CARBONICS

Advanced Composite Engineering & Manufacturing for Marine & Industrial Applications

GMT

GOETZ MARINE TECHNOLOGY PRODUCT BULLETIN • NUMBER THREE 1992

CARBON SPARS: SAILING IS BELIEVING

The spar revolution rolled off the drawing board and onto the sparkling waters of the North Atlantic last summer when sail trials for the first crop of carbon fiber spars for cruising boats were conducted. Although engineering calculations and VPP analysis predicted that the weight savings aloft would significantly improve overall performance, the real proof would come once the boats were sailing. We're now happy to report that results from sail trials

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CARBON SPAR GIVES "NEW BOAT FEEL" TO 19 YEAR OLD CLASSIC

The new GMT carbon spar retrofit to George Carter's beautifully maintained Bermuda 40 "Windswept" is another success story. George knows his boat well. He had sailed the boat extensively before the retrofit in-

"I would advise anyone looking at a new mast to investigate carbon fiber seriously. The gains far out weigh the intial extra cost."
George Carter, Bermuda 40 owner.

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AMERICA'S CUP UPDATE

Goetz Marine Technology has been supplying high performance parts to America's Cup competitors since 1980. During the current campaign, foreign syndicates as well as both American groups have come to rely on us for our engineering and manufacturing expertise.

We got involved right at the start by building ten hull and appendage models to be used in towing tank testing. Since then, we have supplied 5 carbon fiber rudders and over 30

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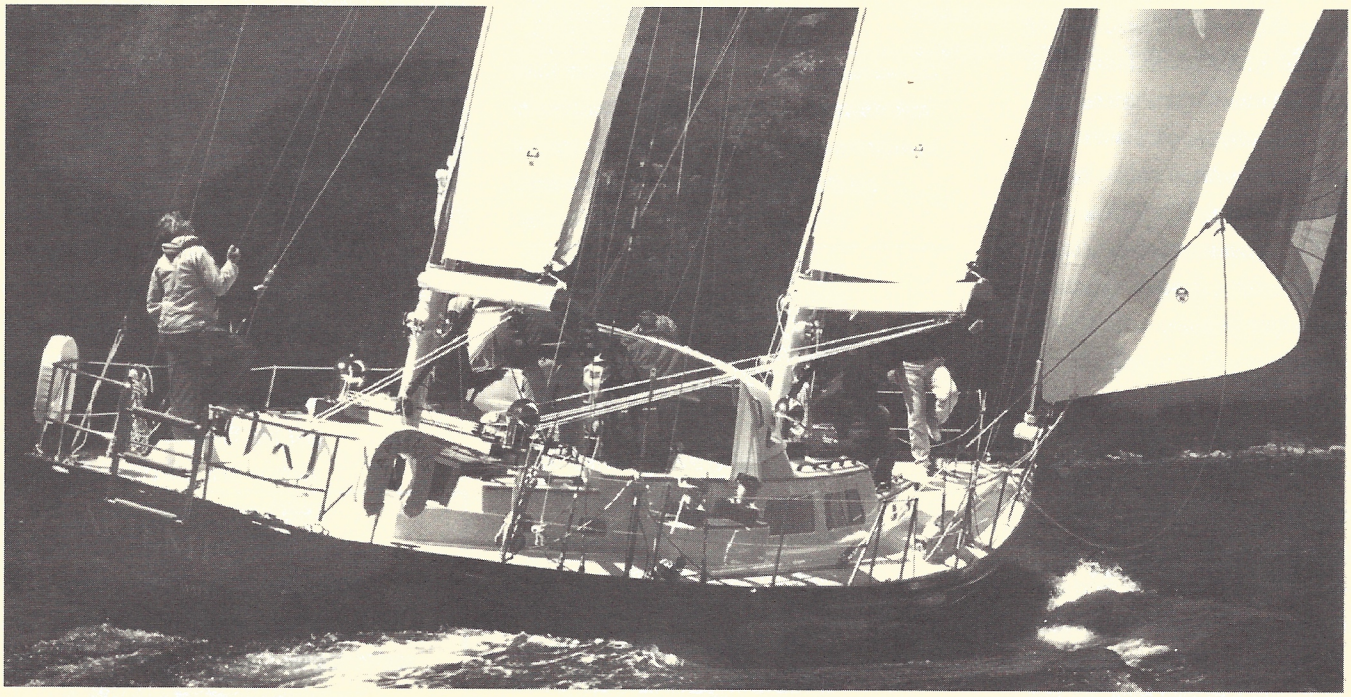

HINKLEY 59 SEA TRIALS: ***"It was very apparent that the boat with the G M T carbon spar had a gentler and more comfortable motion. While some dismiss carbon as a material only for racers, I cannot help but think how much more important it is for the cruising sailor."*** **Phil Bennett,** Sales Manager of Hinckley.

