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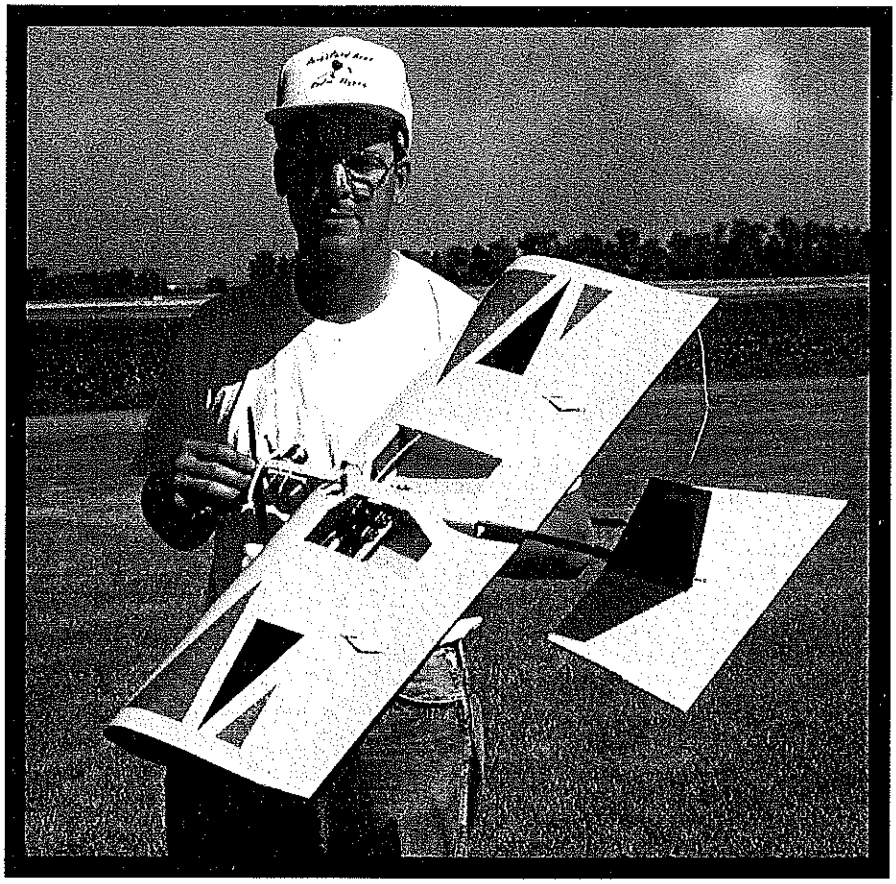
ARROWPLANE

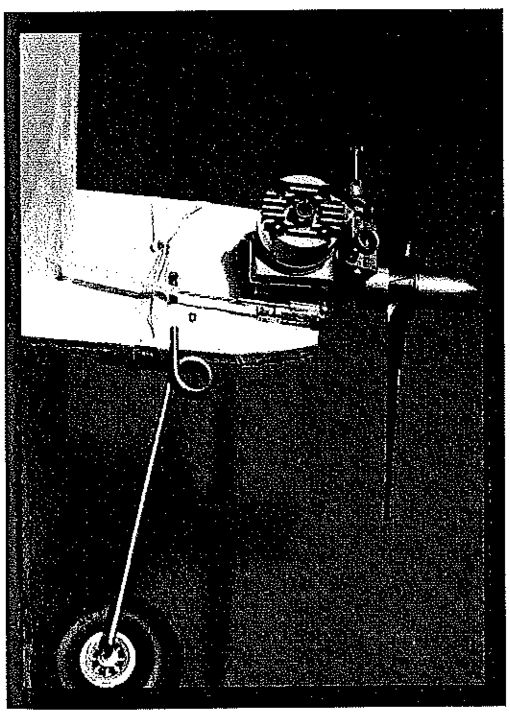


■ **David Larsen**

When the first Competition Fun-Fly (CFF) models arrived on the scene, I thought that I needed one. My flying skills with a trainer had progressed to the point where I could do a touch-and-go with confidence. I reasoned that I needed a model that could do several touch-and-gos in a few seconds—and a dozen rolls in the blink of an eye.

However, CFF models used carbon fiber and other exotic materials. They demanded a computer radio. And I needed (*really* needed) a Pattern trainer, an Old-Timer model, and a float airplane. So I let the urge to have a CFF model simmer on the back burner for a couple of years.

)avid Larsen launches the prototype model with a simple underhand toss. Design has undergone two years of flight testing.



\bove: Engine mount setup shows engine position ınd nose gear mounting. Two-ounce fuel tank 'ubber-banded to opposite side of mount.

