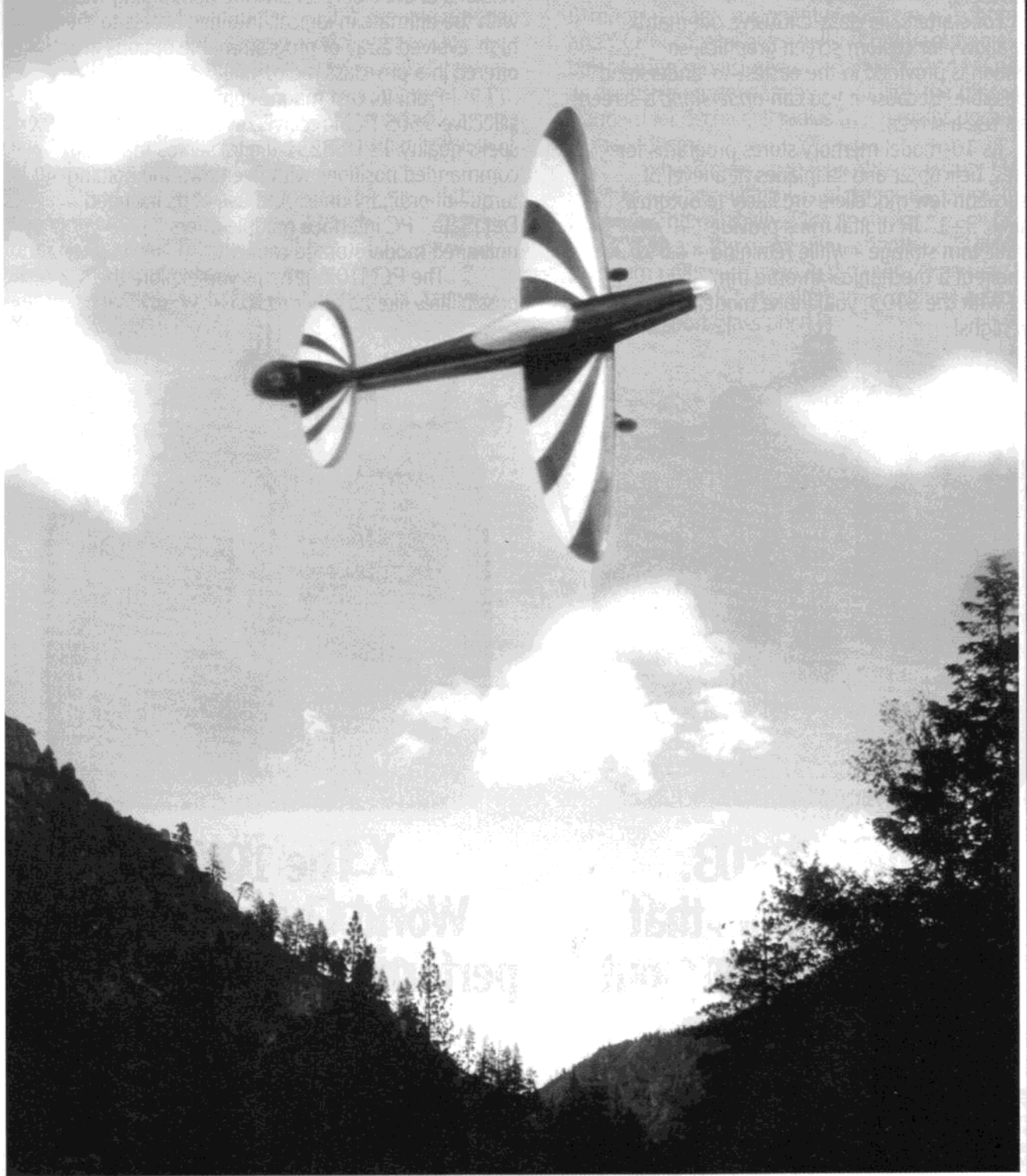


# The Ellipse

**AN I.M.A.A. LEGAL ELECTRIC SPORT FLIER**



*Designed by Jim Young • Color Photos by Matt Jerve*



Designer Jim Young shows off his Ellipse.

For the past few summers, I have had the honor and privilege of flying my club's giant scale DC-3 at several local I.M.A.A. events. I had a lot of fun at these events but never had a plane of my own large enough to fly at these meets. It would have been nice to become familiar with the airspace with my own plane before taxiing out the DC-3. I have built several electric powered planes and have enjoyed clean, quiet flight. So why not build an I.M.A.A. size electric? After knocking around several ideas, I settled on this design with an elliptical wing planform and a sleek fuselage. There is even a little DeHavilland influence in the tail feathers. Several people have told me that it looks like an early CAP series or a Chipmunk, but it's not. What else would you call a plane with an elliptical wing and stabilizer but the Ellipse (emphasis on the "E")?

The plane is powered by an Astro-Flight Sport Wind 60 on 28 SR Max 1800 cells. This is a rather high end power system, but the motor, batteries, and speed control only cost a little more than a typical 1.20 4-cycle. And, you don't have to spend \$10.00 to \$15.00 a gallon on that messy fuel.

The elliptical planform has low induced drag. That, coupled with the sleek fuselage, make this a fast,

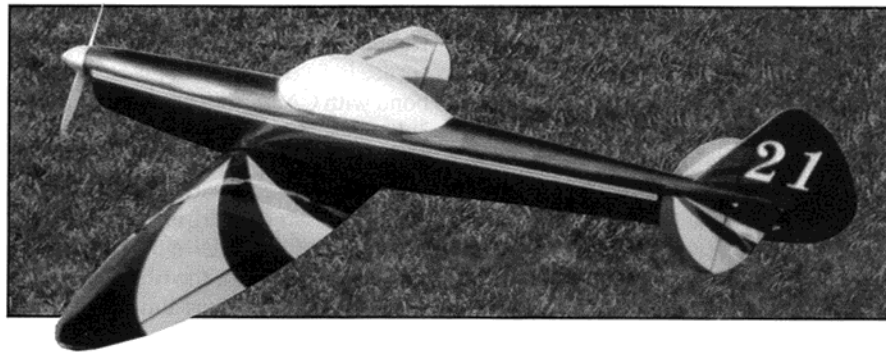
efficient plane. It has a long tail moment for smooth control and enough side area to sustain knife-edge flight. The 12% semi-symmetrical airfoil provides plenty of lift, low drag, and good inverted flight. This is an all-around good flying plane.

