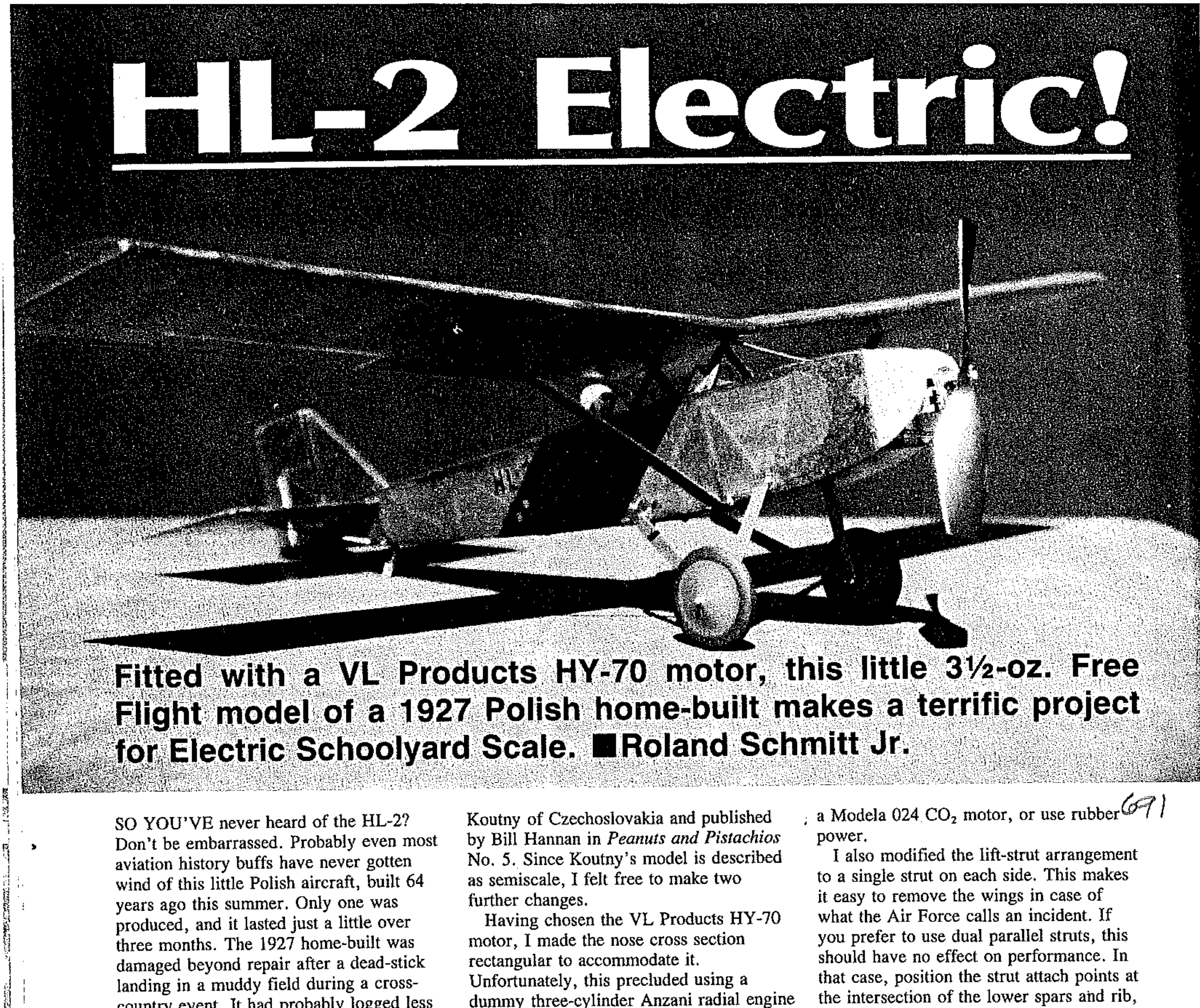
HL-2 Electric!



Fitted with a VL Products HY-70 motor, this little 3½-oz. Free Flight model of a 1927 Polish home-built makes a terrific project for Electric Schoolyard Scale. ■Roland Schmitt Jr.

