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

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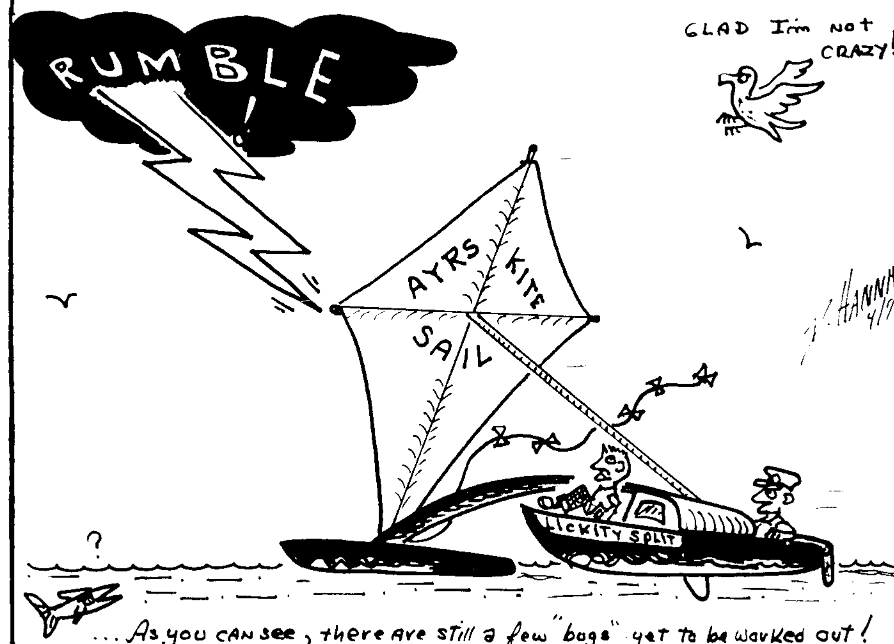
AYRS

KITE SAIL RIGS '76

JOURNAL 85A
OCTOBER, 1976

YACHT RESEARCH, DESIGN, SCIENCE & TECHNOLOGY
MATERIALS AND AMATEUR BOATBUILDING
PRACTICAL CRUISING, SINGLE-HANDING, SELF-STEERING
SAIL RIGS, SPARS & RIGGING
ADVANCED CRAFT
AYRS - FLORIDA - CARIBBEAN CONTACT GROUP



FREE FLYING KITE SAIL
KITE SAILING
KITE RIG
BUILDING KAUMEA
CALISTHENICS OF MATERIALS

THE AMATEUR YACHT RESEARCH SOCIETY

(Founded, June, 1955 to encourage Amateur and Individual Yacht Research.)

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CONTENTS

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

Award of Plaque by Leland Hardy to Pat Kammerer with Ed Doran standing by.

BULLET, winner of $50 Regatta at SM-3 being skippered by Pat Kammerer.

SM-3 Heavy Weather Sailing Panel. Al Stresen-Reuter standing. At table are seated: Bruce DuClos, Bill Osterholt and Neal Henderson.

Part of Audience at SM-3. Left to Right: Tom Baldwin, Al Stresen-Reuter, Meade Gougeon and Bernie Rodriguez.

AMATEUR YACHT RESEARCH SOCIETY

The AYRS is an international society for the amateur yachtsman, boat builder, yacht researcher, inventor, designer, sailor and experimenter. For an annual fee of $15, Members have been receiving four publications a year. However, in 1976 Members in North and South America will have received six issues of the new AYRS Journal plus one book from England. Other Members receive two or more issues of our Journal at one time. AYRS Americas was constituted to assist in the editing and publication of books for the worldwide membership and has worked in close cooperation with the AYRS Committee and Administrator in England. AYRS Americas is a non-profit, tax exempt scientific and educational organization per a June, 1976 ruling of the U.S. Internal Revenue Service.

COMPUTER: We are informed that it is about 99% certain that AYRS Americas will receive a large donated, high speed digital computer for installation in facilities provided by AYRS Member Eric Fletcher in Miami, Florida. NCR, the donating company, has agreed to present a one-time school in Miami for those AYRS Members wishing to learn how to use this powerful machine. The NCR 315 computer is completely accessible by terminal and telephone, so it will be usable by any AYRS Member anywhere in the world for the price of a telephone call and a small contribution to a maintenance fund. Kits for terminals - the black box link between the user and the computer via the telephone - now start at $500 with finished units at about $700.

AYRS 85B: BOATBUILDING AND MATERIALS '76 - Terrence Barragy, our new Assistant Editor, is editing up the taped transcript of a three hour session on this subject from our Fort Myers Sailing Meeting No. 3 which contains information on the WEST System, C-Flex, Foam Sandwich and Fiberglass. We will publish additional articles on this and other subjects.

ACKNOWLEDGEMENTS: My thanks to Harry Stover for all his editing help with this issue as well as the numerous articles he has submitted - not all of which we have yet had space to print, very unfortunately. I am also grateful to Terrence Barragy,Raymond Brown and Peer Lovfald for volunteering to help with the work load. My thanks go to Dick Kelting for publishing our first three FCCG Newsletters in 1975 and the first four issues of our AYRS Journal in 1976. This and the next issue are being published in Florida to relieve Dick for the time being of this laborious and unsung job. He has done well, and we should all be grateful for the many, many hours he has devoted.

SAILING MEETINGS: Several AYRS Members have asked if a large sailing meeting with panel discussions could be held in central Florida, say in the St. Petersburg area, in early or mid 1977. To make such possible, we need one man to volunteer to coordinate the meeting and perform all of the host of organizational details including: site selection, obtaining of speakers, obtaining of boats, publicity, sending out announcements, much planning, etc. etc. Any Volunteers?

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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.

ADVANCED CRAFT

JOHN PLAYERS SPEED WEEK

Letter to John Morwood from Michael Ellison; Amateur Yacht Research Society; Hermitage - Drayton Lodge; Newbury, Berkshire RG16 9RQ, England

Dear John,

The Southampton Boat Show exhibit of TIGER caused interest. A Member has promised to make a model of a Flettner Rotor for display next year.

The Players Speed Week was an outstanding success. AYRS was represented by: Beecher-Moore, Reggie Bennett, Clarence Farrar (Official Measurer) and myself. Also present were Shaun Coleman-Malden and Mike Butterfield who has purchased TIGER from George Chapman. The new CROSSBOW got over 31 knots on about her tenth run with a wind speed of about 15 knots. MAYFLY with a new owner got well over 20 knots with 15 knots of wind. ICARUS got the B Class speed record back to the UK from the USA with a speed of just over 20 knots in 12 to 15 knots of wind. It is interesting to note that the latter two boats achieved slower times as the wind increased above 15 knots. The new CROSSBOW was launched for the first time on the first day of the event, and there seems no doubt that further trials and adjustments plus an increase in wind speed will give improved performance, and at last 40 knots does seem to be possible. It is interesting that the boats from Sydney, Australia with their crews out to windward did manage several runs equal to the wind speed but at no time did they exceed the speed of the wind.

We gave the prize for the outstanding design to EXOPLANE (AIRS 11,60). She was improved to the extent that she managed two runs down the course at 11 and 13 knots. Off the course, she did a short distance at a speed in excess of 25 knots when two of CROSSBOW's tenders were unable to catch her. However, control is still a problem. Her sail is inclined to windward at 45 degrees with a small ski supporting the leeward edge. The hull is double-ended with a foil at each end to steer the boat. The sail resembles a blown-out umbrella.

Sincerely,

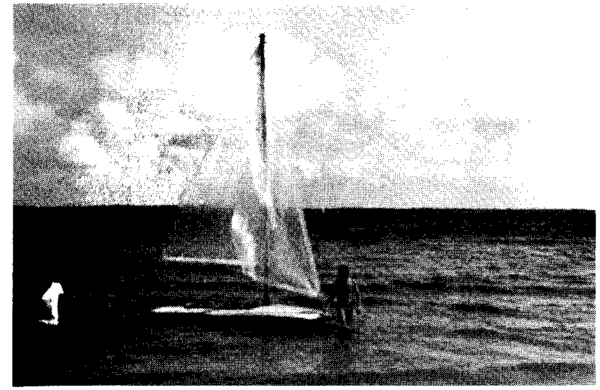
SAIL RIGS

KITE SAILING

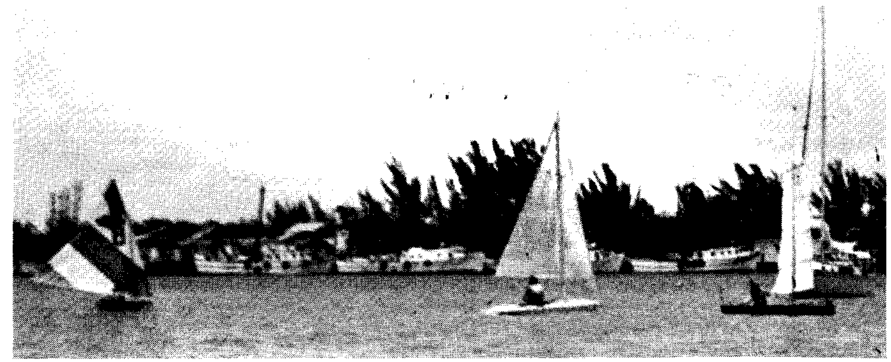
Gordon Gillett, Regency 324; 200 Ave. K-SE; Winter Haven, FL 33880

WHAT IS KITE SAILING?

The subject of kite sailing needs an introduction since it is so new. When you suggest kite sailing, some people think of hang gliders - where you ride on the kite, or they think of riding behind a boat on a kite or a parachute, or they think of flying a kite off the bow and running downwind. None of these things are close to what I am talking about. I define kite sailing as using a kite, or a series of kites, to pull a boat in any direction a conventional sail boat can go - including tacking up wind.



PEARL OF PERIL WITH POLYETHYLENE SAILS



$50 Regatta at SM-3 Fort Myers, Florida; May, 1976. MORS'L in lead (before mast collapse), trailed by PEARL OF PERIL (before rudder failure) followed by BULLET (winner).

Award of AYRS Plaque to Winner of $50 Regatta. From Left to Right: Leland Hardy, Pat Kammerer, Penny DuClos and Bob Bowers.

MORS'L - $50 Regatta Boat for SM-3. Left to Right: Bruce DuClos, Penny DuClos and Editor:

MORS'L (Morwood Sail) Editor and Penny DuClos

Kites have been used for centuries to pull boats down wind. The Chinese even used kites to pull wheeled vehicles in ancient times. Kites have been flown off the decks of boats by Philipino fishermen, who would paddle out to the fishing grounds and sail back with kites.

All efforts at kite sailing until the summer of 1975 had the singular disadvantage that they required some other way to get back home. As far as I have been able to determine, nobody, until June 11, 1975 had actually tacked against the wind with any degree of success using kites in place of sails. We succeeded in tacking against the wind in Biscayne Bay off the Rickenbacker Causeway on that date and, to put it mildly, felt quite good about it. We used four kites at that time - kites of the same type I describe further along.

We have been testing a Sunfish hull driven by six kites against a conventionally rigged Sunfish and find that sometimes we beat the conventional boat and sometimes the conventional boat beats us. Sometimes we can point higher than it does and sometimes it points higher than we. We are now flying eight kites which gives us 180 sq. ft. of sail against the conventional Sunfish area of 76 sq. ft. of sail. We expect to start to pull away.

INPORTANCE OF TACKING INTO THE WIND

There are two important reasons why a kite sail boat must be able to tack against the wind. First, you must be able to get back home and/or reach any desired destination. Second, any sail boat which sails at high speed finds itself tacking into the apparent wind almost all the time, regardless of the true wind direction. This effect is thoroughly discussed in AYRS 82, *Design for Fast Sailing,* and the faster the boat the more pronounced the effect.

THE KITE REQUIREMENTS

To tack against the wind, you must have a highly efficient kite, i.e., a kite that will fly almost directly overhead. It must have a line angle, including sag, of about 75° to start. Not too many kites will do that. This 75° corresponds to an overall lift-drag ratio including wind drag of the string of 3.7. It also has to be a fairly powerful kite although that is not the major factor. The main thing is the angle.

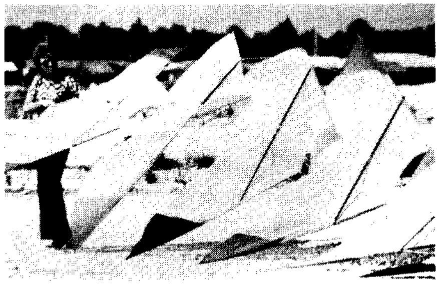
You must also have a kite which will maneuver. If you are going to tack against the wind you must be able to fly the kite well out to either side.

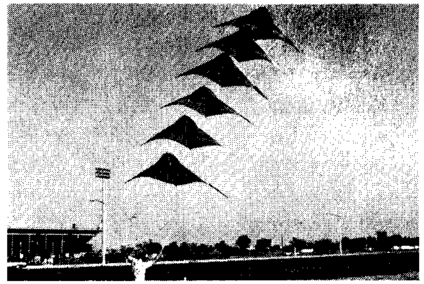
The kite must be light enough to fly in winds of only 5 mph and strong enough to fly in winds of 30 to 35 mph. Not too many kites will fly well in a 35 mph wind and hold their shape. The principal reason the kites are exposed to 35 mph winds is that as the boat speed increases the kite "sees" an apparent wind much greater than the real wind which is the combination of the real wind and wind due to boat speed.

MY PRESENT SOLUTION OF KITE REQUIREMENTS

My present solution to these kite requirements is to fly a series, or stacked array, of small, delta shaped, kites - 10 ft. wide and 4½ ft. tall with 22½ sq. ft. of area in each kite.

The principal reason for using small kites is that the desired area is obtained





with less overall weight. It is a matter of scaling laws. When you double the size of something you have four times the area and eight times the weight unless you refine the structure. The structure of my present kites is about as refined as I am capable of at this point. The kites are made of ripstop nylon and they have fiberglass sticks. All together they weigh less than a pound apiece. This works out to be 0.044 lbs. per sq. ft. of kite surface. It is interesting to compare this unit weight to that of a conventional sail rig for a Cougar catamaran which has 250 sq. ft. of sail and weighs 73 pounds including mast, boom sail, rigging, etc. The Cougar rig works out to 0.3 lbs. per sq. ft. of sail area. This is 6.8 times as heavy as the kite rig.