It will greatly speed the construction if you "kit" the model first. The hardest part will be cutting out the wing ribs. Compufoil makes it easy to plot out wing ribs for an elliptical planform, but you'll have to cut them two at a time. All construction is with balsa, spruce, and aircraft grade birch plywood. Do not substitute lite plywood for any of the plywood parts. Lite plywood does not have the necessary strength. The prototype has been flying for four years and the airframe shows no signs of weakness. Take your time and make the joints fit before gluing.

## CONSTRUCTION

### Tail Feathers

Start construction by laminating the wingtips and tail feather outlines. Laminating balsa is an easy way to make light, but strong complex curves and shapes. Cut templates from corrugated cardboard to the shape of the inside edge of the piece. Mark a few key locations (like rib and spar locations) on the templates so you can



## ELLIPSE

Designed by:

Jim Young

### TYPE AIRCRAFT

Electric/Sport Aerobatic

### WINGSPAN

80-1/4 Inches

### WING CHORD

11-1/2 Inches (Avg.)

### TOTAL WING AREA

921 Sq. In.

### WING LOCATION

Low Wing

### AIRFOIL

NACA 1412

### WING PLANFORM

Elliptical

### DIHEDRAL, EACH TIP

1 Inch

### OVERALL FUSELAGE LENGTH

74 Inches

### RADIO COMPARTMENT SIZE

8" (L) x 4-1/4" (W) x 3-1/2" (H)

### STABILIZER SPAN

29-3/4 Inches

### STABILIZER CHORD (inc. elev.)

7-1/2 Inches (Avg.)

### STABILIZER AREA

222 Sq. In.

### STAB AIRFOIL SECTION

Flat

### STABILIZER LOCATION

Mid-Fuselage

### VERTICAL FIN HEIGHT

8-3/4 Inches

### VERTICAL FIN WIDTH (inc. rud.)

10-1/2 Inches (Avg.)

### REC. ENGINE SIZE

Astro 60 Sport Wind

### BATTERY SIZE

28 Cells/SR Max 1800

### LANDING GEAR

Conventional

### REC. NO. OF CHANNELS

4

### CONTROL FUNCTIONS

Rud., Elev., Throt., Ail.

### C.G. (from L.E.)

5 Inches (At Fuselage)

### ELEVATOR THROWS

1" Up - 1" Down

### AILERON THROWS

5/8" Up - 5/8" Down

### RUDDER THROWS

2" Left - 2" Right

### SIDETHRUST

1° Rt

### DOWNTHRUST/UPTHRUST

0°

### BASIC MATERIALS USED IN CONSTRUCTION

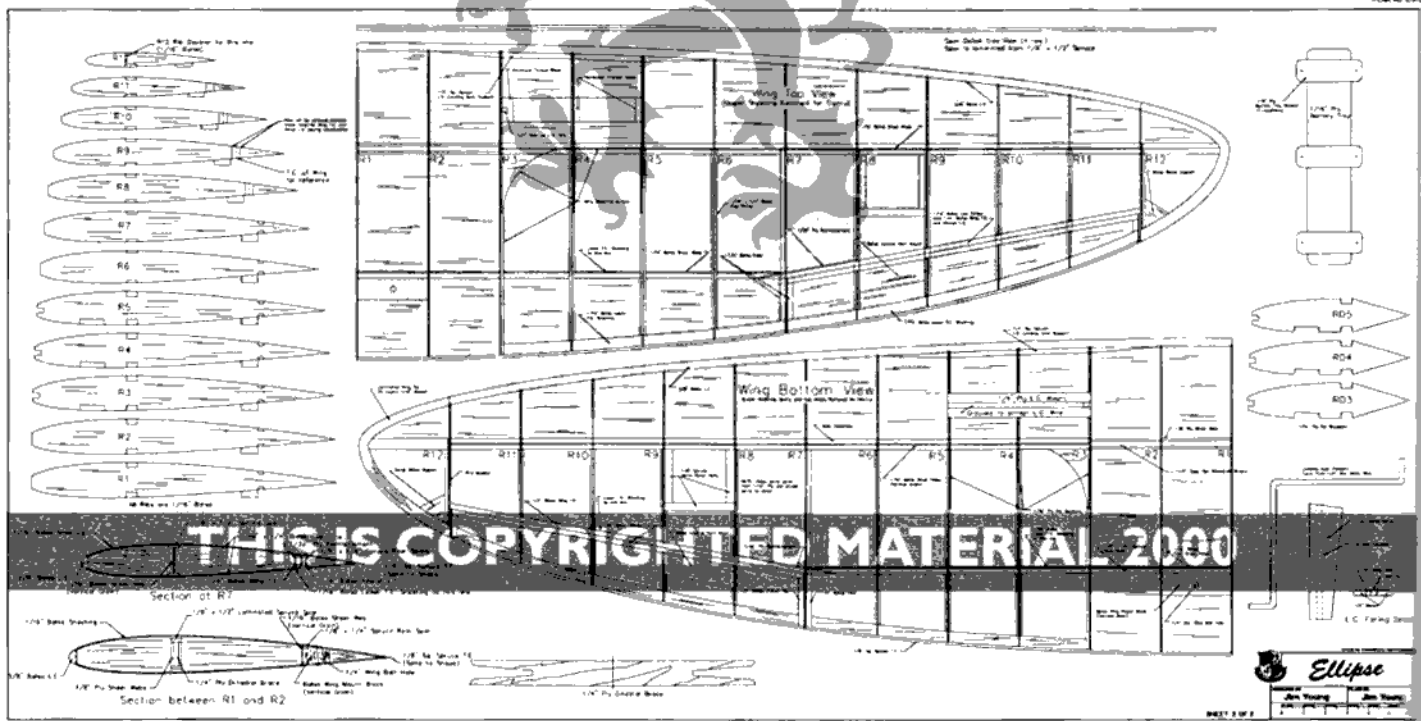
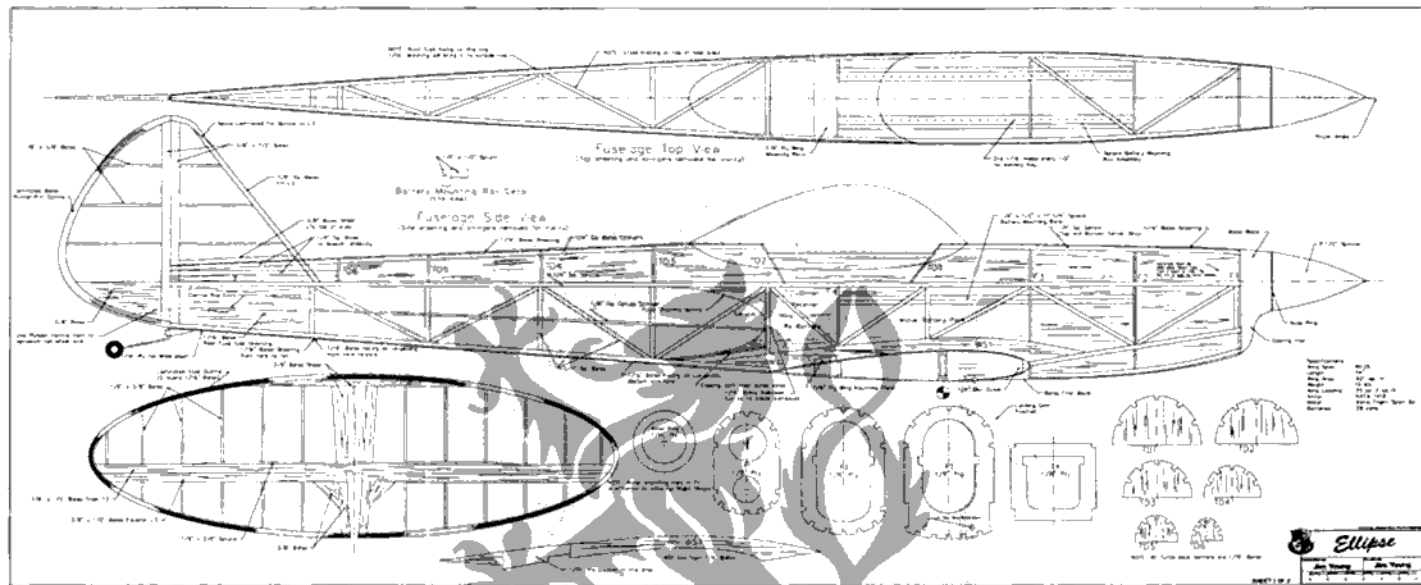
Fuselage ..... Balsa, Spruce & Ply

