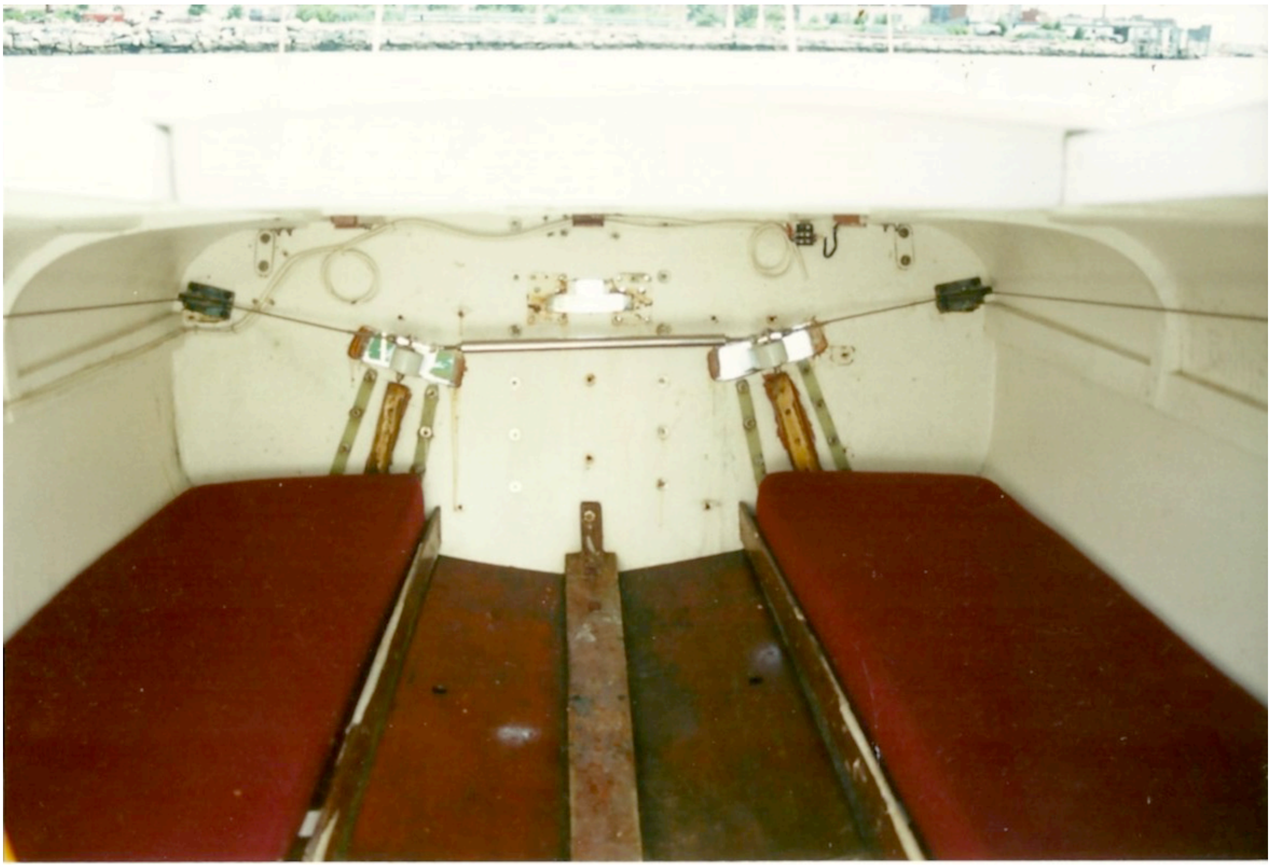
A146 Picks up a Few Appendages

The original rudder of A 146, Le Bateau Iyre, ex Bluff, ex Sherpa, was finally worn out. The upper part had severe corrosion and stress cracks were appearing around the lower gudgeon. Plus, the dropdown blade was just a flat plate with no balance, as I had it made before I knew what was the original profile. Hydrody-namically the design is a disaster. This situation led to a lack of confidence structurally and difficulty, due to excessive weather helm when heeled, of sailing in rough conditions. Michelle had a hard time steering the boat, she would tire quickly. The other addition is a 3 foot (originally 2 foot) bowsprit with which to fly an asymmetrical spinnaker.



