In Defense of Symmetrical Airfoils

Flightline Airy musings by Tom Arnold

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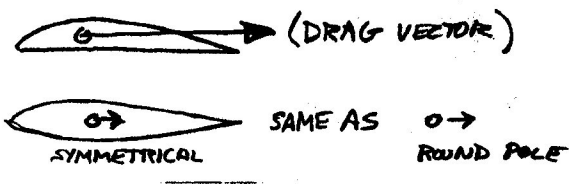
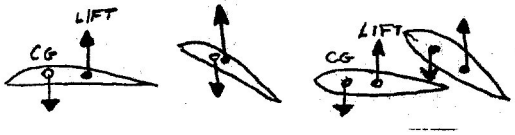
I always love to hang around the big kids and see what they fly and try to figure out **The Secret**. Have not found The Secret yet but it is fun trying. Clarence Mather had a couple of jumbo, high flying, (does he build any other kind?) Folkerts racers and they had symmetrical airfoils. When asked why he used them when the rest of the world uses flat-bottomed airfoils he had an interesting line of reasoning. First (assuming the same thickness) a symmetrical airfoil has less drag than a flat bottom example. In fact, a symmetrical airfoil has the same drag as a circular wire or pole 1/10 the thickness of the airfoil. Now you see where all the drag of a wire braced biplane comes from.



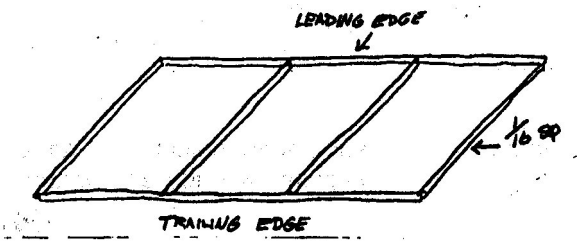
A symmetrical airfoil has another characteristic that Clarence used. As a flatbottomed airfoil is rotated to a higher and higher angle of attack (think stall), the center of lift, which is behind the center of gravity, begins to move forward, literally decreasing the normal anti-stall moment of a wing. In other words, the closer a flat bottomed airfoil gets to a stall, the more it wants to stall. See the diagram. A symmetrical airfoil does not have this characteristic and the center of lift stays put through out the whole stall evolution doing its best to keep the airfoil flying.



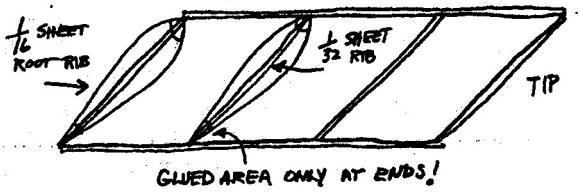
Clarence felt this built-in stall resistance kept his models out of trouble far longer than the flat-bottomed examples and the examples he flew sure seemed to bear it all out. I can hear the hoots already from the peanut gallery as Clarence can make anything fly well. His trimming and flying skills are legendary but, Hey, if he thinks it works, lemme at it!

So I decided to build a symmetrical wing for one of my mass launch hounds and promptly found out why we build flat bottomed ones--flat bottom is incredibly easy to build straight and true and symmetrical is incredibly hard as there is no way to anchor the whole structure. After building 6, count 'em 6, wings I think I have hit upon a method that works and I humbly share it for any other poor soul who takes this on.

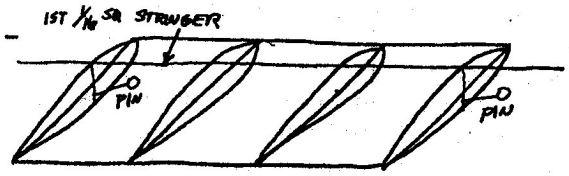
Step 1: Build a flat framework of the wing with the leading edge and the trailing edges connected by 1/16'" sq where the ribs go. Call these "rib braces" for lack of a better word.



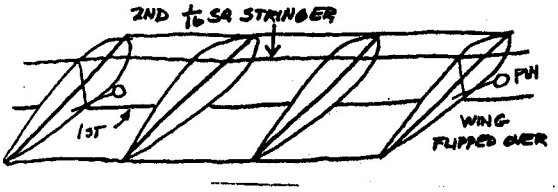
Step 2: Unpin the wing frame and glue the symmetrical ribs against the 1/16'" sq rib braces, but **only glue them at the leading and trailing edges**. We will cut,away the center section leaving. the ends to reinforce the naturally weak attach points and save some weight in the process.



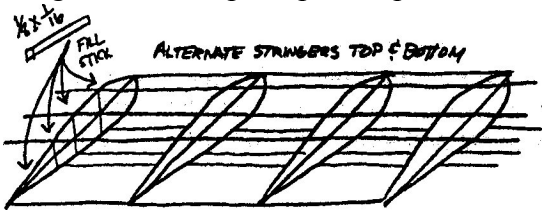
Step 3: Lay the floppy affair back down on the workbench and pin it at the high point on the airfoil to the bench. Glue a 1/16'" sq stringer along the top from root to tip.