Wing ..... Balsa, Spruce & Ply

Empennage ..... Balsa & Spruce

Wt. Ready To Fly ..... 160 Oz. (10 Lbs.)

Wing Loading ..... 25 Oz./Sq. Ft.



accurately position the completed laminates on the plans. Pin the templates to your board over wax paper. Cut several 3/8" strips (they will be sanded down later) of 1/16" balsa and wet them in a solution of ammonia and water. Wrap one strip tightly around the template and pin it in place. Using carpenter's glue or even CA if you work fast enough, glue and pin successive strips to the previous strip. Stagger the joints between the layers to avoid weak spots. Keep the strip's edge flat on the board and build up five layers of balsa. The stabilizer/elevator outline is

laminated as one complete ellipse and cut during assembly. Allow the laminates to dry overnight. Transfer the key locations to the laminated pieces before removing them from the templates.

Position the laminated stab on the plans. Cut, fit, and glue in place the 3/8" x 1/2" balsa stab T.E. and elevator L.E. Glue the 1/8" x 3/8" spruce stiffener to the front of the stab T.E. Add the rest of the 3/8" balsa sheet center pieces and the 1/8" x 3/8" ribs. Cut and glue in place the 3/8" balsa elevator ends and horn mounts. Separate the elevators from the stab and each other. Sand the L.E. of the elevators to a "V" shape and temporarily install hinges. The elevator halves are not joined together; use a "Y" pushrod to drive the elevators. The fin and rudder are assembled over the plans in a similar manner. Sand the

completed tail surfaces flat, and round the leading and trailing edges.

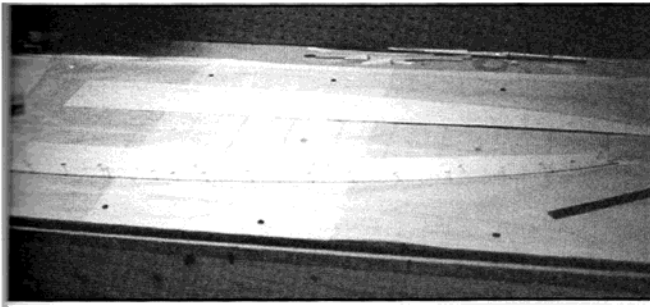
### Wing

Prepare the lower trailing edge sheeting. Cut one piece of 1/16" balsa sheet from the root of the wing to R7 and one piece from R7 to R12. In both cases, the sheeting extends to the front of the rear spar with the wood grain parallel to the spar. With the two pieces of sheeting pinned over the plans, glue the 1/8" sq. spruce T.E. to the sheeting. Rubbing some baking soda on the spruce before gluing will give a strong bond with CA glues. The two pieces of balsa sheeting will only be held together by the spruce, so be careful handling assembly and set it aside.