Another reason for using small kites is that the smaller kites maneuver much faster. Stiffness scales as the fourth power so stiffness increases 16 times when you double the size. Thus, large kites are more difficult to maneuver. I have tried large kites - 20 ft. wide, but they are poor in light winds, and they do not maneuver well.

The problem you run into with a series of small kites is that you do have a lot of lines and do have some foul ups once in a while. The normal launch system is to string the lines full length, tie them down to the deck of the boat, and have someone steady the boat so it does not move. We set the kites on the beach, nose down, all eight kites in a line, one behind the other, and then someone grasps the last kite and gives a quick snap. As the last kite rises up, it raises the noses of all the rest, domino fashion, and they all launch into the air very quickly. They will be high overhead in 4 or 5 seconds. You launch the boat at the same time and you are underway. To retrieve the kites you can fly them into the water. The kites can also be retrieved by flying them well out to the side, over a beach, and stalling them out. We are working on more efficient launching and retrieving methods.

For tacking into the wind, you fly the kites in an unnatural position for kites. They have to be flying clear off to the side of the wind and they look like they are running horizontal. They are perfectly horizontal much of the time. In order to tack into the wind successfully you have to fly the kites at least 65° off from the down wind direction.

To control the kites I use a two line control system. The two lines are fastened to the kites with a six point suspension and each of the three fore and aft sticks has its own bridle. The bridle system all comes to two main lines which are actually one continuous line that goes around a pulley, at the boat, and back up to the other side of the kites. The pulley is attached to the deck of the boat near the centerboard. I find that just behind the centerboard works best. You can actually

The hull was constructed in approximately 18 manhours. Frames and centerboard trunk were drawn and cut out and set on a strongback with a 12 degree reverse counter to the transom. Stringers were ripped to 3/4''x1'' and fastened to the frames with 4 d galvanized nails and Weldwood glue. The planking and decking were then fastened in place. Both the rudder and CB were laminated and shaped. A 1'' dowel was used for the thru-hull rudder shaft which turned freely inside a 1'' PVC pipe.

An 18 ft lodgepole (2x4) made an excellent mast. A diamond stay was used to stiffen the mast which was supported by solid clothesline wire. A 2x2 pine boom was attached to the mast by interlocking eyebolts for a gooseneck. Small turnbuckles were necessary for tuning the rigging.

The mainsail and jib were fabricated using 4 mil polyethelene. Duct tape reinforced the luff and foot. Inexpensive grommets enabled bending the sails to spars and rigging.

My brother, Clayton, and I were very pleased with our scow's performance even though we suffered a broken rudder shaft at the 2nd mark which sank our chances of a win. Both of us were very happy we took time out to attend SM-3 and would like to take this opportunity to thank all those fine people responsible for it's success---THANK YOU!

End-on View of the PEARL OF PERIL being fitted out for race at SM-3.

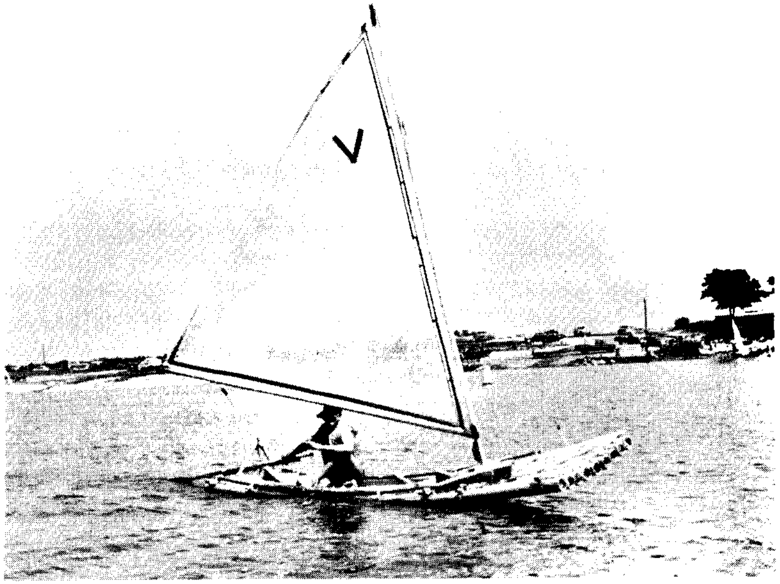


Fig. 6. Doran and raft finish first.

HOW TO BUILD A $50 REGATTA BOAT: *PEARL OF PERIL*
By Bob and Clayton Bowers; 214 Payne Road; Pensacola, Florida 32507 USA

A brief synopsis on the good boat *"Pearl of Peril"*, a $50 Regatta entree of SM-3 held in Fort Myers Beach, May 15-16, '76. Her design is that of a sloop rigged, centerboard scow of the following dimensions:

LOA . . . . 15' 5"
LWL . . . . 12' 7"
Max Beam . . . . 5'
Draft
  Board up . . . . 4"
  Board down . . . . 34"
SA . . . . 110 sq. ft.

For the sake of brevity here is a list of materials with the corresponding components:

3/4" CDX Plywood--major frames, centerboard, centerboard trunk, rudder.
5/16" Plywood (damaged)--Secondary frames.
1/4" Interior Paneling--planking, decking.
2"x4" Pine--mast, tiller, mast step, boom.
1"x4" Pine--stringers, frame lumber.
Solid Clothesline Wire--standing rigging.
Polyethelene--sails.

control all eight kites in a strong wind with just a thumb and forefinger on one line.

HOW TO PILOT A KITE BOAT AND HOW IT FEELS

The piloting of a kite boat is quite different from piloting a sail boat and therefore requires some explanation.

Several things are opposite from sailing. For example, if a sail luffs and loses power you turn down wind somewhat to fill it again. If your kite loses power, turn up wind. This takes the slack out of the line and pulls the kite through that spot of dead air as quickly as possible.

To spill the wind out of your sails you round up into the wind. A kite boat turns down wind to do this.

It is generally recommended that you tack a sail boat rather than jibe. A kite boat always jibes. If you try to tack by turning into the wind, the strong steady pull of the kite will pull you backwards. It is perfectly safe to jibe. Just swing the kites in a graceful arc from one side to the other as you turn the boat around. It's one of the more exciting maneuvers you can do with a kite boat.

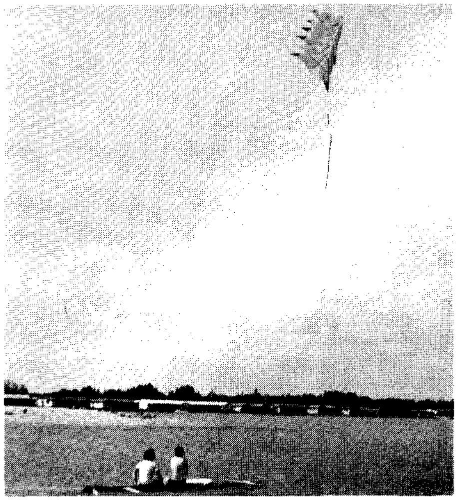
When running down wind, sailors take care to keep the sail from swinging from one side to the other. An involuntary jibe is very dangerous. In contrast, the kite sailor running down wind is only concerned that the kite does not run out of wind as the boat approaches the speed of the wind. To keep the kite from stalling, I suggest that you keep it swinging from side to side thus maintaining its forward speed. The kite actually *tacks* down wind (like an ice boat) while the boat runs directly before the wind (or should I say behind the wind).

Small boat sailors spend most of their time sitting on the windward side of the deck. The kite boat skipper will find it desirable to sit on the lee side. A kite boat does not heel naturally so this provides some artificial heeling which reduces the wetted area on the hull and provides some lift from the centerboard.

While underway you learn to watch for the *position* of the kite rather than the trim of the sail. For tacking to windward, steer the kite down into a position about thirty degrees above the horizon and then steer the boat so that the flying lines are about twenty five degrees ahead of abeam. These angles vary with conditions but that's a good place to start.

When you turn onto a broad reach you will find the kites will provide more power if they are maneuvered up and down (from about 20 to 45 degrees above the horizon). This maneuver increases the angle of attack if done properly. (The maneuvers should not be excessive or they will slow the boat down). Note the difference between this and the sail boat skipper who turns onto a broad reach. He eases off on the sheet to reduce the angle of attack on the sail.

Thus far I have been discussing technical differences. The first thing people comment on when they go kite boating is what they *don't* notice. There is virtually no sensation of speed or even motion. People who have gone kite boating with me usually ride for two or three minutes without saying much. They watch the kites and maybe ask a few questions. But mostly they look around and listen. Finally they look down at the water and exclaim, "Hey, we're really moving". The usual signs of speed they have come to expect of sail boats are simply not there. There is no heeling, no flapping sails, no humming or slapping of the rigging. The view is



completely unobstructed and there is nothing swinging overhead. The two thin lines running off the side of the deck are scarcely noticeable and the kites are far enough away that you think of them as a separate craft (indeed they are aircraft and you are on a water craft). It is this very lack of sensation that I enjoy so much. The vehicle does not impose on you. There is no sail blocking your vision, no noise interrupting your thoughts and nothing hanging over your head. Most of all, the boat does not heel and threaten to throw you overboard. There is no need to hang on or even brace yourself. At the current state of the art, it can be said that kite boating provides a remarkably quiet, steady, ride.

As the kites become more refined and the speed increases these techniques and these sensations will change drastically. Eventually, kite sailing may feel like water skiing. Now, or in the future, when you take down the mast and put up the kites, it's a whole new world.

Editor's note:

After preparation of the preceding article Gordon wishes to add that he has learned that when stacking a deck of kites a spacing of 1.25 to 1.5 times the mean chord should be used, as would be predicted from aerodynamic theory.

Gordon also writes that he is prepared to build a few eight foot wide delta kites for sale to AYRS Members for experimental work. They are the same design he uses on his original kite boat and are made of rip stop nylon and fiberglass sticks with steel fittings. "When flown on a single line they provide a stable platform. When flown on a simple two line control system they are the best aerobatic kites available." Please write Gordon for more information.

A recent issue of "Popular Science," gives a short description and some photographs of Gordon's kite sails flying over Biscayne Bay.

two or three times at both the first and third marks, without doubt the reason that he finished second by 24 seconds instead of winning.

It is a bit embarrassing to have to record that the Regatta Chairman and writer of this article finished first with his sailing raft (Fig. 5). Fine cooperation by six or seven members of the Brazos Sailing Club permitted me to delegate all the chores to others and to enter the race just for fun. Although the raft was modelled after craft in Taiwan and Vietnam which have been sailing successfully for perhaps 5,000 years, and although an earlier test had proved that she would go to windward, it was equally certain that she was no speedster. I just happened to sail out and cross the start near the beginning of the one-hour starting window and get around the course before the wind failed and prevented any better times. Of course, the raft did sail nicely and perhaps a degree of skill was involved, but the wind (and its later absence) certainly was a main contributing cause.

The raft was constructed from nine cardboard rug-mailing tubes, each sealed in a polyethylene "sausage skin". Two boards, one just abaft the mast, the other near the after end, provided ample lateral resistance, and she handled beautifully. On an earlier test it proved to be easy enough to sail the raft with no rudder at all, simply by raising and lowering the after board to change the fore and aft location of the center of lateral resistance. Rafts have been sailed in this fashion in Ecuador and Southeast Asia for probably thousands of years. With such a history of performance the "oldest" craft and the oldest skipper finished first. A view of the raft and sailor crossing the finish line concludes these comments on the Fourth Fifty Dollar Regatta (Fig. 6).

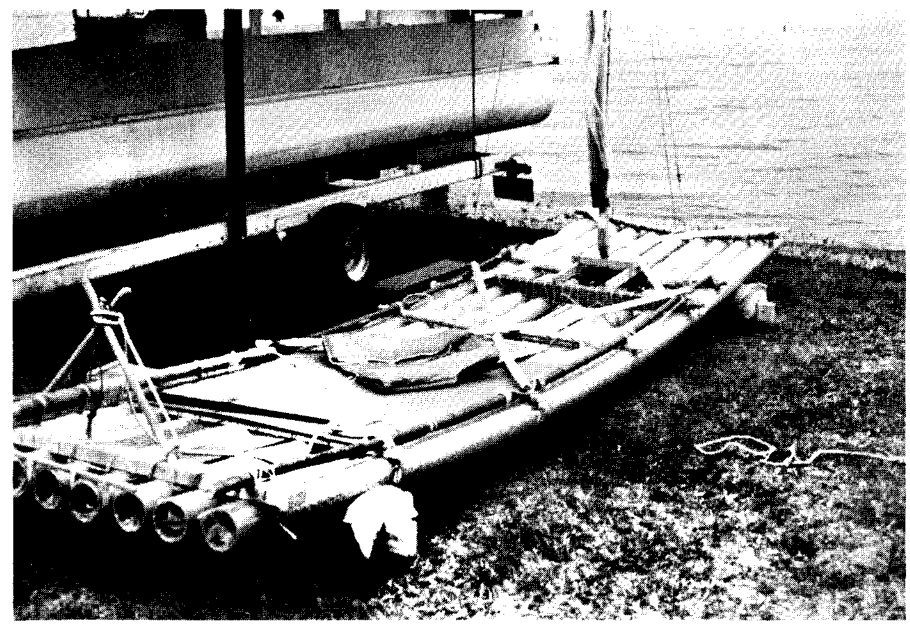


Fig. 5. The cardboard raft before launching.

