

# VECTOR II



**In mechanics, a vector is a line which represents a velocity and its direction. "Vector II" has plenty of velocity and it goes just where you point it.  
By David Coltrin**



**I** love to fly, and to say that I am performance hungry would be quite accurate. However, being an engineering student on a tight budget, I found myself stuck with a tired old K & B .40 engine, a Futaba 4-channel radio, and no money to buy new equipment. Believe me, it is hard to find a kit that will perform really well on this equipment. After a long search for the "right" airplane, I gave up and decided to design one myself.

The Vector II was designed to obtain the maximum performance possible with a standard .40 engine, four channels, and no retracts. As I'm sure you realize, along with the benefits of retracts such as cleaner lines leading to lower drag and a sleek appearance, come some serious disadvantages, especially on a .40 sized ship. One problem is that the inherent weight increase that comes with retracts, although hardly noticed on larger airplanes, can take quite a large bite out of the performance of a smaller airplane. The vertical performance and the landing characteristics both suffer. Another problem is that in making room for retracts in a small airplane, some of the dimensions of the airplane must be enlarged. This increases drag and, at least in part, nullifies the positive aspects of retracts with regards to drag. And probably the most serious drawback to retracts is the cost.

The Vector II takes advantage of all these facts. It is light, fast, and a good, smooth flying pattern ship. Despite the fact that the model has relatively large overall dimensions for a .40 sized airplane, such as a 58" wingspan, it is very light. The all-up weight with the K & B .40 is a meager 3 lbs., 14 ozs.

## VECTOR II

Designed By:

David H. Coltrin

**TYPE AIRCRAFT**

Sport/Pattern

**WINGSPAN**

58 Inches

**WING CHORD**

8½ Inches (Avg.)

**TOTAL WING AREA**

493 Sq. In.

**WING LOCATION**

Low Wing

**AIRFOIL**

Symmetrical

**WING PLANFORM**

Double Taper

**DIHEDRAL EACH TIP**

None

**O.A. FUSELAGE LENGTH**

44 Inches

**RADIO COMPARTMENT SIZE**

(L) 9¾" x (W) 2½" x (H) 2½"

**STABILIZER SPAN**

18 Inches

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

4¾ Inches (Avg.)

**STABILIZER AREA**

78 Sq. In.

**STAB AIRFOIL SECTION**

Flat

**STABILIZER LOCATION**

Mid-Fuselage

**VERTICAL FIN HEIGHT**

6 Inches

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

6 Inches (Avg.)

**REC. ENGINE SIZE**

.40 Cu. In.

**FUEL TANK SIZE**

8 Oz.

**LANDING GEAR**

Tricycle

**REC. NO. OF CHANNELS**

4

**CONTROL FUNCTIONS**

Rud., Elev., Throt., Ail.

### BASIC MATERIALS USED IN CONSTRUCTION

Fuselage ..... Balsa, Ply & Spruce

Wing ..... Balsa & Spruce

Empennage ..... Balsa

Wt. Ready To Fly .... 3 Lbs. 10 Oz. (58 Oz.)

to 4 lbs. 2 Oz. (66 Oz.)

Wing Loading ..... 18 Oz./Sq. Ft.

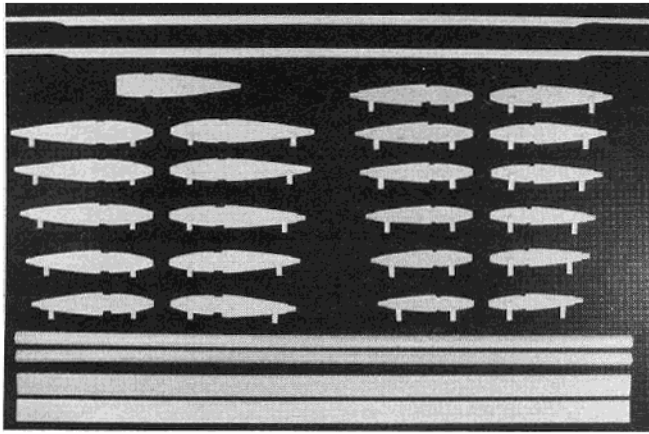
Even so, it is amazingly tough. This combination of light weight and sturdiness comes from the incorporation of new construction designs for portions of the airplane which are mechanically superior to conventional designs. Whether you decide to build the Vector II or not, some of the ideas incorporated into this airplane could be utilized in a variety of designs to improve performance and appearance.