SO YOU'VE never heard of the HL-2? Don't be embarrassed. Probably even most aviation history buffs have never gotten wind of this little Polish aircraft, built 64 years ago this summer. Only one was produced, and it lasted just a little over three months. The 1927 home-built was damaged beyond repair after a dead-stick landing in a muddy field during a cross-country event. It had probably logged less than 50 flight hours.

Why did I think such an obscure airplane worth reviving? Because it's an attractive design, and one that symbolizes the aviation fever that swept Europe and America in the decade after the First World War. The HL-2 is reminiscent of American home-builts like the Heath Parasol and Pietenpol Air-Camper but easily outclasses them in appearance. What's more, the original airplane had the sort of proportions that translate to a model that's easy to trim and fly.

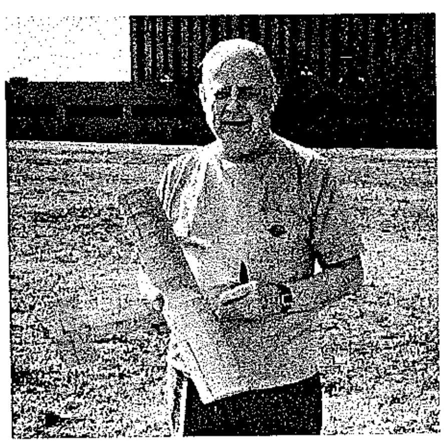
At 3½ oz., this little Free Flighter makes an ideal Electric Schoolyard Scale flier.

An admirer of the American silent film actor Harold Lloyd, designer Jozef Medwicki named the HL-2 after his idol, whose trademark was a large pair of horn-rimmed glasses. No record exists of an HL-1; it may have been simply a design study.

I based my HL-2 design on a Peanut model designed and flown by Lubomir Koutny of Czechoslovakia and published by Bill Hannan in *Peanuts and Pistachios* No. 5. Since Koutny's model is described as semiscale, I felt free to make two further changes.

Having chosen the VL Products HY-70 motor, I made the nose cross section rectangular to accommodate it. Unfortunately, this precluded using a dummy three-cylinder Anzani radial engine to match the prototype.

The HL-2 can also be powered by a HiLine Mini-6 motor. You can even go to a Modela 024 CO_2 motor, or use rubber power.

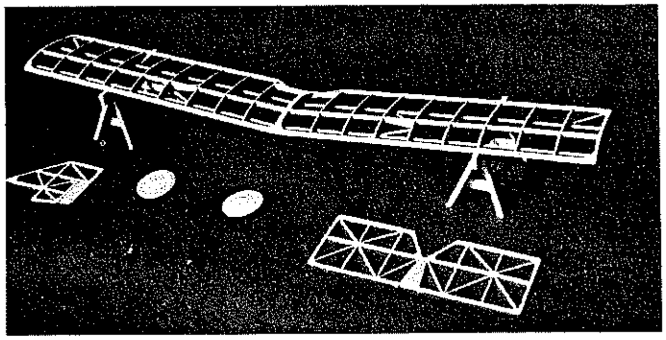


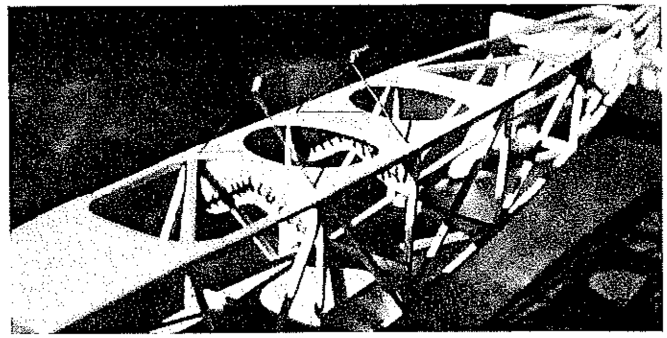
Big picture: Ready to go Free Flighting. That's a dummy of Wladyslaw Szulezewski, test pilot of the full-scale HL-2, in the rear cockpit. Above: The author flies his model at a local field. Performance is great, provided you wait for a day with no wind.

I also modified the lift-strut arrangement to a single strut on each side. This makes it easy to remove the wings in case of what the Air Force calls an incident. If you prefer to use dual parallel struts, this should have no effect on performance. In that case, position the strut attach points at the intersection of the lower spars and rib, and reinforce the wing structure at those points. The front strut will attach at the fuselage location shown on the plan, the rear strut at the next rearward vertical upright.

