

If you're looking for a sport and competition sailplane that's out of the ordinary, Mike Carroll's Windhover is for you. This 99" span machine features elliptical wing tips, a short coupled fuselage, all flying stab, and magnificent performance. Sufficiently stable for the novice, it can challenge the potential of the most seasoned contest pilot.

WINDHOVER



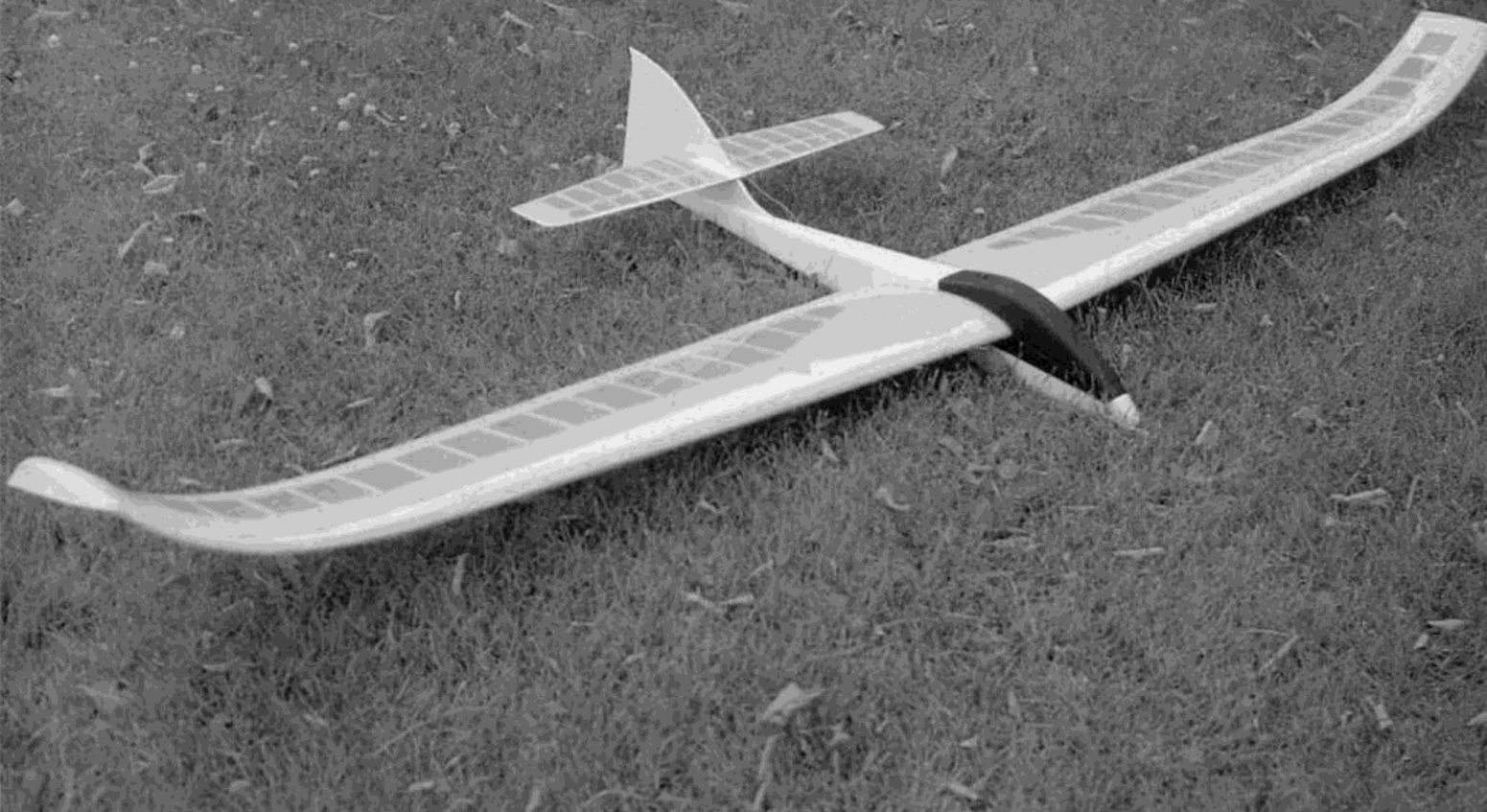
For many years construction articles have tended to fall into two categories, sport or competition. The former included all manner of cumbersome contraptions, sporting gaudy decoration and folksy invitations to docile Sunday afternoons, while the latter advertised themselves as the ultimate answer to the competitor's needs. Windhover belongs to neither of these categories. It is not a novelty nor is it a guarantee of winning. It is simply an honest, rugged, and attractive Standard Class sailplane.

The name is taken from a Gerard Manley Hopkins work, a poem entitled, "The Windhover." Hopkins' subject is the European Kestrel, and it is my hope that those who have seen my Windhover in flight will agree that it demonstrates the grace and beauty of both the bird and the poem.

I am no aeronautical engineer. Rather, I am a reasonably proficient modeler who derives the maximum enjoyment from turning a stack of sheets and sticks into an aircraft which is uniquely my own. While I enjoy competition, neither am I an all-out competitor. My fascination with modeling stems directly from the fact that I have never lost that childlike wonder at watching things moving through the air. I suspect that I share that wonder with at least a fair percentage of my fellow modelers.

Many of Windhover's design features do not originate with me. The short coupled fuselage and elliptical tips were simply scaled down from Jim Porter's 16' Shrikes. The flying stab construction was stolen from Mark Smith's Windfree. In fact, the only technical feature in the whole airframe which I'm certain I thought-up is burying the elevator control horn in a 3/16" thick sub-fin, and undoubtedly someone has already done that, too.

Before we move to the construction sequence, I should add that my original Windhover is now well into its second full season of sport and competitive flying. The prototype, which Ed Harris built from the plans for this article, has also seen extensive use. At no time during the hundred plus



hours which these ships have logged has either of them exhibited any unstable or idiosyncratic flight characteristics. Both aircraft flew well right off the board with only minor ballast adjustments necessary to tune them for maximum performance. For those of you who would like to fly something a bit out of the ordinary, but don't want to pay the performance penalty which unusual designs often entail, try a Windhover. Then drop me a line in care of this magazine and let me know how you liked it.