THE QUICKER PICKER UPPER

More and more industries are finding a place for composite technology as the light weight and high strength properties of composites become better known. One area where the stiffness and light weight of carbon fiber is beneficial is in the moving parts of production line machinery. A light machine part can be accelerated more quickly, thereby increasing production rates.

Recently, GMT won a contract to produce a critical piece of equipment used in the manufacture of compact discs. The composite part weighed just 10 ounces, replacing a metal part that weighed 3.0 pounds. The result; the cycle time for this manufacturing step dropped from 0.9 seconds to 0.4 seconds. The speed up will increase each machines productivity by $100,000 a year!

GMT's involvement in non-marine projects has been steadily growing for several years now. We routinely supply foundry patterns for large ship propeller blades along with the precise jigs and fixtures used to handle and finish machine them. Other custom projects awarded to GMT include composite bow thruster fairings, tooling for a 55 foot windmill blade, and composite hull components for a 6 meter unmanned submarine for a major defense contractor.

PROVIDING THE SPARK FOR SOLAR POWERED RACER

When the design team at Drexel University needed help building a new solar powered race car, they turned to GMT. They knew about our record of innovation in the marine field and explained that every component in this car must be as light as possible yet must stand up to thousands of miles of abuse. Careful engineering and the use of the proper composite materials is therefore critical. For instance, our design for the solar panel support structure will incorporate an Aramid honeycomb core with carbon/epoxy skins. This 7 foot long wing will provide all electrical power, yet weigh less than 25 pounds.

GMT RUDDERS ARE WINNERS

In addition to the rudders being supplied to America's Cup groups, GMT has recently built rudders for two very different yet very successful boats. The first was for Corum, the latest in IOR racing boats. This 50 footer was the top boat in this year's Admiral's Cup. She won going away with a carbon fiber rudder and tiller built by GMT.

The second winner was a 15 year old Swan 44, Temptress. Owner, Dr. Richard Shulman, wanted to improve the performance of his comfortable cruiser/racer. "The new rudder was not only delivered on time and within budget but improved the speed and maneuverability so much that it was a definite contribution to our fleet win at Block Island Race Week." commented Dr. Shulman.

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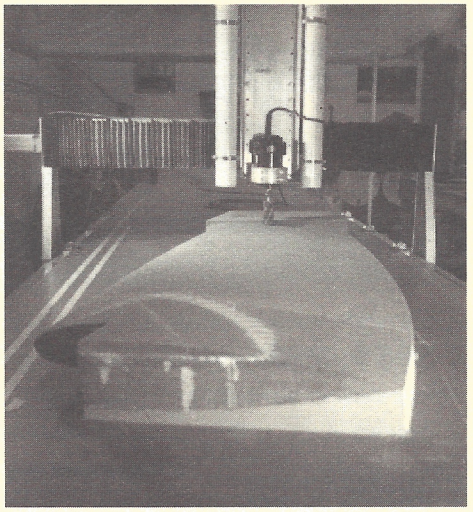
New rudders are not just for boats that race. Recent developments in rudder research have lead to foils that are less prone to stall and have less drag. The rudders can be designed to minimize the force needed to turn the wheel or tiller. These new shapes can be a blessing to older cruising boats. We recently retro-fitted a Seguin 41 with a 52 pound rudder and post. It replaced one weighing 195 pounds! According to the owner," The new rudder dramatically improved the feel of the boat. It turns more quickly with little pressure on the wheel. I now have much better control of the boat when heeled on a reach".



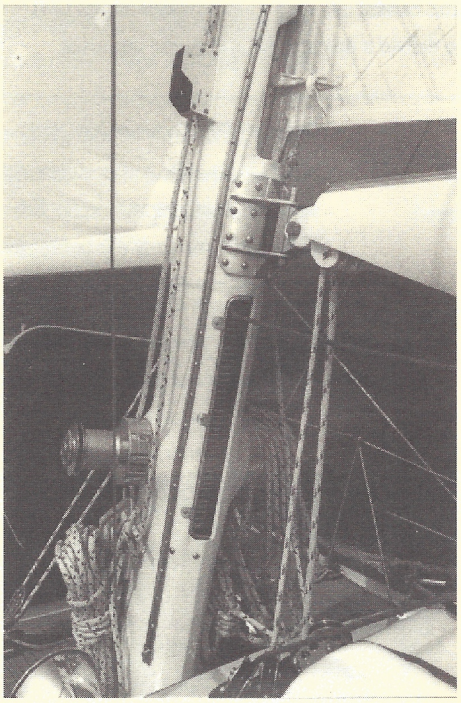
THE OPTIMUM FOIL SHAPE:

Rudder blades are carved by our multi-axis, computer driven milling machine. This ensures a light, symmetrical rudder blade. Rectangular rudder posts are made in either carbon or "S" glass according to rule requirements.