Construction. Most authors claim that their models follow "strictly conventional" construction techniques. The phrasing varies, but that's the idea. Well, this one really *does*. But be forewarned: The HL-2's performance largely depends on keeping the weight to the indicated level. Since the motor and battery weights are fixed, it's up to you to control the airframe weight by careful selection of materials.

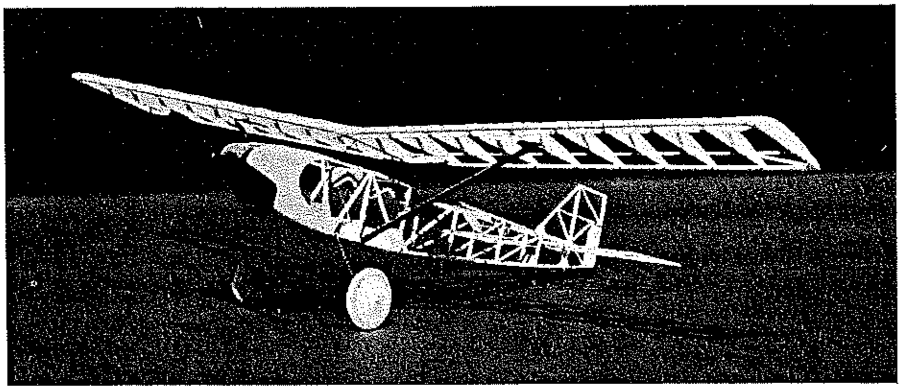
This is especially true for the balsa. If you lack experience in judging the appropriate grades of wood, ask an experienced builder to help. Someone who builds contest Rubber models would be especially helpful. (Electric and Rubber models are actually quite similar. A rubber motor, like a battery, has only so much





Left: The wing and tail structures in their bare bones. Note the additional bracing for the lift-strut fitting on the wing. Right: Close-up of the cabane strut detail. Note the cutouts for the optional rubber power. If you stick wtih Electric, you have a choice of motors.

energy.) Should there be no one to consult, stick to Sig or Midwest contest-grade wood.



The airframe structure completed and ready for covering. Nicknamed Petite Pole by the author, this design is light, simple, and strong throughout. And it flies almost *too* well; it's the first Scale or semiscale project the author has built that has begged for a dethermalizer.

Wing. The wing panels are built individually, then joined later at the dihedral break.

Make a template for the ribs. Recommended materials are $\frac{1}{16}$ phenolic sheet, Formica veneer, thin sheet metal, or $\frac{1}{16}$ plywood. Shape the template carefully, and be sure to position and size the spar notches accurately.

Using the template, cut 18 ribs from $\frac{1}{16}$ quarter-grain sheet balsa (6-8 lb./cu. ft.). Alternatively, you may cut 16 ribs from $\frac{1}{20}$ sheet and two from $\frac{1}{16}$ sheet. Cut three ribs from $\frac{1}{8}$-in. sheet. Make the center section rib by modifying two of the $\frac{1}{16}$ ribs and one of the $\frac{1}{8}$-in. ribs as shown on the plan.

Shape the wing leading edge from a $\frac{1}{8}$ x $\frac{3}{16}$ strip (firm grade balsa—10-12 lb./cu. ft.). Shape the trailing edge from $\frac{3}{32}$ x $\frac{1}{4}$-in. wood (medium grade—8-10). The short center section trailing edge is shaped from a $\frac{1}{8}$ x $\frac{7}{32}$ scrap. The lower spars are $\frac{1}{16}$ x $\frac{1}{16}$ firm balsa; the top spar is $\frac{1}{16}$ x $\frac{3}{16}$ firm A-grade stock. Make sure the grain runs straight.

Tack the plan to your work surface, cover the wing portion with waxed paper or Saran Wrap, and position the two lower spars as shown. Secure the spars with pins on either side; *don't* push the pins through the wood.

Glue all but the center ribs in place, including the $\frac{1}{8}$-in. tip ribs. Install the leading and trailing edges, and add the upper spar.