CONSTRUCTION

Despite the elliptical tips, Windhover is not a difficult airplane to build, and owing to its small size its cost should be within the means of almost any modeler, even with today's balsa prices.

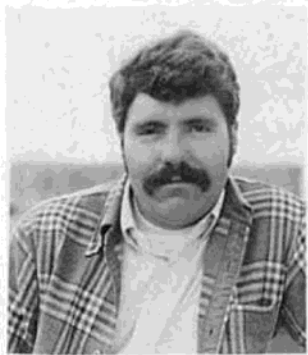
Fuselage:

I strongly recommend starting construction with the fuselage. The wing wires will then be available as a jig, facilitating correct tube placement in the wings. Begin by cutting out and laminating the 3/32" balsa sides and 1/32" ply doublers. After sanding these to match, carefully mark and drill the wing wire holes. Use the bottom forward portion of the fuselage sides as a zero reference. Now, add the 1/4" triangular balsa and the 1/4" square balsa vertical nose reinforcements.

Cut out the 1/16" ply formers, F1a, F2, and F3, and the 1/8" cross grained balsa former, F1, and add the 1/4" square balsa

reinforcements to formers, F2 and F3. Then, cut and bend the 5/32" front wing wire and the 1/8" rear wing wire. Using the holes in the fuselage sides as a reference, mark the position of the wires on formers, F2 and F3, mount them with J-bolts, but don't glue them in place. Slip the fuselage sides on to the wires and adjust the J-bolts, with the fuselage on a flat surface. When you are certain that the dihedral angle is identical for both sides, that the front and rear wires are parallel and horizontally perpendicular to the sides, and that the sides are parallel to each other and perpendicular to the work surface, use quick setting epoxy to glue in the formers and coat the J-bolts and the inside portion of the wires. Again, be certain that everything is square, before the glue sets. If this alignment is not correct, the entire airframe will be skewed and performance may suffer drastically.

Next, cut out the 1/32" ply sub fin sides and the 1/16" ply elevator horn. Drill the appropriate holes in these, as indicated on the plan. Now, cut out the slot which allows the elevator travel by drilling a series of holes and cleaning in-between them with a jeweler's rat-tail file. Epoxy the 1/8" O.D. brass tube forward bushing and the 3/32" O.D. brass tube rear bushing into the horn. Build a generous fillet of epoxy around both, and file the forward bushing down to just under 1/8" total width. Leave enough of the rear bushing on either side so that it projects beyond the sub fin walls. Add the



Michael J. Carroll is a 28 year old graduate student in English Literature, at the University of Northern Iowa, Cedar Falls, Iowa. He expects to receive his M.A. by the time this article appears in print.

His modeling career began with control-line flying during the early sixties. He has flown radio-control since 1970, beginning while serving with the United States Air Force. For the last four years, he has restricted his activity to the design, construction, flying, and competition of radio-controlled sailplanes. He has competed in a number of soaring contests, including the last three S.O.A.R. nationals. His wife Karen is a public school teacher. They have no children. This is his first publication.

PHOTOS BY EDWIN H. HARRIS

1/8" balsa spacers to one side of the sub fin and, when this is dry, slip both sides and the elevator horn onto a 1/4" length of 3/32" O.D. brass tube running through the forward bushing. Now, glue the sub fin sides together.

Before beginning further work on the fuselage, it will be necessary to consider the radio installation. The position of formers, F1 and F1a, will depend upon whether a brick or discrete component system is used. See the accompanying photos for a sample installation of both types.

At this point, mark a centerline on all formers, and on the two 1/4" square balsa transverse nose reinforcers when these have been cut out. Also, draw a reference line on your work surface. Pin the fuselage over this line and glue in formers, F1 and F1a, as well as the transverse nose pieces. Be careful to maintain correct alignment of the fuselage sides. Next, glue in the 1/4" triangular balsa at F1/F1a, add the 3/8" x 1/4" spruce servo rails against the rear of F1 and the front of F2, and glue on the 1/8" cross grained balsa forward bottom sheeting. Finally, add the 1/4" x 3/8" hardwood towhook block. This should be centered in the bottom of the fuselage, extending from F1a to F2.

While waiting for the glue to dry on these pieces, cut out, glue together, and sand the rudder to shape. Use medium 3/16" sheet balsa for the major part, but use hard 3/16" for the cross grained strips. A commercial rudder control horn may be substituted for the 1/16" ply horn shown. If not, cut the slot for it now, but if you intend to use a heat shrink material on the rudder, do not glue the horn on until after covering. The rudder may be hinged to the sub-fin now, or again, you may wish to wait until after covering or finishing. However, be sure that when you do hinge it, the hinges are drilled and pinned with toothpicks and epoxy.

Taper the triangular stock at the rear of the fuselage to accept the sub-fin assembly. Then, using it as a spacer, pinch the rear of the fuselage together and glue on the 3/32" balsa bottom sheeting. Also, add the remaining 1/4" square balsa cross pieces. Now, remove the sub-fin assembly (you didn't glue it in yet, did you?), and install the carrier tube for the flexible rudder pushrod. Support the tube at several places along the fuselage side and make all bends as gradual as possible. I used a fine diameter cable for my rudder pushrod, but there are many commercial products which will serve the purpose. Construct a conventional pushrod for the elevator, and attach it to the elevator horn. A threaded nylon coupler which snaps into place is ideal here for, once the sub-fin is glued in, there is no access to this connection. Glue in the sub-fin assembly, with the elevator pushrod attached, taking care to insure that the sub-fin is exactly vertical. The addition of the 3/32" balsa top sheeting, the 3/16" balsa fin and tailskid fairings, the 1/4" cross grained balsa top sheeting, the 1/2" cross grained balsa nose piece, the hard balsa nose block, and the 1/4" square spruce nose

skid, complete the fuselage.

Hatch:

Before beginning work on the hatch, carve and sand the fuselage roughly to shape. Now, take some scrap 1/4" sheet and bevel two pieces of it to form the fore and aft ends of the hatch. Pin these in place and cut out the 3/16" sheet balsa hatch sides. Wedge these between the ends and glue in place. Remove the hatch frame and add the 1/2" sheet balsa top. Now, replace

core sample. Rotate the brass tube as you push it in and you should be able to draw out the balsa plug. The forward hold-down is completed by epoxying in the brass tube and filing it flush with the nose piece. Use the same technique for the rear hole, then, glue in that tube and file it flush. The track for the removable rear pin is easily produced using a jeweler's rat-tail file.