Right: Light weight, lack of dihedral makes model /ery agile, but not directionally stable; no problem for an experienced pilot.

In 1995 I decided it was time to satisfy the urge. I had studied the plans and looked at the CFF models. I figured I could guesstimate the dimensions and size of the surfaces, but I needed an engine. I had a .40 that wasn't busy and the Fugi .099 from my son's airboat. A .40 is generally considered too big for the average CFF model, so my design would have to fit the Fugi .099.

Two years of fun and 50 test flights later, the prototype Arrowplane is still going strong. I am having a blast with my simple, easy to build, inexpensive semi-CFF model. The airplane was designed to be flown close-in and at low altitudes, so the 36-inch wingspan has not been a problem. Since most common sizes of balsa come in 36-inch lengths, the wingspan limit made building easy.

In retrospect, I'm glad that I kept the size of the model small. A small model uses a less expensive engine. A miserly amount of fuel is needed. The cost in wood and covering is minimal. And an aluminum arrow shaft (from my deer-hunting hobby) fit the bill as a "fuselage."

Do you get the idea that I'm a cheapskate? Well, I don't mind having fun with a model that can be built for $20 and requires two ounces of fuel per flight.

The Arrowplane will ROG (Rise Off Ground) if the wire outriggers are installed, but an underhand toss will launch the model, even in calm conditions. A dual-rate radio is desirable for takeoff and landings, but the real fun happens on high rate. Rolls are very fast, and 20-foot-diameter loops make flying in a confined area easy. The model flies slowly so you have time to enjoy the show your thumbs are creating. (A beginner should save this model until he/she has mastered an aileron trainer.)

CONSTRUCTION

As you begin to study the plans, you will notice that this model is simple. It uses three channels. One standard servo operates the

