 20 knots. The bow cleaved the water and went under perhaps 8 feet (2.4 m.), but no spray was thrown up. Everything loose inside the boat flew forward. While "Williwaw" stood up at this crazy angle for a few seconds, I looked apprehensively at the masthead, and saw that the mainsail peak was still full of wind. Then the bow popped out, and she started moving forward again. I believe that we came out right side up because of the hydrofoils. Coming down the slope, the bow foil kept the nose well above the slope. As the bow foil plunged into the water at the bottom, the large reserve lifting area must have given a tremendous righting force before the boat slowed down. The stern foil maintained perfect rudder control, and would have gone into negative lift and resisted being lifted out.

From Rarotonga to Penrhyn to Hawaii, I sailed solo. Rarotonga was a disappointment, and I didn't want to stay around there long enough to find crew. I had put into the only safe harbor there (Ngatangiia),especially good for multihulls, but officials ordered me out of there. They wanted me in one of the two filthy harbors on the North side, which were extremely bouncy at that season. They charge boats $2.00 per day there.

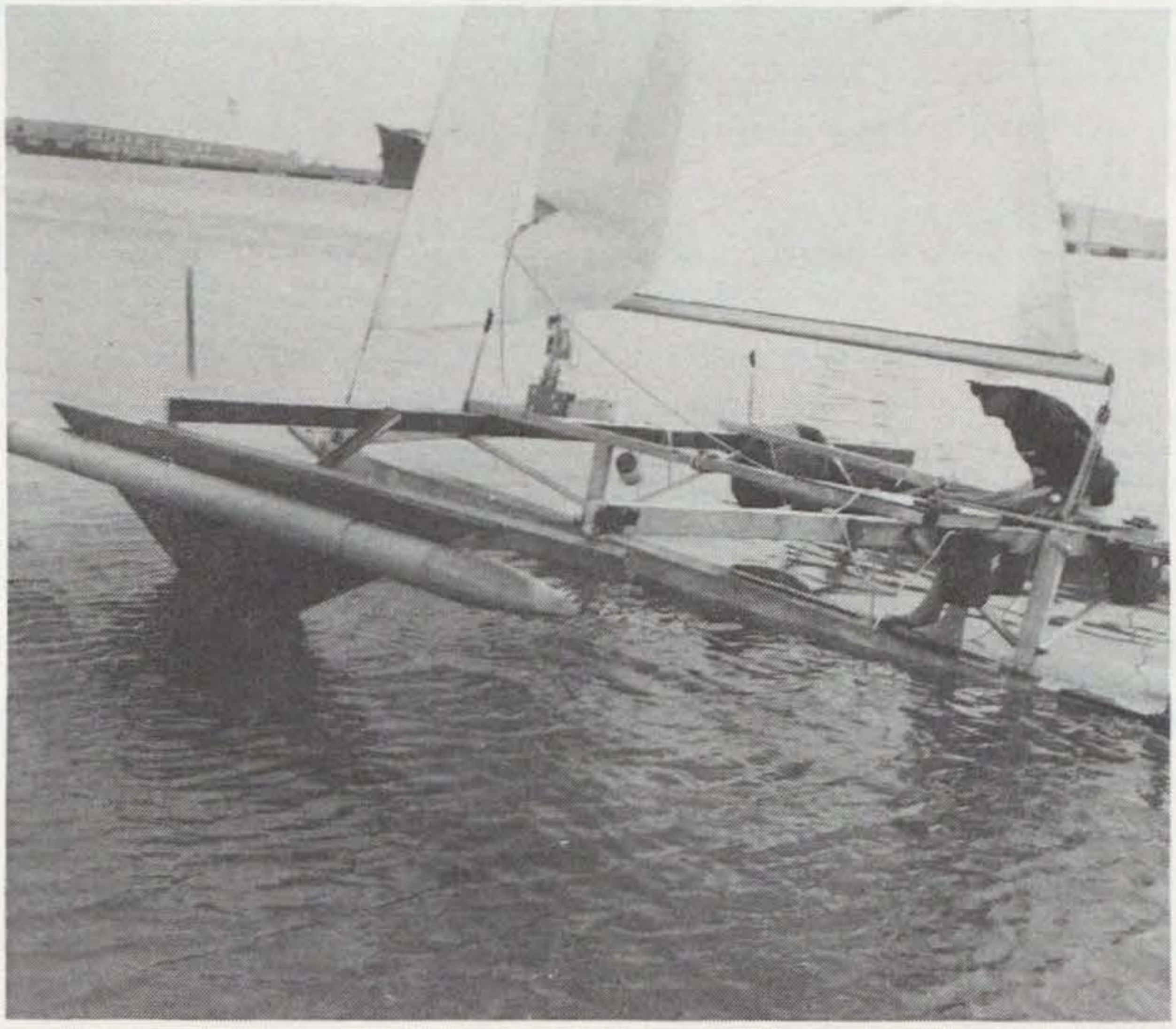
I left Rarotonga with thoughts of raising Bora Bora, but east tradewinds started blowing with a vengeance. The heavy mainsail blew out, and a hull seam (forward and above the WL) started to open up. I suppose I could have fixed things at sea, but I didn't care to. I decided that I had the perfect excuse to visit Penrhyn Island now, which was 400 miles off, on a broad reach. I had wanted to see that place more than Bora Bora, but the Rarotongan officials had refused me permision to go to Penrhyn.

