



# WACO-E

**WHETHER YOU PREFER ELECTRIC POWER OR GLOW ENGINES,  
THIS BEAUTIFUL CLASSIC WAS BUILT TO FLY!**

**By Laddie Mikulasko**

One of the truly classic aircraft in American aviation history is the Waco-E. With its graceful lines, good flying characteristics, and comfortable passenger cabin, it was a "Cadillac" of the skies. Of the many Wacos that were built, those few still flying are certainly treasured by their owners. After completing several scale electric projects, I had the desire to build an electric powered biplane. I couldn't resist the graceful lines of this classic beauty. The size was determined by the fact that I had a geared 15 Astro motor on hand. Although the model is accurate in outline, the construction was kept simple. Use light balsa everywhere. It helps to speed construction by cutting out as many parts as possible to create a "kit." Drill and cut out the holes where indicated. Cut out the ribs. I made my ribs by sandwiching 1/16" balsa sheets between templates. While sandwiched, make slots for the main and sub spars.

## CONSTRUCTION

### Wings:

Start by constructing the main spar and sub spar for the top wing. Glue 1/8" medium hard balsa to the 1/4" x 1/8" spruce, and trim as shown on the plan.

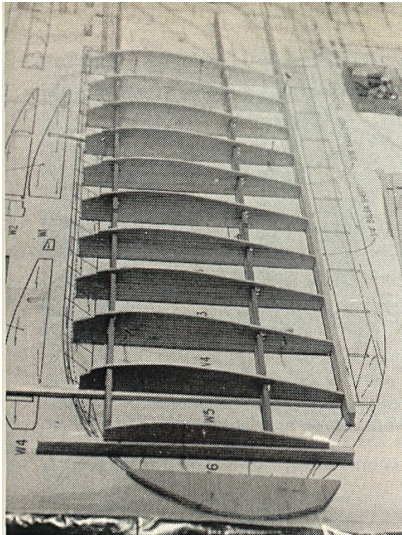
The top wing is built in two halves that are joined later. Mark the locations of the ribs on the spars. Slide and space the ribs onto the spars pinning the ribs to the building board directly on top of the plan. Glue all W3 ribs to the spars. Slide W4 and W5 ribs onto the spars. Place a 1/8" thick spacer under W4 rib and a 3/8" thick spacer under W5 rib. Glue these two ribs to the spars as well. Glue the aileron spar to the ribs. Glue the wingtip to the W5 rib. Glue the 1/8" balsa sub leading edge to the ribs and sand to the contour of the ribs. Glue on the 1/16" balsa leading edge sheeting. Glue a 1/8" balsa strip to cap the leading edge. Notice that this capstrip is glued to the wingtip sheet as well. Glue the wingtip trailing edge to aileron spar, W6, and the

wingtip sheet. Glue in the two plywood plates that support the wing struts. Sand this half of the wing and put it aside.

Build the other half of the wing to the same stage. Before both halves are joined, glue together the 1/16" balsa sheeting for the center section of the wing. Pin the bottom sheeting to the building board. Slide ribs W1 and W2 onto the spars. Place the wing halves on the plan and pin the W2 ribs to the spars. Place a 3/4" block under rib W4 to achieve the correct dihedral. Glue the dihedral braces to the spars and ribs W1 and W2. Glue in the wing dowel support brace. Construct the aileron torque rods as follows: As indicated on the plan, cut a short piece of 3/32" I.D. aluminum tubing and slide this onto the 3/32" piano wire.

Bend the wire to make the indicated shape. Commercial made torque rods are available at your hobby shop. Glue the aluminum tubing to the aileron spars. Glue in the hard balsa blocks that support the wing bolts to the rear spar. Sheet the top





The top left wing panel is shown in early construction stage. After marking rib locations on main and sub spar, slide ribs into position and pin to board. Note spacers under tip ribs. Attach aileron spar to back of ribs, being sure to leave some extra near the tip.

center section with 1/16" balsa sheeting. Remove the wing from the building board and sand the wing to your satisfaction. Glue in the 1/16" I.D. aluminum tubing "N" strut supports to the plywood plates.