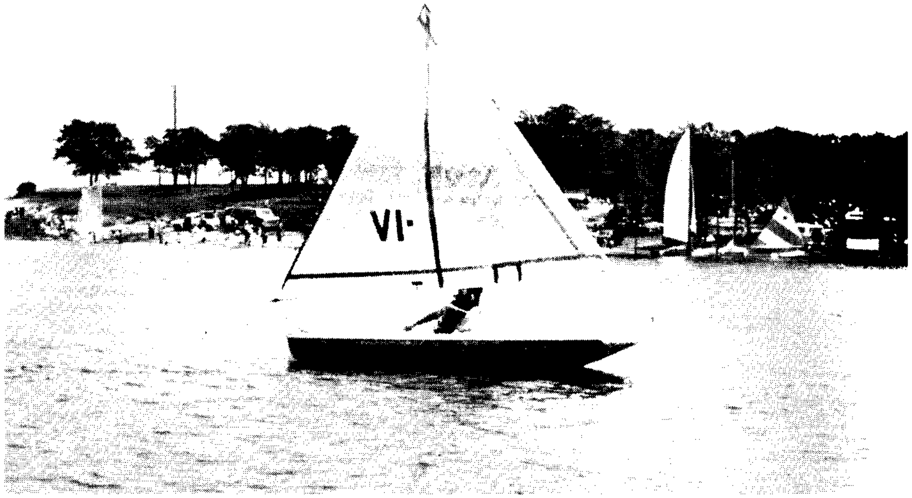


Fig. 3. The Hayden-Rosamond scow, a polyethylene curragh.

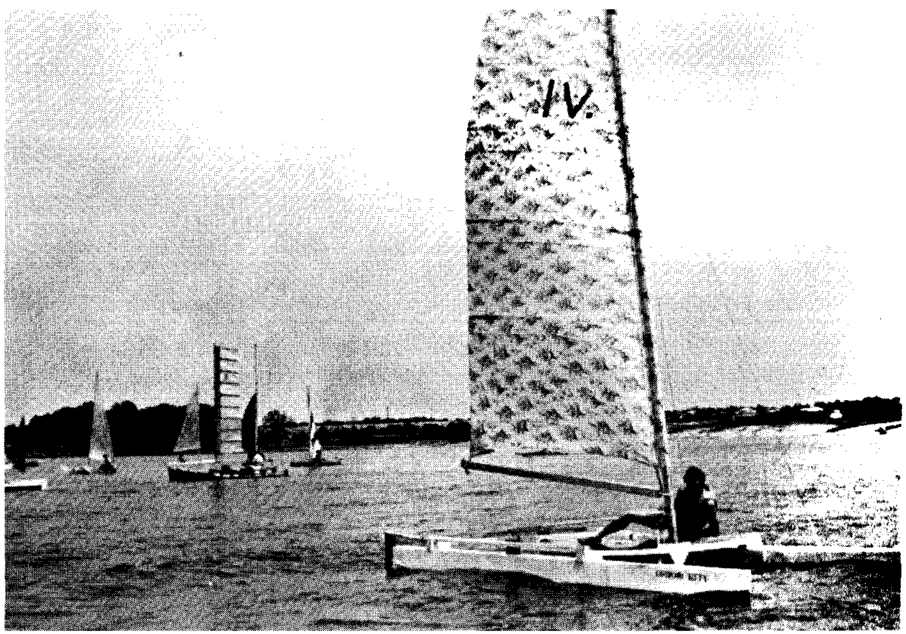


Fig. 4. Second-place winner Rob Murphy, sailing the *Kardboard Kitty*.

THE FREE FLYING KITE SAIL

Harry B. Stover, Rt. 2, Box 434A, Lancaster, Va. 22503 USA

INTRODUCTION

John Morwood, in publication No. 9, Oct. 1956, showed how a free flying kite could pull a boat to windward. Later, in publication No. 37, Oct. 1961, John stated, "But surely, the ultimate in high speed sailing will be the hydrofoil craft pulled by the flying kite; and this last has been utterly neglected since it was first shown in publication No. 9".

It has been twenty years since John first wrote the above and, except for the work of Gordon Gillett, it appears to me that we are almost as far from a practical solution as ever.

It is my view that the problem, although difficult and complicated, is solvable. Furthermore, the benefits of solution would be such that I think it would be worthwhile for the AYRS membership to make a major effort in this direction.

THE PRINCIPLE

For those who do not already know, the principle is as shown by Fig. 1. What is required is a kite which can be flown well to either side of downwind and be stable and pull hard in this condition. The obvious advantage is that, since there is no heeling moment, there is almost no limit to the amount of sail which can be carried. I keep thinking of a canoe with a 500 sq. ft. kite sail. That would give a Bruce Number of about 3.35 which is much higher than the *Crossbow's* Bruce Number.

KITE AERODYNAMIC STABILITY

The kite should fly in two separate modes. It should fly downwind, mostly for holding action such as when the boat is moored. The kite must also be able to fly well out to either side completely under the operator's control.

I have been unable to find a satisfactory discussion of kite stability so I developed my own theory. I believe it is correct but I am not 100% sure. It is offered as a base for anyone who might undertake kite sail design. If anyone finds something wrong in that which follows I will be as pleased as anyone else to hear about it.

First, I am going to discuss downwind stability.

John Morwood has said, "A model glider will not fly as a kite. It will rise well enough and it will climb till it is more or less straight overhead. Then it will side slip to the ground." I have checked this out and agree with John. I have concluded that the reason for this is that the glider has its center of gravity forward of the center of lateral resistance. This is essential for directional and transverse stability in free flight. If the model, in free flight, is disturbed to lean to one side, the nose drops, the model side slips and turns toward the low wing. This turning side slip action causes the wing to be yawed with respect to the relative wind. Thus the dihedral of the wing is brought into play and the model returns to level flight.

There is a misconception concerning the action of dihedral which, unfortunately, is actually found in some text books. The erroneous explanation is

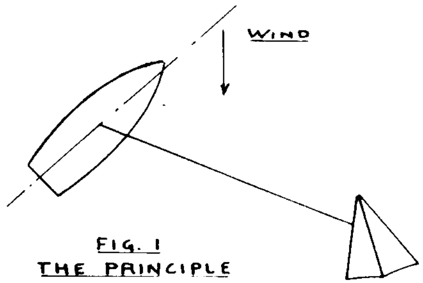


FIG. 1
THE PRINCIPLE

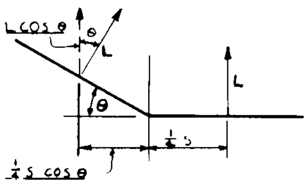


FIG. 2
EFFECT OF DIHEDRAL
ERRONEOUS

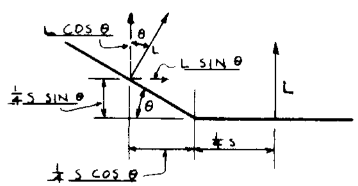


FIG. 2A
EFFECT OF DIHEDRAL
CORRECT

indicated by Fig. 2. The erroneous explanation states that the vertical lift of the elevated wing panel is degraded to L cos θ and thus is less than the lift on the other panel. Accordingly, the wing is supposed to return to a condition of level flight. Fig. 2 is presented incorrectly. It should be as shown by Fig.2 A. The force component L sin θ was omitted from the diagram shown on Fig. 2. If we take moments about the center of the wing and equate clockwise to counterclockwise moments, we get:

$$(L\cos\theta)\left(\tfrac{1}{4}S\cos\theta\right) + (L\sin\theta)\left(\tfrac{1}{4}S\sin\theta\right) = \left(\tfrac{1}{4}S\right)(L)$$

$$\tfrac{1}{4}SL\cos^2\theta + \tfrac{1}{4}SL\sin^2\theta = \tfrac{1}{4}SL$$

$$\text{or } \tfrac{1}{4}SL(\cos^2\theta + \sin^2\theta) = \tfrac{1}{4}SL$$

$$\text{or } \tfrac{1}{4}SL = \tfrac{1}{4}SL \text{ since } \cos^2\theta + \sin^2\theta = 1$$

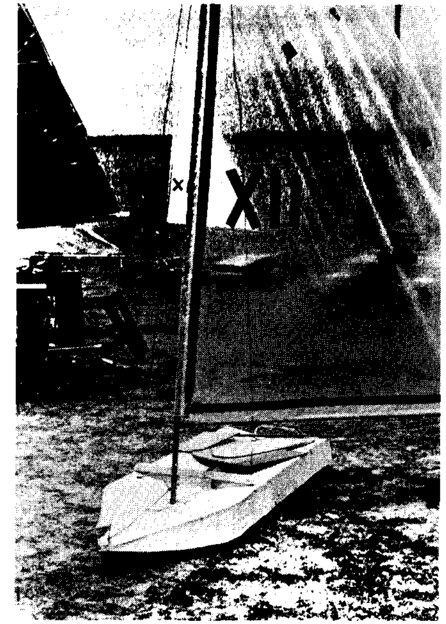


Fig. 1 Jack Anding's cardboard scow.

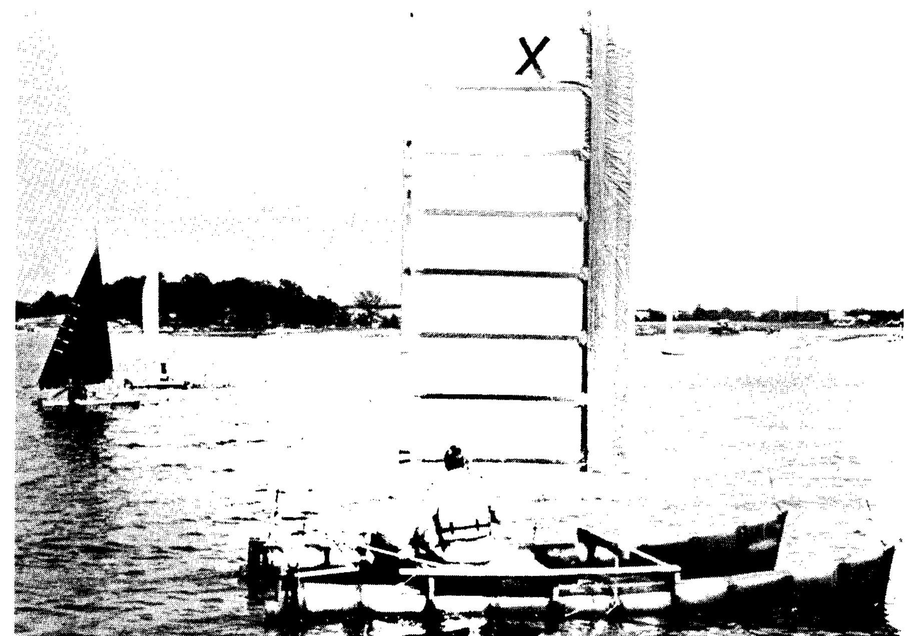


Fig. 2. Joe Gray sailing *You Can Too.*

filament tape. The largest field yet was preparing for the fourth annual regatta sponsored by the Brazos Sailing Club and the Amateur Yacht Research Society. As the spectators clustered around the boats, speculation about the probably winner was rife and guesses on which boats would go to windward well enough to cross the starting line were even more varied. The builder and sailor of the ultimate winner knew that his craft would sail against the wind (an opinion shared by few observers) but aspired only to sixth or eighth place as he evaluated the faster boats.

The weather, which became a critical factor in the results, must be described. A severe cold front was in the near offing, but the mid-morning saw a good 15-knot breeze out of the south. As starting time (and the front) approached the wind dropped to about 10 knotts, then declined during the race to practically nothing. About two hours after the event the front came through with north-west winds at 40 knots, capsizing half the conventional boats on the lake. Opportunely for many flimsy creations, the regatta took place precisely in the short, calm period before the front arrived. The fact that nine of eighteen entries circumnavigated the course, an unheard-of proportion in previous races with good breezes, is witness to the "window" in the wind.

Entries were far too numerous to describe each, but a few of the more striking might be mentioned. The light aggregate concrete board boat of last year again entered but again had rigging problems. Several catamarans used cylindrical cardboard tubes of 10-inch diameter for hulls which were amply buoyant but poorly faired and slow. "Pipe Dream" had a larger sail this year, but the PVC tubes were too small and the drag of the central flotation too high. Although a facsimile of a Hobie 14, cardboard hulls with V-shape, appeared to be a dangerous competitor on the beach she had leeboard and rudder trouble and did not start.

Among the successful circumnavigators, but toward the lower end, was Jack Anding, youngest skipper in the race at age 13, with his tiny cardboard scow (Fig. 1). Joe Gray's welded-can catamaran had surprisingly well-faired hulls, and his sail was unquestionably the most interesting in the race (Fig. 2). The high aspect ratio, rectangular, partial-wing sail utilized individual sheets from each batten, leading aft to a vertical spar and down to a multiple-sheaved winch. Unfortunately the sheets fouled and by the time he got to the starting line the wind had dropped to about two knots. As a result one of the two or three most innovative boats in the race, a probable winner if the morning's wind had held, finished well down the list.

Third in starting and in finishing was a sort of small, inland scow built by S. Hayden and M. Rosamond, architecture students (Fig. 3).

Widely-spaced and curved battens formed a framework, over which was stretched two layers of polyethylene sheeting to produce a beautiful, transparent hull. Luckily it encountered no floating objects. In second place was a cardboard catamaran, sailed by Rob Murphy of the Houston Sol-Catters Club, which truly deserved a high place in the finish (Fig.4). The hulls were fine and well-faired, and the sail was a real beauty, not only for its fine shape but also because of its origin as a lovely flowered bedspread. Mrs. Murphy, sail-maker and donor of the spread, perhaps deserves as much credit as the sailor. Although the long hulls were fast they had little rocker. With no jib to push him around Rob missed stays

and there is no restoring effect.

So what is the correct explanation? It is simply that a yawed wing with dihedral will experience an increase of angle of attack, and thus more lift, on the lower wing panel than on the higher wing panel. This might be somewhat difficult to visualize, but if you fold a piece of paper so that it simulates a dihedraled wing and hold it in a yawed position in front of your eyes, I believe you can see what I mean. I have tried to sketch this as Fig. 3.

I would not have gone into all this except that the action of dihedral is explained incorrectly in many places and it has an important bearing on why a model glider side slips to the ground when flown as a kite.

When a model glider is flown as a kite and is disturbed to one side the nose drops but the model is prevented from turning toward the low wing by the restraint of the kite line. Thus, the necessary yawing action required to restore transverse stability is prevented and the model simply side slips to the ground.