Flying Stab:

Begin by laying down strips of 3/32" scrap balsa over the leading and trailing edge position on the plan. Make sure that these extend just inside the line so that when the 3/16" x 3/8" balsa leading and trailing edges are pinned on top of them the tips of the lower rib halves will be supported. Also, remember to cover these shims with something so that they don't become part of the stab. With the leading and trailing edges pinned in place, glue in the 3/32" x 1/4" balsa lower rib halves. Then, before the glue dries, add the 1/8" x 1/4" spruce spars and pin them down to achieve the bottom of the symmetrical airfoil. Now, add the top rib halves. Remove the stab halves from the board when dry, and add the 3/8" x 1/2" x 3/2" balsa tip blocks, and the 1/8" balsa end plates. To install the 1/16" music wire and 3/32" O.D. brass tube use a sharpened piece of tubing as described in the hatch hold-down section, above. A 1/64" shim is required between the spar and the forward wire in order to maintain exact alignment between the stab halves. I have found that a fillet of epoxy on both sides of the wire, or tube, where it passes through the ribs is sufficient to keep them in place, and no wrapping or other reinforcement is necessary. Take care when installing the stab wires and tubes to see that they are parallel, and use the elevator horn as a jig to insure correct placement. To complete the stab, drill two 3/4" lengths of 3/8" square balsa to accept the forward wires, and pin one to the end of each half of the stab. These will form the sub-fin/stab fairings. Now, sand the stab halves to shape, and remove the fairings. Mark the sides of the sub-fin assembly so that the fairings will indicate the proper neutral position for the stab when attached. Push the fairings over the brass tube which runs through the forward elevator horn bushing, and epoxy them to the sub-fin assembly. Be certain that this tube is well anchored with epoxy so that it can't work in the soft wood of the fairing. Also, mount the stab before the epoxy sets up to insure that it will be perpendicular to the sub-fin assembly. Now, file the brass tube flush with the fairings.

Wing:

Begin wing construction by building the laminating fixture. Cut out three 1/4" ply fixture formers. Now add the 1/4" x 1/2" spruce cross pieces, allowing the ends of the bottom two to protrude 1/2" or so beyond the fixture sides. Drill some holes in the ends of these so that the fixture can be pinned solidly to the board. Next, glue the 1/16" ply top in place.

With the fixture completed, cut four 1/16" x 1/4" x 36" spruce spars in half to

WINDHOVER
Designed By: Michael J. Carroll

TYPE AIRCRAFT
Stand. Sport & Comp. Sailplane

WINGSPAN
99 1/4" (Projected)

WING CHORD
Root 9 1/2" — Tip 5"

TOTAL WING AREA
703 1/4 Square Inches

WING LOCATION
Top of Fuselage

AIRFOIL
Flat Bottom

WING PLANFORM
Double Taper

DIHEDRAL, EACH TIP
Elliptical Tips

O.A. FUSELAGE LENGTH
36 Inches

RADIO COMPARTMENT AREA
(L) 8 3/4" X (W) 1 7/8" X (H) 2 1/2"

STABILIZER SPAN
23 1/2 Inches

STABILIZER CHORD (incl. elev.)
4-5/32" (Average)

STABILIZER AREA
97 1/2 Square Inches

STAB. AIRFOIL SECTION
Symmetrical

STABILIZER LOCATION
Flying Stab on Fin

VERTICAL FIN HEIGHT
3 3/4 Inches

VERTICAL FIN WIDTH (incl. rudder)
7" (Average)

REC. ENGINE SIZE
NA

FUEL TANK SIZE
NA

LANDING GEAR
NA

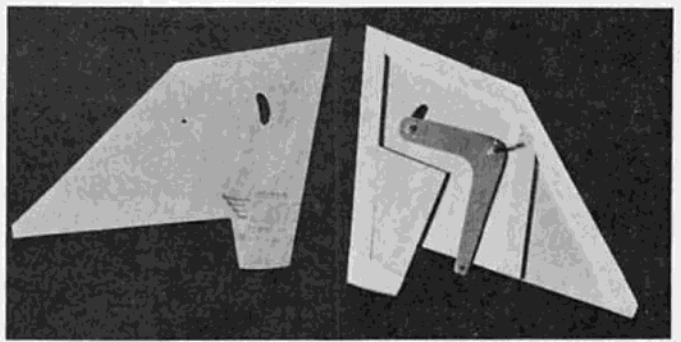
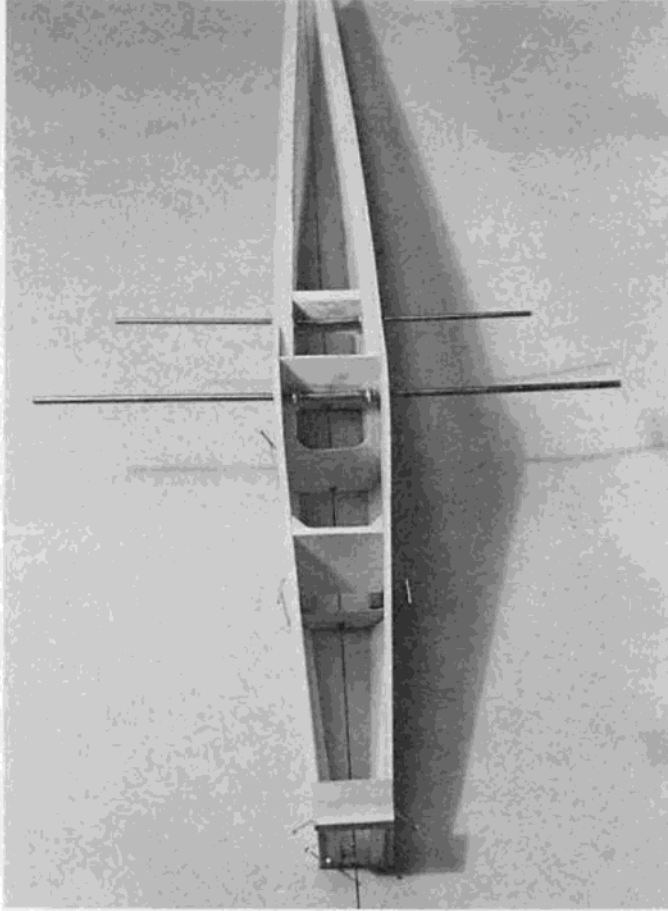
REC. NO. OF CHANNELS
Two