Twin Rudders

I had been considering the idea of twin rudders for some time, I think that the flat profile of the Atalanta aft is particularly well suited to a twin rudder setup. The center of the volume aft moves outboard rapidly due to the rapid shape change of the boat when heeled. Twin rudders would put the leeward rudder more in the center of this volume, plus canting them would result in the leeward rudder being more vertical when heeled and the windward rudder coming clear of the water more rapidly, helping to reduce drag. As the rudder would be more vertical when heeled, the area could be reduced, since the projected area of a. vertical rudder is reduced when the boat is heeled. I wanted to do a general cleaning up of the boat, hydrodynam-ically, at the stern. Eliminating the skeg and the slot resulting from the drop rudder would go a long way towards this goal. Eliminating the skeg wasn't a problem as I don't normally dry out the boat, and I think that it wouldn't be a problem anyway.

The clincher was access to a mold. David Lovelock's article also added inspiration. I was still working at Goetz Custom Boats, so had access to the shop and all of the tools. My design is rather different from Cdr. Lovelock's, my rudders are two daggerboards working in trunks, the trunks being clear of the waterline. The blades are raked forward relative to the axis of rotation, resulting in some balance. At the time, the winter of 92-93, my project at the shop was to install a daggerboard in a 55 foot ketch with a canting keel named Red Herring. The mold for the daggerboard was from a Formula 40 catamaran, and was about 9 feet long. I did some rough calculations and decided that the mold was quite well suited to making a pair of Atalanta 26 rudders.

Rudder Blades

I made the blades first, as they would be the molds for the trunks or "rudderheads." The blades were made in two halves, as this was a female mold. The laminate consisted of three layers of 12 ounce double biax E glass, with five layers of 160 gram unidirectional carbon fiber material, tapering towards the tip. I made the halves as one long 9 foot piece, just starting the laminate in the middle of the mold. The core was H-80 Divinycell, about a 3 pound PVC foam. I also put a Skim Spruce spar that was 4 inches wide at the thickest portion of the blade, along with a spruce leading edge piece, the better to withstand impact. It was all made with a vacuum bag.

After one half was made, I surfaced the half flat, then removed it from the mold and set it aside. The second half was then made. After surfacing, the second half was left in the mold, and the first half was placed on top. I drilled 1/8 inch holes through the first half where the spruce was into the second half, stopping before the outer skin of the second half. Into these holes I placed small finishing nails, long enough that they could be removed after the glue set. The first half was then removed, glue smeared all over the mating surfaces, then the first was placed back onto the second half, alignment nails inserted, then vacuum bag over everything. When it had cured, I took the whole mess out of the mold. I had built up the mold, using sandblasting tape which is about 1/16 of an inch or so thick, along the leading edge, and where the top and bottom tips were. This left a rebate along three of the four edges. The trailing edge was thin so it was glued skin to skin.
At this point I cut my 9 foot piece into two 4.5 foot pieces. Then placed two layers of 12 ounce biaxial E glass across the seam along the rabbet and vacuum bagged it down. After that point, it was a matter of painting and fairing in the edges, as they were already quite smooth due to having been made in a female mold. Vacuum bagging helped a lot in terms of eliminating voids, especially when taping the edges together, and helping to ensure good contact between the core and the skins, and an easy way to apply even clamping pressure to the two halves when joining them.