O.K., how can we modify a model glider so it will fly as a kite? The key is in the relative location of center of gravity and center of lateral area. In the free flight glider it is essential that the center of gravity be forward of the center of lateral area for directional stability. In a kite the opposite is the case. The center of gravity of a kite must be aft of the center of lateral area. When a kite is disturbed to one side, the kite is flying to some extent on its side. If the center of gravity is aft of the center of side area, as it should be, the aft weight causes the tail to drop, and the nose to rise, which, in turn, causes the kite to return to the stable downwind condition. The best example I can think of is an ordinary box kite, as shown by Fig. 4. The center of gravity of the box kite is at midlength as shown. The ordinary center of lateral area is also at midlength. However, as is well known, the effective center of lateral resistance is somewhat forward of the center of area, which is where I have shown it in Fig. 4. As can be seen, the string axis is still somewhat forward of the center of lateral resistance, which is essential for directional stability.

Thus, I conclude that if a model glider is to be modified to fly successfully as a kite, the center of lateral area - center of gravity relationship must be altered to place the center of lateral resistance forward of the center of gravity.

So much for transverse and directional stability. Now for longitudinal stability. This is fairly simple. Fig. 4 shows that the box kite line is attached to a bridle which provides considerable longitudinal stability. Thus, longitudinal stability is not much of a problem when flying in the downwind condition.

Probably 90% of our kite sail activity will be with the kite out to one side or the other. What happens to our kite, which was stable in the downwind condition, when we fly it out to the side? We find that, if we have a good downwind kite, it will not fly out to the side. When flying to the side, the kite is flying up on edge and is supported by its side area. Since the center of gravity is aft of the center of side area the tail drops and the kite zooms back up to the stable downwind position. You can force a kite to the side by two lines which can attach directly to the kite, or to a rudder. However, it has been my experience that if you try to get the kite very far out and try to get some pull on the line the slightest disturbance will upset everything, The kite will either flutter to the ground, out of control, or it will zoom back downwind.

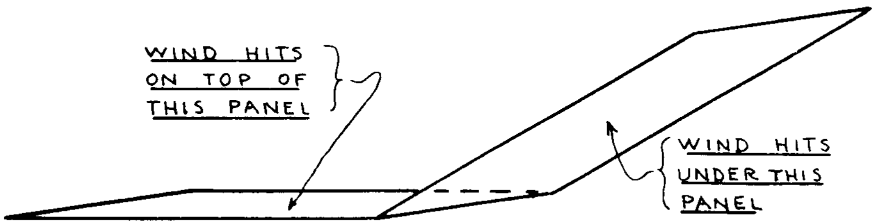


FIG. 3
YAWED DIHEDRAL

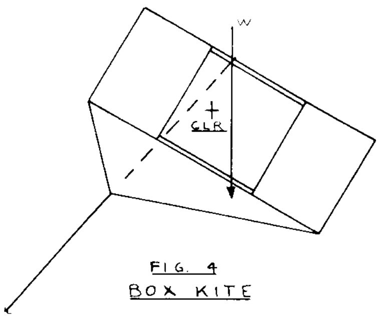


FIG. 4
BOX KITE

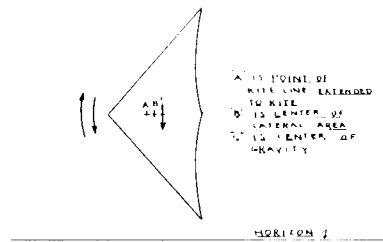


FIG. 5
OPERATOR'S VIEW
SIDE FLYING KITE

So, the relationships have to be different for out to the side flying. Fig. 5 is supposed to be the operator's view of a side flying kite. When the kite was flying overhead the location of center of gravity was not especially critical as long as it was aft of the center of side area. The direction of the weight force was vertical which was pretty much in line with the kite line and stability was assured by the bridle. When flying to the side, however, the weight force is at right angles to the kite line and the slightest shift in center of supporting pressure causes the nose to turn up, or down, quickly. When flying to the side we need two things to maintain stability around the string axis. We need a longitudinal distribution of side area (which is supporting the kite's weight) equivalent to the wing and stabilizer of a model glider and we need some additional control to bring the nose up or down when relative wind speed changes. A normal model glider has a wing forward and stabilizer aft. Other configurations are feasible and can be considered for our kite. A canard arrangement is possible and a single, swept-back, wing is also worth considering. Don't forget that I am talking about side area here because the kite is flying on its side. Side area consists of fin area, projected area of dihedral, or if the kite is flat it is horizontal projected area of the flat kite - or any combination of these things.

Thus, it is my conclusion that the two requirements, i.e. flying overhead and flying to the side have mutually conflicting requirements and to satisfy both will require considerable compromise in our kite design. Since I feel that at least 90% of the time we will be flying the kite to the side, I think the kite design should be based on the side flying requirements and we should add only the minimum features that will let us fly downwind.

ester. This is contrary to what we know about the shear strength properties of epoxy versus polyester. Accordingly, Line 4 and 4N are suspect. My suspicion is that the laminate was resin starved. You will note that, although the wet-out characteristics of epoxy are superior to those of polyesters, the fiber volume percentage in Line 4 is quite high and is in the region where one must be particularly careful with regard to starvation, entrainment, and re-entrainment of air. Then again it may have been faulty fabrication technique such as the entrance of contaminants. Lastly, I may be perfectly wrong in my suspicions."

"Just so I don't spoil my record, I'll vote for 'Lastly' and Line 4/4N."

"I knew you would, Joel, on both scores."

Joel then brought up an intriguing question. He asked what the comparative values would be if he made the laminates of equal weights by increasing the thickness dimension, using the laminate material of Line 4. I told him that, if he did this, the new thickness of his solid laminate would be -

$$(1/0.79) \times (0.250) = 0.316'', \text{ and}$$
$$c = 0.158'' \; ; \; w = 1.00''.$$

'I', and therefore the stiffness, would increase by a factor of 2.02;
'S', and therefore strength, would increase by a factor of 1.60.

"Which means," Joel said as he commandeered my calculator, "that the new relative factors, relating back to the standard, are (3.131) for flexural modulus and (1.856) for flexural strength."

"Which means...?" I signalled him to go on.

"...that weight for weight, Kevlar - and epoxy - would give me a solid laminate that was about three times as stiff and approximately twice as strong ... either way, 'Sold American'."

"Glad you said that because it reminds me of another factor that must be taken into account. Cost factor. Using epoxy just doubled your resin costs and, if I remember correctly, your fabric costs would go up three or four times."

"Boy, you never let a guy dream, do you?"

"You're the one that's always cryin' about costs," I replied.

Joel turned his head suddenly. "That's Bill Hopkins coming into the shop. We'll have to break off and continue our discussion on foam sandwich the next time we get together."

"Maybe you can sell him on some Kelvar and epoxy," I teased.

"Kevlar," Joel corrected.

"Whatever."

THE FOURTH FIFTY DOLLAR REGATTA

by

Edwin Doran Jr.

Edwin Doran Jr.; 1114 Langford St.; College Station, Texas 77843 USA

April of 1976 once again found the shoreline of Lake Somerville in Texas crowded with a strange assortment of sailing craft. Eighteen unusual boats were being rigged with such nautical materials as cardboard, binder twine, and

MECHANICAL PROPERTIES OF HAND-LAYUP KEVLAR 49 ARAMID FABRIC REINFORCED COMPOSITES STYLE 281

Line	Specific Gravity	Fiber Volume Percent	Flexural Strength (psi)	Flexural Modulus (10 6 psi)	Interlaminar Shear Strength (psi)	RESIN
(3)	1.26	37.0	32,100	2.54	4,420	Polyester
(3A)	(0.77)	(1.00	(1.02)	(1.25)	(1.36)	"
(4)	1.29	42.6	36,600	3.16	3,750	Epoxy
(4A)	(0.79)	(1.15)	(1.16)	(1.55)	(1.15)	"

"I know that you pulled lines 1, 2, 3 and 4 from the DuPont Memo", Joel questioned, "but where do 1N, 2N, 3N and 4N come from?"

"As we went along, I normalized all of the data to Line 1 which represents your laminate, and is the composite that I said that we would take as the 'standard'. In other words, I divided all of the data by its couterparts in Line 1 and set the results in parenthesis in the 'N' lines. And, of course, Line 1 normalized to itself yields all (1.00's) as you see in Line 1A."

"Hey, I get the picture, now. This is really neat!"

"Well, since you think that you've hoisted all of it aboard, tell me what the normalized data tells you."

"First, I am correct in assuming that we are talking about solid laminates?"

Getting a nod from me, he continued.

"It's all elementary. I'll take you to the bottom line straight away. If I had built my solid laminate test strip using Kevlar (He got it right!) 281 in an epoxy, building to the same dimensions - a quarter inch by one inch - I would have: -
-Reduced the weight by 21%
-Increased the strength by 16%
-Increased the stiffness by 55%

"This all comes out of Line 4N," he announced with an air of authority.

"Beautiful, you are correct in your interpretation, but you failed to notice something in the data."

Joel's eyes rolled skyward as I continued on.

"You must continue to remember that the manufacturer's data applies to his results on the specimen that *he* prepared; they do not necessarily apply to what you will get. In this particular case, I think you might have done better than the manufacturer, namely, I think you could have fabricated the Line 4 laminate with better results.

"I appreciate your new and rare confidence in me, but how can you use the data to come to this conclusion?"

"Elementary. Compare Line 4 against Line 3 under interlaminar shear strength. Notice that the value is poorer for the epoxy laminate than for the poly-

CONTROLS

To control the kite, one immediately thinks of two kite lines and this is probably the best basic system. However, we could use radio control, we could send electrical signals up the kite line (wire) or we could get some response by twisting the kite line. My present feeling is that we should use three lines. Two of these lines will be for steering the kite right or left and the third line will be to change the angle of attack. For example, if we anchor out, or tie to a wharf, and leave the kite up, we should be able to reduce the angle of attack to obtain minimum drag or force on the kite line. We would also like to reduce the force when we haul the kite down to the boat.

With regard to the two main control lines, I am working on a system as shown by Fig. 6. The system employs a yoke with kite lines attached to the yoke ends. The idea is that the kite will follow the position of the yoke. As shown, if the kite goes lower the front rudder, or elevator, is turned to bring the kite back up. If the kite goes up the opposite occurs. I think a front rudder, or elevator, is preferable to a rear rudder, or elevator, because the kite can be balanced so that when flying to the side a small amount of lifting rudder is used. This provides a small amount of longitudinal dihedral which is desirable for longitudinal stability. If we want the kite overhead, we put the yoke horizontal and the kite follows. The only thing which keeps the kite overhead is the constant action of the rudder because the kite is set up for flying to the side. So far I have been able to get the system to work but the kite I have used is not efficient enough to make a good kite sail. For a practical system on a full size boat the yoke arrangement will have to be combined with winches to pay out and retrieve the kite lines. I think three winches are required because I favor a third line to control angle of attack. This does not appear to be impossible.

EFFICIENCY

How efficient should our kite be? Gordon Gillett says that the kite should fly with the kite line at an angle of 75° with the horizontal in the downwind mode. Such a kite, which is better than most, is efficient enough when flown to the side to permit a boat to go to windward.

I visualize the future of kite sailing to include, for different purposes, several different types of kites such as Gordon's which are Delta type stick and fabric kites, to highly sophisticated built up airfoil types. This range of kite types is roughly equivalent to the range of glider types, spanning from the hang glider with a gliding angle of perhaps 4 to 1 to the high performance sailplane which has a gliding angle of better than 20 to 1. Each type would have its uses and limitations.

Gordon's kite at 75° line angle has a lift drag ratio of 3.7 to 1. Most airfoils have a lift drag ratio of about 20 to 1 for aspect ratios of about 6. It appears to me that it should be possible to build a kite with airfoil surfaces that would have a lift drag ratio, including air drag of the lines, of about 15 to 1. This would mean that the kite line would stand at 86° to the horizontal in the downwind condition. Such a kite would be quite expensive but perhaps very useful if maximum speed is desired.

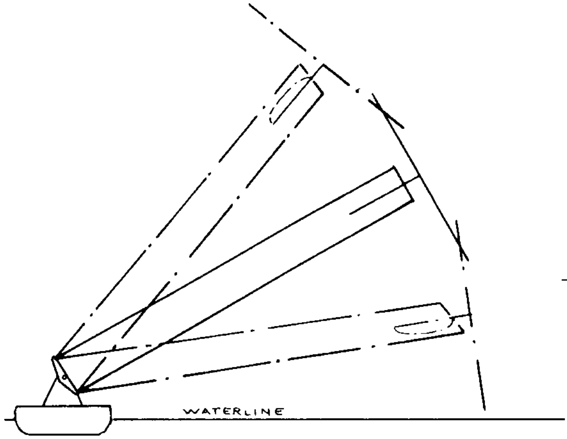


FIG. 6
MY PRESENT CONTROL SYSTEM

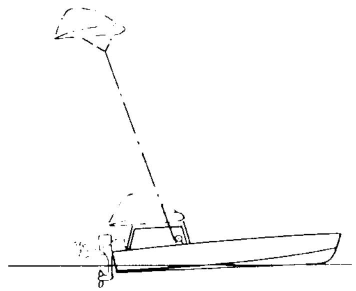


FIG. 7
AUXILIARY POWER FOR TAKEOFF

LAUNCHING METHODS

Our kite is no good if we cannot get it into the air.

I have thought of several methods and I am sure there are several more.

We could have floats on the kite and allow it to drift away from the boat. At the proper time we could increase the angle of attack and fly it off the water.

We could have an elevated structure on the boat and launch from that.

We could have a skyhook system. I got this idea from one of Gordon's kites. At SM-3 he flew a single kite of about 6'-0" spread. This kite flew at a steep angle and pulled like a mule. In fact, I dared not hold the line for fear of cutting my hand. I held it by a stick tied to the line. The line was so tight that it was strumming like a banjo string. At any rate, we could fly a kite such as this and use it, or an attachment to the kite line, to act as a skyhook to get another, larger, kite into the air.

We could use auxiliary power. For instance, we could use, say, a 25 horsepower outboard motor which might drive our boat at about 20 miles per hour. Going against the wind, we could fly our kite off an aft support as per Fig. 7. Once aloft and underway, we would have two things going for us. The kite would be up where the wind was stronger and once the boat was moving the apparent wind "seen" by the kite would be much greater than the true wind. As soon as we got underway we would shut off the motor and raise the propeller from the water.