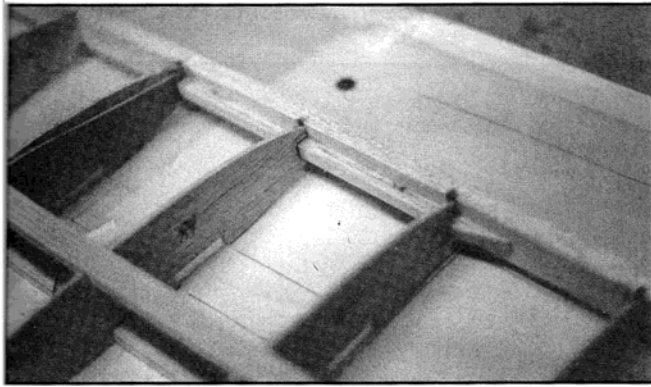
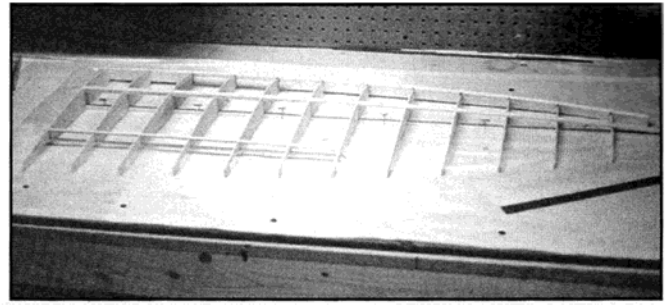
Cut the wing L.E. from 3/8" balsa. Bend and pin the L.E. to the plans and mark the location of the ribs. Remove the L.E. from the plans and use a

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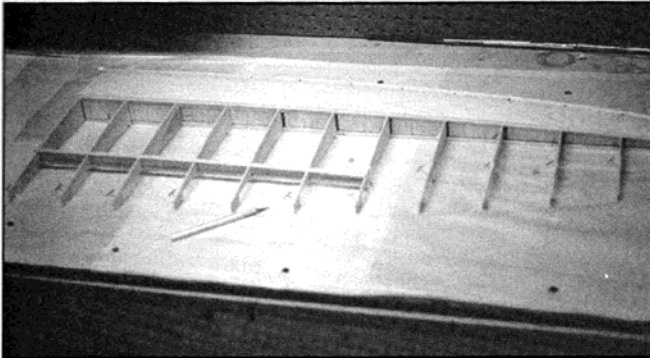
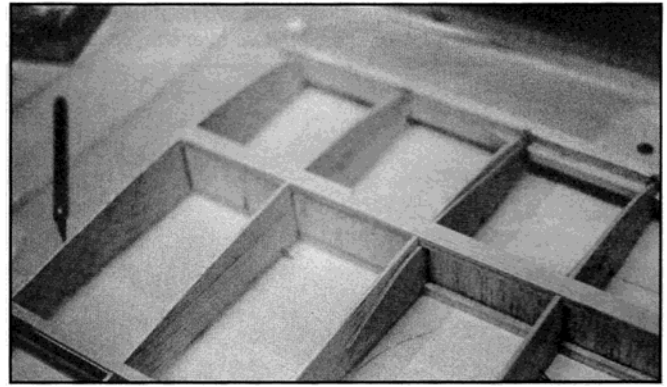
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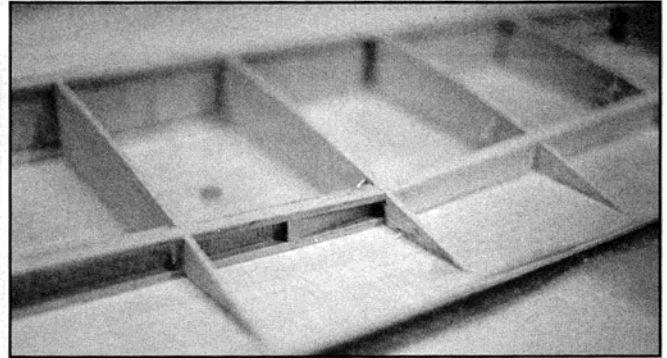
**LEFT:** 1/8" sq. spruce is added to the bottom T.E. sheeting to give a thin, dent-resistant edge. **RIGHT:** The wing assembly with the main and rear spar installed. Note tabs on ribs for proper alignment.



**LEFT:** 1/4" sq. spruce reinforces the L.E. around the landing gear mount. **RIGHT:** The root end of the wing; notice the plywood rib doublers for the landing gear mount.



**LEFT:** The leading edge sheeting can be cut from one piece. Make sure that the structure is firmly pinned down so as not to induce a twist. **RIGHT:** 1/32" ply is used to reinforce the rear spar at R7.



hacksaw blade to notch it 1/16" deep at each rib location. The notches should be 1/8" wide at R3, R4, and R5 to allow for the rib doublers and angled slightly at R1 for the dihedral. Glue on the 1/4" sq. spruce L.G. support from R2 to R6.

Prepare the wing spar assemblies from 1/8" to 1/2" spruce. The spars are doubled from the root to R6. The doubler tapers down from R5 to R6. You'll notice that several key supports and reinforcements taper from full width to nothing. This avoids having stress risers in the structure which concentrate flight loads at a single point.

Glue the rib doublers to R3, R4, and R5 with the doublers on R3 and R5 facing each other. R12 is doubled on the outboard side with 1/16" balsa from the main spar to the T.E. Mark R8, R9, R10, and R11 for the wing T.E. and aileron L.E.

Pin the lower spar over the plans and glue the ribs to it. Angle R1 to allow for the dihedral. Make sure that the building tabs are pinned flat on the building board. Mark and cut a 1/4" slot in R2 centered over the lower spar to accommodate the dihedral brace. Add the top spar assembly and the leading edge. Cut and glue the 1/8" x 1/4" spruce rear spars. These rear spars extend from R1 to R7.

Add 1/16" balsa sheer webbing from R3 to the wingtip. It may take a little more time to cut I-beam sheer webbing and fit it tightly, but the strength benefits are worth it. Four pieces of 1/8" plywood sheer webbing are used from R1 to R3. This webbing is glued flush with the front and back of the spar to form a 1/4" wide box for the dihedral brace. Use some 1/4" scrap between the sheer webs to ensure a tight fit. Cut and

glue 1/16" sheer webs to the front of the rear spars from R1 to R7.