The airplane is also fast. I can honestly say that I could not have made the lines on this model any more aerodynamically clean than I did. It is the low drag coefficient (not the horsepower, certainly) which accounts for its high speed.

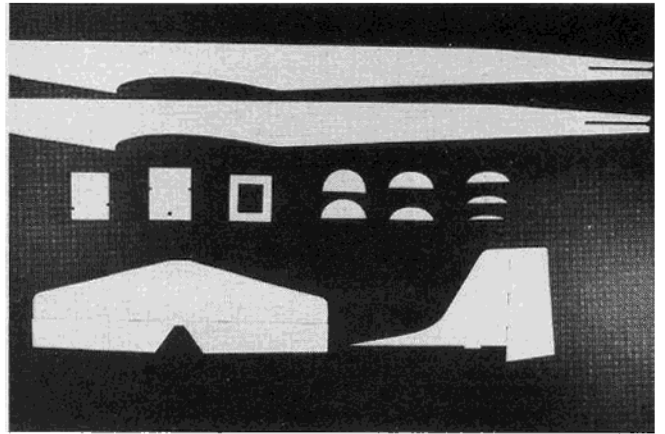
Whether the model's appearance is pleasing or not you may judge for yourself. To me, beauty is just the icing on the cake, and the real meat of the meal lies in how the airplane flies. This airplane's outstanding feature is that on top of being an excellent performer, it is a very smooth flier. It tracks wonderfully, making maneuvers seem easier to perform, and it looks controlled and graceful. This is due in part to the model's unusually long wing and fuselage dimensions, providing large axial moments and rotational inertias.

### CONSTRUCTION

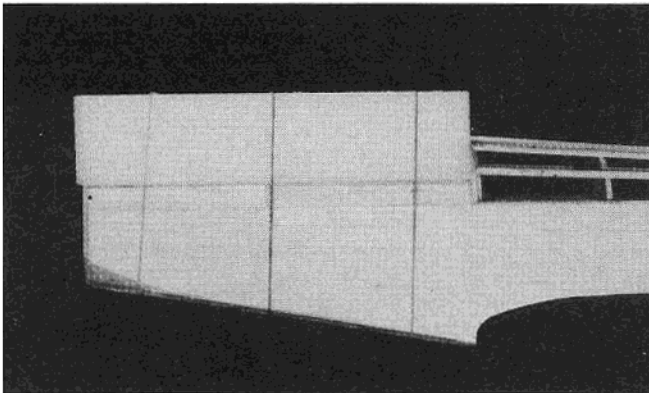
At the risk of sounding a bit like my engineering professors, I would like to address briefly the topic of stress on beams (wing spars). To most, this will not be new, but to all it should be a good review. When a beam is under a load, the highest stresses are at the surface of the beam. Therefore, when a beam fails, the crack or deformation begins at the surface and travels



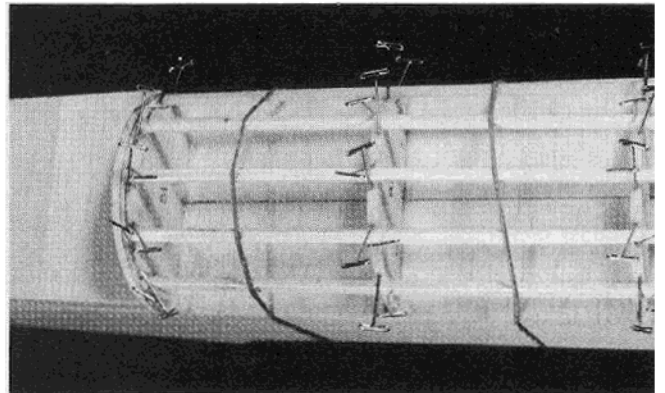
*Layout of major wing components. Note the rib tabs which are added on if a wing jig is not used.*