OTHER USES FOR KITE SAILS

There are probably a number of applications for kite sails, other than for ordinary sailing, not yet apparent. Some, which I have thought of, are:

We could use kite sails to provide "come home" capability in event of dismasting or capsize. Harry Morss, at SM-3, said that people are beginning to think that we should make some arrangement whereby we can sail a capsized multihull to shore. Several hundred square feet of kites, such as Gordon Gillett demonstrated, can be folded into a relatively small bundle. Such a package could be carried aboard a multihull for emergency use in case of capsize, or dismasting.

$$\frac{\text{FLEXURAL MODULUS (SYSTEM A)}}{\text{FLEXURAL MODULUS (SYSTEM B)}} = \frac{Q_A}{Q_B}$$

" 'Flexural Strength' and 'Flexural Modulus' are the two data parameters that we are particularly interested in using because they apply to the laminate composites as a result of bending, i.e., their values were obtained by laboratory bending and measuring devices, operating on specimens of the actual material of interest. More importantly, these parameters reflect the combined effects due to the difference of the materials compressive strength versus its tensile strength, and the tensile modulus of elasticity versus the compressive modulus of elasticity -- including the shift in the axis of rotation induced thereby. You remember my mentioning these things earlier. Kevlar happens to be one of those materials whose compressive qualities are significantly different from its tensile qualities. By any event these are the data that you should utilize in getting comparisons of strength and stiffness.

"The most useful way to obtain comparison values is to select one of the laminate systems as a standard and normalize all of the others to it, say 'System B'. Our expressions would then take the following form;

$$\frac{T_X}{T_B} = \frac{F_X}{F_B}\ ;\ \frac{K_X}{K_B} = \frac{Q_X}{Q_B}$$

As a matter of fact, where ever a direct proportionality exists between parameters, you may take the values of the parameters of System B and divide them into their conterparts of the other systems to normalize them to the standard, System B. It so happens that the DuPont Memo lists a laminate system which we could take as our standard with particular advantage. It is the laminate made up of 'E'-Glass, Style 181, in polyester, shown in Table IIB of the Memo. As you recognize, this is the exact same composite that you used in your test strips. For discussion purposes, and to illustrate what we have just been talking about, let's also focus our attention on one other laminate system presented therein: Kevlar 49, Style 281. And, let us also look at the data for these reinforming materials as presented in Table IIA, which presents there epoxy matrix counterparts or versions."

I extracted the pertinent parts of these two tables so that Joel and I could examine them closely. We then had the following data before us:

MECHANICAL PROPERTIES OF HAND-LAYUP FIBER GLASS FABRIC REINFORCED COMPOSITES.... "E"-GLASS, STYLE 181

Line	Specific Gravity	Fiber Volume Percent	Flexural Strength (psi)	Flexural Modulus (10 6 psi)	Interlaminar Shear Strength (psi)	RESIN
(1)	1.63	37.0	31,600	2.04	3,254	Polyester
(1N)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	"
(2)	1.67	34.9	31,800	2.34	3,580	Epoxy
(2N)	(1.02)	(0.94)	(1.01)	(1.15)	(1.10)	"

bottom of the brochure it was stated that the resin used was epoxy, the composite was cured in an autoclave (therefore heat and pressure were applied), and that the fiber volume content was 55%. Now, epoxy cured under elevated temperature and pressure yields an entirely different material than what we get in land lay-ups at room temperature. Also, lots of luck in trying to get that 55% fiber volume content.

"The point is that we not only need the date on the composite, but on the composite as we would produce it. Hopefully, it should be for the exact same composite materials we would be using. If the aforemented conditions were met, are there, even so, other questionable aspects with regard to a manufacturer's data? Yes. More than likely his test samples would have been produced under laboratory conditions that were far more benign than what we have in our boat shops. I'll mention one small item, Humidity. Have you ever taken the trouble to dry out your glass fabrics in an oven prior to using? Humidity affects glass fabrics and the applied resins. Did you know that the moisture and carbon dioxide in the air will contaminate the surface of an epoxy laminate? And then there is the thing I keep harping about: Fabrication techniques ..."

"What I have been aiming at is to encourage you to be careful about using the manufacturer's data and the conditions under which it was generated. The absolute results you achieve, in general, will not be as good as those of the manufacturer. However, the more you improve your fabrication techniques by observing aspects I've noted, the closer you will approach the full potential of the materials with which you are working. Because all of us need improving, and because no two of us are alike, you can now appreciate why comparison factors, rather than absolute values, ought to be a bases for discussions concerning improvements in strength and stiffness. When absolute data is presented, we are in fact starting what someone else has achieved; when we give comparison factors, we are stating the kinds of improvements you should be able to achieve over and above what you are getting with your current materials and systems - as produced by you. And that is as it should be."

"Talk about preaching." Joel interrupted.

"Let's get on with the Kelvar business."

"Kevlar," I corrected.

"Whatever."

"O.K." I said, "What we'll do now is to take a look now at the two mathematical relationships that I promised previously."

I penciled out the following:

$$\frac{\text{STRENGTH IN BENDING (SYSTEM A)}}{\text{STRENGTH IN BENDING (SYSTEM B)}} = \frac{T_A}{T_B} =$$

$$\frac{\text{FLEXURAL STRENGTH (SYSTEM A)}}{\text{FLEXURAL STRENGTH (SYSTEM B)}} = \frac{F_A}{F_B}$$

$$\frac{\text{STIFFNESS (SYSTEM A)}}{\text{STIFFNESS (SYSTEM B)}} = \frac{K_A}{K_B} =$$

Such a system would also take care of steering the boat if the kites were flown from a bridle attached to the ends of the boat.

We can use an efficient, uncontrolled, kite out to leeward as aerodynamic ballast. If the kite has a lift drag ratio of 15 to 1, it can generate an upward force more efficiently than a hydrofoil which probably will not do better than 10 to 1. There is an unusual advantage to aerodynamic ballast in that the drag of the kite is in the direction of the relative wind, not along the course made good by the boat. Thus, the increased boat drag, due to the kite, is less than otherwise.

We could use a kite to augment the speed of a fast power boat. Very few fast power boats have an overall weight to drag ratio (or lift drag ratio which is the same thing) better than about 4.5 to 1. If such a boat were towing an efficient kite with a lift drag ratio of, say, 15 to 1 the power boat would pick up speed. This is because for every 1000 pounds of weight lifted by the kite the boat drag would be reduced by 156 pounds. This is due to the difference in lift drag ratios of boat and kite. A strange thing about this is that the boat resistance would be further reduced when towing the kite against a wind since more of the boat weight would be shifted to the kite.

CONCLUSION

I have not told you specifically how to build a kite sail simply because I have not yet built a very successful one myself. I have built a lot of kites but so far nothing I am proud of. The best kites I have seen are those of Gordon Gillett. However, I do think that the considerations I have outlined in this article can eventually lead to a satisfactory solution.

THE KITE RIG

by Roger Glencross, 71 Stuart Road, Wimbledon, London
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My interest in the kite rig arose from my interest in manpowered flight and my failure to design a manpowered aeroplane of compact design, i.e. with a wingspan of up to 20 ft. Dr. Keith Sherwin states in his excellent book, "Man Powered Flight", that the development of manpowered flight depends on the construction of aircraft of wingspans of the order of 50 to 65 feet which could fly in wind strengths of *up to* 12 m.p.h. Any higher wind velocity would be too much for the structural load-factor that the high aspect ratio wings have to bear.

My object is to design a manpowered or nonpowered aircraft capable of carrying one man, capable of flying from any point of the compass to any other point in most wind conditions, not dependent for forward motion on wind direction (like a free balloon), or on thermals and height (like a free glider), about 20 ft. in wingspan and not requiring a ground crew to be always in attendance. The kite rig appears to fill this role admirably.

THE KITE

This should not cause difficulty since a commercially produced hangglider can be bought over the counter and used as the kite. This has been suggested by Halsey Jones in AYRS No. 8, p. 79. As stated in "Aerodynamics I" p. 38, a kite can pull a boat at an angle of 80° from directly downwind, which would pull the boat on a course of about 45° from the eye of the true wind. The rope would have to pull forward of the beam. Since the natural tendency of the kite would be to pull the boat directly downwind, the boat could move both upwind and downwind. With tacking if necessary it could thus reach any point and thereby prove itself a practical means of transport.

When an aircraft is in a state of steady flight its weight equals the lift that the wings generate. This lift is computed by the following formula:

$$\text{Wing coefficient of lift} \times \frac{\text{air density}}{2} \times \text{wing area} \times \text{airspeed}^2$$

In order that the kite can fly in the maximum of light wind conditions airspeed^2 must be kept as ow as possible. To achieve this the wing area must be as large as possible so one should choose the largest hangglider available, and not the hangglider recommended for a pilot of a given weight. Take the 18 ft. long Skyhook IIIa of 227 sq. ft. weighing 45 lbs. I weigh 126 lbs. naked so all-up-weight is 171 lbs. The coefficient of lift for this wing is 1.08 and air density is a constant at 0.0024 slugs/ft.^{3} so the equation is:

$$171 \text{ lbs.} = 1.08 \times \frac{0.0024}{2} \times 227 \times \text{Airspeed}^2$$

$$\therefore \text{Airspeed} = 24.11 \text{ ft./sec.} = 16.43 \text{ m.p.h.}$$

For the kite to be practical it must be able to fly in a wide variety of wind strengths. In England the wind strength is at light force 3 (8 - 12 m.p.h.) or more for 70% of the time. This figure is for day and night combined, and as light winds are more frequent at night, the 70% is exceeded during the day when flights would take place. Coupled with this the kite would encounter even stronger winds than this when above the earth's boundary layer. This is the region of the atmosphere where the wind velocity changes from zero at the actual surface to the free airstream velocity. The boundary layer roughly extends to 100 - 200 ft. altitude depending on he wind speed and type of surface. The Beaufort wind scale immediately above "light" is "moderate" (13 to 18 m.p.h.). A kite which could take off in winds of less than moderate would probably find sufficient conditions in which to fly to be a practical proposition.

The velocity of 16.43 m.p.h. computed above is the *apparent* wind velocity felt by the kite. Taking Edmond Bruce's polar graph of a multihull yacht's performance given in "Sailing Figues" p. 47, which assumes $V_B/\sqrt{L} = 1$ we see that on a course of 45° to the true wind $V_B/V_{AW} = 0.36$. Assuming $V_{AW} = 16.43$ m.p.h. we get the triangle of velocities in figure (1). A V_T of at least 11.71 m.p.h. is required to enable flight to be achieved on this course. The kite would keep perfect station with the boat on all courses, therefore V_B = kite speed. The kite would face the direction of the apparent wind. In any higher V_T the boat and kite would travel proportionately faster on this course. On a course of 90° to the true wind the polar graph gives V_B/V_{AW} as 0.75. At a V_{AW} of 16.43 m.p.h. this gives the triangle of velocities as in figure (2). This requires a V_T of only 10.67

laminate that had many voids, resin rich areas, and resin starved area. I reminded him of his attempts to achieve a high ratio of glass to resin, and the way the glass sucked in air and nullified his efforts...

"Drink your coffee." By the way he said, "O.K., Pal", I knew that he was going to have at me again. "So how are you going to write that article about Kelvar?"

"Kevlar", I corrected.

"Whatever. How are you going to answer your friend J.S.?"

"You mean Jack ... the Third?"

"Whatever."

"I'm going to do the same in the article as we've been doing here this morning. In essence I'll be saying. 'On a comparative basis, these are the kinds of improvements that can be expected through the use of Kevlar'. What I'll be dealing with are multiplication factors or percentages which relate back to a given standing. In this way, many of the worries connected with differences in fabrication techniques, *et al*, are largely done away with. This will become clear as I go along.

"I'll present only two mathematical relationships of the proportions variety, and a rationale, so simple that anyone can reproduce, and extend, what I will present."

"I'll drink to that!" responded Joel, raising his cup on-high.

"At the moment, the only good source of useable data is that which the manufacturer of Kevlar, DuPont, is putting out. Here's a copy of their *A Preliminary Information Memo*, Number 344, of 18 August 1975; all of the data that I'll be using comes out of this pamphlet. Now let's talk a bit about the use of manufacturer's information.

"A lot of the data presented has no practical use for our purposes, however impressive, and, if used to draw conclusions, can be misleading. In other words, you've got to know what data you should use for your purposes. For example, if you were to look up the Modulus of Elasticity for Kevlar and glass fiber, these would be respectively, 19×10^{6} psi. Since stiffness is directly proportional to the modulus of elasticity, this would tell us that, for equal cross sections of material, Kevlar is 2.24 times as stiff as glass. You would also find data that gave the modulus of elasticity in terms of equal weight (Kevlar has a lower specific gravity than glass). The Specific Moduli of Elasticity for Kevlar and glass are: 365×10^{6} psi and 98×10^{6} psi, respectively. On a weight-for-weight basis, then, Kevlar is 3.72 times as stiff as glass. The point I want to make now is that this data is of academic interest only because it applies to the basic material. What we really need is the data that is applicable to a *laminate system*, i.e., the final fabric/resin *composite*. When dealing with reinforcement material for plastics, it's not like dealing with aluminum or steel. If someone tells you that you have 6061 T6 aluminum, its properties are defined then and there - except where you bugger it up with weldments that alter the heat treat.

"As long as I'm telling you about data that you should steer clear of, let me tell you about another category that you should avoid - and then I'll get to telling you what you should use. In one of the brochures I read about Kevlar, some very impressive results were set forth for Kevlar properties. In small print at the changes. Accordingly, in your tests, when you applied loads, 'c' was changing. Furthermore, it was changing as a function of time because it does take time for the PVC to compress. This was the reason for your erratic results. If you could have loaded and unloaded, and taken your readings, instantaneously, you would have gotten the equation results for the designed 'c'. But with a soft core, things are not quite so nice and neat."