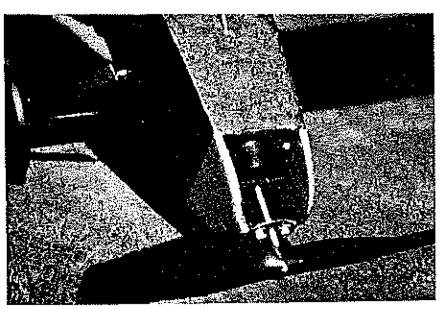
When the glue has cured, loosen the assembly from the waxed paper and block up each tip rib 1¼ in. Bevel the leading and trailing edges and the ends of the top spar to achieve a close fit. Glue the panels together at the butt joint.

Shape the $\frac{1}{64}$ ply doublers, then glue them to either side of the top spar and the rear of the leading edge. Laminate the two $\frac{1}{16}$ ribs and the $\frac{1}{8}$-in. center section ribs together. Install them in place vertically, and allow to dry.

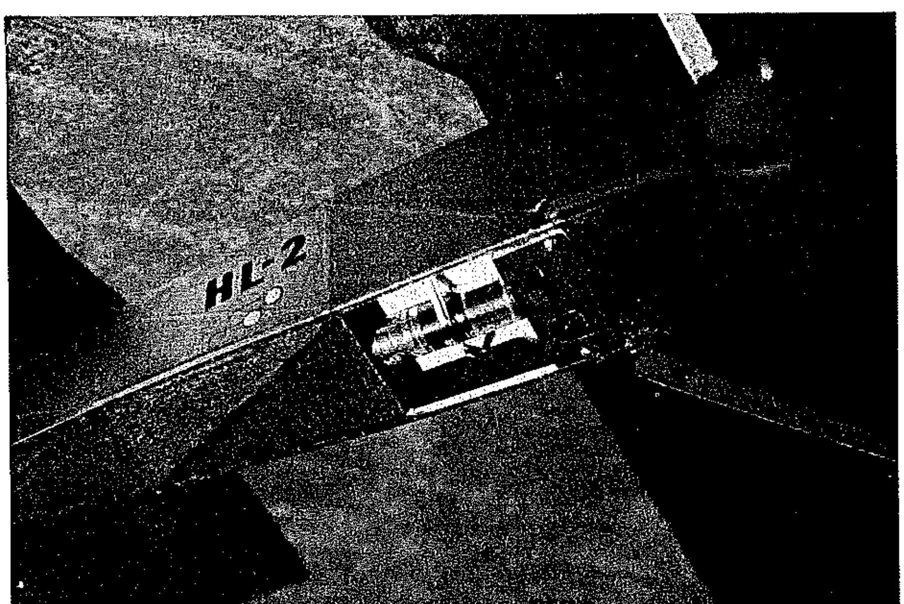
Remove the wing structure from the plan. Sand it all over, smoothing out any irregularities and rounding off the outer edges of the tip ribs. Install the bond paper gussets as shown on the plan. In addition to strengthening the structure, the gussets prevent unsightly wrinkles in the corners.

Build the horizontal stabilizer and elevator flat over the plan (protected as above with waxed paper). Use $\frac{3}{32}$-sq. firm balsa for the leading edge, tips, and spar. Make the corner gussets from lightweight $\frac{3}{32}$ sheet. For the ribs and diagonals, use $\frac{1}{16}$ x $\frac{3}{32}$ balsa cut from the 8 lb./cu. ft. rib stock set on edge. Make the trailing edge from $\frac{1}{16}$ x ¼-in. medium balsa.