Slide the lower T.E. sheeting assembly under the rear of the wing and glue it to the bottom of the ribs. Cut R8 through R11 for the wing T.E. and aileron L.E. Cut a wing T.E. and aileron L.E. from 1/4" balsa and notch them for the wing and aileron ribs. Cut these pieces slightly taller than necessary and carve and sand them to the rib profile after they are installed. Glue these pieces to the ribs and lower sheeting, **not** to each other. The aileron L.E. should not be glued to R7 or R12. The

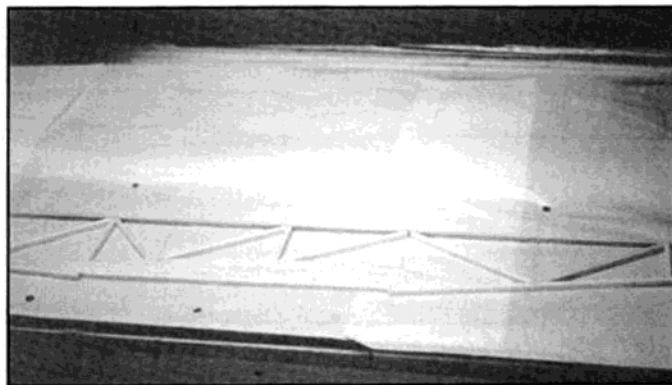
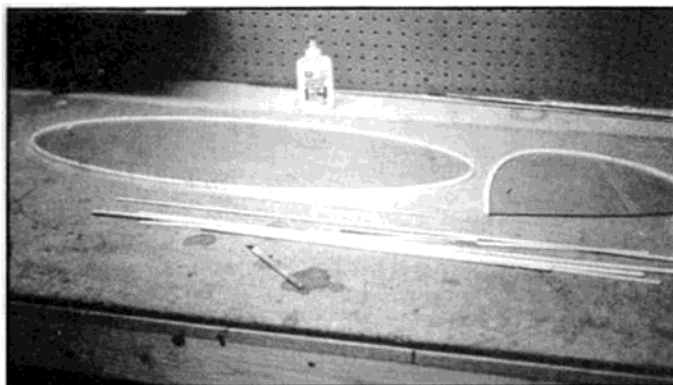
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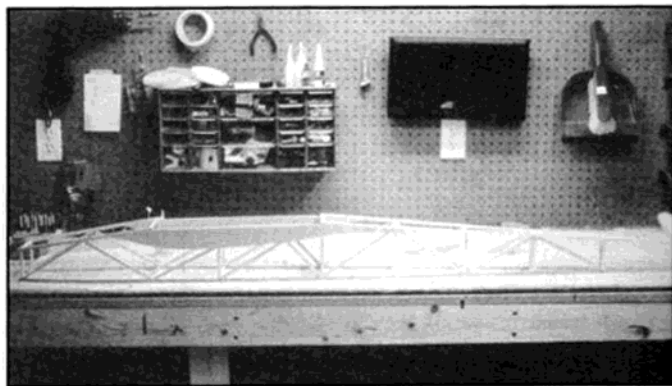
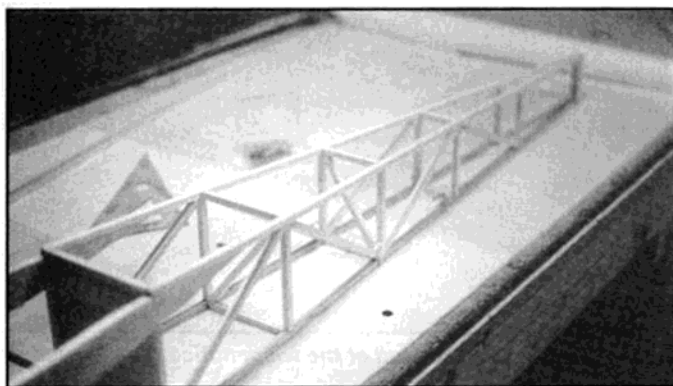
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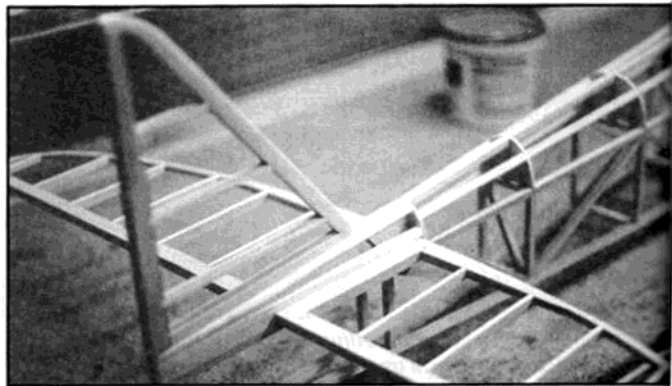
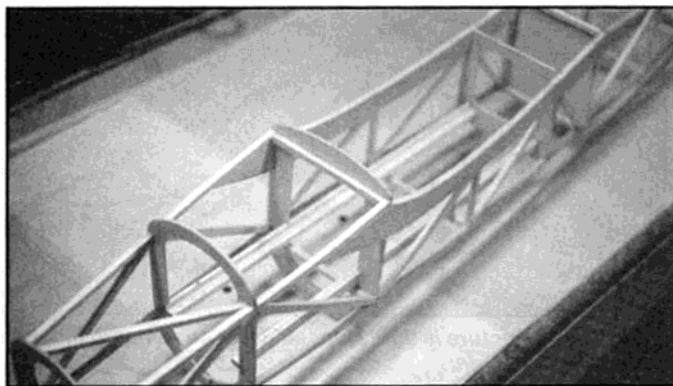
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**LEFT:** The rudder and stabilizer outlines are laminated from 1/16" x 3/8" balsa strips around cardboard forms. **RIGHT:** The fuselage sides are traditional stick trusses, built up over the plans.



**LEFT:** The fuselage is assembled upside down over the plans. **RIGHT:** The basic fuselage frame ready to be removed from the building board. Light, but strong!



**LEFT:** After the fuselage has been removed from the board, the forward formers and battery rails are added. **RIGHT:** Add scrap balsa around the tail feathers for something to glue the sheeting to.

weakest spot on the wing is the rear spar at R7. Reinforce this area by gluing a piece of 1/32" ply to the front of the balsa wing T.E. through R7 and between the top and bottom spruce rear spars. This will require several trial fittings and trimmings, but you need to tie the two spars together structurally. Glue 1/4" balsa control horn mounts between R8 and R9 to the aileron L.E., the ribs, and the lower sheeting. Cut two 1/4" balsa aileron end caps to the shape of R7 and R12. Space these end caps 1/16" from R7 and R12 and glue them to the aileron L.E. and the lower sheeting.