Cut out an appropriate hole in the bottom sheeting of the top wing center section to mount the aileron servo. Glue in the 1/8" plywood plate to which the servo will be attached.

To construct the ailerons, pin the leading edge and trailing edges to the building board. Glue in all of the ribs. Sand the ailerons. The hinge line is close to the top as shown on the plan.

The bottom wing halves are built in a similar fashion to the top wing. After the bottom wing halves are built, insert two 1/16" piano wires into the holes in rib W7 and attach them with thread to both spars — but do not glue yet. Cut two lengths of 1/16" I.D. aluminum tubing to match the width of the fuselage. Slide the wires of both wings into the tubing. Pin the root ribs to the building board and place a 3/4" dihedral block under the W10 rib. Now glue the thread to the wires and spars. Glue in the plywood support for the "N" struts at the location shown. Drill 1/16" holes for "eyes" which hold the struts in the plywood plates. The "eyes" are made either from cotter pins, or by bending soft 1/32" steel wire to form the "eye." Insert the ends of these "eyes" into the holes and bend the ends out on the other side, so they cannot be pulled out. When bending the ends of the legs out, make sure that the center of the "eye's" hole is 1/8" away from the plywood. This is necessary to leave enough room for a wheel collar to hold the strut to the bottom wings. Put the bottom wings aside.

## WACO-E

Designed By:

Laddie Mikulasko

**TYPE AIRCRAFT**

Sport Scale Biplane

**WINGSPAN**

Top 52"; Bottom 35 1/2"

**WING CHORD**

Top 8 7/8"; Bottom 5-15/16"

**TOTAL WING AREA**

606 Sq. In.

Top 414 Sq. In.; Bottom 192 Sq. In.

**WING LOCATION**

Biplane

**AIRFOIL**

Flat Bottom

**WING PLANFORM**

Constant Chord

**DIHEDRAL, EACH WING**

2.5 Deg. (3/4")

**OVERALL FUSELAGE LENGTH**

40 3/4 Inches

**RADIO COMPARTMENT SIZE**

(L) 11" x (W) 5" x (H) 6"

**STABILIZER SPAN**

18 1/4 Inches

**STABILIZER CHORD (incl. elev.)**

5 1/2 Inches (Avg.)

**STAB AIRFOIL SECTION**

Flat

**STABILIZER LOCATION**

Top of Fuselage

**VERTICAL FIN HEIGHT (incl. rud.)**

5 1/2 Inches

**VERTICAL FIN WIDTH (incl. rud.)**

5 Inches

**REC. ENGINE SIZE**

15 geared electric; 15-29 glow

**FUEL TANK SIZE**

4 Ozs.

**BATTERY PACK**

12-14 Cells (14.4-16.8V)

**LANDING GEAR**

Conventional

**REC. NO. OF CHANNELS**

4

**CONTROL FUNCTIONS**

Rud., Elev., Spd. Contr. (Throt.), Ail.

**BASIC MATERIALS USED IN CONSTRUCTION**

Fuselage ..... Balsa & Ply

Wing ..... Balsa & Ply

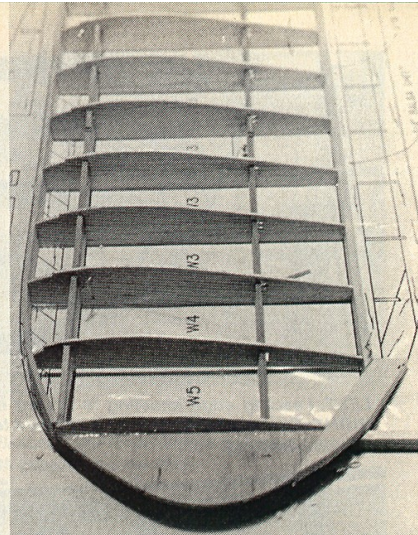
Empennage ..... Balsa

Wt. Ready To Fly (elec.) ... 72 Ozs. (4.5 Lbs.)

Wing Loading ..... 15 Oz./Sq. Ft.