ARROWPLANE

Type: RC Sport

Wingspan: 36 inches

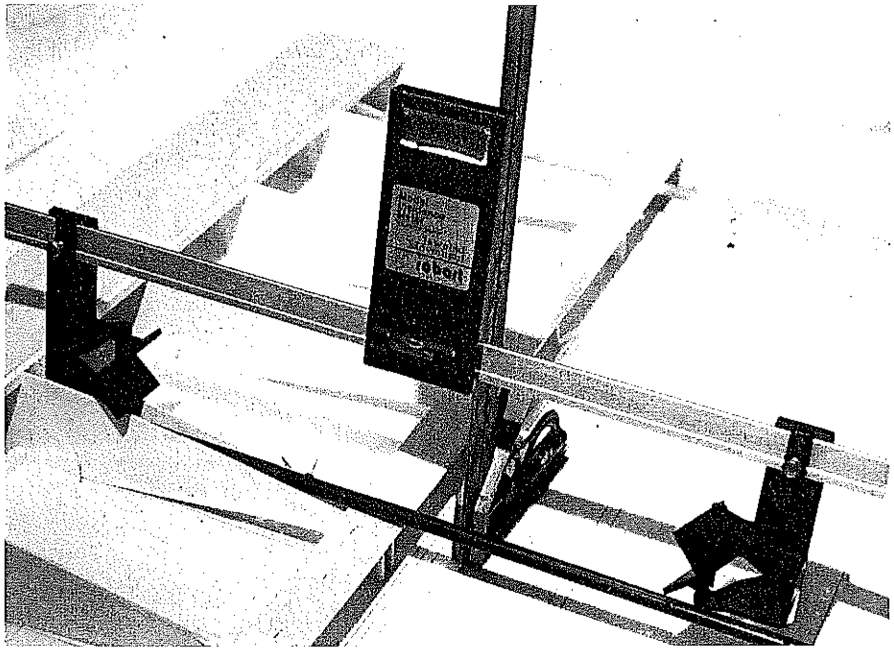
Engine: .09-.15 two-stroke

Functions: Elevator, aileron, throttle

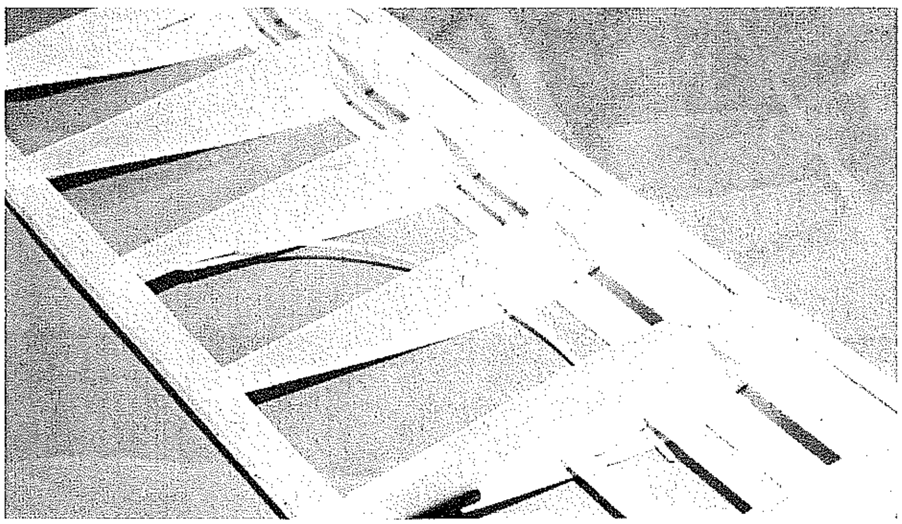
Flying weight: 36 ounces

Construction: Built-up

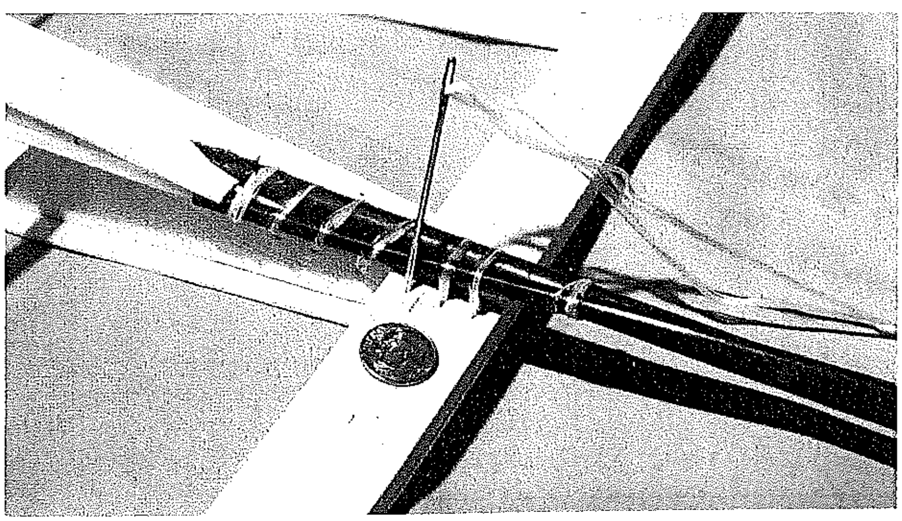
Finish: Heat-shrink film



With wing still pinned down, incidence meter is used to align arrow shaft. With shaft resting on TE, hole is drilled so "fuselage" is parallel to building board.



View from wing bottom shows aileron flex cable tube, plywood outrigger mounting points, and servo rails. Bottom sheeting will be glued on next.



Tailboom is attached to fuselage with medium CyA, then sewn with Kevlar™ ribbon. Saturate wood and ribbon with thin CyA when sewing is complete.

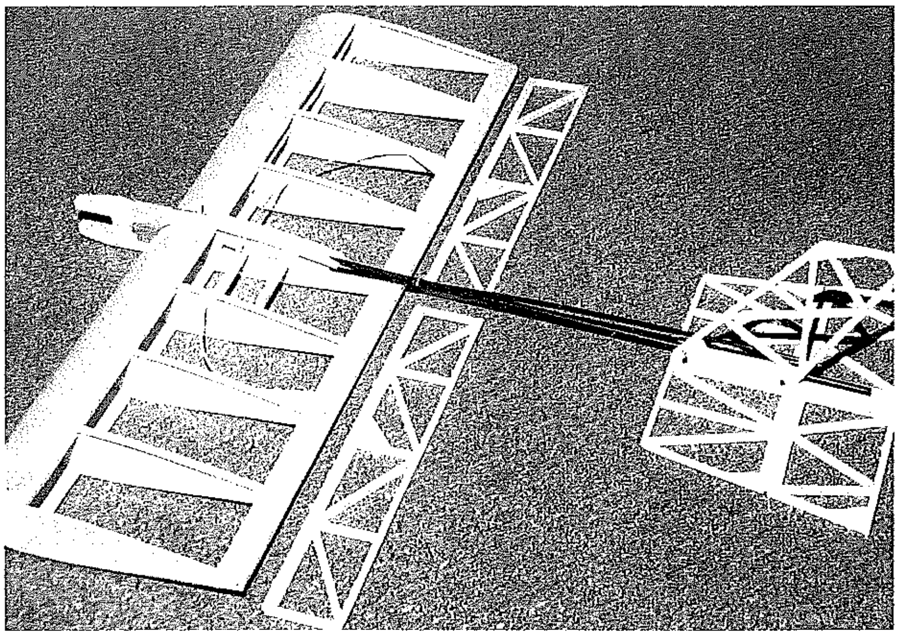
ailerons; another is hooked to the elevator; a miniservo handles the throttle. A standard servo can be used for the throttle, but I had the mini and I wanted to save as much weight as I could. I do miss the rudder on occasion, but not enough to include it on prototype Number Two (I have other models that will do knife-edge and stall turns).