Fit the laminated wingtip to the wing. The spars are cut to fit the inside edge of the wingtip. The lower spar is braced up 1/16" at the wingtip to allow for the lower L.E. sheeting. Cut and fit

the upper L.E. sheeting from 1/16" balsa. This sheeting extends from the middle of the spar to the rear of the 3/8" L.E. and from root to laminated wingtip. Use the outline on the plan to cut the sheeting roughly to shape. Then trim and sand it for a tight fit. This sheeting will have a gentle compound curve, but can be cut and installed in one piece.

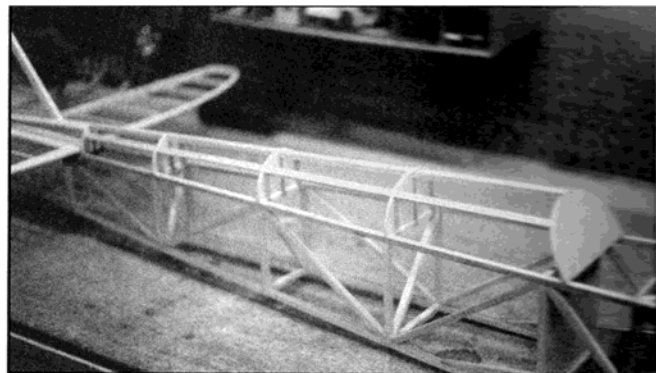
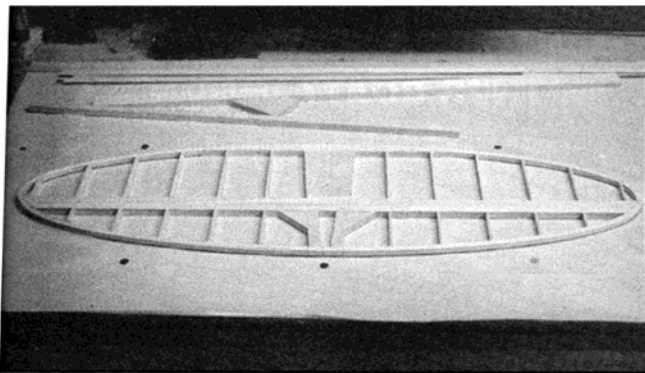
Remove the wing assembly from the board and turn it over. You will not be able to pin it down because the top spar is curved. Epoxy a 1/2" x 1" x 1" hardwood block to the R3 doubler at the L.G. mount location. Epoxy the 1/4" plywood landing gear mount to R3, R4, and R5. Reinforce these joints with 1/4" hardwood triangle stock at R4 and R5. After the epoxy has cured,

drill a 1/4" hole through the landing gear mount into the hardwood block. Try to keep this hole close to the R3 doubler and perpendicular to the landing gear mount.

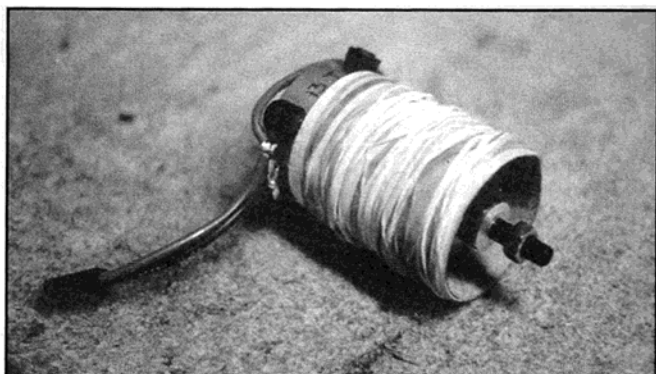
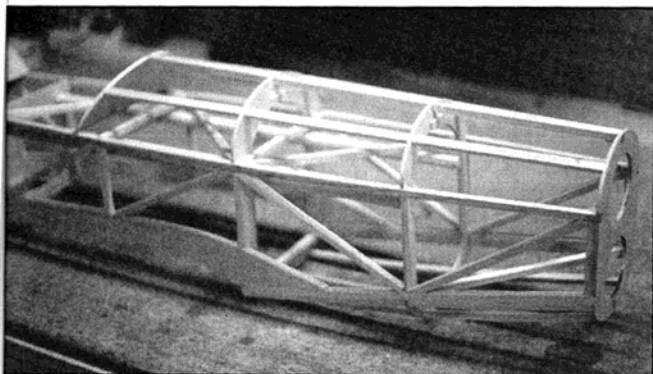
Cut and install the lower leading edge sheeting, making sure not to induce a twist in the wing. Build the other wing half.

Join the two wing halves with the 1/4" plywood dihedral brace and epoxy. Pin one wing half to your board and brace up the other wingtip 2" at R12. Carve and sand the L.E. to shape.

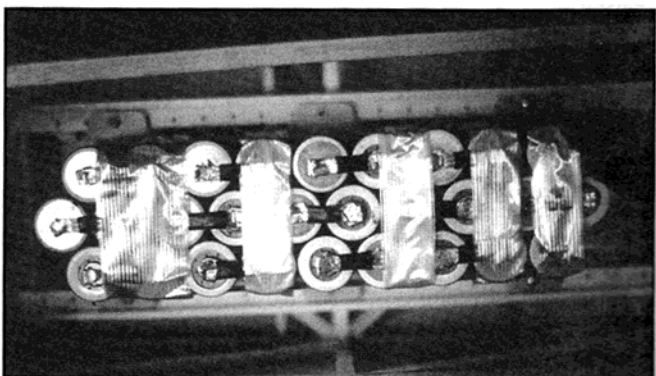
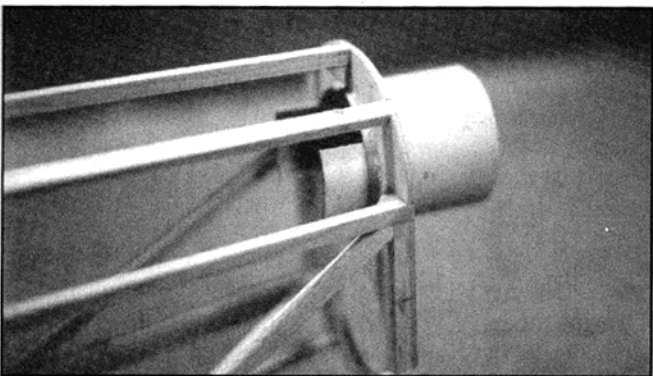
Cut and glue the 1/16" bottom center wing sheeting. This sheeting should span from one R3 to the other R3. Cut and glue vertical grain balsa wing mount blocks behind the rear spar between the R1s and R2s. These blocks



**LEFT:** The stabilizer and elevator are built as one unit within the laminated outline, then separated after assembly. **RIGHT:** The turtledeck formers and stringers prior to adding 1/16" balsa sheeting.