### Fuselage:

When making the fuselage build a left and right side by pinning the longerons to the building board and gluing in the uprights. Glue in the 3/16" balsa sheet with the windows cut out. On the inside of each side, glue 1/16" sheeting to the cabin area. The grain of this sheeting between formers



Sub leading edge and wingtip (W6) are now glued into position as is the 3/16" sheet wingtip trailing edge.

F3 and F5 must be vertical to allow the fuselage to bend when gluing formers F3, F4 and F5. Remove the sides from the building board and, on the outside, mark the location of all stringers. Stand the fuselage sides upright, and glue in former F7 and all the rear cross members. Use a square, to check alignment. Glue in front formers F6, F5, F4, and F3. On the outside, glue on quarter formers F3, F4, and F5, and glue 1/16" balsa sheeting to them. Sheet the top between the F3 and F5. Insert the two 1/16" tubes you have cut previously at the bottom of the cabin floor. The bottom wing will plug into these tubes. To achieve proper alignment, temporarily plug the wing halves in and adjust the tubes to get zero incidence; then glue the tubing to the sides.

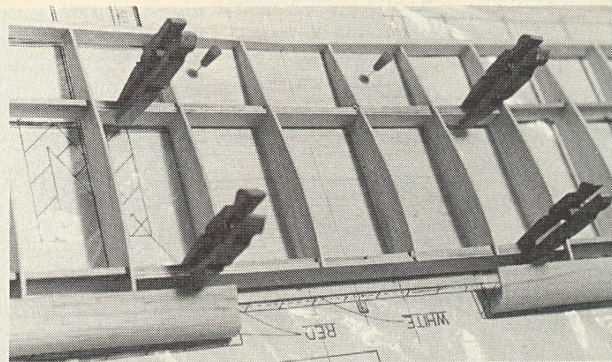
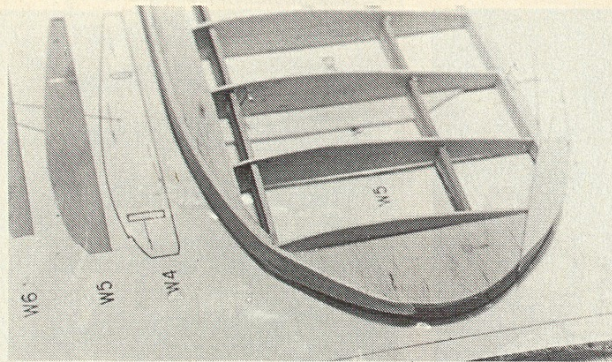
### Landing Gear:

Next, construct the landing gear as follows: Cut and bend music wire to the shape shown on the plan. Using strong thread, attach the gear to the F5 former. At the bottom of F5, attach the "U" shaped piano wire. Attach rear landing gear strut to the F6 former. This strut is bound with copper wire and soldered to the main legs. Once the landing gear is done, glue bottom quarter formers F5 and F6 to the fuselage. Glue 1/16" balsa sheeting to them.

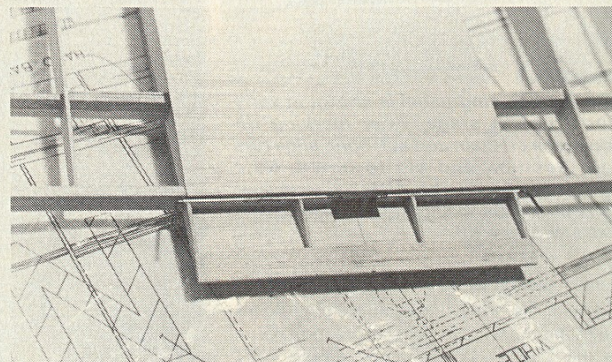
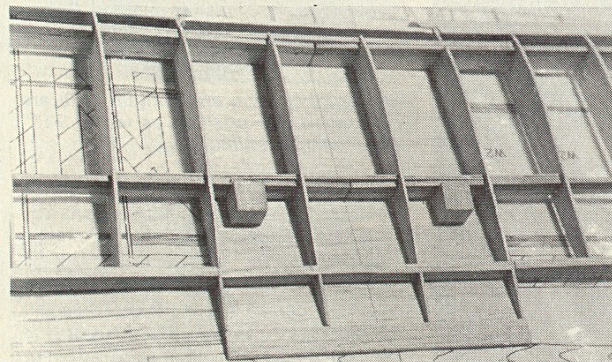
Make the tail wheel assembly as shown on the plan, and attach it to former F8. Glue in this former and glue all of the stringers to the fuselage. Note that some upright and cross braces in the rear of the fuselage have