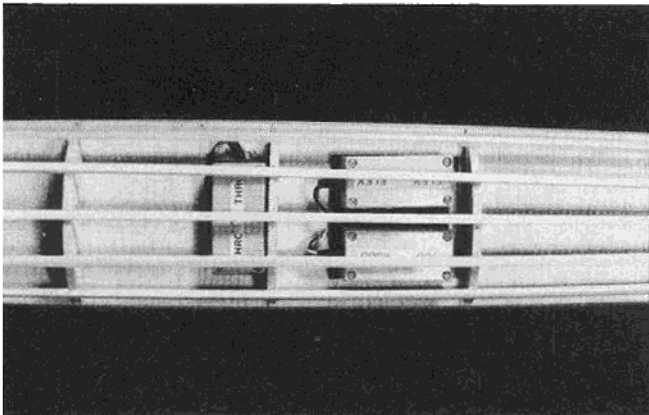
*Main components of the fuselage.*



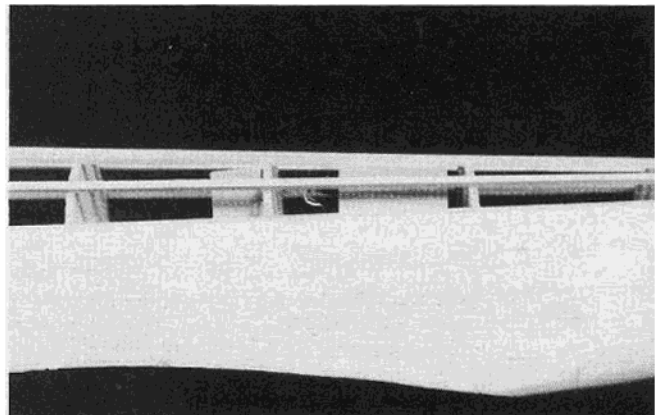
*Foam block, which will soon become a canopy, is spot-glued into place for shaping.*



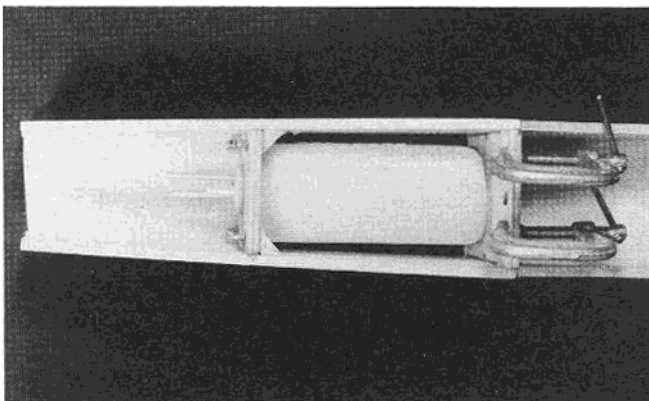
*Stringers being glued to the bulkheads on the turtledeck assembly.*



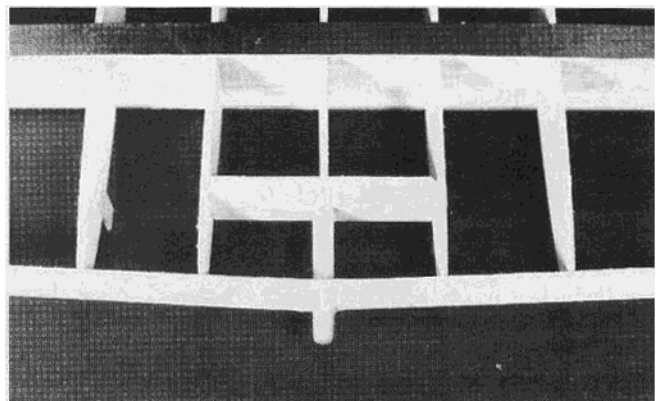
*This top view of the fuselage shows how clearance holes are cut in the sheeting for the servos.*



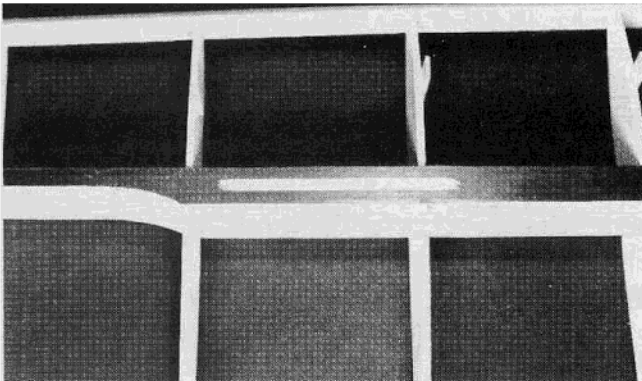
*Side view of fuselage shows servos poking through the sheeting.*