Rudder Stocks

Then it was onward to the rudderheads. These were made directly over the blades. At this point on I had to be careful to keep each head with each blade, as there were slight differences due to fairing. I temporarily padded out the tops of the rudder blades about 1/16 per side to allow for paint buildup, etc in the future. Believe it or not, they are tight, I could have padded even a bit more. The rudderheads are about 15 inches high at the forward edge, about 12 inches high at the trailing edge. I used a tight layer of plastic on the rudders as a release film. Mylar (box sealing) tape would have been a better choice. A layer of epoxy with graphite powder mixed in was first brushed on, followed with three layers of 12 ounce biaxial glass. The 12 ounce glass was cut in a strip and just wrapped around three times, minimizing overlaps. A band of unidirectional carbon fiber about 50 mm wide was then wrapped around the glass approximately in the position of the top and bottom edges of the finished rudderhead. An X of the same width unis was ran from each corner on both sides. I don't remember the exact number of layers, but the finished thickness was about 3 mm. This was then cured under a vacuum bag. The resin used was Gougeon 105/205 for the first rudderhead, which is their fast hardener, but this turned out to really push the working time. The second head was built using the same technique only with 105/206 (slow hardener). The results were much better. After they had cured, the rudderheads were removed from their respective rudders without too much trouble.

Now, these rudderheads had to somehow be attached to the transom. I had decided to make the axis of rotation of the rudders vertical. That way when I raked the rudders forward to create some lead giving a balanced rudder the rudders wouldn't be raked forward forward in too extreme of a manner. I cut blocks of wood to a 10 degree angle, about 8 inches long, triangular in section. To the apex of the triangle, I glued a piece of fiberglass tube, with an inside diameter equal to the outside diameter of the rudder pin, which is one inch (25 mm). These blocks would be bolted to the transom. I put two layers of the ubiquitous 12 ounce biax under the blocks, then a layer or two of 12 ounce biax over the blocks, followed by several layers of unidirectional glass going across the axis of the tube, covered by two more layers of the 12 ounce biax. All of these layers extended out beyond the edge of the block about an inch and a half or so, say 40 mm. Once again, it was vacuum bagged. After curing, the end of the tube was cleaned out (the vacuum tends to push the glass into the opening which makes it easy to find), and the resulting flange around the perimeter of the piece was trimmed to about 25 mm along the long edge, and only about 5 mm along the top and about 15 mm along the bottom. Two blocks, of course, were made.

It was then time to put in the bushings on the rudderheads. A coworker had the idea to use roller bearings out of a winch, which seemed like a good idea. I used 1 inch i.d. bearings out of a Lewmar winch (might have been a Barient actually, but I ordered the bearings from Lewmar). These bearings would have to be greased. A machinist friend made up the pins using one inch od stainless tube with I believe a 3/16 inch wall. A 3 mm plate was welded onto the bottom of the tube, and turned to about a 50 mm diameter. The other end was plug welded after the tube was cut to length. Holes were drilled at the positions of the bearings, and also at the very top for a 1/8 inch cotter pin, to keep it from falling out, as the pin must be inserted from underneath. A hole was drilled in the center of the bottom plate and threaded for a stainless steel 90 degree grease fitting. These steps were actually done when the rest of the system was almost built, as the final measurements were not a known quantity until that point.

I used two bearings at the top and bottom of the rudderheads. They were one inch long, for a total length at each end of two inches (which I guess is kind of obvious). Stainless steel bushings two inches long were turned to the outside diameter of the bearings, which I believe was 1.25 inches, but might be 1.375 inches. I had decided on raking the rudders forward about ten degrees, based upon a balance of about 15• of the total area forward of the axis of rotation.