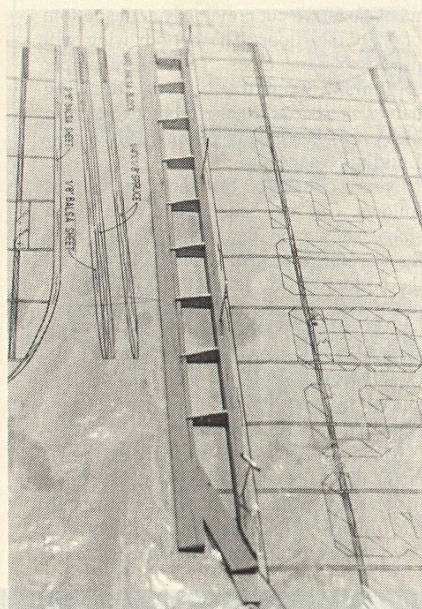




**LEFT:** Leading edge sheeting is shown in place as is the 1/8" leading edge. Note how leading edge continues around wingtip. **RIGHT:** Center sheeting is glued to ribs after dihedral braces are epoxied in place. Note aileron spar is tapered to fit against bottom sheeting.



**LEFT:** Hard balsa blocks are added behind sub spar to back up wing bolts — make these flush with top of W-1 and W-2. Trailing edge of center section is built up from ends of W-1 and W-2, add 1/16" sheet to continue airfoil. **RIGHT:** Before finishing up top wing sheeting, install aileron control rods.



**Ailerons are built-up over plans. Note ribs are notched into trailing edge.**

notches to accommodate the stringers. Glue in the cockpit floor. Glue in the plywood plates that are used to hold the hard wood blocks for the wing bolts inside the cabin. At the bottom, this plate will hold the "eye" for the rigging wire. Sand the fuselage to your satisfaction.

#### Cowl:

Construction of the cowl is straightforward. First cut 1/16" balsa sheeting into 3 3/4" lengths. Glue enough lengths together to wrap around the perimeter of the cowl. The next step is important! Using a long ruler as a guide, trim one side in a straight line and square both ends. At this time, glue 1/8" x 1/8" balsa braces to the front and back ring of the cowl. Do not be concerned that it is flimsy at this point. Place the bottom brace on top of this sheeting at one end. Put a drop of Hot Stuff or similar glue, then start rolling, making sure that the straight edge of the sheet is right on the front former. While rolling, keep putting drops of glue on the contact point of the sheet and formers. When finished, trim the excess balsa. My cowl is held to the fire wall with two screws in the back of the cowl. To facilitate access to these screws from the front, I installed tubes between front and rear former to guide the screwdriver. The tubes are outer NyRod tubing. Glue the balsa ring to the front of the cowl. Round the corners to the radius shown on the plan. Screw the cowl to the fire wall and sand on perimeter lightly to match outline of the fire wall.

#### Tail Surfaces:

Cut the tail surfaces out of lightweight balsa sheets. Glue and sand each surface. Before the stabilizer is glued in, bend a length of 1/16" music wire to a "U" shape to join both halves of elevator. Insert this