Ailerons and Tail Feathers: Construction begins with these pieces. They are made of ¼ medium-weight balsa sticks. Cut to length and pin down the ⅜ x ¼ leading edge for the ailerons. Add the ¼ x ¼ pieces until both ailerons are completed. It would be better if the control horn mounting plates were made from hard balsa. An alternative method is to poke holes in the wood and saturate the mounting area with thin cyanoacrylate (CyA) glue.

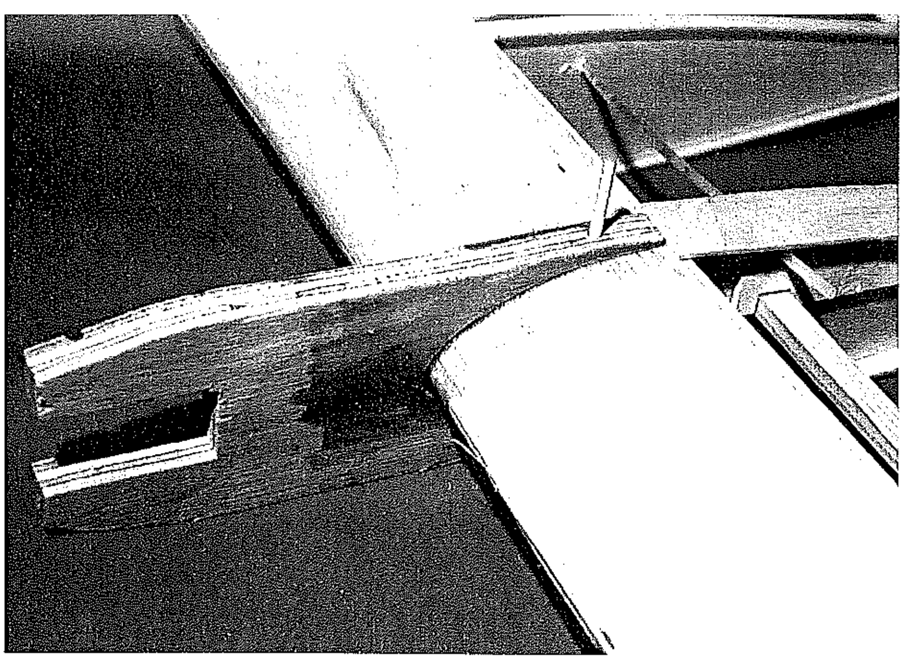
The vertical fin is built directly on the plan from ¼ x ¼ balsa sticks.

The horizontal stab includes the 1½ wide center section, but the remaining pieces are all ¼ x ¼.

The elevator is built up in a similar fashion except it uses the ⅜ x ¼ leading edge piece. The leading edge is wider because the bevel for the hinge must be sanded into this piece. If you are a builder who routinely glues a piece of triangle stock onto the leading edge of your ailerons and elevators so you don't have to go to the bother of sanding that bevel, you can use the ¼ x ¼ leading edge material.



Arrowplane in the bones. Tail section not attached until after covering and installation of all gear—adjust position under proper balance obtained.



Engine mount is epoxied to wing; a 1/8 dowel pins the mount in place. Slight right thrust is acceptable, but no left thrust, please.

When preparing for hinge installation, you must bevel the leading edge of the moving pieces. The plan shows the ailerons and elevator hinged from the top, because I use sewn cloth hinges that my wife makes for me. The hinges are one-inch-wide pieces of Supershrink Coverite, Solartex, Worldtex, or whatever fabric covering I have available. White or natural colors seems to work best, since they don't show under other hues. It is more convenient if the covering has adhesive.

Draw a straight line down the middle of a strip of covering and sew two strips of the covering together, using the line as a guide. The adhesive sides should face each other. One seam of medium-to-fine stitches is great. My wife uses a computerized sewing machine, but a $20 treadle job will do the trick. Granite State has an iron-on gapless hinge that will work the same.

The greatest advantages of these hinges is that they are gapless and free moving. If you like to use the CyA hinges or Robart hinges, please glue ¼ pieces of scrap at the hinge locations for more secure gluing.

When the ailerons and tail feathers are dry, remove from the building board and sand smooth. This model is a slow flier, so it is not necessary to round the leading edges of the tail feathers too much; just take off the corners. Don't taper the elevator or aileron trailing edges. Leave them ¼ thick but sand the edges slightly round. Vacuum the balsa dust from the pieces and wipe with a tack cloth.