"Which brings up the matter of why I don't provide scantling data. The foam sandwich sample which you produced will make a fine hull material. But there's no way you can insure, having given the information to some builder, that he will employ that material properly. And the shear load aspect which I have just mentioned gives a good example of the kinds of things that happen. Where you have high, static shear (compressive) loads, such high loading exists, you must substitute another core material of much higher compressive (normal) strength. Too often this is not observed and much complaining and suffering results. You might say, in such instances, that the individuals involved, as well as the material structures, lose their "S's"."

"That's because they don't have an "I" for it," Joel interjected.

I told Joel that one had to be careful when using formulas as our discourse brought to light. However, the equations and the comparison technique were useful in generally determining the performance of a proposed, new system if he knows the performance of an existing material system. As far as restrictions and precautions went, I mentioned a few more. In our discussions it was assumed that the same fiberglass laminate material was used in both cases. Furthermore, the relationships hold only if the tensile and compressive moduli and strengths of the glass laminates were equal, i.e., the two moduli were equal and the two strengths were equal. If they were not, this resulted in a shift of the axis of rotation which then required a new formulation of the 'I' and 'S' equations. In the case of fiberglass laminate this is not necessary for practical purposes.

"You sure worry these things to death. Must be mal-practice suits you're leary of when you say that you won't put out scantling dope", Joel said with a simpleton's smile and wide-eyed innocence.

"That's one way of putting it." was my retort. "Care to talk about the Hopkins' boat that you built? jerking my thumb toward a nearby hulk that he had in for repairs.

Joel started making a new pot of coffee.

During this interlude I went through the litany of my reasons for not putting out scantling information: No two builders could come up with an identical laminate, even if they used the same materials and the same set of instructions; fabrication techniques differed; even the same builder was hard put to insure consistency and reproducibility; much depended on the glass to resin ratios achieved; the type of coupling agent used or an absence thereof; whether the reinforcing fabric floated or sank in the resin; the viscosity of the resin; curing temperatures; contaminants; amount of entrained air; type of resin; resin formulation; degree of wet-out; time delay between the application of successive layers of the laminate; and on and on.

I reminded Joel of what had happened to the Hopkins' boat because of that crew of Keystone Kops he had employed in its construction - that resulted in a hull

m.p.h. and may be the course requiring the lowest V_T which still permits flight. On a course of 110° to the true wind the polar graph gives V_B/V_{AW} as 0.94. At a V_{AW} of 16.43 m.p.h. this gives the triangle of velocities as in figure (3). So in winds of less than 13 m.p.h. the kite can fly both upwind and downwind, and by tacking can reach any point of the compass. Any course between 110° and 250° to the true wind requires a windspeed higher than 12.54 m.p.h. By tacking, the kite can make 5.15 m.p.h. directly downwind and 4.1 m.p.h. upwind in this wind.

ALTERNATIVE METHOD OF SAILING

At courses between 110° to 250° the windspeed required would be considerable, eg. at a course of 138° V_T must be at least 24.6 m.p.h. These speeds would be seldom obtainable so in order to reduce the V_T required the boat could sail in an unconventional way by being dragged sideways: the keels acting as an anchor. If keel resistance was sufficient to slow the boat down to one m.p.h. in a 17.43 m.p.h. wind, the kite could fly on all possible courses as follows:

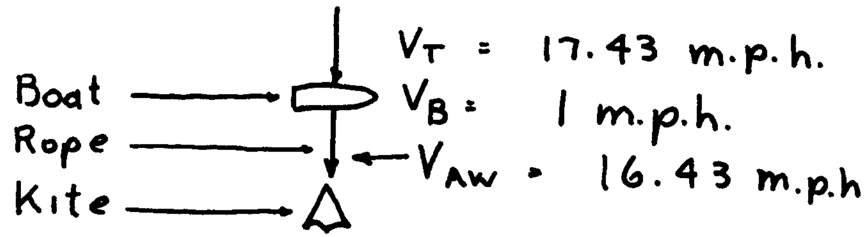


FIGURE (1)

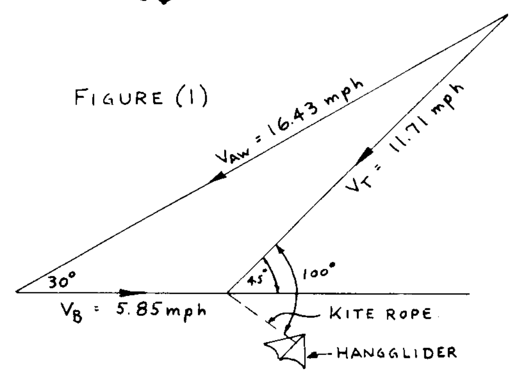


FIGURE (2)

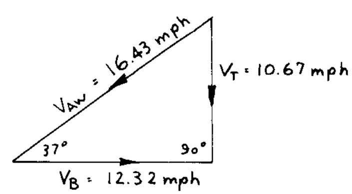
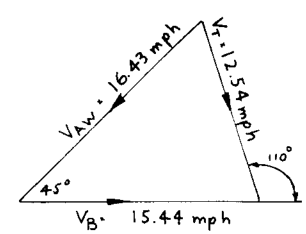
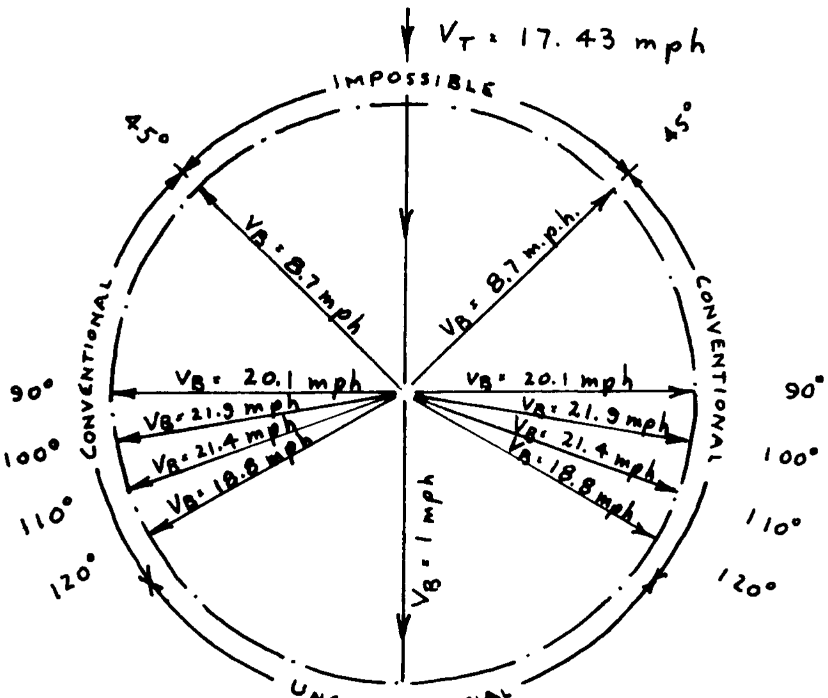


FIGURE (3)



At V_T of 17.43 m.p.h. the kite's performance on various courses would be as follows:



Since the boat could tack to an 180° course at an effective speed of 9.4 m.p.h. on an 120° tack, the conventional method of sailing would be used unless a voyage up a river or through narrows necessitated a course between 120° and 240°.

The performance of the boat is not exactly earth-shattering, but it is the performance of the *kite* which is most encouraging. Its advantages over a free hangglider are as follows:

(1) It does not depend on thermals for prolonged flight.

(2) It does not need to commence flight from a hill or cliff, and it is not tied to cliffs and hillsides.

(3) There is not the problem of getting permission to use suitable flying sites that hangglider clubs experience. The sea is free.

(4) The need to seek out thermals restricts the free hangglider's ability to fly directly to a chosen destination.

(5) Flights over the sea do not encounter the dangers of collision with pylons, power lines, fences, etc. as do flights over land.

The kite's advantages over present manpowered planes are that the latter can only fly from, and stay near, well maintained runways, which are difficult to hire,

to the Section Modulus (S).

"All of this is true if we have pure bending and our samples are prismatic and doubly symmetrical. 'Prismatic' means having the same cross section in the entire length of the sample, and 'doubly symmetrical' means having shapes such as the capital letters H, I, O, and X."

"If you'd give your simple explanations first, it'd save wear and tear on both of us. I'm anxious for you to get on with figurin' "I and "S" for my samples that you drew."

I ran the measurements through the calculator in accordance with the formulas and shoved the foillowing results over to Joel for his inspection:

Solid Laminate	*Sandwich*	*Ratio*
$I = 0.0013\ in^4$	$I = 0.0247\ in^4$	19
$S = 0.0104\ in^3$	$S = 0.0659\ in^3$	6.3

Joel divided the remains of the joe pot between us - the peace sign. "Them's mighty useful figurin' ", he admitted. Though gaffed, he gave one more wiggle. "How come, then, when I turn the solid laminate on its side and try to bend it, its stiff'r'n anything?"

"Joel", I said, "you weren't listening." "You just changed the axis of rotation and in this situation 'w' would equal 1/4" and 'c' would equal 1/2"."

I then went through the calculations and obtained the following for the solid laminate on end:

$$I = 0.0208\ in^4 \qquad S = 0.0417\ in^3$$

Something was still troubling Joel. Several times he started to put something into words, but then stopped. I knew what it was. I hold Joel that it was "Tell the Truth" time.

"You couldn't possibly have measured a six-fold increase in strength, now, did you?"

"Your equations do ... but how did you know I didn't get the measurement? Actually, I had so much trouble trying to measure it, and such erratic results, that I finally dug into the books and found some figures on sandwich construction. I borrowed the figure."

"I'd be willing to bet that the sandwiches that you were looking at, Joel, were not foam, and, more than likely, were honeycomb construction."

Hey, how did you know that?"

"Deduction, my dear Joel, deduction!" I replied, continuing with an explanation.

"There is no such thing as pure bending; it is always accompanied by shear loading, namely, compressive loading normal to the skins. Whereas the honeycomb resists such shear loading rather well, PVC will compress appreciably. Now, when this happens, that is, when the PVC compresses, 'c', the distance to the center of rotation decreases with a consequent decrease in both 'S' and 'I'. Look again at the equation. They do not lie; they tell you exactly what happens when 'c'

"As you can see, the core in the sandwich is 1/2" and the two skin laminates are each 1/8".

"Do you know what my tests showed? The sandwich strip is about 20 times stiffer; it deflected only about 1/20 the amount of the solid 1/4" laminate under equal loading conditions. Also, the sandwich was about six times as strong because it took six times the load to put the sandwich in a state where it started bending like a banana - out of proportion to the additional weight being applied."

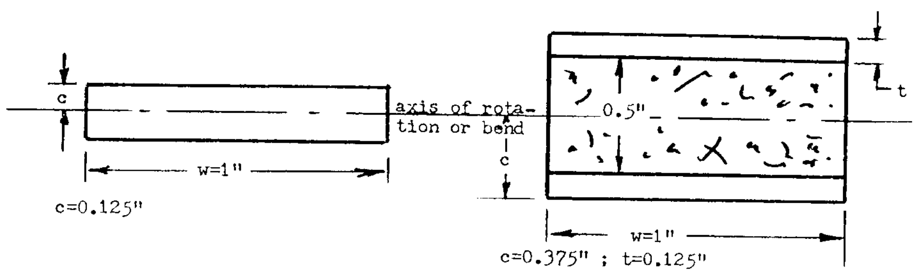
To which I replied, "Obviously".

As Joel's head and eyes turned upward seeking divine aid and sympathy, I set the barb, "I could have told you that without having made or tested the sandwich sample - or the other sample for that matter."

A dog-eared pad of paper and a poor excuse for a pencil materialized out of nowhere, landing with a slap and a clatter on the bench before me. The gauntlet had been thrown. Joel took a sounding on the joe pot, then poured two scalding cups. This would be a long siege. Courteous to a fault, he allowed one sip and then, in a measured, deliberate voice, said, "I think your gyro just tumbled ... show me, but go easy on the fancy math."

"No fancy math, just some sketches and a few useful algebraic expressions, Joel. You don't mind if I use my calculator too?"

There was no answer. His head lifted skyward again. I proceeded to scribble the following on the pad as Joel's attention drifted back slowly to the earthly matters at hand ...



Section
Solid Laminate

$$I = \frac{2wc^3}{3} \quad ; \quad S = \frac{2wc^2}{3} = \frac{I}{c}$$

Section
Sandwich

$$I = \frac{2w}{3}\left(c^3 - (c-t)^3\right) \quad ; \quad S = \frac{I}{c}$$

I then explained to Joel that "I" was termed the Moment of Inertia and "S", the Section Modulus, the latter being determined by dividing "I" by "c", the distance between the axis of rotation (or bend) and the outside of the skin. The equations showed how to get the value ot "I" and "S" and these were important in that -

= Deflection in bending was inversely proportional to the Moment of Inertia (I); alternatively, the stiffness or rigidity was directly proportional to "I".

= The amount of loading that could be sustained was directly proportional

whilst the sea is always available and covers 75% of the globe. The fragile 60 ft. wings cannot fly in winds above force 3 (Puffin II could not fly in winds above 3 m.p.h.). Flight duration is limited by the pilot's pedalling ability. The planes have to be individually designed and built whilst hanggliders are available off the peg.

THE ROPE

The kite rope must always be kept taut. A slack rope means that the motive power is cut off and the kite starts to fall under some loss of control. It is important for the kite to be under full control at all times, especially at takeoff and landing. The rise and fall of the waves may cause trouble, so the rope may be attached to the boat's deck by a spring which would take up the slack. In order that sufficient keel resistance is achieved during unconventional sailing, the rope can be attached both to the boat's deck and to the bottom of the keel. This should prevent resistance being reduced by the deck rope causing a list toward the kite. The rope's junction with the kite would be at a drum driven by pedals at the pilot's feet. The pilot would let the rope out when he wished to climb and wind it in when reducing height. A second rope from the kite to the boat's tiller would enable the pilot to operate the boat's rudder. The rope must be strong enough to withstand a considerable breaking strain since the pull on the rope rises by the cube of the speed of the apparent wind.

THE BOAT

The boat would be a flat-decked "Aircraft carrier" with no unnecessary obstructions above deck such as flagstaff, mast etc. to obstruct the rope. The needs of the boat are:

(1) Ability to perform as well as the polar graph of Edmond Bruce.
(2) Sufficient stability with no-one on board to right it.
(3) Be capable of being handled by one person.
(4) Sufficient keel resistance to enable unconventional sailing to take place and to provide sufficient thrust at high V_{AW}.
(5) Sufficient weight never to leave the water.