Glue on the leading and trailing edges,

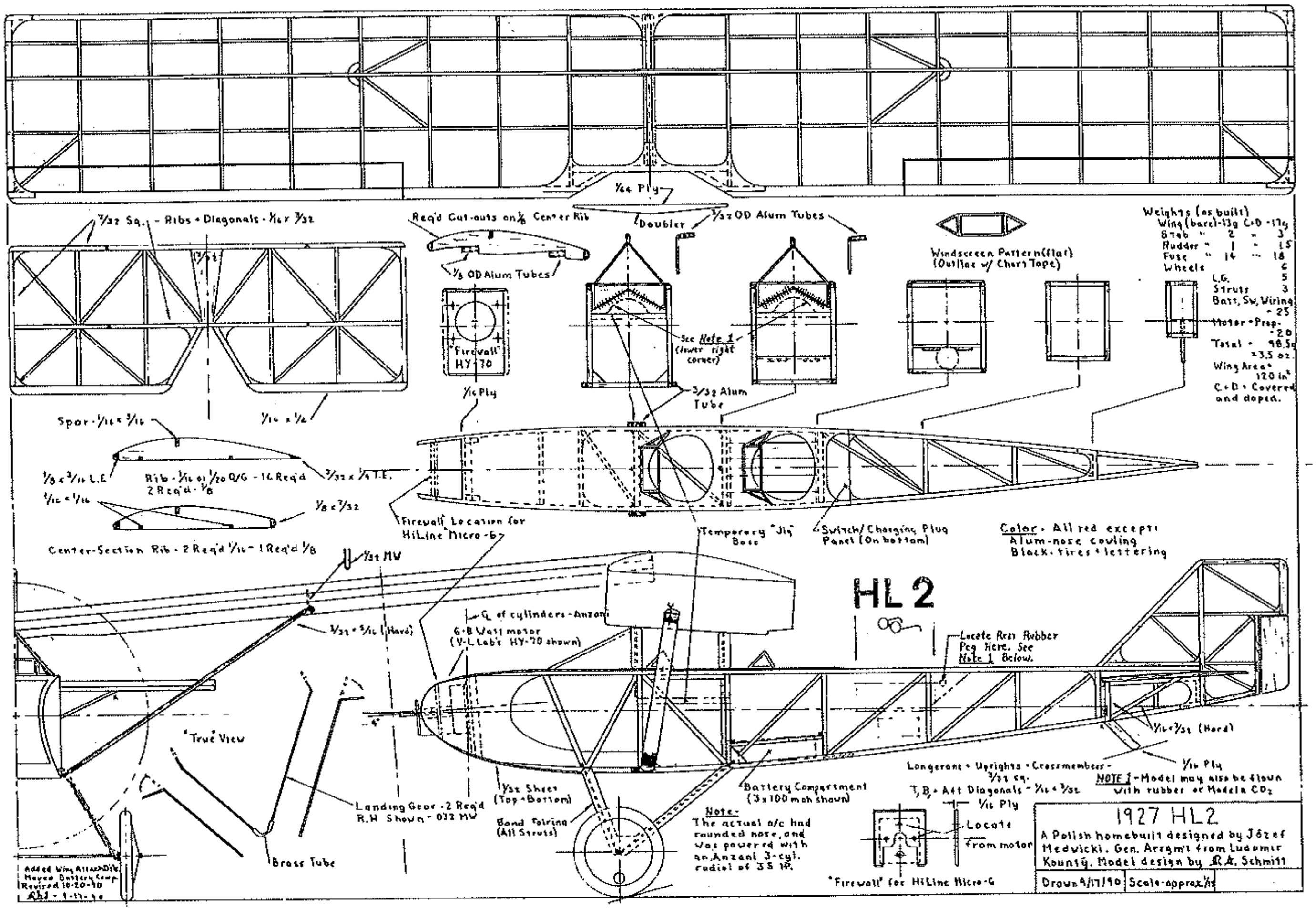


The author used the VL Products HY-70 motor. Correct downthrust is built in; the modeler can add side thrust as desired.



The switch, charging plug, and battery installation. The battery is half of a rechargeable nine-volt (actually 7.2-volt) transistor radio battery. The author located the battery compartment precisely at the horizontal balance point to eliminate the need for trim weight.

Full-Size Plans Available . . . See Page 203



then the spar, tips, and ribs. Install the gussets, and fit and glue the diagonals. Allow the structure to dry, and remove it from the plan.

Round off the leading edge and tips. Taper the ribs and diagonals aft of the spar to the thickness of the trailing edge (1/16 in.). Sand the assembly all over, and set it aside.

Make the fin and rudder in much the same way as you made the horizontal stabilizer and elevator. Shape the trim tab separately, and attach it to the structure with soft copper or iron wire. Sand the assembly, and set it aside.

Fuselage. Cut out two nose pieces from 3/32 firm sheet balsa. To spare your plan, Xerox the appropriate section, glue the copy to a piece of cardboard, cut it out carefully, and use it as a template to make the identical nose pieces.