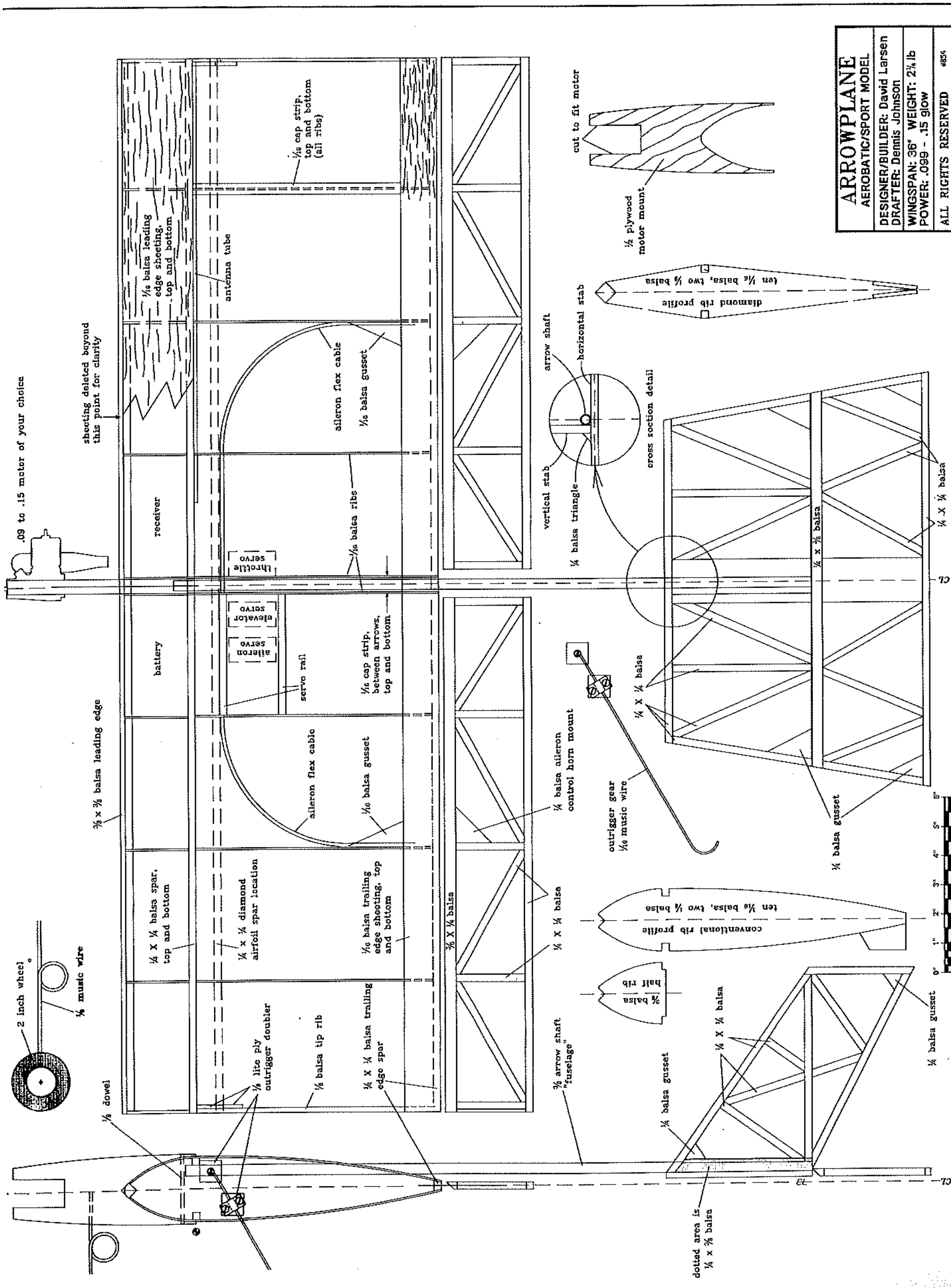
Mark the centerline of the horizontal stab. This is where the center of your arrow shaft "fuselage" will be attached. Determine the location of the vertical stab and glue it in place. Remember that the vertical tail feathers will be a bit off center. Use a right triangle to keep the vertical stab perpendicular to the horizontal stab while the glue dries. Glue a piece of ¼ triangle stock on the side of the vertical stab that is opposite the arrow shaft location.

Hinge the elevator and cover the tail feathers. (If you are not using the sewn hinges, cover first and then do the hinge job.) Set these pieces aside for final assembly.

Wing: Two rib outlines are shown on the plans. Dennis Johnson, who drew the plans, suggested a diamond-shaped airfoil. Since I already had several dozen flights on the prototype with the original airfoil, I knew that the conventional shape worked great. We have not had time to build the diamond airfoil version, but we have included it on the plans for your consideration.