(1) suggests a multihull. As for (2), a kite rig removes the need for much stability in the sailing hull (see "Commercial Sail" p.31) but, as Harry Stover states in AIRS No. 6, p 45, we need "a craft with sufficient inherent stability to support a launching structure for a really large kite." He suggests a catamaran. (3) suggests a length of up to 12 feet. (4) suggests keels the size of a keelboat. Perhaps a tricatamaran with three keelboat-size keels is the answer.

With regard to (5), if the apparent windspeed rose high enough, the lift generated would exceed the combined weight of the kite, pilot, rope and boat, in which case the boat would lift out of the water, and control would be largely lost. For example, if V_{AW} = 40 m.p.h. (58.68 ft./sec.) we get:

$$\text{Lift (lbs.)} = 1.08 \times \frac{0.0024}{2} \times 227 \text{ sq. ft.} \times 58.68^2$$

= 1,013 lbs.
less weight of kite & pilot 171
Excess lift 842 lbs.

So in order to prevent lift-off , the weight of the boat less the weight of the water displaced by the boat must be at least 842 lbs.
This is rather on the heavy side, but a lighter craft would be possible if hydrofoils were used. Their use in conjunction with kite rigs was suggested by Professor Hagedoorn (AIRS No. 1, p 45) and Harry B. Stover (AIRS No. 6, p. 47). M.F.M. Osborne suggests the use of negative lift hydrofoils in 'Trimarans 1970'' p. 54. Our hydrofoil would provide negative lift, so the faster the boat goes the stronger would be the downward force of the hydrofoil, thereby counterbalancing the excess upward lift generated by the kite. The upward lift force increases with the square of V_{AW} , whilst the negative lift force increaces presumably with the square of V_B . The latter force must always exceed the upward-acting force.

As has been pointed out to me by Harry Stover, the excess lift of 842 lbs. would not in fact be as high as this value, since the angle of the kite rope with the horizon would be considerably less than 90°. This results in only a small part of the total lift force acting in a vertical direction and so the danger of liftoff and the need for a heavy boat recedes.

OPERATION

The pilot stands on the boat's deck holding the hangglider aloft, his feet locked in a ring on the deck. He is like a human mast. A course of 45° to the true wind is set, since takeoff on this course can be achieved at a boat speed of only 5.85 m.p.h. in a 11.71 m.p.h. wind (see figure (1)). As soon as the ventimeter of the pilot shows V_{AW} of at least 16.43 m.p.h., he releases his feet and soars to a height of, say, two feet where the taut rope restrains the kite. He keeps the kite to an angle 80° from downwind with the kite's nose facing directly into the apparent wind. As soon as he has got his balance, and his feet are on the pedals, he lets out the rope until cruising altitude of, say, 200 feet is reached. He then sets course for his destination, tacking where necessary. Landing would be on the same course as for takeoffs and would be onto the deck of the boat, *not* into the drink, by winding the rope in as he descends. The rope must be kept taut at all times to maintain control. If the windspeed cannot sustain the course being flown, the pilot must change temporarily to a course requiring a lower V_T eg 90° to the true wind. If windspeed drops, the rope could be kept taut by frantic pedaling by the pilot, who could thereby ensure a controlled landing. The hangglider could not, of course, fly in very low windspeeds i.e. V_T of less than 10.67 m.p.h. (see figure 2), but then even a conventional yacht is becalmed at times! Movements of the kite to left and right are made in the same way as in conventional hanggliding. Climbing occurs whenever V_{AW} is above 16.43 m.p.h. (and the pilot permits the rope to be played out) so long as the rope is taut. Controlled descent occurs whenever V_{AW} is below 16.43 m.p.h. and the rope is kept taut. Sideslipping may be a useful means of descent.

The author of the article in "Aerodynamics I" explains how to put about. "One would go from one tack to another by executing a sweep through the sky downwind. At the same time the rudder of the boat would be steered from one tack to the other through the eye of the wind. This should be the only time when it would be necessary to steer the yacht." He also states that "self-steering should automatically occur because the rope would always be put on the leeside of the center of lateral resistance."

this boatshop was the site of many debates between him and me, debates that rivaled those of Lincoln and Douglas.

Joel's a very good friend of mine, a boatbuilder who's been working in fiberglass reinforced plastics for many years. I enjoy visiting him because he is forever putting together new combinations of laminate materials and testing the results. As a matter of fact, Joel's the only guy I know of who could build his own Navy out of all of the test strips that he's produced.

Well, as I suspected, Joel did have something on his mind, signified by his throwing me one of his test strips. I made a pretense at shoving it into the stove, well knowing that this was the opening event to another debate.

He cut my action short with a growl, "Feel it. It's not very strong."

I bent it and it flexed as I would expect a 1/4" x 1" laminate would bend. I queried him as to what he meant by "not very strong". He explained that the test strip was an example of the material that he was putting into the skins of his current boat production. Because of its flexibility a lot of complicated stiffening measures had to be applied. And, even so, there remained an undesireable amount of oil-canning.

I looked again at the test laminate and then at him. With a hint of disdain in my voice I asked, "'Not very strong' ... compared to what?" The slight grin that immediately made its brief appearance on his face told me that I had asked the precise question he had been baiting me into. Without looking, he reached behind and brought forth a second test strip which I at once recognized as a foam sandwich specimen.

Skewering this into my hands, he proclaimed, "Now, this is strong!"

As in the first case, I attempted to bend the sandwich strip, and, whereas I could have snapped the first sample, it took all of my strength to put a very slight bow into this second offering.

"What's more," Joel continued, in his evangelical best, "the weight's the same except for a mite more due to the addition of the PVC foam."

At this point, let the reader note the items of significance that are apparent in the foregoing:

-The manner in which I tested for stiffness and strength was exactly what the reader would have done had the samples been placed in his hands

= *Bend* to sense stiffness, i.e., rigidity.

= *Bend* to sense the amount of bending force that would be required to destruct the sample.

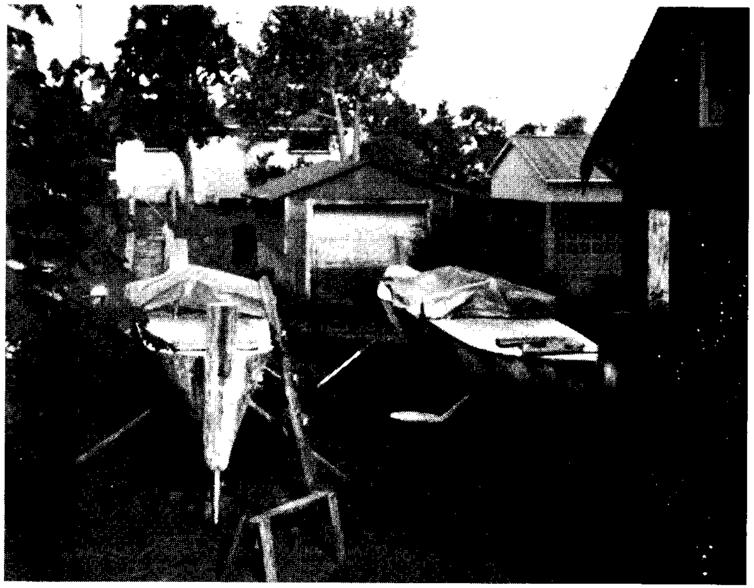
-The essential difference between the two samples lay in the distribution of the primary material.

-There was an implied interest in ascertaining the *comparative* increase in strength and stiffness that could accrue as a result of a different distribution of an equal weight of the same material.

"Strength" and "stiffness", as ascertained by pure bending, is the topic to which this article limits itself - the bending calisthenics of materials, so to speak. And, as in humans, the manner of distribution of material governs in large part the "suppleness" of the subject - as Joel proved with figures derived from tests he had run. The following is a continuation of our discourse.

See last photo, preceding page.

Looking from aft forward, the bulkheads slotted in place. Onto the backbone and stem and stern post will go five laminations of 1'' wood. The bow and stern storage compartments are completely waterproof. Each hull has four compartments which from one end to the other are as follows: storage, bunk cabin, center cabin, bunk cabin, storage. In one center cabin is the galley, in the other a combination head-shower-chart room. The bulkhead openings will be enlarged once the deck is on.



This is pretty much where I am, except the hatches are in now and I'm working on the center cabins. Her specs are as follows. 34' OA, 28' on the waterline, 5'6'' hull beam, 16'6'' OA beam, 6100 lbs displacement. Since unladen weight will be about 3000 lbs that will give a payload of 3100 lbs. Draft is 24'' although she can go 2'' to 3'' deeper without affecting performance too much.

CALISTHENICS OF MATERIALS
MENTAL AND PHYSICAL

Edmund B. Mahinske; 5515 Ivor Street; Springfield, Virginia 22151 USA

The other day I was warming myself at the pot-belly stove in Joel's boatshop, savoring the peace and calm, which by previous experience, I was assured was only of a temporary nature. Joel was uncharacteristically quiet as he put the finishing touches to a job that he was working on, a warning that he had some very heavy matters on his mind, the nature of which he would soon reveal to me. For

THE NEXT STEP

The next step is to tether a hangglider to a fixed point and await a 16.43 m.p.h. wind. This can be done on land or sea. Then the pilot can test whether he can manoeuver the kite round to an angle of 80° from downwind on both tacks.

If any reader can suggest the design of the boat, especially the length, or better still identify an existing boat which is suitable, I would be most obliged.

YACHT RESEARCH, SCIENCE & TECHNOLOGY

SAILING SCALE MODELS - the $5 REGATTA

Letter from: Robert W. Hodgen; 1814 Dormieone Road N.; St. Petersburg, FL 33710 USA

Dear Jack,

As I type this letter, the varnish is drying - the third coat - on the hulls of my latest model sailing creation. She'll be a proa - 24 inches (61 cm.) LOA - with a stabilizing foil on the outrigger to windward. So far, I've spent only about $4 (£2.22) on her for balsa, aerogloss dope, and some spruce sticks. I started carving the hulls this afternoon and expect I'll have her in the water tomorrow.

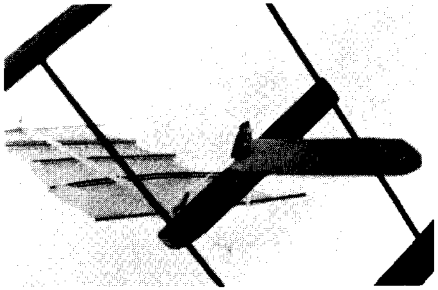
I build the hulls of balsa wood, which I get from hobby stores. It comes in 36 inch (0.91 m.) lengths in varying widths and thicknesses. I cut the stuff to the right lengths (usually 18 inches (45.7 cm.) so I can get two hulls from a 36 inch piece), and scribe a centerline down the bottom. Next, I carve out a decent looking hull shape with a X-Acto knife. Sandpaper follows this step until she's fair. I give it a coat of airplane dope, and when dry sand it silky-smooth. The hulls then get a couple of more coats and perhaps some paint to add color. Thin dowels make a fine connecting structure and mast. I cut my sails from plastic garbage bags, and I use scotch tape to hold them to the mast. My centerboards are clamped to the side of the hull with clothespins. This makes it easy to balance the rig so it'll go in a straight line.

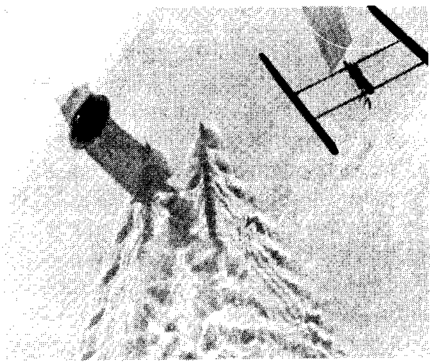
I do most of my sailing in our swimming pool. When I go sailing on big waters - ponds and lakes - I rig a masthead float so that after the inevitable capsize, the model will drift to shore within a short time.

From sailing these, I've learned that any form of ballast only slows a boat down. Eighteen inch monohulls are depressingly slow, and if they're not positively floated, they'll eventually end up on the bottom.

I got into trimarans by taking the ballast out of a monohull and adding outriggers. That made a 1000% improvement! I learned that my tris worked well with the beam equal to the length of the main hull. Pitchpoling forces are countered by leading the outriggers forward of the main bow for about one-quarter their length. It also worked out that when a gust hit, making the boat heel, weather helm was created by the immersion of the lee outrigger shifting the CLR forward. In strong winds, this boat rarely capsized because she'd automatically luff up in the puffs.

On my cats, I mount a single centerboard between the hulls. If the sails are pretty far aft, heeling will produce weather helm as the centerboard is lifted out of the water, luffing the sails. Perhaps these ideas could be applied to cruising multihulls?





I did some work on a kite-rigged model which was very fast on a run only when I received AYRS 83A from you. The article on hydrofoils captivated me, so I added a foil on the windward hull of one of my cats and tried it out. It made an enormous improvement. It was very windy, and the weather hull would not lift out. In the gusts, the lee hull buried to the cross arms. I think the hulls needed more buoyancy. Now I'm building an improved version.

How about AYRS, Americas sponsoring a $5 Regatta? Materials could cost not more than $6.50 as proved by receipts (inflation factor). This would be a multihull development class whose only restriction would be length overall of 18 inches maximum (45 cm.). Beam, sail area and rig type are open.