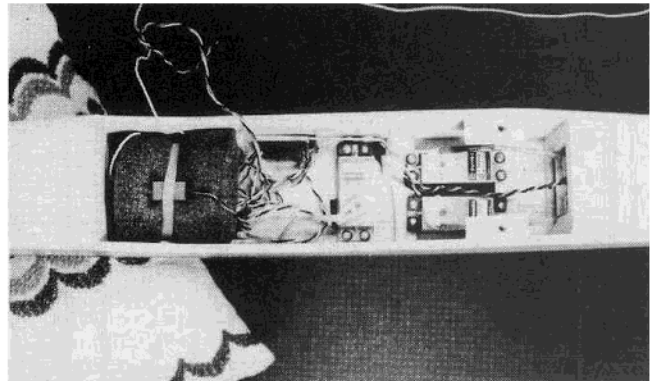
*Tank installation. Preparations for mounting the engine have already been made at this point.*



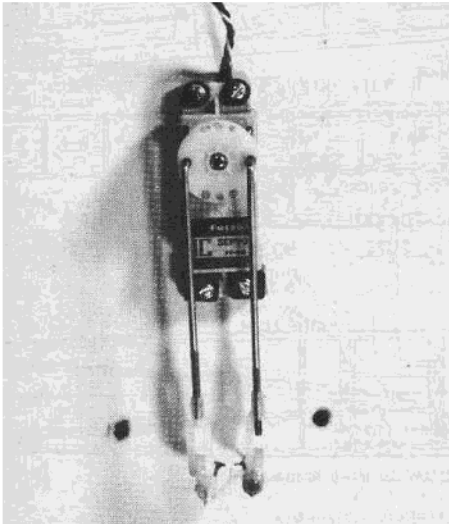
*Wing dowel assembly. Note the lack of a center joint on the main spar.*



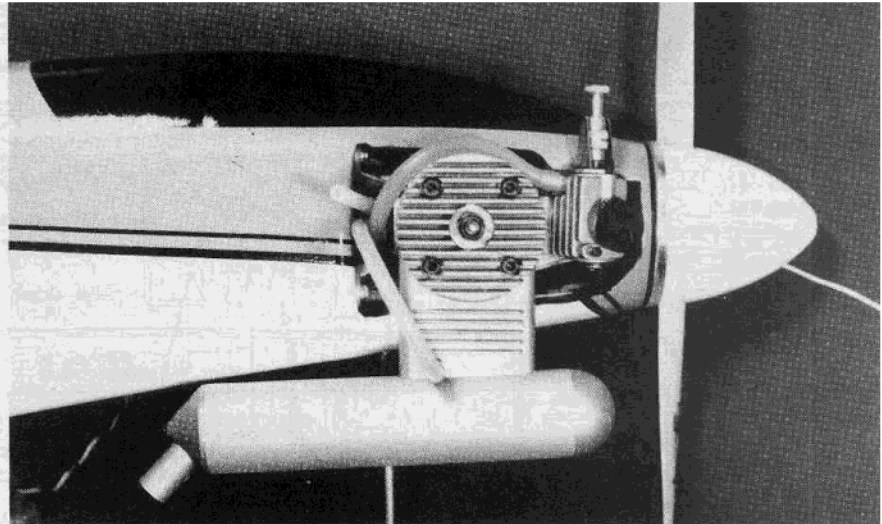
*Shows slot for main L.G., and L.G. blocks between upper and lower spars. Note carbon fiber lamination.*



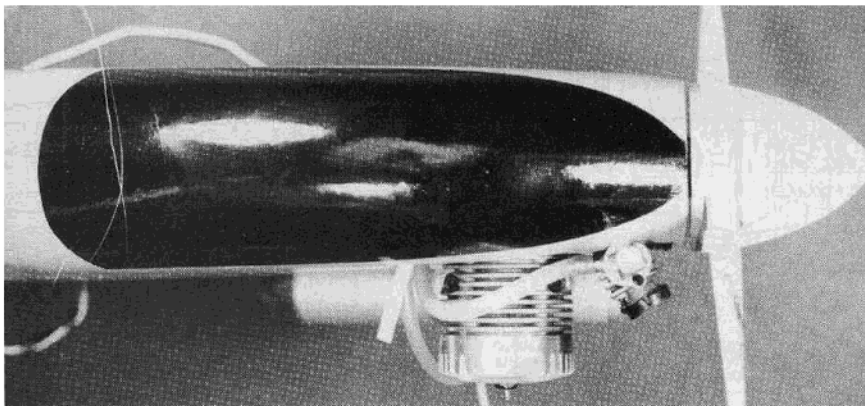
*Radio installation is simple, with plenty of room. Note battery pack at rear for balance.*