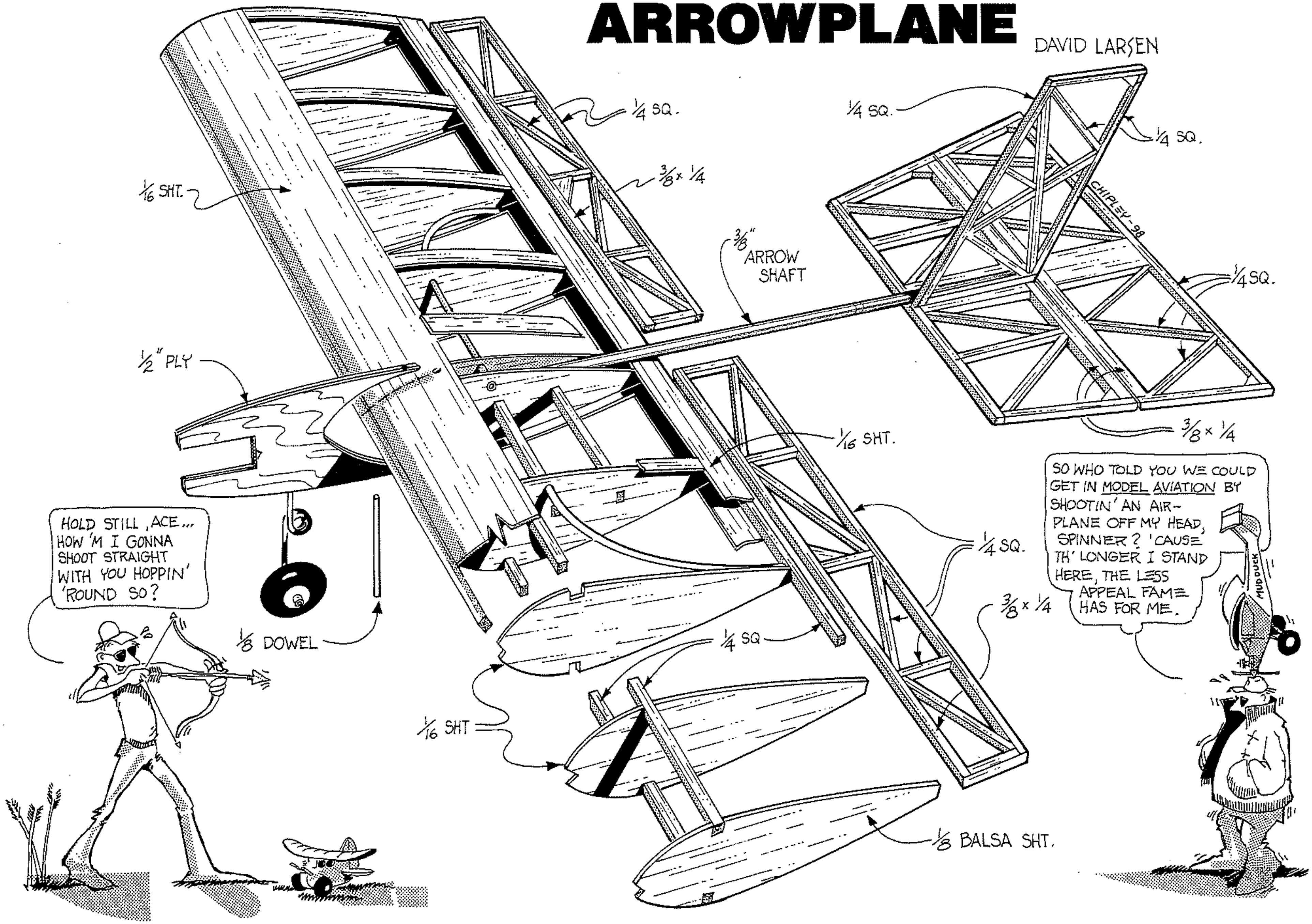
The ten ribs and a single half rib must be cut out before starting wing construction. I use See-Temp, a semitransparent template material, to make the pattern from the plan. This template can

Full-Size Plans Available—see page 189



ARROWPLANE

DAVID LARSEN



then be used to trace the rib outline onto 1/16 and 1/8 balsa sheets, or you can stack all ten ribs and cut them on a band saw. When I cut ribs separately, I like to make the rib template from Formica, since a #11 knife blade slides smoothly around this material.

The half-rib is made from 3/8 balsa and is glued between the two center ribs. The arrow shaft is then glued into this half-rib.