CONTROL FUNCTIONS
Rudder and Elevator

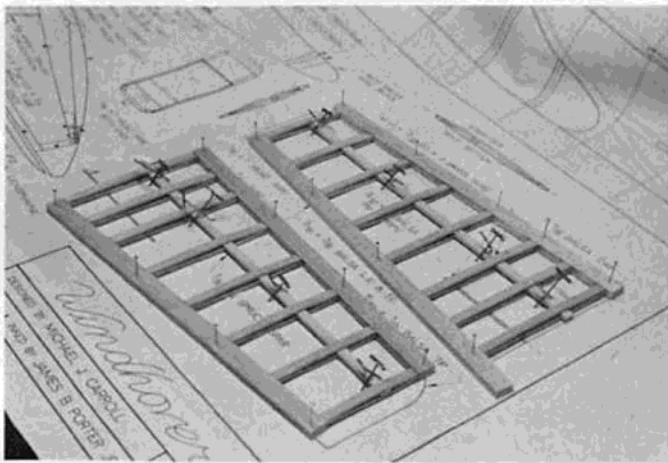
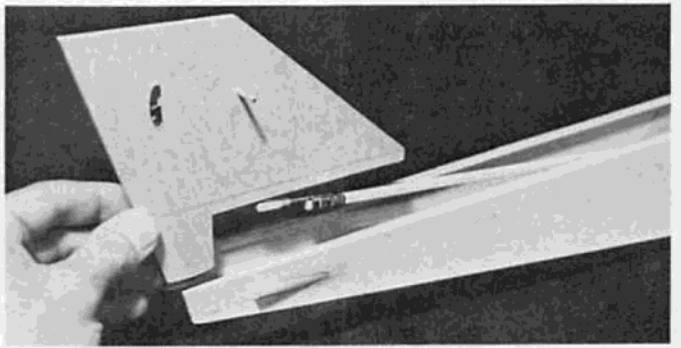
BASIC MATERIALS USED IN CONSTRUCTION

Fuselage	Balsa and Ply
Wing	Balsa, Spruce and Ply
Empennage	Balsa and Ply
Weight Ready-To-Fly	41 1/2 oz. (w/90z. radio)
Wing Loading	8 1/2 Oz./Sq. Ft.

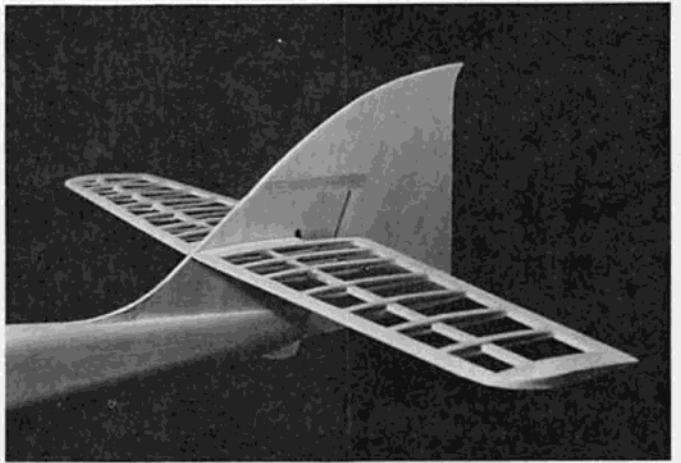
the hatch on the fuselage, pin it down, and sand it to shape. Begin installation of the hold-downs by driving a 1" length of 1/16" music wire through the forward end so that it can be glued flush with the inside top surface of the hatch. After marking the correct position on the cross grained nose piece, sharpen one end of a piece of 3/32" O.D. brass tube with a file and use it to drill the hole. This process is much like taking a



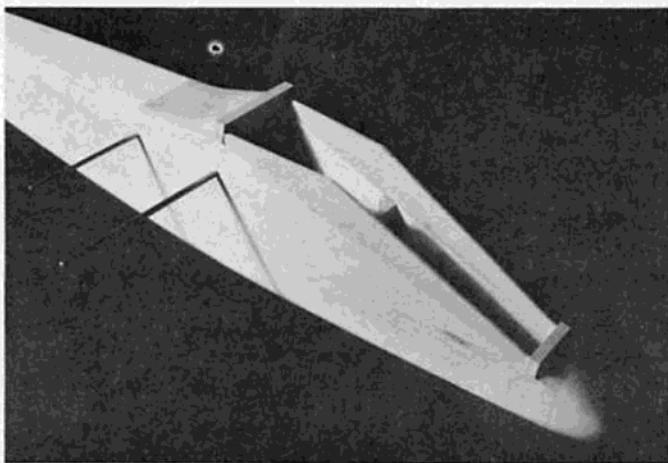
LEFT: Fuselage pinned over the reference line. ABOVE: Sub-fin halves, ready for joining. BELOW: Sub-fin assembly, ready for installation.



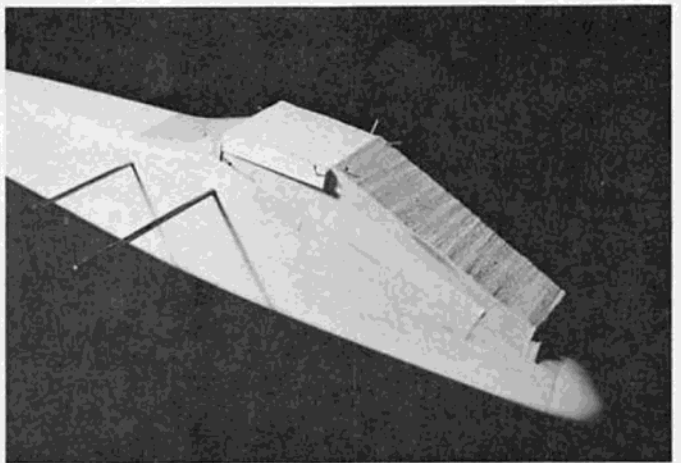
Stab halves on the plan.