**LEFT:** The nose formers and stringers prior to adding 1/16" balsa sheeting. **RIGHT:** The motor mount is laminated from three layers of 1/64" plywood.



**LEFT:** The motor mount is glued to F1. A balsa nose block is added later for additional support. **RIGHT:** 28 cells fit comfortably in the fuselage. The battery tray and mounting rails allow for quick changes in the Center of Gravity.

should be keyed to fit between the rear spars. Sand these blocks flush with the tops of the ribs. Cut and glue the 1/16" top center wing sheeting, again spanning from R3 to R3. No fiberglassing was used on the wing joint on the prototype and it is more than strong enough. Cut and fit the 1/16" balsa upper trailing edge sheeting. This sheeting is 1/2" wide and follows the shape of the trailing edge from the center sheeting to the laminated wingtip. This sheeting should butt up to the 1/8" sq. spruce T.E.

Add 1/16" x 1/4" balsa capstrips to ribs R4 through R12. Add capstrips to the top of the wing T.E. and the aileron L.E. Take care not to glue the wing T.E. and aileron L.E. together. Cut between

the balsa wing T.E. and the aileron L.E. through the lower wing sheeting. Now, by cutting through the 1/8" sq. spruce T.E., the ailerons can be separated from the wing. Sand the aileron openings and the ends of the ailerons for a uniform fit. Sand the L.E. of the ailerons to a "V" shape and temporarily install hinges.

Add 1/8" x 3/8" spruce servo cover mounts between R8 and R9 and cut covers from 1/16" plywood. The aileron servos are mounted to the covers which are held in place with four #2 wood screws. Cut slots in the servo covers to allow for the control arm. Mark the location of the control horns on the ailerons and drill mounting holes. Trial-fit the control horns to the ailerons and glue the top mounting plate to the top

of the horn mount. Once you cover the aileron, you won't have any ugly hardware showing on the top of the wing.

Measure and cut a 1/4" wide strip from the lower wing sheeting where the landing gear will rest. Bend the 1/4" music wire landing gear to shape according to the plans. Trial-fit the landing gear and drill holes for nylon hold-down straps. Make landing gear fairings by sandwiching 1/4" balsa between 1/64" plywood. Don't forgo this step; nothing has more drag than a round wire landing gear. I carved wheel pants from balsa and used Sig wheel pant mounts. This way I could cover the wheel pants with MonoKote (I can't paint). Alternately, suitable fiberglass pants are available from several

suppliers. Properly faired landing gear and wheels are almost as good as retractable landing gear (I'd like to see pictures if anyone builds an Ellipse with retracts).

### Fuselage

Splice together 1/4" sq. spruce for the top fuselage longeron. Pin a longeron and a 1/4" balsa WS1 over the plans and assemble the 1/4" balsa truss structure to it. Do not put any bracing at F2, F3, or F4. Place wax paper over the completed side and build the next one directly over it. Taper the tail of the fuselage sides according to the plans.

The fuselage is built upside down over the plans. Glue F4 square to one side and pin this assembly over the plans. Glue the other side to F4 and pin in place. Glue the tail together keeping the sides square to the board and centered over the plans. Working from F4, add 1/4" sq. balsa crosspieces to the fuselage assembly. The crosspieces at F2 and F3 will be removed when the formers are installed. Add 1/4" sq. balsa diagonal cross bracing aft of F4, making sure the fuselage sides are square to the building board. Install a 1/16" balsa sheet bulkhead in the structure at the T.E. of the wing. Glue 1/16" plywood doublers between F4 and the balsa bulkhead to the WS1s. Epoxy in the 1/4" plywood wing mount. Reinforce the mount with 1/4" spruce triangle stock. The wing mount is installed flush with the wing saddle to help the mounting bolts shear during a crash and hopefully avoid serious damage.

Remove the fuselage structure from the board. Install F1, F2, and F3. Block up the fuselage over the plans and, using a square, make sure that the nose is still centered. Add diagonal bracing from F1 to F2 to keep the nose straight.

The battery tray mounts extend from F2 to F4. Assemble two tray mounts from 1/4" x 1/2" spruce. Each mount consists of two pieces glued into an "L" shape. Mark and drill 1/16" holes every 1/2" along the tray mounts. This will allow you to move the battery pack to balance the model. Glue the tray mounts into the notches in F2, F3, and F4, making sure the holes line up between the two rails.

With the fuselage still blocked up, center the wing on the fuselage and square it up. Sand the wing saddle until the wing is level to the building board. Once satisfied with the fit, tape the wing in position and drill through the 1/4" holes in F3 into the wing L.E. Temporarily install 1/4" dowels in the holes. Next drill two 13/64" holes

through the wing into the 1/4" plywood wing mount. Make sure you drill through the balsa wing mounting blocks in the wing. Remove the wing and enlarge the holes in it to 1/4". Remove the lower wing sheeting around the holes to inset the heads of the wing mount bolts and expose the end grain of the reinforcing blocks. Harden the reinforcing blocks with thin CA. Tap the holes in the wing mount for 1/4-20 bolts and harden the threads with thin CA. Drill through the 1/4" holes in the wing L.E. into the dihedral brace. Round the ends of two 1/4" hardwood dowels and glue them in place. Trial-fit the wing and check the attachment points.

Cut three pieces of 1/64" plywood 2-3/4" by approximately 5-1/2" for the motor mount tube. Use slow cure epoxy to laminate these pieces into a motor tube. Wrap your Astro 60 with waxed paper and tape the end bell holes shut. Wrap one sheet of plywood round the motor and trim it to an exact fit. Spread a thin layer of epoxy on the plywood. Tape another piece of plywood and overlap it halfway onto the first piece. Wrap these two pieces around the motor and trim

second sheet for an exact fit. Secure these two pieces temporarily with a few rubber bands. Use the brush holders to keep the tube square. Spread a thin layer of epoxy on the last sheet of plywood. Remove the rubber bands and wrap the final sheet around the motor, staggering the seam. Trim the last piece to size and pile on the rubber bands. After the epoxy has fully cured, mark the brush housing locations on the tube and cut notches in the tube to tightly fit them. The notches should be deep enough so that the front of the tube is flush with the front of the motor. Trial-fit the motor mount into F1. With the fuselage blocked up over the plans set the thrust angle of the motor and epoxy it in place. Use the tops of the fuselage longerons to set the vertical thrust angle. Right thrust is shown on the plans, but is not necessary if you use your left thumb a lot. You just don't want to build any left thrust in, so try for a little right.