Pin the lower 1/4 x 1/4 balsa spar to the plan. Glue each rib in the location indicated, using a triangle to aid alignment. The tip ribs are 1/8; all other ribs are 1/16. Be sure to pin the rear "foot" of each rib to the building board, so the trailing edge will be straight.

When the ribs are attached to the bottom spar, glue in the top spar, the 3/8 square leading edge, and the trailing edge piece. After this has dried, the top leading and trailing edge sheeting can be attached. Keep the spar and ribs pinned to the building board so you don't end up with a twist in the wing.

Cut and glue the eight outboard capstrips. The two center ribs will be capped with a single piece of 3/4 wide balsa after the arrow shaft is glued and sewn into position.

Before unpinning the wing from the building board, get out the incidence meter and determine the location for the arrow shaft fuselage. The arrow shaft will need to be approximately 22 inches long for an .09 engine. If you are planning to use a heavier .10 or .15 engine, you might want to start with a 24-inch arrow shaft (most arrows are 29-33 inches in length).

I used aluminum on the prototype, but a fiberglass arrow might work just as well. A carbon-fiber kite stick could also be substituted, but then you would have to change the name of the model!

Check the incidence of the wing before sliding the arrow shaft into position between the center ribs. The middle of the arrow shaft should rest on the trailing edge sheeting. Use the incidence meter to make sure the arrow shaft is at the same incidence as the wing. Mark the position of the front of the arrow on the 3/8 half rib and remove the arrow. Drill a 1/2 inch-deep hole in the half rib, using a bit the same diameter as the arrow shaft. Do not glue the arrow shaft into position at this time. Install the antenna tube to route the antenna out the right wingtip.

Finish the wing by removing it from the building board and repinning it upside down. Use scrap wood pieces to prop up the trailing edge. Cut the tabs off the bottom of the ribs and install the leading edge sheeting, trailing edge sheeting, and capstrips. You can glue the bottom 3/4 wide capstrip over the two center ribs.

When the glue is dry, do that magic thing with filler and sandpaper, and the wing will be almost ready to cover. Take a few minutes to sit back and plan your radio equipment installation.

Engine Mount and Radio Installation: The engine mount is made from 1/2 plywood. I used construction-grade plywood, because it is lighter and the added strength of aircraftgrade plywood is not necessary. Make a template and cut the mount with a band saw or scroll saw. Use sandpaper and a rasp to shape the inside part of the mount to fit the contour of the wing leading edge. Remove the wood from the front of the motor mount to fit the engine you plan to use.

Epoxy the mount to the middle of the wing. If you feel that you need some right thrust, you can angle the mount a degree or two to the right while the glue dries. You do not want any left thrust, upthrust, or downthrust when the glue has dried.

The arrow shaft can also be epoxied into the hole in the center rib at this time. When the glue has dried the ¾ center cap strip can be glued to the top of the wing. A ⅛ hole should also be drilled vertically through the engine mount and through the center half rib. Glue a ⅛ hardwood dowel into this hole to keep the mount from parting company with the rest of the model. Coat the entire engine mount with thinned epoxy to fuelproof it.

Start on the radio installation by gluing the servo rails between the ribs in the left wing. I like to add scrap Lite Ply braces around the servo rails, since they are only being glued to 1/16 balsa ribs. Drill holes for the aileron flex cable tubes in the wing ribs as needed. Cut away a bit of the capstrip material so the flex cable tubes can be glued to the ribs at the exit location.

I install my aileron control horns on the top of the wing, since that makes it easy to get aileron differential with one servo. After you have figured out the aileron flex cable locations, glue the outer tubes in place with silicone glue or thick CyA. When this has dried, add the gussets around the exit locations. This will make covering easier.

The elevator servo is located near the center rib, so plan the routing for this Nyrod. Glue the front of the elevator Nyrod to the rib and glue the rear section to the arrow shaft in two or three locations. Remember to leave the Nyrod long enough so that it will nearly reach the elevator control horn when the tail assembly is attached.

The throttle servo is attached to the right center rib using servo-mounting tape. Drill a hole through the lower leading edge of the wing for the flex cable tube. Glue this tube into position after the leading edge is covered.

The battery compartment is located in the forward part of the left wing. Wrap the battery with plenty of foam padding and use some scrap balsa to make a shear web to keep the battery in position. I used a 500 mAh battery, but a smaller, lighter unit would also be feasible. Route the battery and servo wires through access holes drilled through the center ribs.

The receiver should be wrapped in foam and secured in its position in the forward part of the right wing. I did not use a switch harness on the prototype, but I recommend that you install the switch. Mount it on the left side of the model because the engine exhaust will be "oiling" the bottom and right side.

When the radio equipment is installed, cover the wing, except for the two middle bays on top. You *will* have to make servo adjustments, won't you?