Step 4: Flip the affair over and glue a second stringer at the same location along the bottom. You have just constructed the center "spar", so to speak.



Step 5: Continue to do the same at each of the points you want a span-wise stringer, flipping the wing over to complete pairs top and bottom as you go along.

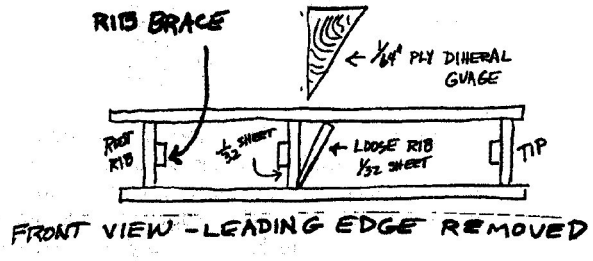


Step 6: Fill in at the root rib with soft 1/8'" X 1/16'" between the stringers over the edge of the root rib and sand FLAT between the stringers.

What this gives you is a structure you sort of semi-built in the air and semi built on the work board. The airfoil is built up of flat planes, which I find more visually appealing for a metal wing as opposed the hills-and-valleys of conventional rib and stringer construction. You also did not have to struggle with lining up notches and stringers, which I also find is a losing battle. I have not addressed the attachment method of the wing to the fuselage as you can use any number of ways and let me know when you find a really good one.

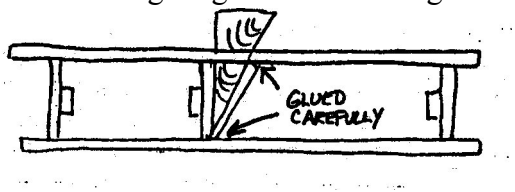
On my particular example, a Short Seamew, there was a dihedral angle built into the outer half that drove me nuts and accounted for 3 of the 6 wings until I figured it out. In case you are faced with this here is my solution.

Step1: At the dihedral break, slip in 2 1/32'" sheet ribs and DON'T glue them to the stringers as you attach the stringers to all the other ribs.

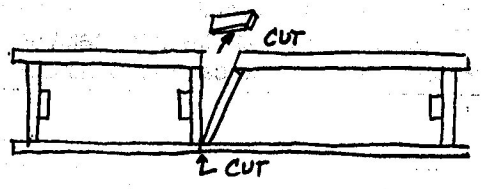


Step 2: Pin the wing down at the main "spar" and glue the inside loose rib in place and perfectly vertical. Use a little square piece of balsa to help.

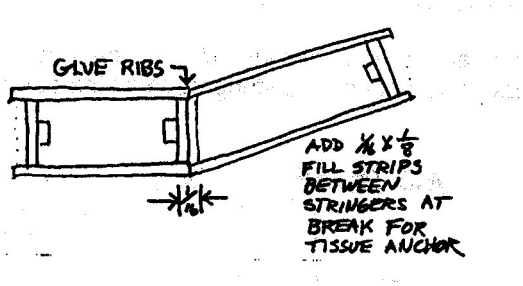
Step 3: Now take a very carefully cut wedge of 1/64'" ply or balsa that is cut to the dihedral angle and slip in down between the two ribs and glue the second into place. Slide your wedge along the chord before gluing to insure the angle is the same all along the rib.



Step 4: Cut the outer half free, clean up the surface between the 2 ribs and reglue at the now correct angle.



Step 5: Fill in on the top of this dihedral rib with soft 1/8'" fill as you did on the root rib. .



In this whole evolution you need precisely plotted ribs for the stringers to lie on. I have found the use of "Simplex" airfoils to be ideal and they work marvelously. For those not familiar with the term, a Simplex airfoil is an airfoil that when you cut any length off the trailing edge, you will always have a perfectly proportional smaller example left. Contrary to what I have seen advocated, this will NOT work by just chopping off the tail of any old airfoil. If you do, by the time you get to the tip rib, you will have a very different shape and worse, the stringers will not lay flat. The Simplex family comes from a type of helix that almost identically mimics the shapes we use which really are not precise anyway. I have made up family of Simplex. a![foils (% of chord such as 6% chord, 8% chord, etc.) and mounted them to lithographic plate--easy to cut and shape. I then just slice out what I need from sheet balsa at whatever chord is desired and they all are proportional. Works like a charm.

So are there any drawbacks to this method? The only one I have found is that it gets hard to do in very thin airfoil examples. The stringers work best when they are square for ease of gluing so I have a hard time doing the 1/32 X 1/16 stringers that I like. I am stuck with 1/16 sq. Clarence used 1/32 sheet ribs and 1/32 X 1/16 strings notched into the ribs and he did admit that it took a lot of careful work and jigging to build his wings but, Boy, did they look nice.

For those interested in the Simplex airfoil family, I found several examples on the web by just typing in "Simplex Airfoils". Just print them out--any size is fine and take to Kinko's and expand to what ever working size you need to make some shop templates. You can use them to make semi-symmetrical airfoils of any thickness as well as under cambered just by flipping them over and upside down.