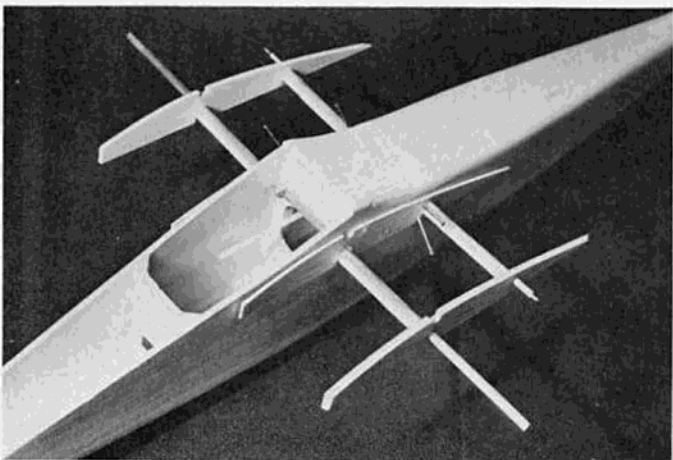
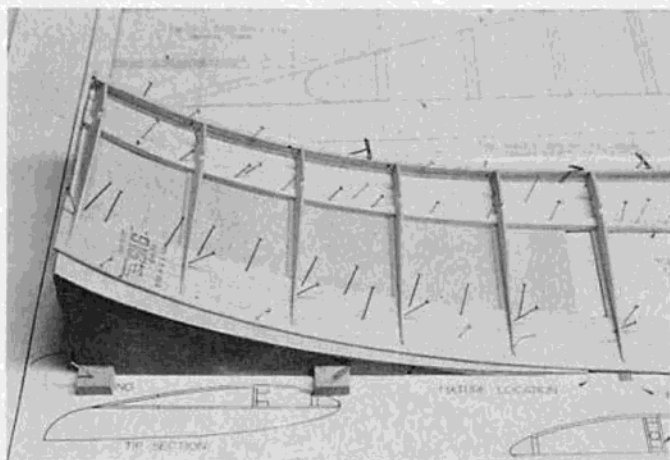
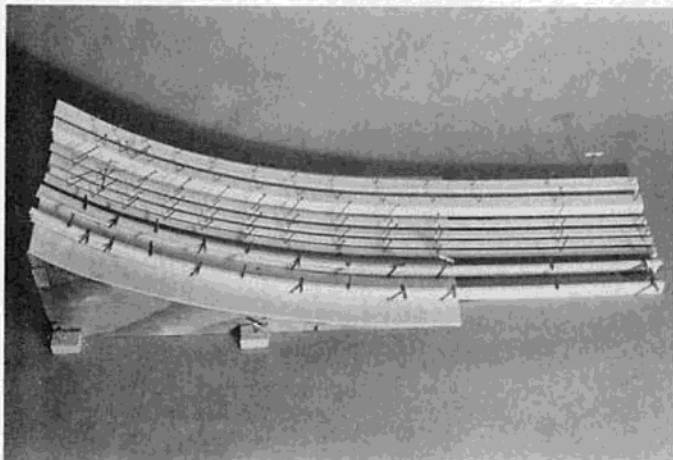
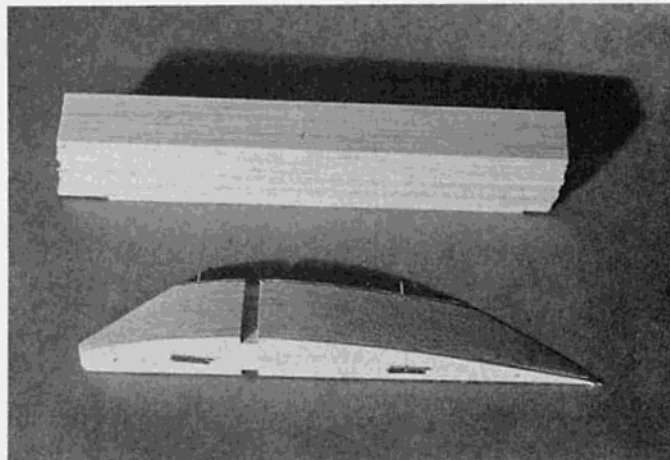
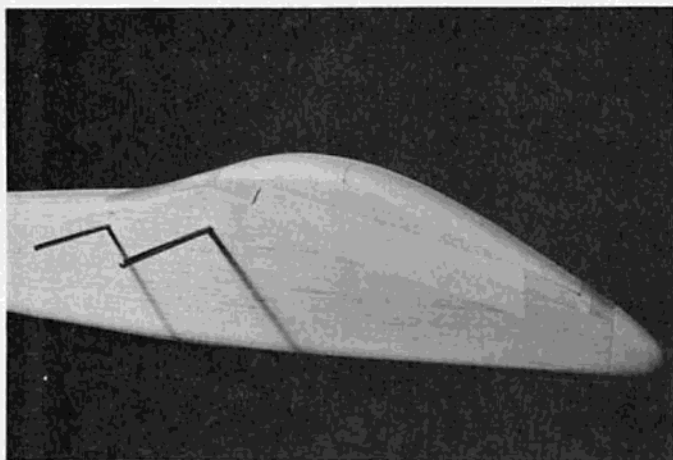
Empennage near completion.



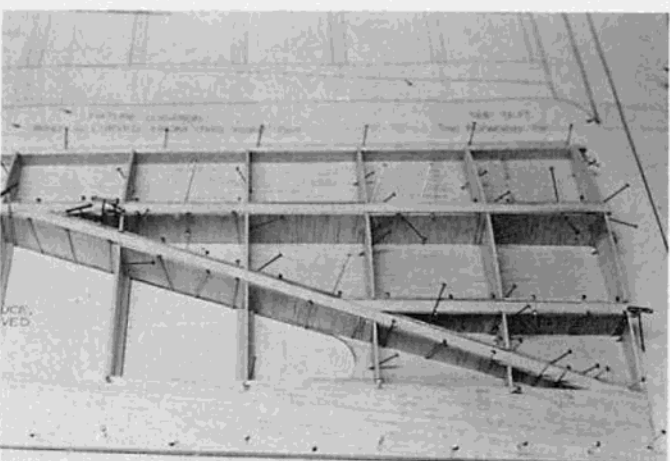
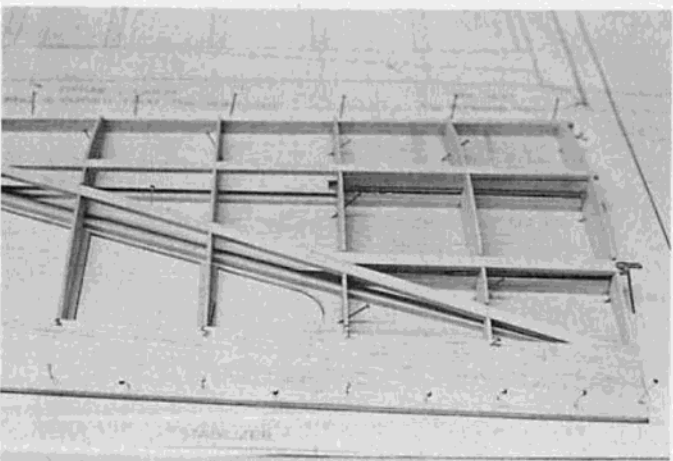
Basic hatch frame.