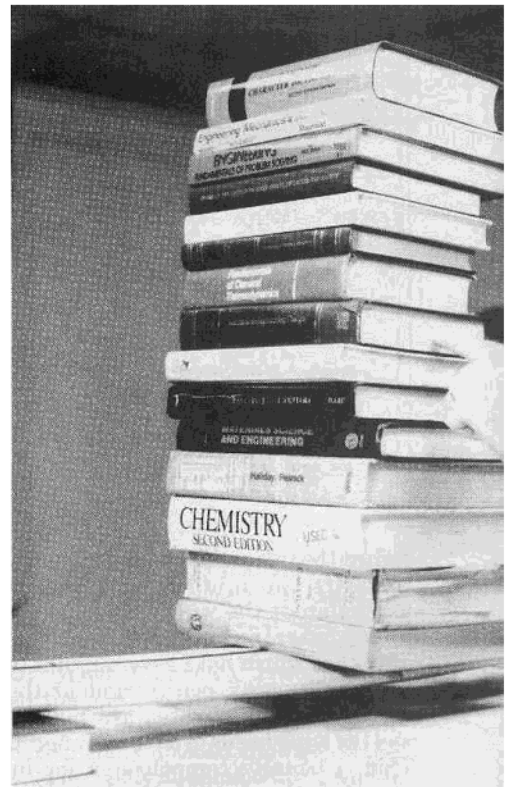
*Aileron servo installation.*



*Side mounted K & B .45 engine installation.*



*Top view of engine installation.*



*"Stress test" of the unfinished wing. This loading was equivalent to approximately 15 G's.*

inward. If you take a pencil in your hands and bend it gradually, you will see that it begins to crack first at the outside edge of the bend. This is why steel "I" beams are used so commonly in the construction of large buildings; they provide nearly the same strength as a solid beam with perhaps half the weight by putting a large percent of the beam cross section at the top and bottom edges where the stresses are highest.

The same idea can be applied to a wing spar, which is essentially a beam

running through the middle of the wing. The idea is to place as much of the wing spar's cross section area near the surface of the wing as is feasible. This model uses an "I" beam design which is light, yet very strong.

I would like to make one more note on wing spar designs before moving on. When was the last time you heard of an airplane wing breaking near the wing tip in a high-G maneuver? Probably never. They almost always break at or near the center. This is because the stresses on the wing are

## From page 85

zero at the tips and increase gradually towards the middle, reaching a maximum at the wing's center. This poses particular problems for airplanes which have a center joint (a potentially weak point) right at the spot where the stresses are highest and the wing needs to be the strongest. This is usually compensated for by sheeting the center panels and/or fiberglassing the center joint, etc., which may result in a considerable weight gain.

Upon looking at the Vector's plans, however, you will notice that because the wing has no dihedral, there is no need for a center joint. The main spars are designed to run the full length of the wing without a seam or joint. In addition, at a point just past the main landing gear mounts, the main spars notch inward to half the width of the center portion of the spars. This is because this portion of the wing near the tips does not need to be as strong as the center. Of course, a spar like this is not available at the hobby shop. It must be carefully cut from spruce on a table saw. But it is worth the effort. This spar design is the best I've seen in a model airplane, and the weight savings are considerable. If you absolutely cannot get access to a table saw, I have provided an option on the plans for a three piece spar that may be spliced together with wood available at most hobby shops.

The lack of a center joint greatly simplifies the wing construction. The whole wing can be built as one piece. I recommend using a wing jig, but if one is not available, the wing may also be built on a flat surface by using the optional rib tabs shown in the plans.