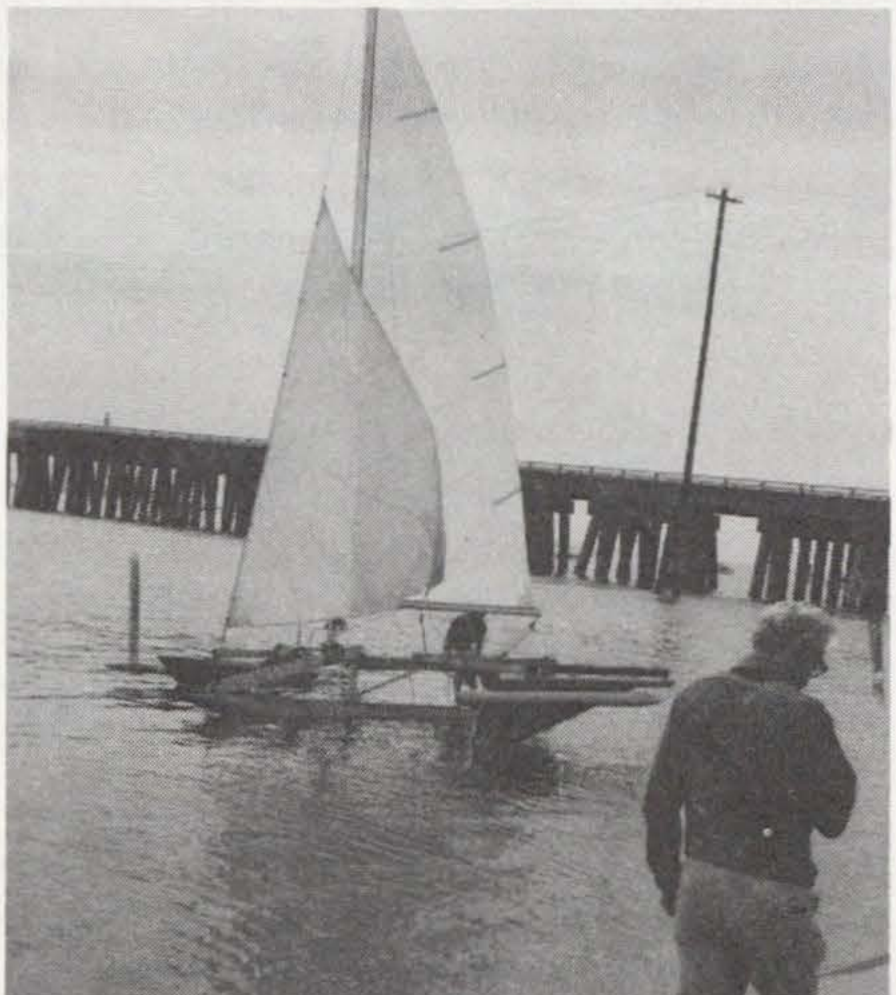
The Penrhyn islanders gave me a very enthusiastic welcome. (It seems that very few yachts get to go there.) Most of the Penrhyn people are opposed to the present Cook Islands government in Rarotonga, which is presently run by Albert Henry and his family. Perhaps in spite, the Rarotongan officials try to keep Penrhyn isolated! Anyway, a couple dozen Penrhyn islanders lifted "Williwaw" up and set her down on the beach, so that I could work on repairs more easily. (Not many 31 foot yachts can be picked up that way.) I lived ashore with a family while there. During World War II, there was a U.S. air base on Penrhyn, and the people acquired a taste for the products of the outside world, but at present they are very much cut off. I ended up giving away or selling assorted boating hardware and tools.