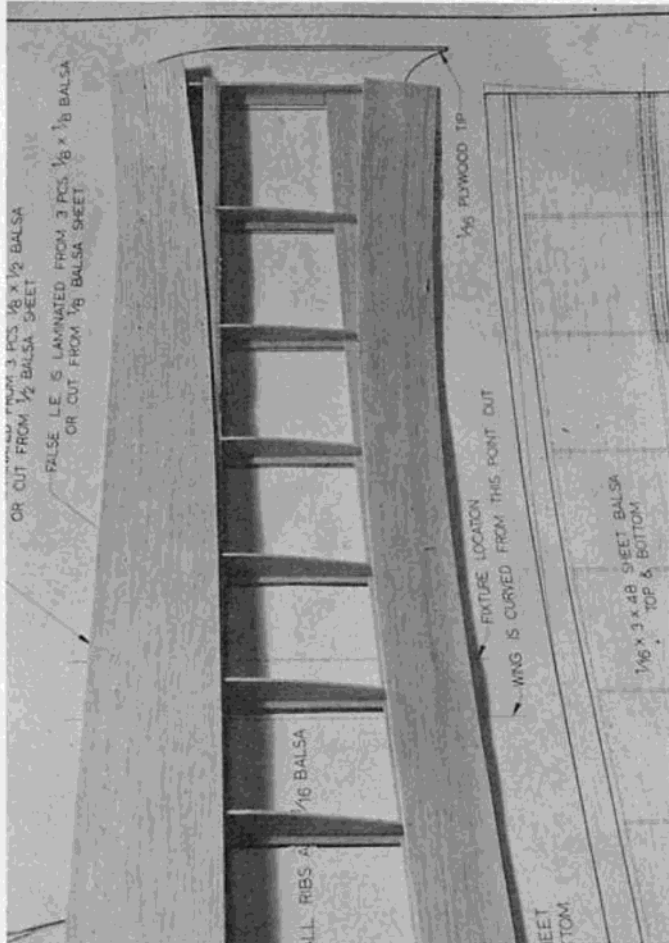


Hatch in place with top added.

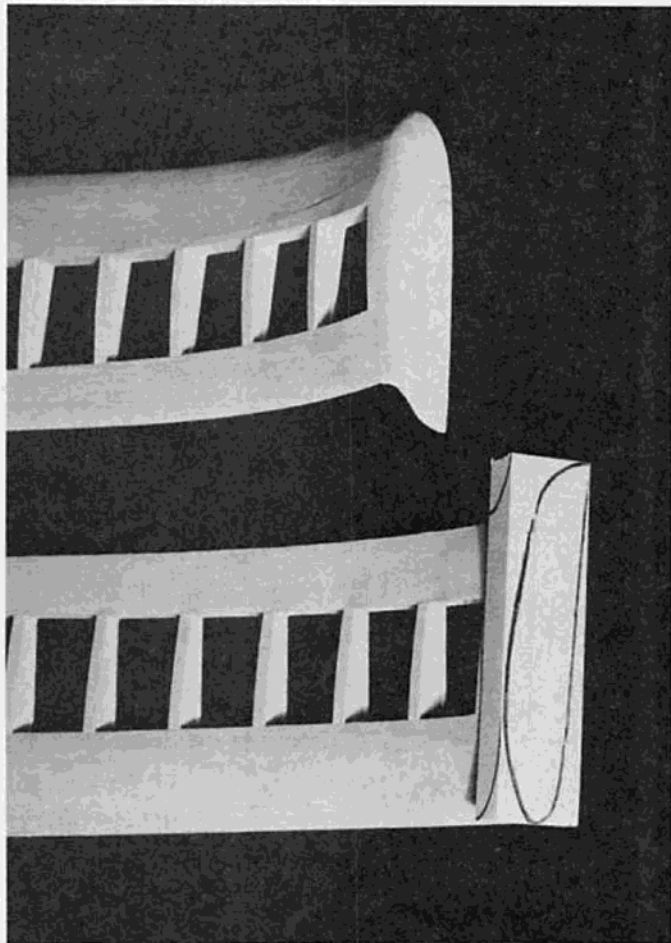


TOP ROW, LEFT: Hatch sanded to shape. **TOP ROW, RIGHT:** Rib blanks, before and after. **ABOVE, LEFT:** All laminations in place on the fixture. **ABOVE:** Tip in place on the fixture. **LEFT:** Using the wing wires as a jig. **BELOW, LEFT:** The sandwiched wing tubes. **BELOW:** Webbing in place.