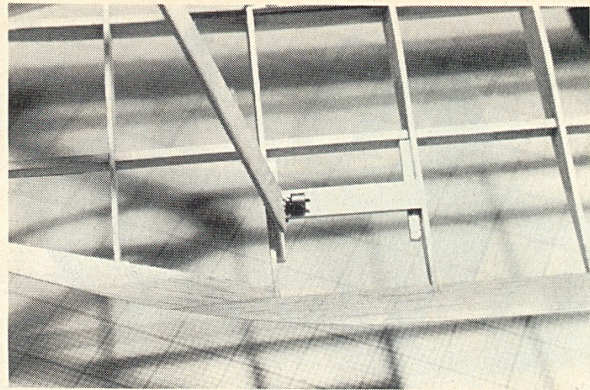
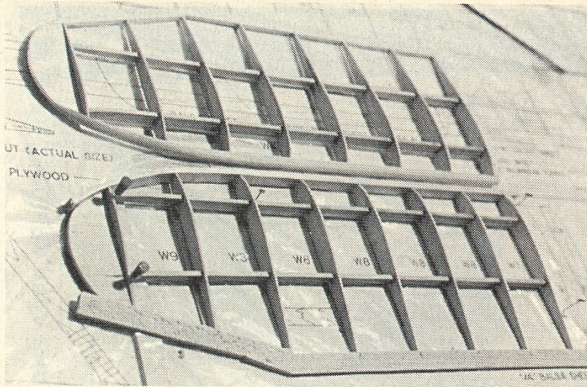
wire in the slot and glue in the stabilizer making sure that it is square with the fuselage. Glue in the fin. Next, make the wheel pants and landing gear fairing. This fairing is made from two 1/8" thick sheets of balsa, that are grooved to accommodate the landing gear legs. Sand the gear fairing to a symmetrical airfoil. Glue half of one leg to the wires and then the other half on the other side, to hide the wire of the main leg. Repeat this process for the other gear leg.

#### Wheel Pants:

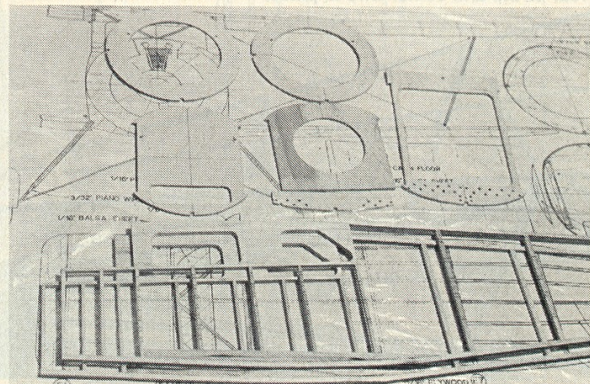
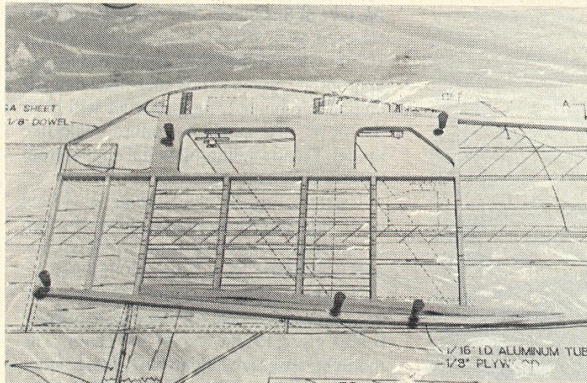
To construct the wheel pants, trace their outline on a balsa block, and cut it out. Glue the 1/8" balsa sheets to both sides of this middle core. Sand the wheel pants to the shape shown. Do not glue them to the landing gear legs yet.

The last separate items to make, are the "N" struts. Use 1/8" plywood or basswood. Cut out all pieces and glue them together to form the "N" strut. Cut out a groove on the outside edge, at the top and bottom. Cut and bend a length of 1/16" wire to the shape shown, so the top will go into the holes in the top wing, and the bottom wires will go into the eyes in the bottom wing. Insert each wire inside the groove and, using strong thread, attach each wire to the struts — but do not glue in yet. Place the top wing in its saddle. Drill a 3/16" hole into the center of the wing dowel brace from the front. Insert the dowel and drill two holes from the top of the wing into the wing bolt blocks.