Glue on the fuselage top formers TD1 through TD6. Cut and install the 1/4" sq. stringers to the fuselage. The front top and bottom center stringers are spruce, the rest are balsa. With the fuselage assembly upright, install the wing, trial-fit, and glue the stabilizer in place. Trial-fit and glue the fin to the stab. Add scrap stringers to the top of the stab and side of the fin to aid in sheeting this area.

Sheet the fuselage with 1/16" balsa. The fuselage sides are sheeted from the nose to the T.E. of the wing and from the front of the stab to the tail. The front top and bottom have a compound shape and should be planked in 1/2" to 1" strips. The turtledeck sheeting should extend from one spruce longeron to the other. The bottom of the fuselage from the front of the stab to the tail is sheeted next. Use a small piece of ply at the tail for a tail wheel mount. Finally, the lower rear longerons receive 1/16" facing on the sides and bottom to blend them into the other sheeting. Install a 1/8" sq. spruce stringer on each side of the aft fuselage. This stringer should blend into the front and rear side sheeting. Install the rudder and elevator servos aft of the balsa bulkhead at the T.E. of the wing. Cut a hole in the bulkhead for access to the servos and to allow cooling air to flow through. Build a cooling vent on the bottom of the fuselage from the T.E. of the wing to the next cross brace using scrap 1/16" balsa. With the wing in place, use balsa to add a fairing between the wing and F3.

Cut a balsa block for the nose. The block should fit tightly around the motor tube to provide support. Use the motor and spinner to set the length of the block and allow 1/16" for the plywood nose

ring. Glue the nose ring in place and carve and sand the nose block to final shape. The motor is held in place by friction; use a few strips of tape to get a tight fit. If the plane noses over, the motor will slide back and the spinner will be supported by the nose ring. This helps to prevent any damage to the prop shaft.

Glue three 1/16" plywood doublers to the 1/16" plywood battery tray. Drill the mounting holes carefully so that they will line up with the holes in the tray mounts.

#### **Final Assembly**

Final-sand the model and cover it with any of the iron-on plastics. Avoid any of the fabric materials because of weight. Trial-fit the canopy (available from The Builders) and install it.

Install hinges and hook up the servos. I used a pull-pull system for the rudder. It's light and gives good response. The receiver and battery are installed behind F4.

I used an Astro-Flight Model 204 Electronic Speed Control. It is one of the few ESCs that can handle this much power. Install the motor and speed controller. The power system is protected with a 45 amp automotive fuse soldered between the battery and ESC. If the plane noses over, your first instinct should be to turn off the motor to avoid stalling it. If you don't, the fuse should prevent a meltdown. Install the propeller and spinner. I use a cleaned-up Zinger 13 x 10 which performs well.

Assemble the power battery pack. The prototype uses 28 SR Max 1800 cells. They are soldered together with 1/4" grounding strap and uses 12 AWG megastrand wire with Sermos connectors. Be careful with the assembled pack; any metal contact could result in a major meltdown. Charge and discharge the pack a few times at a slow rate (C/10) to equalize the cells. The pack is held to the battery tray with packing tape or nylon straps. Install the battery pack tray with six #2-3/4" wood screws. Move the battery pack tray fore and aft to balance the model. I suggest you try a slightly nose heavy position until you are familiar with the plane. The prototype came out at 10 lbs. 4 oz., but I framed and planked the canopy out of balsa. With the vacuum formed canopy, getting closer to the 10 lb. goal should not be a problem.

#### **Closing Remarks**

I've taken the Ellipse to several I.M.A.A. events and a lot of big gas burners were amazed that you could fly such a large electric powered model. They were even more amazed that it could fly so well! One guy even tried to talk me into entering a pattern contest with it! I'd like to thank Keith Shaw for his

construction tips and for sharing his advice and wisdom.

#### **Flying**

**Take-Off and Landing:** Make sure the batteries are charged and range-check the radio with and without the motor running. Apply power gradually (power should never be slammed on in any electric to start your take-off roll. A small amount of right rudder is needed to keep it tracking straight. The Ellipse is lightly loaded for a plane of its size and it will be airborne before you know it, so be ready for it.

I start setting up for a landing after about five minutes of hard aerobatics. This gives me a little reserve in case I have to go around again. The Ellipse has a clean, low drag design and does not slow down quickly. The first few landings ended up in the weeds at the end of the field! Make your landing approach long and low and cut power sooner than your other planes. The nice thing with electrics is you can shut off the motor and restart it if you need more power. Go for a wheels-first landing and slowly add elevator to get the tail wheel down. Add too much, too quickly, and you'll be airborne again! You can side slip it to help bleed off excess speed.

**Slow Flight/Stall:** The Ellipse is fine at slow speeds. It is lightly loaded and will just float along. Control authority remains good down to stall speed. Low speed stalls may drop a wingtip, but it is the slowest tip stall I have ever seen, so you can correct for it.

**High Speed Flight:** This is a fast plane as electrics go and is very stable at top speed. The plane grooved well and does not exhibit a high speed stall.

**Aerobatics:** This is where you will amaze your "wet" buddies. The clean design of the Ellipse allows it to do just about any pattern. Loops are big and round, there is enough power for avalanches and sustained knife-edge flight. Stall turns and Cuban Eights are big and beautiful. Snap rolls are a little slow to start because of the long tail moment. Roll rate is not head-snapping quick so you will need a little down elevator when inverted. The aileron size has been increased slightly from the prototype. Vertical performance is not unlimited but it's close. It helps the vertical performance if you add some right rudder while climbing. The one thing electrics teach you is to use the throttle, because the more you can throttle back, the longer your flights will be. You will quickly realize that you don't need full throttle to complete many maneuvers.