Although the lightest rudders are built in carbon fiber, boats racing under the IMS rule use "S" glass as the material of choice. GMT has done extensive testing of laminates made of this high performance fiberglass material. Our "S" glass rudder posts have allowed designers like Bill Tripp and Jim Taylor to achieve the optimum in thin, effective foil shapes. GMT has supplied rudders and complete steering systems in a variety of materials and often generates the design and engineering as well. Our engineering team is always ready to explore all options with you.

NEW SPARS FOR THE SPRING

The marked transformation of the boats which have been equipped with new GMT spars has encouraged many other owners to look seriously at the carbon alternative. The "new boat" feel these masts give to the older classics has extended the life of these boats. That's not a bad investment when you consider the cost of new boats. Ready for sailing this spring will be new carbon spars for several Hinckley veterans as well as the innovative 55-foot ketch, "Red Herring" and a Frers 33.



CHEREBINI 48:

Gooseneck, sail track, halyard stoppers and internal furling mechanism demonstrate the use of standard parts for most rigging situations.

CARBON FACTS:

Pound for pound carbon fiber is:

- ***9 times stronger than aluminum***
- ***2½ times stronger than fiberglass.***
- ***30 times stronger than steel.***

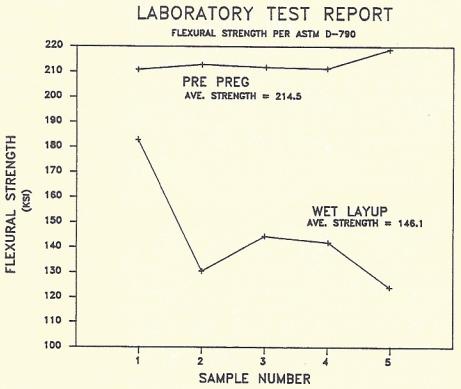
NOT ALL CARBON SPARS ARE CREATED EQUAL.

Thinking about purchasing a carbon mast for your boat? There are some facts that you should consider before deciding on the material and the method by which the spar is built.

A composite mast maker has two basic types of materials to choose from. The carbon can be pre-impregnated with resin by precise machines under controlled conditions. The material is then shipped frozen to the mast maker. Alternatively, the builder can buy dry fiber and manually work the resin into the fiber in his shop. There is much less control in this process even when a braiding or filament winding process is used. Although GMT started out seven years ago by building small wet lay up parts, we have followed the lead of the aerospace industry and switched to pre-pregs. There is conclusive evidence that parts built from pre-pregs are stronger, stiffer and more reliable. The accompanying graph shows results from an independent testing lab. They performed bending tests on samples cut from 12" square pieces of both pre-preg and wet lay up panels. On average the pre-preg part was 50% stronger. The strength of the individual samples was also much more uniform. There was only about 6% variation in the pre-preg parts versus a 33% spread in the wet lay up. Imagine the variation in something the size of a masts if the wet lay up process can't even be used to make a uniform 12" flat plate!

The manufacturing process that is used is as important as the material. Again there are two basic choices. Masts can be made on a braiding or filament winding machine. The machine draws dry fiber through a resin bath then weaves them into shape. Fibers must kink around one another much as they do in woven fabric. Unfortunately, the yarn crimp that occurs in the braiding process dramatically reduces the strength and stiffness of the part because of the mechanical stretch that takes place under load. In addition, braiding machines can not lay fibers longitudinally aligned to the loads, so the strength and stiffness of a machine made part is reduced.

GMT has chosen to use a different manufacturing process; one used to produce most aerospace parts. In this method, pre-preg tapes of unidirectional material are accurately



Not only was the pre-preg on average 50% stronger than the wetlay-up part, but the strength of the individual pre-preg samples was much more uniform.

placed to coincide with the mast loads. Since the material is applied layer by layer, the fibers remain flat and straight. Think for a moment about the concrete columns supporting a bridge. Are the reinforcing rods in these columns straight to resist buckling or do they weave in and out in random fashion? The answer is obvious. To get the high strength, stiffness and safety, the fibers (whether carbon or steel rod) must be straight. This makes hand applied pre-preg fibers the preferred process when quality, performance and cost are considered.