Final Assembly: Bend the ⅛ nose gear to the outline on the plans. If you can find a factory made item that fits, it can be modified by making a 90° bend in the top ½ inch. This bend will fit into a hole drilled in the engine mount. A single ⅛ nylon landing gear strap (Du-Bro #238) holds the nose gear in place. Mount the nose gear, wheel, and fuel tank.

Mount the engine, muffler, prop, and optional spinner. My Fugi .099 swings a 7 x 4 Master Airscrew prop, which provides plenty of power and speed. If you use a .12 or .15 engine you might want to consider an 8 x 4 prop. Whatever the engine choice, remember to keep the model's speed moderate. With the large control surfaces, it is possible to experience flutter and/or failure at high speeds.

Finish attaching the arrow shaft by making a filler block from ⅜ balsa. Glue this to the trailing edge sheet and use medium CyA to glue the arrow shaft to the center ribs. Bore three 1⁄16 holes on each side of the arrow shaft, through the top and bottom trailing edge sheet (but *not* through the ¼ x ¼ trailing edge piece).

Now comes the fancy sewing. Use a Crewel Embroidery needle and K&S Kevlar™ 49 Ribbon to sew the arrow shaft to the trailing edge and trailing edge sheeting. When the stitching is done, saturate the wood and Kevlar ribbon with thin CyA for a permanent bond.

If you are going to use the 1⁄16 music wire outriggers, make and attach those now. A #2 screw will hold the top loop in place; a Sig #131 Nylon Landing Gear Strap will secure the wire at the correct angle. The outriggers make ROG takeoffs and touch-and-gos much easier—the wingtips don't drag in the grass.

Tack-glue the tail in position to check the Center of Gravity (CG). The model should balance on the spar. If the CG is off, break loose the tack-glue and move the tail group; reglue and try again.

When the CG is correct, note the position of the arrow shaft on the tail group. Drill several 1⁄16 holes through the horizontal stabilizer next to where the arrow shaft will be located. Also drill several holes on a 45° angle from the top of the arrow shaft location, through the base of the vertical stab and out the bottom of the horizontal stab. Use the Kevlar thread to stitch the tail group to the arrow shaft. Pull the thread tight, then be sure that everything is square and in the right position. Saturate the thread with thin CyA.

Install and adjust the flex cable to the throttle. Install all of the control horns. I used small horns, since I knew that the surfaces would have a lot of movement.

Install the inner Nyrod and clevises for the elevator. Adjust the travel for one inch up and down on high rate; ⅝ up and down elevator travel would be good for low-rate flying.

Install the aileron flex cables and solder 1⁄16 wire to the ends of the flex cable. Make Z bends in the wire and connect to separate servo arm holes about 60° apart. This will give more up aileron travel than down (1½ inches up and 1¼ inches down on high rate. About half that much travel would be enough for low rate).

When the radio installation is complete and the control surfaces are adjusted, the two center bays of the top wing surface can be covered. Be sure that you have some means of adjusting the clevises on the throttle and control surfaces without having to get back into the wing.

Flying: Finally, the fun begins.

Fill the fuel tank, start the engine, and adjust for best running. Try to get a good idle, unless you like to do deadstick landings. This model flies slowly and does not "want" to land unless the engine is idling (or stopped). After range-checking the radio and having someone verify that the controls are moving in the right direction, you should be ready for your first flight.

To hand launch, have an assistant grab the model between the fuel tank and the wing. Rev up the engine and have the assistant use an underhand toss so the model is about four feet high and in a level attitude. It should fly away very nicely.

After gaining some altitude, you can begin to test the controls. My prototype is not directionally stable and will not fly for long distances with the hands off the controls. The model has no dihedral and is very light; any breeze changes its flight attitude and the straight wing is not self-correcting. However, these traits make for great agility.

The Arrowplane will do an aileron roll at the rate of about 360° per second. Be sure you made the top a different color than the bottom; it is easy to lose track of the model's orientation unless you can distinguish top from bottom.

Loops work well and can be small or as large as the engine power will allow. The Arrowplane flies inverted fine but does need some down elevator. Cuban Eights can be done right at field center. Single, double, or triple rolls work as well to the right as to the left.

Before it is time for a landing, come back on the power and try some slow flight. Switch to low rate to get used to the landing feel. If you have the security of altitude, do a low-speed stall to find out just how slowly the model will fly. When landing, bring the power back to idle and set up an approach. The model's momentum bleeds off quite rapidly, but the thick wing with an eight-ounces-per-square-foot wing loading will allow for a slow landing speed. Keep the wings level and the landing will be uneventful.

Now pick it up, fuel it up, and try again.

Where else can you have this much fun with two ounces of fuel? ✈

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