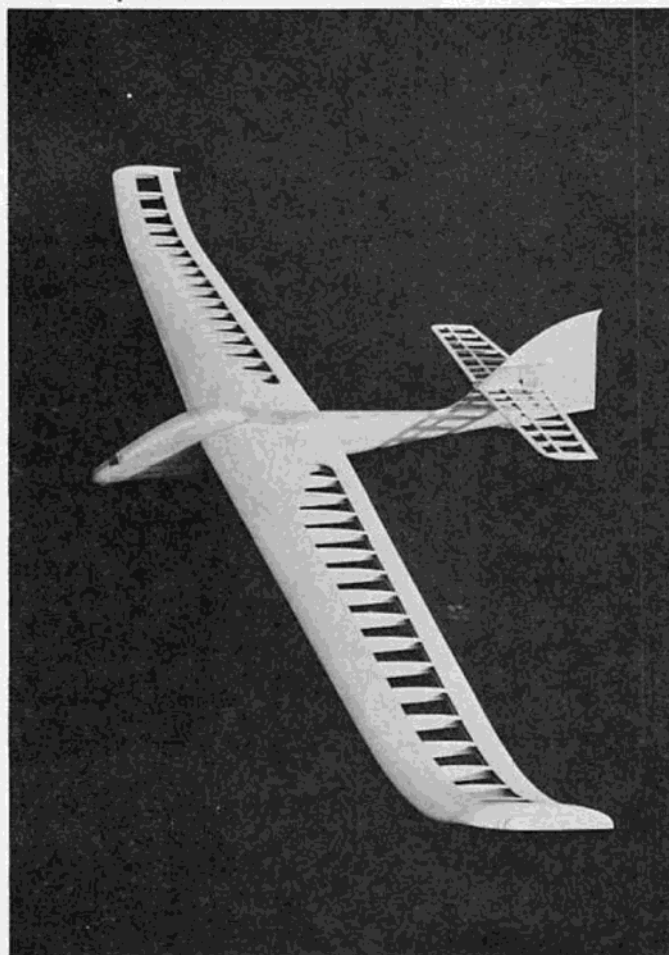


Top sheeting run-off before trimming.

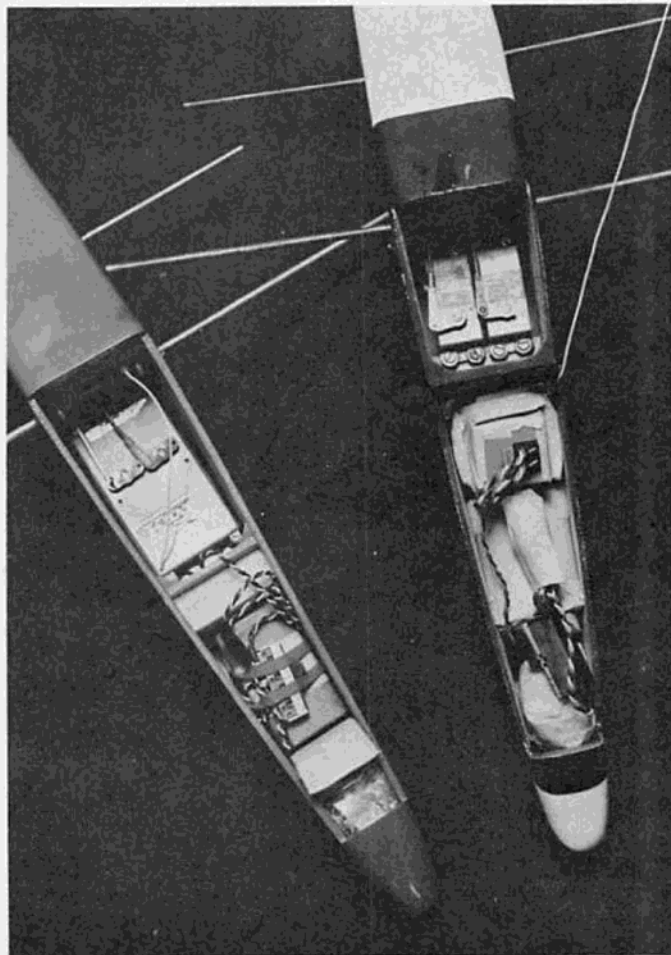


Tip block and completed tip.

The completed airframe.



Alternate radio installations.





The author, waiting to fly at a 1974 Iowa City contest.

Ed Harris and his plan's prototype on a slope near Platteville, Wisc.



form eight 18" segments. These are the spar laminations. Also, cut six 1/8" x 1/2" x 18" balsa strips, and six 1/8" square by 18" balsa strips, to form the leading edge and false leading edge laminations, respectively. Now, stack four sets of spar laminations, two pieces to a stack, and two stacks each of the leading edge and false leading edge laminations, three pieces to a stack. Glue liberally between all pieces and pin the stacks to the laminating fixture with heavy pins and a tack-hammer. Be sure that the fixture is covered to prevent gluing the laminations to it, and that the pieces are stacked neatly to avoid having to sand beyond the required thickness. Allow the bottom piece in each stack to extend beyond the top of the fixture and mark each stack at both the top and bottom of the fixture for reference. Also be certain that each stack is exactly perpendicular to the fixture base so that the same curvature exists in all the stacks. Now, splice the curved spar sections to lengths of 1/8" x 1/4" spruce, the leading edge sections to 1/2" square balsa, and the false leading edge sections to 1/8" x 1/2" balsa. The difference in height

BILL OF MATERIALS

(In the order of Material Type, Quantity, and Description and Notes.)

Balsa

- 10 — 1/16" x 3" x 48"
- 3 — 1/8" x 3" x 36"
- 4 — 3/32" x 4" x 36"
- 2 — 3/16" x 3" x 36" (one hard, one medium).
- 1 — 1/4" x 3" x 36"
- 1 — 1/2" x 3" x 36"
- 2 — 1/2" x 1/2" x 36"
- 1 — 1" x 2" x 12" (cut this diagonally in the middle to form the tip blocks).
- 1 — 1/2" x 1/2" x 1 1/2"

Spruce

- 4 — 1/16" x 1/4" x 36"
- 7 — 1/8" x 1/4" x 36"
- 1 — 1/4" x 1/4" x 36"
- 1 — 1/4" x 3/8" x 12"

Music Wire

- 1 — 1/16" Dia. x 36"
- 1 — 1/8" Dia. x 36"
- 1 — 5/32" Dia. x 36"

Brass Tube (hard)

- 1 — 3/32" O.D. x 12"
- 1 — 1/8" O.D. x 12"
- 1 — 5/32" O.D. x 12"
- 1 — 3/16" O.D. x 12"

Miscellaneous

- 4 — 4/40 J-bolts.
- 4 — Control clevises.
- 1 — Flexible pushrod and carrier tube.

between the straight and curved pieces in the leading edge and false leading edge is due to the double taper of the wing section, so be sure that these pieces are spliced with the outside of the curve flush to the straight stock's lower edge.