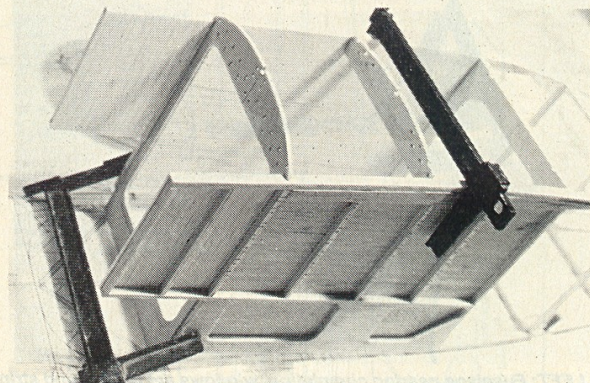
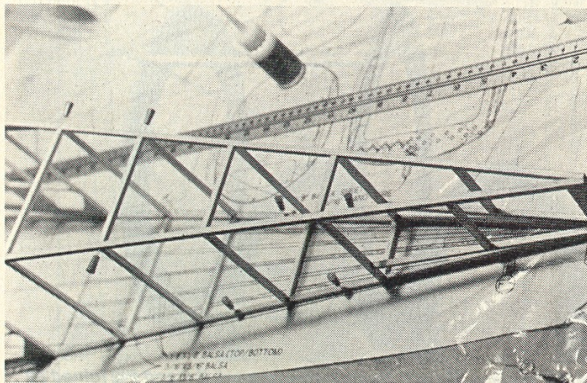




**LEFT:** Lower wing panels are built in the same manner as the top with the exception of ailerons. The lower wings will plug into the fuselage (see text). **RIGHT:** Lower wings are fitted with plywood plates to which the "N" struts attach (see text).



**LEFT:** Fuselage assembly starts with 3/16" sheet balsa and 3/16" sq. sticks. Note stringer locations marked on outside of fuselage sides. **RIGHT:** Fuselage sides and formers shown before assembly begins.



**LEFT:** 3/16" cross members are glued in place. **RIGHT:** Cabin area assembly. Note grain direction of 1/16" cabin sheeting.

#### Covering:

The model is ready to be covered with your favorite material. I used MonoKote for both covering, and the numbers and letters. Trace the numbers on a sheet of paper. Cut a strip of MonoKote large enough to accommodate the complete registration number. Place this paper with the numbers on top, and secure it to the bench with masking tape. Using a sharp knife, cut out the numbers. A ruler is used as a guide to cut straight lines while the curves are cut free hand. After the model is covered, the

windshield is glued on. I used .010" thick clear plastic. Do not cover the side windows as this provides for better cooling.

#### Rigging:

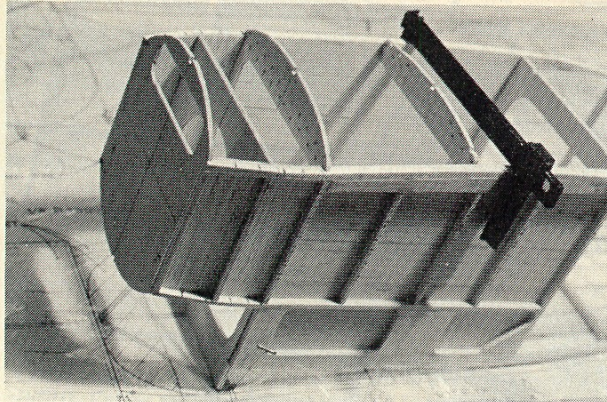
Secure the top wing to the fuselage, with self tapping wood screws. Plug the bottom wing into the aluminum tubes in the fuselage. Prop up the fuselage tail so the top wing is level with the bench. Place a support under rib W7 at the bottom of the wing, and then a 3/4" taller support under rib W10. Plug the "N" struts into the eyes of the bottom wing. If necessary, readjust the

wires at the bottom of the strut to remove any twist in the bottom wing. Now put drops of Hot Stuff on the thread to secure wires to the struts.