Sincerely,

Editor's Note:

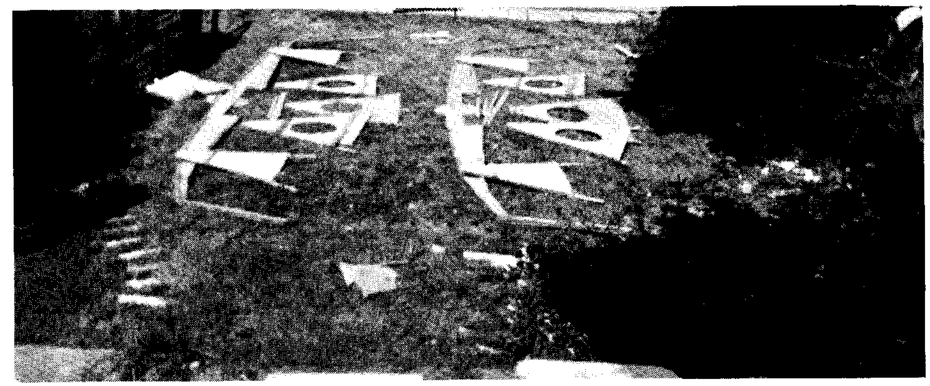
Bob is one of our new student members. We hope to increase this category of membership and to encourage same we have reduced membership fee in The Americas to $10 per year for bona-fide university and high school students only up to two years maximum. It would be good in time to have student chapters of AYRS at some of our schools. Bob has shown that it does not take a great deal of time or money to get into hull research. He echoes the words of the famed naval architect Weston Farmer in "National Fisherman" a few years ago, who recommended to all young naval architects that they design yachts using scale sailing models as well as mathematical tools.

I have to say that the mistakes I made were due to my own ignorance, and each problem I had was solved earlier through the Polynesian Catamaran Association publication: *The Sailorman*. By the way, I would urge anyone intending to build a polycat to become a member of this association and to get any back copies of *The Sailorman* he can find. The publication contains a wealth of tips and information - all submitted by polycat builders.

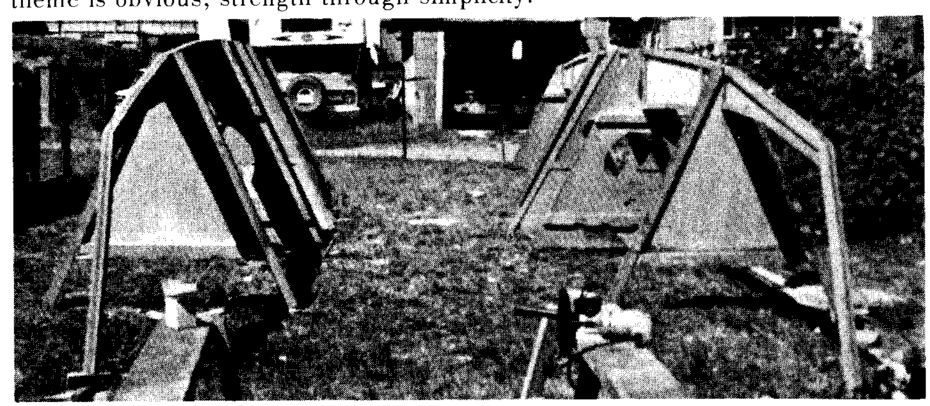
At this point, I am working on the main cabins, getting the furniture in and the roofs on before the weather here turns sour. With luck, I'll get the outside paint on too. That will just about complete the hulls. Needless to say, working full-time gets the work done much faster now.

Again I wish you success with Americas Journal and hope they will continue to be published. If they are, I will try to have something for each issue.

Sincerely,



This is the basic skeleton of all polycats; the backbone with four bulkheads. The end two bulkheads are completely waterproof. The center bulkhead shown here is simply a spacer to give flare to the stringers. It comes out when the hulls are turned over. Whether 27' or 52' all Wharram designs start with this skeleton. The theme is obvious, strength through simplicity.



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some more. A big old-timer can take a gang for a ride and with her immense power, she can drive over rough ice and through snow cover. She will have one little trait that can be unnerving. The forces on the mast can lift the steering runner up, and the instant she does this (we call it the "flicker"), crew are apt to fly out in all directions as she goes into a flat spin! It is awesome. There are a lot of little hand holds and hand rails around the cockpits of those old timers - and in a flicker you find why they are there.

Such were ice boats up till about 1930, when the new understandings in aerodynamics lead to a period of intense development and new forms were produced, to be described in our next.

We can only add here very happily that the JACK FROST, the WILDCAT, the PUFF, the WHIFF and many others are still going strong on various lakes, and on any cold winter week end one will hear the creak of blocks and the thunder of heavy cotton duck as gaffs are peaked and the gang piles on for another regatta in the grand old tradition. Varnish shines and bronze hardware gleams, pennants flap, and it is all quite as if Mr. Manfred Curry and the others who pressed modernity on sailors had somehow never been!

MATERIALS AND BOATBUILDING

More on Building KAUAMEA - 34 Ft. Wharram Catamaran

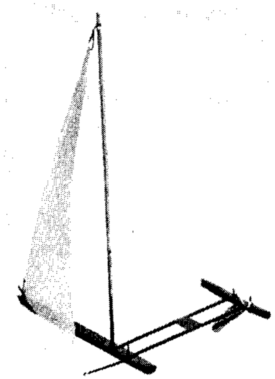
Letter From: George Snyder; P.O. Box 66538; Seattle, Washington 98166 USA

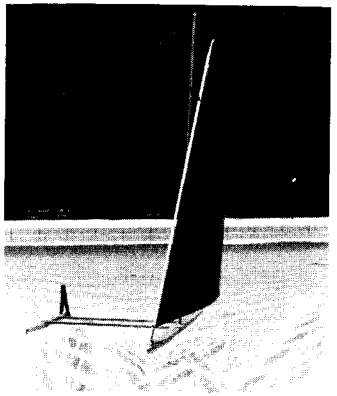
Dear Jack,

Regarding KAUAMEA, my 34 Ft. Wharram-designed catamaran, I've just taken steps to speed up progress. Money is always a problem, of course; money for rent, to eat on, to buy materials; but I have enough in my savings to last three or four months. So, I've quit my job to devote full time toward the completion of KAUAMEA. I'm determined to finish her this winter and to launch her very, very early in the spring. That will put me almost two years behind my first schedule.

Speaking of money, there is very little written on how builders live and eat while they complete their projects. Sometimes you read articles on how much it costs to cruise full time, but never how to live while you build your boat. While some people have, like me, been holding full-time jobs and boatbuilding evenings and weekends, many are building full-time. It would be interesting to know how they do it.

In reviewing my last letter to you, it seems to me that I was unduly harsh on the information provided with Wharram plans. Let me assure you that I consider Polynesian catamarans as alike to other multihulls as I consider multihulls alike to monohulls. Wharram polycats have two things which I find lacking on other multihulls. One is the flexible mounting of the hulls allowing up to eight inches of independent movement for each hull. Second is the slatted deck with no structure between the hulls, allowing the wind and water to flow unchecked between the hulls. Couple this with very narrow hulls, and you have a vessel about as seaworthy as you can get. As the years go by and more and more polycats cross oceans, they are compiling a very impressive safety record. As I said before, there is probably less living area per foot of boat then any other design, but what you lose in area you gain in seaworthiness.





PROA FOIL SAILING MODEL

Letter from: Robert W. Hodgen; 1814 Dormieone Road N.; St. Petersburg, FL 33710 USA

Dear Jack,

Here are two photos of the proa I mentioned in my last letter. She carries a Bruce foil to windward. While I was satisfied with her original performance, I cut her down to 18 inches so she would be eligible for any $5 Regattas that might come along. She is now a starboard tack machine and can only sail one way - like CROSSBOW. She is by far the fastest 18 inch boat I've ever built or seen. Her only fault is that the cross-arms are mounted too low. In any kind of a chop the connecting structure drags through the tops of the waves slowing the boat down.

I tried and tried to get the foils to work in a leeward position - without success. I could not get the boat to balance. I tried moving the rig and the foil around but nothing worked. At best, she would sail straight for about two feet. When the wind strength changed, the hull of the outrigger would bury in spite of the Bruce foil, and the drag would cause the boat to slew around to leeward. I do not like the idea of leeward foils for speed because the foil does not increase the ultimate stability over plain hulls. It just lessens hull burying which in a properly designed hull should not be a problem anyway. Leeward foils are also unstable to yawing perturbations.

Joe Norwood points out that windward Bruce foils are unstable to rolling perturbations - you go over if the foil pops out of a wave. This is true, but I think that a high aspect ratio foil running deep would not pop out except in the roughest water. In *Design for Fast Sailing* (AYRS 82) it is pointed out that as a windward foil is raised out of the water, the angle of attack is increased due to sideslip and the force exerted by the foil increases to bring it back down. In my models, capsizes were infrequent and were largely caused by the buried connecting structure stopping the boat dead in its tracks. In day-sailing boats, a capsize would only mean that you would get wet and righting would be east. Such a boat might not be a practical ocean crosser, but I believe the windward foiler has great potential as a speed machine.

With a windward foil, the limit of stability is not the amount of weight carried to windward but the buoyancy of the main hull. In strong winds, the displacement is increased by the amount of weight which would ordinarily be needed on the outrigger to keep the boat level. The foil does this without actually adding that weight that would slow you down when it was not needed. Under any conditions, the foil's depressing force adds only enough to keep the boat stable. Since the outrigger's lever arm is long, hull depression is minimized and is not serious in all but the strongest winds. I am really amazed by the speed of my 18 inch Bruce Foiler, and I'd love to be able to build her full size. Do you know of anyone with an extra Tornado hull they would like to dispose of cheaply ?

Sincerely,

Editor's Note: I had the pleasure of seeing Bob demonstrate his models at our Sailing Meeting Number 4 at Pensacola, Florida, and much of what he says appears to be true. I am very impressed by the photographs, some of which show wave trains from both hulls colliding and interfering - as shadows from sunlight reflected onto the pool bottom. Although the hulls are relatively widely spaced, this clearly is a source of energy loss in all multihulled craft, and there is very little in the literature on this subject.

HOW TO WEIGH LESS ON WATER THAN IN THE AIR

by Nils Lucander; Lucander Designs; Box 3184; Brownsville, Texas 78520 USA

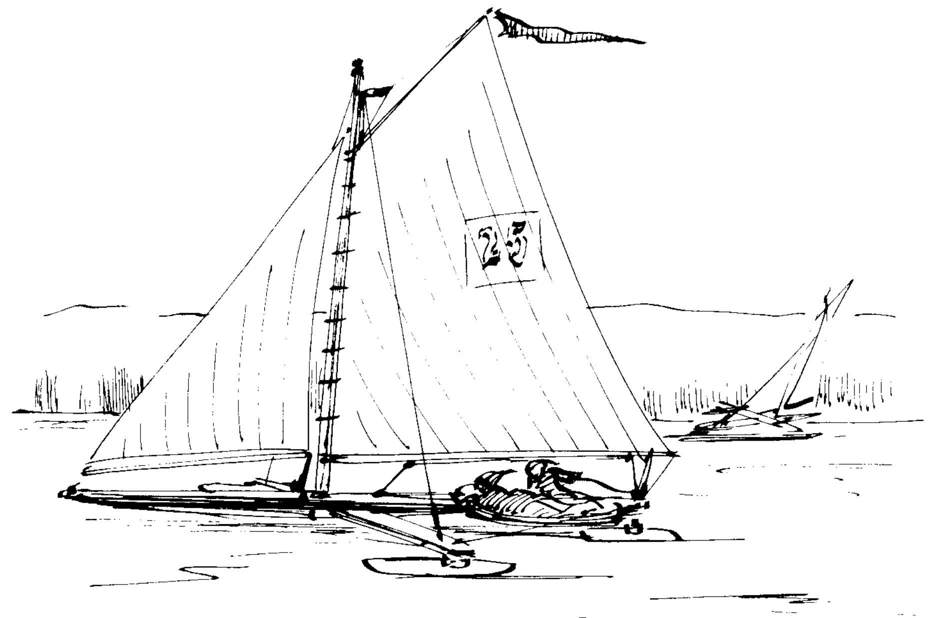
During Sailing Meeting Five in Galveston bugs were placed strategically in my poor brain, and this morning I woke with them skitting along over the water without effort, supporting sometimes large bodies with minimum water-touch area.

Nature seems to have answers to almost all our efforts, only we need to look closer and study same far more than we do. I have tried this method in heavy boats, and come to some pretty good results far above what the rules permit, but if we try to reduce friction and area in the water, we can again look to nature, because nature has the answer. It has been sitting there for thousands of years, only modern man is too engrossed in writing theories so he has not looked.

We have all seen all kinds of small bugs skit along the surface of water, at sea, in ponds, all over the world. What makes them be able to have about 6 one half millimeter feet on the water, supporting a one hundred square millimeter body, or something like this! (I don't have a bug in my apartment to look at). So now we begin to think! Could it be those small feet are producing such a powerful water repellent that this prevents those small feet from sinking, and allowing those bugs to move incredibly fast over the waters surface, without any apparent friction.

So now AYRS has to find a bio-chemist amongst its membership to find out what does this. It could herald a totally new era, especially in multihulls. (I can just see Norm Cross going hunting for bugs and placing them all over the bottom of his tri's.)

The "Bug" bitten Finlander......



ICE BOATS - Part I

By Dick Andrews; 25 Audubon Drive; Ossining, New York 10562 USA

First let me tell you what an ice boat is. It is not a "boat". It is a "T" configuration - a longitudinal member and a cross arm - and there is a runner at either end of the cross arm and another at the far end of the long member. The third runner in the middle, at the far end, is pivoted to steer the craft. There is a mast stepped on the long member, and stayed to it and the cross arm. We call the length member the "hull" or often the "fuselage", and the cross arm is called the "plank". Other terms relate to boat terms.

I don't know where the sport got started. We know that it went on in Holland from early on, and probably it developed concurrently in the other European countries active in it now:- Germany, Austria, Hungary, Poland, Sweden, and the Baltic states now part of Russia. In the USA it turned up first on the Hudson - doubtless the Dutch tradition. But the ability of the boys in ice boating in the midwest suggests that it is in their blood too - quite naturally!

The natural tendency for a boat sailor is to sail his "T" sled with the plank end forward, so that he can have the steering runner aft like a rudder, and control it with a short tiller. So ice boats were made on this pattern for long years, and were rigged with more or less water-craft rigs - gaff cats, gaff sloops, lateens, etc. Some of these craft were very large - upwards of fifty feet in length and with large sail areas. It is a pleasant fact that we don't have to look at old photos and prints to gain an idea of them. They are still around - many of them! Old ice boats don't die; they just get put away and forgotten - and then are found and restored and sailed