SPEED & SAFETY TO THE FOREDECK.

When the nineteen year old McCurdy & Rhodes 61-footer, Alphida, prepared for last summer's Marion-Bermuda Race, she needed a spinnaker pole capable of several functions. The race prohibits the use of spinnakers so emphasis is placed on efficient use of poled out headsails. Dual purpose aluminum poles tend to get as heavy as family sedans parked on the foredeck. GMT designed and built a double tapered carbon spinnaker pole that could be extended from a legal "J" dimension of 25 feet for IMS racing to 1.4 times"J" for use with headsails.The carbon pole at it's 35 foot extended length was half the weight of it's alloy cousin and a good deal safer to handle in the washing machine action of the Gulf Stream.

Watch captain, Nick Nicholson writing in the October 15, 1991 issue of Practical Sailor said. "In heavy reaching and running of the 1991 Marion-Bermuda race, the pole paid for it's three-second-mile penalty without difficulty. GMT's solution for the dual purpose nature of the pole worked remarkably well."

Sailing is believing *Continued from Pg 5*

exceeded all expectations.

The most convincing sail trial was between two Hinckley 59's. One was equipped with a carbon Stoway spar, the other with a taller, aluminum racing spar with full batten mainsail. The boat with the GMT carbon mast was faster on every point of sail. She sailed with less angle of heel, more power, less pitching and with a more stabilized motion. In this case, less weight aloft, was more important than sail area.

The breakthrough of the new carbon mainsail furling design delivers all the convenience of "from the cockpit" sail handling without the overwhelming weight penalty of a comparable aluminum spar.

GMT COMPOSITE SPAR DESIGN

Masts generally fail by buckling under compressive loads. The ability of a mast to resist this type of failure is proportional to its stiffness. The stiffness of a structure is the product of two factors; the geometry and the material. The shape, size and wall thickness of the mast cross section are used to calculate the moment of inertia (I) of the mast. The other important number is the modulus of elasticity (E) of the material used to build the spar. "E" relates to the amount of stretch you will get when you apply a given load to the material. For instance, steel has a much higher "E" than rubber since it stretches less for a given load. Stiffness (and resistance to failure) is then the product of "E" x "I".

Aluminum spars are often quoted with just the value of moment of inertia. This is because all 6000 series aluminum has the same "E" value (10 x 10^6 psi). When comparing composite spars, however, "E" can vary drastically. It depends on the materials being used, the manufacturing techniques and the orientation of the carbon fibers. In order to compare different spars, it is important that the manufacturer quote and guarantee the stiffness ("E" x "I") of the spar since this number also effects the price and the weight. At GMT we guarantee results. We weigh and test the stiffness of every mast that we build to make sure it conforms to our original proposal. Sound engineering, manufacturing experience and careful attention to every detail allows GMT to deliver a product that meets our promises.

19 year classic *Continued from Pg 5*

cluding a solo Transatlantic crossing. Here's what he has to say about his experience. "My new mast from GMT was beautifully painted and detailed. The boat now has a new boat-feel and sails better in all conditions. Most noticeable is that it accelerates faster and hobbyhorses less. The lighter mast makes the boat stiffer and more powerful. It's a lot harder to put the rail under. As a result, the boat speed is almost a knot faster in lumpy seas."

On a 40 footer the weight reduction aloft is comparable to pulling a couple of your crew members off the spreaders and on to the rail. A 120' design project under way at GMT will save 4,000 pounds aloft, the weight of a large sedan parked on the second spreader. That will help any boat sail better!

America's Cup *Continued from Pg 5*

other composite parts, accuracy, strength, lightness and design flexibilty have made GMT computer shaped rudders the choice of more than one syndicate.

"Your spinnaker pole is 20 pounds lighter yet bends less than the other poles. This stabilizes the chute and lets us sail faster. The GMT pole is the one we will use in the races."

America's Cup crew member.

Our contribution to the Cup includes; spinnaker poles, quadrants, pedestals, steering wheels, hydraulic tanks and structural members have all been designed and built by GMT.

When the Cup finals take place in May, a boat built by Eric Goetz Custom Sailboats will be the defender and both boats will carry parts supplied by GMT.

GMT

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