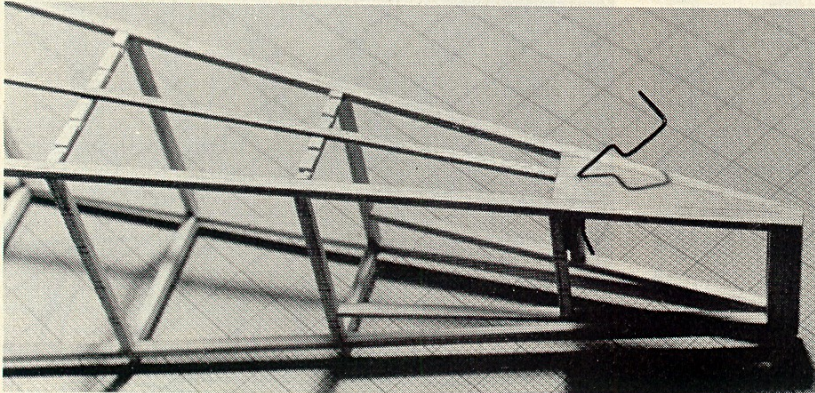
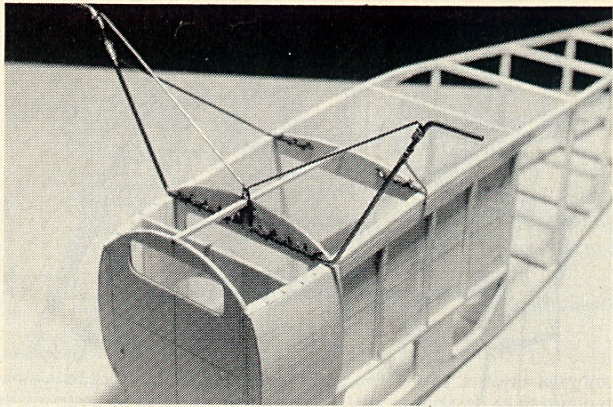
At this time, cover the "N" struts with MonoKote.

Next, make the rigging wires as follows: Take a length of 1/64" diameter music wire and make a "U" bend at one end. Feed the wire through the hole in the eye at the root of the bottom wing. Slide a 1/8" long piece of 1/16" O.D. brass tubing over the "U" bend as close to the eye as possible. Solder this





**LEFT:** F-3 and F-4 are glued into place after cutting 3/16" sq. longerons to facilitate bending. **RIGHT:** After quarter formers are in place, cover with 1/16" balsa sheet. Landing gear is attached to F-5 and F-6 with strong thread. After checking alignment of main struts, solder rear struts and center wire in place.

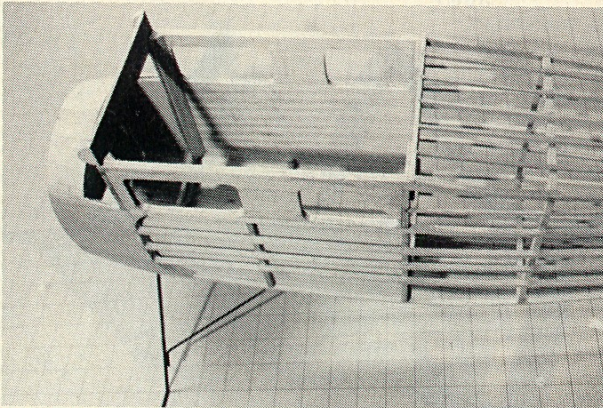


**Notch lower cross members to accept stringers. Note marks on fuselage side for side stringers.**

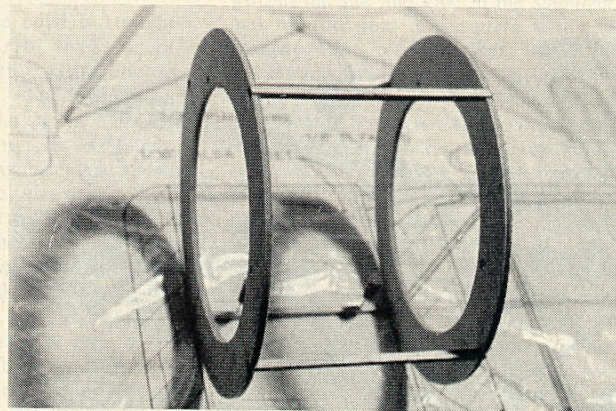
the face of this block. The motor mount was screwed to it. If you are planning to use a .15 or .19 size glow engine, then make an appropriate plywood box such that when the engine is mounted, the propeller will clear the cowl. To achieve a more scale-like model, I made a dummy radial engine from balsa blocks and sheets.

Vacuum formed wheel pants, the front cowl ring, and the dummy radial engine can be ordered from Easy Built Models, Box 425, Lockport, New York 14095-0425.