I just drew it out on the rudders as I knew approximately where the waterline on the rudder would be and where the blocks would be located on the transom. Then, I clamped each rudderhead in a carpenter's vise so that the leading edge was up. Blocks of synthetic closed cell foam, fairly high density, maybe 15 pounds per cubic foot, were glued on in the positions of the bushings. These bushings were located, in terms of distance apart, by making sure that the transom blocks would fit between, as I was planning on making a delrin thrust washer to take up end float when it was finally assembled. In otherwords, farther apart was better than too close together. I cut a piece of cardboard in the shape of a quadrilateral with a 10 degree angle at the lower end that would essentially represent the empty space between the rudderhead and the transom block, and affixed it to the leading edge. Then I made a mistake. Not catastrophic, just annoying. To align the bushings, I took the pin, and put a bearing on each end and then slipped the bushings over the bearings, placing them on the blocks of foam. I filed away at the foam until the pin met the cardboard, having remembered that I needed to allow for the fact that the pin was about 3/8 (.375) inch below the surface of the transom block. The outside of the bushing had been thoroughly scuffed up with coarse (36 grit) sandpaper. When everything was lined up, the bushings were glued to the block of foam. My mistake was in using only one bearing at each end. On one of the rudderheads, one of the bushings cocked ever so slightly, and two bearings binds in the top, so I have been using only one bearing at the top of the port rudder. I think that I might have been able to fit in the second one recently as everything wore a bit and clearances increased ever so slightly. Use both bearings, basically.

The bushings were then capped with carbon fiber after the glue to the foam had dried. I wrapped them with a considerable amount of unidirectional carbon fiber, I think something like 12 layers of 160 gram unidirectional fiber. After every third unidirectional layer I placed a layer of 12 ounce biaxial carbon, to help give some torsional stiffness. The unis were 50 mm wide, the carbon biax was wider in order to lap onto the rudderhead. In addition, a thin width of unidirectional fiber was used to "hoop" this resulting bundle of unidirectional fibers between the bushing and the rudderhead. The ends of this uni were started and terminated on the rudderhead itself, to sort of tie the loads into the X from the original lamination. A layer of 12 ounce carbon biax was then applied over the whole thing. I realize that this is overkill, but major overbuilding here still only incurs a quite small weight penalty. Once again, each bushing laminate was vacuum bagged. After the resin had cured, tiller arms of the high density foam were extended from the top bushings. These tiller arms are about 6 inches forward of the center of the pin at the top. A glass tube with a 3/8 inch inside diameter was glued to the forward edge of this arm, and the foam was shaped to a point at this end. This tube would carry the pin for the steering cables and tie rod. Then a similar laminate to the bushing laminate was installed over the tiller arms, making a 50 mm X 50 mm box beam tiller arm, essentially. After this, it was mostly a matter of cosmetics and trimming to final dimensions. Flats were made on either end of the bushings, normal to the axis of rotation, to create a landing surface for the thrust washers controlling end float and the flange at the bottom of the pin. It was at this point that the pin was finally cut to shape.

Fitting to the transom

Then a final location was determined. I decided to angle the rudders at 15 degrees off of vertical, rea-soning that was about the maximum amount of heel in normal conditions, and it was also very close to normal to the bottom of the boat at the transom. The intersection of the rudders with the bottom of the boat was approximately in line with the ballast keel centerline, very similar to Cmdr. Lovelock's positioning. The vertical positioning of the transom blocks is such that the rudderheads are clear of the water at rest, although it turns out that I could have angled up the bottom of the rudderheads a bit more as they are somewhat immersed underway in certain conditions. I believe that the bottom of the blocks, on the blocks' centerline, is approximately four inches (100 mm) above the transom/bottom intersection. The centerline of the blocks is about 14 1/2 inches off of the boat's centerline at the top and about 16 1/2 inches off of the boat's centerline at the bottom. The blocks were then bolted to the transom with four 5/16 inch stainless steel bolts per side, total 8 per block. Slots were then cut into the transom (emotionally this was the hardest part). The slots were trimmed until there was adequate clearance. The edge of the plywood was then sealed with three coats of epoxy. A knee was laminated onto the inside of the transom to strengthen the area. This knee was built in line with the longitudinal stringer under the bunks. The knee was laminated from 32 layers of 1/32 inch ash veneer, two inches wide.