One last observation worth mentioning before you begin construction. It became apparent to me during the course of this project that, within certain limits, you can design and build an airplane to be any weight you like. For example, suppose I said to myself that the airplane was going to be 3½ lbs. all-up. Then, when designing the landing gear, I would use a lighter gear since it doesn't need to be as strong for a plane this light. When designing the main spar, I would use a very thin spar because a plane this light doesn't need a massive spar. When I finished, I would find that the plane would indeed weigh in at around 3½ lbs. On the other hand, if I had initially decided that the plane would probably be about 6 lbs., I would have, of course, used much beefier landing gear, main spars, etc. And the

To page 88

## From page 88

### Finishing and Final Assembly:

Position the wing in the saddle and align by measuring from the wing tips to the fuselage tail. Make sure the distance from each tip is equal. When it is aligned, drill the holes for the wing bolts. Then thread the holes with a tap and harden the threads with a little cyanoacrylate glue. Also, insert the main landing gear and cap with 1/32" plywood. To save space on the firewall, the engine mount can also double as a nose gear mount. Depending on your hardware and installation, you may have room to use a conventional landing gear mount (see plans).

Since the Vector II has a built-up turtledeck which requires covering with EconoKote or equivalent, it is convenient to cover the entire fuselage with EconoKote. On the prototypes, I chose a more durable finish of polyester resin, Soft Glas and epoxy paint, along with Coverite Super-shrink over the turtledeck and on the wing. Despite this and the fact that I spray painted the entire wing with two coats to get my colors to match exactly, the all-up weight of the model with the K & B .40 was still only 3 lbs., 14 ozs. With the heavier K & B .45 mounted in the nose, the model topped 4 lbs.

### Flying:

Because of the sharp leading edge and other experimental factors, I was understandably anxious and unsure on the Vector II's maiden flight. However, with only a few adjustments to the C.G. and the control sensitivity, the prototype flew extremely well. I feared the stall characteristics might be vicious, but, instead, it proved to be quite predictable, with very low landing speeds for a pattern type airplane. It performs extremely well with a sport .40 engine, and without retracts. You will find that the Vector II tracks so well that it seems to go through the pattern effortlessly. It is truly a pleasure to fly.

As the Vector II accumulated more flight time, something more should be added about trimming the airplane. The C.G. shown on the plans is where the plane should be balanced for the initial flights. At that position, the airplane is very stable, and very manageable. After the pilot has accustomed himself to the flying characteristics of the Vector II and feels comfortable with it, he may move the C.G. backward gradually by adding tail weight, until he is satisfied with the responsiveness and neutral stability of the model. I fly my Vector II with the C.G. about 3/4 of the way back on the main spar. □

From  
RCModeler  
Aug. 1988

plane would actually end up weighing about 6 lbs. I think that it is the mentality in which you design and build your airplane that determines its weight. So keep it light!

#### **Wing:**

Begin by cutting out all the necessary parts. Unless otherwise noted on the plans, all balsa throughout the plane is medium hardness. Note that there are two of every rib size except the center rib. The lower spar must be slotted to accept the main landing gear wires. Next add the spruce spar doublers to the lower spar with epoxy. If a table saw is unavailable, splice the three sections of each main spar together using epoxy and clamps. If you aren't using a wing jig, carefully glue all of the rib tabs to the ribs as shown on the plans. Then block up the lower spar using books or whatever is handy, so that the spar is high enough that the rib tabs won't touch your flat surface. Glue several of the ribs into place along the length of the spar in their correct locations. The R-10s, R-8s, R-5s, and the R-3 ribs will work well. Then remove the blocks and carefully place the lower spar-rib assembly over the plans, so that the wing is "standing" on the rib tabs. Then add the remaining ribs and the upper spar.

If a wing jig is to be used, carefully position the ribs on the rods and then add the spars. Then for either method, glue on the 1/2" leading edges and the 1/4" x 3/8" balsa trailing edge strips, making sure everything lines up properly. Epoxy the landing gear blocks into place between the spars. This landing gear assembly is very light and utilizes the strength of both spars.

The black you see on the top of the wing spar in the photos is .007" thick carbon fiber reinforcing. Although the carbon was used on this model, prototypes both with and without the carbon reinforcing have been tested. No wing failures were experienced with either version. If you are in the mood to experiment with these new materials, this would be a good opportunity. Otherwise, don't worry about it, as the model is sufficiently strong without any reinforcement.

Cut and insert the shear webbing between the upper and lower main spars. Install the balsa and plywood necessary for the wing bolt holes using epoxy. Drill a hole through the leading edge at the center joint for the wing dowel. Add the dowel brace, and epoxy the wing dowel into place.