Cut the four longerons from firm, straight-grained 3/32-sq. balsa. They should be of equal stiffness. One way of ensuring this is to strip the longerons yourself from the same piece of wood.

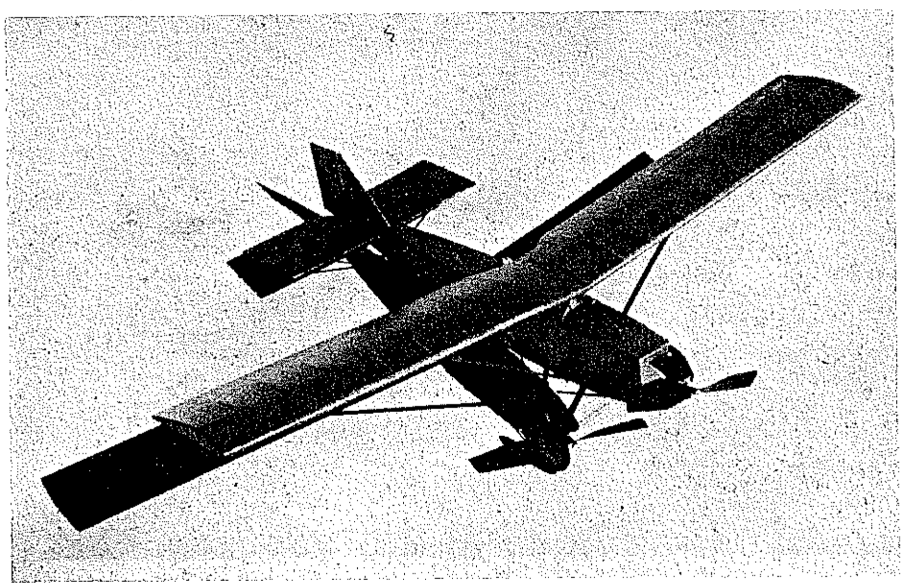
Pin one nose piece to the waxed paper-covered plan. Fit, glue, and pin the upper longeron. Soak the first 12 inches of the lower longeron in boiling water for about 10 minutes, and pin the longeron in place on the plan while still wet. Glue it to the nose piece when dry.

Cut the fuselage uprights, crosspieces, and forward diagonals from medium 3/32-sq. strip. Cut the aft diagonals (behind the front cockpit) from 1/16 x 3/32 strip. Accurately fit each piece before gluing it in place to ensure correct fuselage alignment. One way of ensuring that the sides are identical is to build the second side directly over the first, separating the glue joints with small pieces of waxed paper.

Make the 1/8-in. semi-bulkheads to which the cabane struts will be attached. Accurately bend the .032 music wire parts, bind them to the bulkheads, and CyA them in place. Slip a 5/16 piece of 3/32-O.D. aluminum tubing over the top joined section, which plugs into the wing; hold it in place with a drop of CyA. Note that the struts are of different heights to provide the correct angle of incidence.

Joining the fuselage sides begins with the construction of a temporary jig. It is used to install the two bulkheads which carry the cabane struts.

Continued on page 179



The HL-2 has simple, aerodynamically clean lines. Its proportions are perfectly suited to a semiscale Free Flight fun model. The design is easy both to trim and to fly.

possessions, hundreds of engines and models went up in flames.

There was some cheery news about the Vacaville, California site for the next FAI Team Trials. Besides being a wonderful boost for flying on the West Coast there will be the opportunity for a great vacation time for out-of-staters who may want to attend the $1,000 Half-A meet the following weekend at Whittier Narrows Recreation Area in Los Angeles. Bet the little lady would really *love* a nice modeling vacation.□

HL-2/Schmitt

Continued from page 60

The jig is a rectangular piece of 1/8-in. balsa 1 5/8 wide and 2 1/16 in. long. Tack-glue one of the semi-bulkheads at each of the 1 5/8-in.-wide ends, taking care that the bulkheads are parallel to one another and sitting vertically on the jig.

It may seem odd to have a firewall in an electric-powered model, but the term has been used for so long to describe the forward plywood bulkhead in powered models that we are obliged to use it for the sake of clarity. (In powered aircraft of all sizes, a structural barrier has always been placed between the engine—where a fire may readily start whenever the engine is operating—and the passenger compartment or other area on the opposite side as protection against the spread of any fire.)