To link the rudders, I turned to my machinist friend again. I wanted a solid tie rod of some type, that would easily allow the toe in to be adjusted. I hit upon the idea of using turnbuckle ends with integral toggles. The nice thing about this is that turnbuckles have one end threaded right hand, the other threaded left hand. Carlos the machinist then took two plugs of stainless steel, about 3/4 of an inch thick, and drilled and tapped them for the turnbuckle ends. These plugs were then welded into the end of a stainless steel tube, similar to a stanchion tube (which it might very well have been). The blocks for the steering cables were appropriately repositioned, and also refastened, and a new steering cable was made up, also with integral toggle ends at the rudder end. The quadrant end used turnbuckles. At this point it was just cosmetics, and the usual late nights as the launching date loomed.

The Rudders in Practice

However, all of the effort has been worthwhile. The boat now turns on a dime, and is finger tip steering. Michelle can now steer the boat in any of the conditions we have so far encountered, and overall responsive¬ness is incredible. The rudders are a little too sensitive, I probably should have used less lead, although at larger angles of heel weather helm increases, which is not surprising. The profile of the rudders is almost rectangular, so after the first season I cut off the forward lower corner of each rudder and made it a 6 inch radius to help reduce sensitivity. This helped some. I think sensitivity is a feature of the swept forward orientation. It is still worlds better than the old design. The ability to just pull the rudders out is also nice, makes them easy to keep clean, and if you catch a lobster trap buoy you just go to the stern and lift up the offending rudder.

Accommodating the engine

All this repositioning of the rudders also necessitated repositioning the motor. A 146's inboard engine was removed for the 1976 OSTAR, so she now sports a Tohatsu 8HP longshaft outboard. At 68 pounds it is light enough to be relatively easily removed form the transom and stowed below. It is nice to not have to drag around a prop and shaft, plus the under cockpit storage is nice. As I had vowed at some point during the fall of 1992 to throw away the old motor mount (and I did, first thing after hauling for the winter), a new design was in order. I had this piece of carbon cutoff left over from the building of Matador 2, a TOR maxi. It was in the shape of an omega, sort of. To the flanges of the omega I bolted four Harken small traveler cars, and to the flat of the omega I bolted a plywood pad for the motor to clamp to. To the transom was bolted two pieces of Harken traveler track. A padeye was mounted on the transom, and a line goes from the padeye, to a block on the underside of the omega and back up to a cam cleat mounted on the transom. When you use the motor, just tilt the motor down, grab the line, uncleat the line, and lower the whole assembly. To pull it up, just pull the line, cleat it, and tilt up the motor. Quite simple. It is mounted on centerline between the two rudders. I clearcoated the carbon with Awlgrip clear linear polyurethane, so it looks pretty cool. Also quite light. One feature of the motor's mounting, though, is that steering with the prop thrust is not very effective if the rudders are straight, as in either direction the thrust hits one of the rudders, creating an equal and opposite reaction, i.e. equilibrium situation. Just have to get used to it, mostly. If the rudders are turned, it is possible to turn the propeller such that the thrust is parallel to the rudders, which works well in tight spaces.

A Bowsprit for the Spinnaker

Onward to the other end of the boat. I wanted to improve the spinnaker handling of the boat. A spin-naker pole did not come with A146, so when I was a sailmaker in the late eighty's I just made an asymmetrical cruising spinnaker, with a tack pennant that attached to the jib tack shackle. This arrangement was okay, but not great. To improve matters, I decided to install a bowsprit, for the spinnaker. This was a relatively easy task.

First, I found an aluminum tube that looked about right. Turns out that a section of broken Sunfish mast is perfect. I initially settled upon a length that extended two feet forward from the stemhead, this decision was driven partly by PHRF rating considerations. Using the tube as a mold, a tubular piece was made out of fiberglass, which was then cut into various pieces to make the attachments. One piece was cut to eight inches long. This one was destined to be the attachment at the actual stemhead. A piece of fiberglass tube with an inside diameter the same as the anchor roller bolt was epoxied at right angles to this piece. After curing, many layers of unidirectional glass and biaxial glass were wrapped over this little tube and around the big tube. Again, the major overkill approach was used. For the inboard end, it was located in line with the middle of the mooring bollards on the stem fitting.