Sheeting the wing adds lateral strength, but just as importantly, it prevents the wing from twisting or fluttering at high speeds. Sheet the front panels and center section with soft balsa. When sheeting the front panels, it is very important to center

the first strip of balsa in the middle of the wing so that there is not a joint there. Notch the center trailing edge stock for the aileron torque rods and install rods and tubing. Epoxy these center pieces to the trailing edge. Hinge and install the ailerons. Cut and sand the wing tips so they are flat, then glue on the balsa tip plates and sand them to a pleasing shape. "Sharpen" the leading edge of the wing with a sanding block until it is at least as sharp as the contour shown in the wing cross section. It is desirable to sharpen the center section of the leading edge more than the tips. This will help prevent tip stalling by forcing the center of the wing to stall first. This completes the wing construction. The rest is downhill.

#### **Fuselage:**

The fuselage was designed to be as aerodynamically clean as possible, yet construction is quite simple. Without the turtledeck and foam top, the fuselage is a basic box. Cut out all the necessary parts. Rather than using hard, thin balsa for the fuselage sides, I chose to use thicker, soft balsa. This still provides the necessary stiffness while allowing the fuselage to be contoured to a much more pleasing shape with no weight gain. Choosing the balsa carefully can make a noticeable difference on the strength and finished weight of the model.

Engine, radio, and tank installation will be much simpler if you do some preparation now. Drill the firewall for the engine mount, pushrods, and fuel lines. Drill the engine mount for the engine and for the nose gear assembly. In order to reduce frontal area, the engine compartment was designed with very tight quarters. I recommend blind nuts on the bottom side of the engine mount and the back side of the firewall to simplify engine installation. The engine may be mounted either sideways or inverted. Drill and cut the F2 and F3 formers to accept the pushrods and wing dowel.

Now mark the positions of the three main formers on the fuselage sides. Slots to accept the horizontal stab should be cut before assembling the fuselage. Position the sides and formers upside down over the plans and epoxy F2 and F3 into place. Glue the tail together, and fit and insert trailing edge stock into the tail. When the glue has set well, turn the fuselage over and glue in the firewall. There is no offset on the engine, so make sure the firewall is square to the centerline. Add the 3/16" x 1/2" nose pieces to the top of the fuse. Glue in the triangular stock at the top of the tail end, as shown in the plans, and then sheet the entire top of the fuselage cross grain.

Radio and tank installation is easiest at this point of the construction. Mount the servos as far aft

in the radio compartment as possible without interfering with the positioning of the bulkheads (formers) which will be added later. Locate the servo mounting rails below the top sheeting. Cut out the sheeting between rails to accept the servos (at this point the servos will poke through the "top" of the fuselage). Depending on your gear, it may be necessary to make similar clearance holes for your battery pack and/or receiver. Add the F2 doubler for the wing dowel and triangular stock along the fuselage as indicated in the plans. Install pushrods, and sheet the bottom of the tail section and the tank compartment.

At this point, the "basic box" is complete and you are ready to add on the turtledeck and canopy. Mark the stringer positions on all of the bulkheads, and mark the bulkhead positions on the fuselage top. Using a square, glue the bulkheads into place. When they are completely dry, add the stringers. This is best done with two people and a cyanoacrylate glue like Hot Stuff or equivalent to eliminate clamping problems. I chose to use spruce stringers so that I could hold the fuselage tightly without fear of snapping a stringer. However, hard balsa would also work fine and save a little weight. If spruce stringers are used, it may be necessary to wet four of the five stringers, give them a 1/4 turn, and let dry so that they will lay relatively flat across the bulkheads.

A suitable block of styrofoam for the canopy construction can be purchased at any craft store. Spot glue the block into place on the fuselage. Cut and sand the block roughly into shape with a sharp, long bladed knife and a rough grade of sandpaper. When you get close to the desired shape, finish it off with a finer grit sandpaper. Now carefully pull the shaped styrofoam loose and hollow it out with a curved X-Acto blade. When it has been hollowed out to a wall thickness of about 1/2", glue it permanently back into position on the fuselage with wood glue. While you've still got your sandpaper out, round the bottom of the fuselage until the triangular stock begins to show through the joint. This completes the construction of the fuselage.

#### **Tail Assembly:**

The tail assembly is simple and I will only comment briefly. The horizontal stabilizer is set in so that clearance for the elevator tie bar is made in front of the rudder, rather than cutting a clearance notch in the rudder. The vertical fin is made from two pieces of balsa. Notch the fuselage top sheeting to accept the tab on the bottom of the vertical fin. Hinge, sand, and attach to the fuselage, again using a square.