At any rate, the material used to fabricate the structural bulkhead—which will be the firewall for the VL motor—depends on what motor you will be using. Make it from 1/16 ply if you're using the VL; make it from 3/32 balsa if you use the HiLine (or similar) motor. The firewall for the HiLine will be mounted farther forward as shown on the plan.

Back to joining the fuselage sides: Temporarily join the tail posts with a rubberband, and set the firewall/bulkhead in place (don't glue it yet). Wrap another rubberband around the nose to keep the firewall/bulkhead in position.

Insert the jig at the correct location between the fuselage sides, making sure the taller cabane is to the front, and glue the bulkheads to the corresponding uprights. Install the lower crossmembers at the bulkhead stations. Allow the assembly to dry.

Be sure the fuselage sides remain vertical and parallel. Once the glue has set on the cabane bulkheads, glue the tail posts together and add the remaining upper and lower crosspieces and diagonals. Cut the temporary cabane jig base loose, discarding it if you wish, and install the firewall or front bulkhead. Continually monitor the fuselage for alignment and squareness throughout assembly, correcting as necessary.

As noted, your choice of motor

determines the configuration and location of the $\frac{1}{16}$ plywood motor mount/firewall. The VL Products HY-70 motor was mounted to the firewall with four 2-56 x ½-in. screws and blind nuts as shown on the plan. The location of the mounting holes in the firewall was determined with the motor in place, and the holes were then enlarged to accept the blind nuts.

My flying buddy Jim Smith powers his HL-2 with HiLine's Mini-6, so he installs his motor mount/firewall $\frac{11}{16}$ in. forward of my location (detail shown on plan). Prior to installing either motor, cut and glue ⅛-in.-sq. mounting strips to the inner surfaces of the nose pieces at the location and angle shown on the plan (the 4° angle creates downthrust). Be sure the mounting strips are parallel. One way of accomplishing this is to make a template from scrap sheet to use in positioning them. Pull the fuselage sides partially together—with a rubberband, if desired—to fit the firewall correctly.

Add the two $\frac{1}{32}$-I.D., $1\frac{15}{16}$-in.-long aluminum tubes for mounting the landing gear. They should extend completely across the fuselage and protrude slightly as shown. Cement them securely in place with CyA.

Fit the lift-strut attach points. These are ½-in.-long pieces of $\frac{1}{16}$-I.D. aluminum tubing, bound with thread to the lower longerons and CyA'd in position as shown. Add the $\frac{3}{32}$ gussets.

Sheet the top of the fuselage from the firewall to aft of the rear cockpit with medium $\frac{1}{32}$ sheet, running the grain crosswise. Trace the cockpit outline from the plan, transfer it to the fuselage, and cut out both cockpits. Plank the lower surface of the nose with $\frac{1}{32}$ sheet, extending it back to the crossmember at the forward landing gear fitting. If you're using the VL Products motor, glue the forward edge of the $\frac{1}{32}$ sheet to the firewall. If you're using the HiLine motor, install a ⅛ x ⅛-in. crossmember just aft of the rear of the motor, and begin the covering at that point.

Carefully sand the completed structure all over and set it aside.

Landing gear and wheels. For years, I've had difficulty bending three-dimensional music wire landing gears. Finally, in desperation, I devised (or reinvented) a simpler method.

Each of the two main landing gear struts will be formed from two pieces of bent music wire—a forward strut and a rear strut. Make two forward and two rear pieces as shown on the plan. I use a piece of brass tubing to join a front and a rear strut piece.

The piece of brass tubing used to join the pair of strut wires takes some special preparation. Anneal (soften) a short piece (a couple of inches long) of $\frac{1}{32}$-in.-I.D. brass tubing by heating it in a flame (your gas kitchen stove or a propane torch, for example) until it changes color, then quenching it in water. Cut two pieces each ⅝ in. long and flatten the midsection of each with a pair of needle-nosed pliers.

Take a front strut piece and a rear strut piece of the music wire you bent previously and insert the straight ends into opposite ends of one of the pieces of annealed brass tubing. Now you can bend the brass tubing until you achieve the correct "true view" of the landing gear strut assembly as shown on the plan.