To make the ribs, first cut out the 1/16" ply root and tip templates. Using a razor saw, make full depth cuts at the positions of the sides of the spar notches, and then, drill several holes in each template to accept the T-pins used to sandwich the rib blanks. Now, cut forty rectangles of 1/16" balsa, each slightly larger than the root template. Sandwich twenty of these between the two templates, securing them with T-pins from

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both sides. Be sure that the grain of the blanks is parallel to the bottom of the templates, that the template bottoms are parallel to each other, and that the spar notches are aligned. Sand the ribs to shape using a sanding block. Work across the stack of blanks until the sanding block is in contact with both templates. This insures uniform taper in the completed ribs. You will notice a marked angle in the edges of the completed ribs. For this reason, reverse the positions of the templates when sanding the other set so that this angle will also follow the taper of the opposite wing panel. When sanding is complete, use a razor saw to cut in the sides of the spar notches, employing the pre-cut templates as a guide. The excess material will break cleanly out of the ribs after unstacking. Finally, to avoid confusion, number the ribs as you unstack them, beginning with the root rib as W1.

The construction of the actual framework is begun by pinning the fixture over the plan. Remember to place the base exactly

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perpendicular to the spar line. Using a flexible straight edge, mark the spar line on the fixture, and then mark the rib locations. Now, cover the plan and fixture, and pin and glue the 1/16" balsa bottom sheeting and capstrips. It is best to cut the 1-1/2" trailing edge bottom sheeting from one 3" wide sheet. Use one half for one wing panel and save the other for the second panel. This will insure an equal amount of flex in both pieces and avoid an unequal curvature in the elliptical tips. It is not necessary to soak any of the material in the tips, to achieve the curvature, but the bottom leading edge sheeting will follow the curve of the fixture more easily if you trim it roughly to shape. Next, glue on the bottom main spar, slanted stub spar, and tube spar, and add ribs W4 through W20.

To install the wing wire tubes, carefully mark the positions of the tube holes on rib W1. Drill the holes using a sharpened piece of 3/16" O.D. brass tube for the front hole and a similarly sharpened piece of 5/32" O.D. tube for the rear one. Now rib W1 is available as a jig. Use it to drill the remaining ribs, W1 through W3, one at a time, for both panels. Align each of these with W1 by placing them on a flat surface over a scrap piece of spar material. Also, remember to delete the rear hole in both W3 ribs. In order to insure correct tube placement in the wings, I like to use the wing wires as a jig. To do this, first cut the 3/16" x 1/4" balsa lower tube spacers to lengths which match proper rib spacing. Next slip the brass tubes over the appropriate set of wing wires, and slip ribs, W1 through W3 over these. Glue in the lower spacers to get the correct rib spacing and to add stiffness, and then, holding the fuselage beside the work surface, press the structure flat so that the bottoms of the ribs are parallel. When dry, remove the assembly from the wires and place it over the wing structure. Mark the locations of the necessary stub spar and tube spar notches on the ribs, and cut them free hand with a razor blade. Now, glue the tube

assembly in place over the wing structure. Next, add 1/4" balsa scrap as necessary to bring the tube assembly to the level of the top spar. Then, add the top, main spar, stub spar, and tube spar, the false leading edge, and all required 1/16" vertical grained balsa webbing.

The top trailing edge sheeting for both panels is cut from a single sheet of 1/16" x 3" x 48" balsa, as was the bottom sheeting. When gluing this piece in place, allow the material to run-off the back of the wing as it is forced down onto the curve. The approximate line that it will take is shown on the plan. When dry, remove the wing from the board and carefully trim the top trailing edge sheeting along the back edge of the wing. The resulting piece, when flipped over, will exactly fit the space left in the top sheeting. After sanding the false leading edge to shape, repeat the above process on the top leading edge sheeting. Now, add the remaining top sheeting. Trim and sand the sheeting along its front edge and glue on the solid leading edge. Next, add the 1/16" x 5/16" top capstrips. The tips are carved from 1" x 2" x 6 1/2" balsa blocks, which are first glued to the ends of the panels. Also, a 1/16" x 1" x 5" ply tip plate is added to the lower rear corner of the block, prior to shaping. The inside curve of the tip is best formed by wrapping sandpaper around a large thread spool, a section of broom handle, or a similar object. The 3/16" balsa root fairings complete the wings. Attach these in two pieces, one extending ahead of the front wing tube, and one extending behind the rear tube. These are then sanded to conform to the root section and the curve of the fuselage sides.

Finishing, Trimming, and Flying:

After sanding the entire structure, I applied two heavy coats of finishing resin to the fuselage and rudder. This was then wet-sanded, and sprayed with an epoxy base paint. The article prototype was finished in a similar manner, and the wings and stabs of both were covered with a heat-shrink covering material. However, I see no reason why other conventional finishing techniques could not be used.

As mentioned earlier, both aircraft flew well, directly off the board. If you use the indicated CG and towhook positions as a starting point, I am certain that you may expect similar results. The aircraft's design automatically yields a slightly nose-down attitude in flight. If you are not used to this appearance, you may be tempted to employ too much up-trim, resulting in a deterioration of performance. Also, for those of you who are used to ships with a conventional tail-moment, Windhover may seem touchy in elevator response, particularly when the speed is increased on those inevitable hot spot landings. However, with a minimum of practice, you will find that this sensation will disappear. If it does not, try limiting the elevator travel with a smaller servo arm.

The principal benefit of the ship's elliptical tips is that they allow extremely tight turns without an appreciable loss of altitude. This is of particular importance when working lift at low altitudes. You will discover that once centered in a thermal, the aircraft requires almost no rudder command to keep turning. Therefore, the best indication that you are losing center is a pronounced increase in the need for rudder commands.

Both existing Windhoovers have been launched from winches, hi-starts, and hand-tows. They have been flown over both flat land and slopes, and have turned in consistently satisfying performances, even under the most extreme conditions. In fact, last year in a contest south of the Twin Cities, my Windhover took a first in class and a first over-all, in a wind that must have been gusting to 40 mph. The only damage it incurred during nine rounds of flying was a broken rudder when, before I could retrieve it after landing, the wind sent it cartwheeling across the field.

This aircraft continues to be my most satisfying design to date, and I am certain that my present skills as a pilot have not allowed me to tap the ship's ultimate potential. It is sufficiently stable to be flown by the novice, but will present a challenge to the seasoned competitor. I hope you enjoy your Windhover, as I have enjoyed mine. □