Finally, install the radio. The elevator and rudder servos are mounted on hard balsa beams close to the rear of the cabin. The motor batteries are held to the fuselage sides with the Velcro. Check the position of the C.G. and if not correct, reposition the motor



**LEFT:** Fuselage nearing completion, windows are cut out and stringers are in place. **RIGHT:** Basic frame of cowl, F-1 and F-2 joined by 1/8" sq. balsa braces.



tubing to the wire. Screw a threaded coupler into a clevis. Attach the clevis to the eye in the top wing. Cut the rigging wire slightly longer than the hole in the coupler. Bend the end of this wire close so it can be inserted into the hole in the coupler and soldered inside the coupler. Adjust the clevis to achieve just enough tension to hold the wing in place. All other rigging wires are done in the same manner. Once the rigging wires are installed, remove the blocks from under the wingtips and observe whether both wings maintain the correct position. If not, readjust the appropriate wires. The rigging

wires will hold the bottom wing in place when flying.

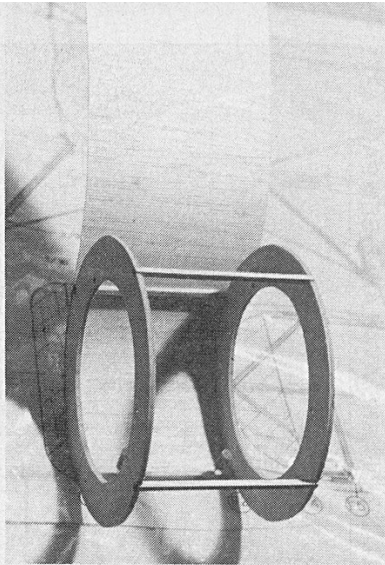
Next, install the wheel pants. I installed mine by sliding the wheel pant, spacers, and the wheel onto the axle. Now I glued the wheel pants to the leg fairing with white silicon glue. After many flights the wheel pants are still secure. Install the motor. Because I used the Astro 15 geared mounted onto Sonic-Tronics adjustable mount, I had to extend the fire wall so that the propeller cleared the cowl. This false fire wall was made from a balsa block glued to the fire wall with 1/8" plywood glued to

batteries until the C.G. matches the location indicated on the plan. Check the throws of the control surfaces. Run the motor and all control functions before heading to the flying field.

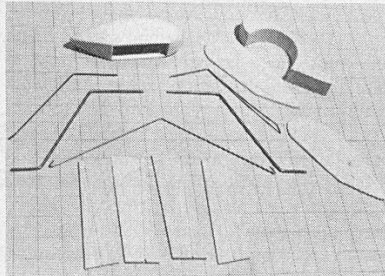
#### **Flying:**

Although there are no unusual flight characteristics, please observe the following cautionary notes: Because the model has wheel pants, limit flying to short grass or from a hard surfaced runway. The take-off is short with positive rudder control. This model will perform graceful turns. The model is capable of performing

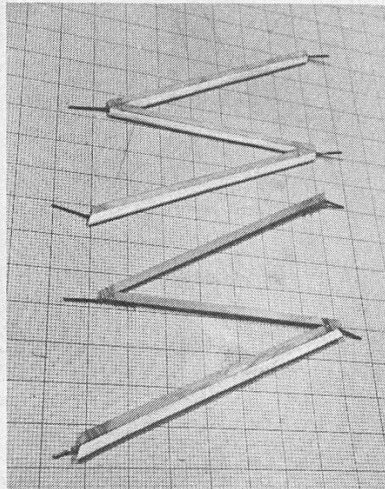




*Cowl is covered by rolling 1/16" balsa sheet around formers, adding glue as you go.*



*Landing gear is shown with balsa strut fairings and built-up balsa wheel pants.*



*"N" struts are built-up with 1/8" plywood or basswood and 1/8" balsa (see text).*

loops and rolls, but I feel that this is not appropriate for this type of model. This model is robust enough to withstand normal flight and landing loads; however, do try to land the plane before the charge in the motor batteries runs out. It is much safer to land on a smooth runway with some reserve power than to land in the rough and risk bending your little gem.

Have Fun!