Due to the fact that on Le Bateau Ivre the hawse pipe is on the starboard side, this whole assembly was located on the port side of the stem head fitting. A long bolt was purchased to replace the anchor roller bolt, and the stem head piece was attached to the port side of the stem head. The aluminum tube was then inserted into the stem head piece. A two inch section of the fiberglass tube was cut and placed over the inboard piece of the aluminum tube. Mylar tape was then taped over the deck in the vicinity of the inboard end of the tube. Then placing two layers of 12 ounce biax glass, wet out with epoxy, onto the mylar tape, the glass tube over the end of the aluminum tube was then placed onto this glass. The aluminum tube was then secured so that it would not move. More layers of biaxial glass were then placed over the top of the glass tube and around the inboard end, a fiberglass plate having been already glued on the inboard end previously. This resulting glass strap extended over the stem fitting to the starboard side.

After curing, it was removed, trimmed to shape, painted and then bolted down to the deck with one bolt to each side. The loads here are inboard and down, so lots of bolts were not required. The outer end of the tube received a little glass fitting with a glass tube on the top through which a bolt attaching a block was placed. This small glass tube was also glued to the bigger glass tube with unidirectional fibers, and a glass plate across the end keeps the fitting from sliding in along the tube. Two machine screws tapped into the aluminum keep the piece from rotating and also prevent it from falling off the aluminum when there is no load. A line with a snap shackle on the end is run through the block and back to a mooring cleat. A small hole was drilled in the top of the inboard fitting and into the aluminum tube. A quick release pin through here keeps the aluminum tube from rotating and serves as a secondary attachment for the tube. As long as the line is attached, the tube cannot come loose. However, I also have a small section of tube with which I replace the bowsprit when mooring anywhere they charge by the foot. The quick release pin then holds this small tube in place. This tube is necessary as otherwise the piece on the side of the stem fitting rotates around its attachment bolt and bangs the paint. The spinnaker was also modified, extending it by one panel, so the luff is now about three feet longer, as the tack goes right to the end of the bowsprit. The sail sets much better, and gybing is much easier as there is now space for the clew to go between the tack and the forestay. After one season, I made a longer piece of tube, so now it extends three feet forward of the stem head. The end can still be reached from the stemhead, or alternatively the tack line can be slackened and the shackle led back to the pulpit for hooking up the spinnaker. This longer bowsprit has improved gybing even more, and also allows a slightly lower angle to be sailed off the air before the spinnaker is blanketed by the mainsail. All in all, a pretty satisfactory conversion.

Verdict on the Appendages

These features have helped make Le Bateau Iyre a more enjoyable boat to sail. Changes I would consider are a little less lead on the rudders, and perhaps slightly smaller rudders. However, when sailing off the air in five foot waves, occasionally surfing, there were no problems with control. Going upwind in heavy air, she is easy to steer and doesn't miss a tack. In light air you can scull effectively with the rudders. I think that overall the flow of water is much better, as now there are just two foil shaped blades in the water, instead of the old flat plate with its attendant slots and bolts, although there does appear to be some interaction between the wakes of the rudders. As the rudders are daggerboards there are no troublesome downhauls and uphauls, although I want to attach some type of line as a leash, just in case the worst happens. Wouldn't do to be knocked down and watch your rudder blades float away, not that they come out of their slots that easily. I approached the lack of kick up ability, in terms of surviving impact, by way overbuilding everything. As long as the transom stays attached, everything should be fine. For waterproofing the tiller arm entrances, the plan I have finally decided upon, after much mopping up of the aft cabin sole, is to build a box around the tiller arms. The top of the box would serve as a shelf, which would be nice. The front I am considering making out of clear lexan, to get more light into the stern. To waterproof the steering cables where they go through the sides of the box I have ordered steering rack boots for a car, which should do the trick. The front of the box will be removable, either screwed or perhaps even hinged so that it could double as a ventilation port. The box will drain through two small holes in the transom at the low point of the box, and any major amounts of water will just go right back out through the tiller arm slots.