From Rarotonga to Penrhyn, it had been 6½ days sailing. The direct distance is 780 miles, (1250 km.) but my roundabout route had been a thousand miles. (1600 km.) I departed Penrhyn with light Southeast trades, and worked my way Northeast (although Hawaii is due North 1800 miles (2900 km.) from Penrhyn). The Southeast trades continued light. Then I had six days of doldrums, with interminable rain squalls and light shifty winds. It wasn't until the Northeast trades that I started making good time (occasionally 180 miles per day (290 km) with no effort on my part). It was 18 days sailing from Penrhyn to Hawaii.

I found solo sailing on "Williwaw" rather easy. I got more sleep at night than when I'd had crew, for I saw no point in trying to keep watch. I was far from any shipping lanes. The only sea traffic seemed to be dolphins, and they always yielded right-of-way. I spent very little time at the helm. Mostly, the tiller was tied. When the boat would go off course, I could tell by the change in sounds. A change in sound would also wake me up at night. There were quite a few nights that I slept straight through.

Eleven years earlier, I had covered a somewhat similar route in "Nimble #1, that is, a windward tradewind passage to Hawaii. "Williwaw" is a far more sea kindly and easy to handle boat. On "Nimble #1", the quick motion from beating into waves had nearly reduced my crew member and myself to being "zombies".





Harry Morss in Ed Doran's modified $50 Regatta hydrofoil sailboat at SM-5, Galveston, Texas - Oct. 1976

Clayton and Bob Bowers at SM-4 Pensacola, Florida - Sept., 1976 with John Morwood Rotating Cup on deck between awarded to winners of $50 Regattas.

AYRS FLORIDA - CARIBBEAN CONTACT GROUP

Sailing Meeting No. 4 of the AYRS-FCCG was organized by Bob and Clayton Bowers at Pensacola Florida on 25 and 26 September, 1976. Bob Hodgen brought and demonstrated some of his scale sailing models. Participants were able to sail aboard: *Pearl of Peril*, Clayton and Bob's very successful $50 Regatta racing sailboat, and a Sol type racing catamaran.

Sailing Meeting No. 5 of the AYRS-FCCG was organized by Ed Doran at Galveston, Texas on 2 and 3 October, 1976. The meeting was held on the campus of Moody College of Marine Sciences and Maritime Resources of Texas A & M University, and we all express our appreciation to Dr. William H. Clayton and Dr. James McCloy for permitting us to use their fine facilities. Dr. Clayton welcomed us as the first organization which Texas A & M has hosted on their new Galveston campus. My own special thanks are also extended to Pat McCloy and Gin Doran for their hard work as well as to Ed Doran and Jim McCloy.

There were about 180 attendees at SM-5 from: Australia, Florida, Louisiana, Massachusetts, Michigan, New Mexico, Texas, Virginia and there were panel discussions and demonstration sails aboard various craft. The panel on: *Boatbuilding, Materials and Techniques* was moderated by Ed Mahinske, and participants included: Dick Steffy on ancient boatbuilding methods, Meade Gougeon on wood and the WEST system, and Barrett Kennedy on C-Flex. Ed Doran presided over the panel on *Multihull Speed and Safety*, and participants were: Andrew Simpson, and Norman Cross. The Editor moderated and presented a paper at the panel on: *New Ideas for High Speed Sailing*. Other participants were: Nils Lucander and Harry Morss. An illustrated evening lecture on *Nautical Archeology* was given by Dr. George Bass at the meeting barbecue. Several of us enjoyed sailing Ed Doran's hydryofoil converted $50 regatta sailboat.

From:
AMATEUR YACHT RESEARCH SOCIETY
John W. Shortall III - Editor
10822 92nd Avenue North
Seminole, Florida 33542 U.S.A.

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