Insert the upper ends of the landing gear strut assembly into the brass-tube fittings in the fuselage. Assemble the second strut in the same manner and fit it on the other side of the fuselage. Now you will find it easy to bend minor adjustments into the strut geometries to get them into alignment with each other.

Once you are satisfied with the fit and alignment of the landing gear struts, you can finalize the assembly by using a drop of CyA in each end of the annealed brass tube which joins the front and rear strut wires. You must make sure that the tubing and wire are clean and free of grease or oil before the CyA is applied, otherwise the joint will not hold.

Using CyA to join the wire/tube joints is only feasible on a small, lightweight model like this one. Larger, heavier models would require that the joint be soldered or brazed. Make sure that you have made a left-hand and a right-hand strut!

Laminate the wheels from two disks of ⅛-in.-thick medium balsa, cut slightly oversize, with two small disks of ¾-in.-dia. $\frac{1}{32}$ ply (cut separately) on each side. Drill through the center of the wheel with a $\frac{1}{16}$-in. drill (preferably on a drill press), and insert a 2-56 screw. Place a nut on the far side to secure the wheel for further shaping. Chuck in an electric drill (a Dremel tool works fine), and sand the wheel to shape with an emery board or sandpaper block.

Remove the wheel from the screw mandrel, and insert a ½-in.-long piece of $\frac{1}{32}$-I.D. aluminum tubing, allowing it to protrude just slightly on one side. Secure the tubing with CyA. Fit a shallow bond paper cone over the other side of the tube, and cement it to the wheel. Complete the second wheel the same way, making sure the two are nearly equal in diameter. Set the wheels aside.

Cut the $6\frac{9}{16}$-in. lift-struts from a piece of $\frac{3}{32}$ x $\frac{5}{16}$ hard balsa. Sand to an oval cross section. Bend the upper and lower fittings from $\frac{1}{32}$ music wire. The upper fitting is a hook that engages an eye protruding from the lower surface of each wing panel. The lower fitting is merely an L, with a very slight kink in the base so that it sits snugly in the tube fitting on the fuselage. It should be snug, but *not* tight. Adjust the kink as necessary to allow the fitting to slip out aft if the wing should be knocked off. Bind both the upper and lower fittings to the strut with thread, secure with CyA, and set the assembly aside.

Covering and finishing. Give the completed structure two coats of dope; I recommend Lite-Coat thinned 30:70. Sand lightly after each coat. Give the wheels and lift struts four coats to almost fill the grain.

Keeping the airframe as light as possible limits our choice of covering materials. The lightest covering available, Japanese tissue, has sufficient aerodynamic strength but little puncture resistance. Silkspan, often used in Rubber models, is somewhat stronger. The lightest plastic covering (other than the Mylar film used by Indoor builders) is Micafilm. About 25 percent to 50 percent heavier than doped silkspan, it's also appreciably stronger.

Faced with these few choices, I opted for colored silkspan—red, in this case—to achieve the appropriate scale color without the weight of colored dope.

Silkspan is much easier to work with if you predope your structure. Simply position the silkspan, reactivate the dope with thinner, and press the material down as you move along the framework. Be sure to smooth and eliminate all wrinkles. Try to limit the size of your covering pieces to just slightly larger than the structures being covered.

When covering the wing, do the lower surface first, position and CyA the lift-strut fitting (the eye portion), and then proceed with the upper surface. Don't cover the bottom of the fuselage—I'll explain why later.

I shrink the covering by spraying on rubbing alcohol with an atomizer. After spraying, pin the tail surfaces (or weight them down) to a flat, paper towel-covered surface; this controls warpage.

Spray the wing one side at a time, and pin or weight down the center on a strip of ¼-in. balsa. To create the desired amount of washout, while the covering is still wet, weight down the tip leading edge on a ¼-in. block, and raise the tip trailing edge an additional $\frac{3}{16}$ in.

After shrinking all surfaces, carefully dope them with two coats of Lite-Coat thinned 50:50. To prevent warpage on the tail surfaces, apply the dope one side at a time, preferably by spraying rather than brushing. Pin the untreated side to a flat surface while you spray (or brush) the other side. When the dope is dry, turn the piece over and spray the other side. Allow it to dry, and repeat the two-step process for the second coat.

Follow the same procedure with the wing panels. Block up each panel to maintain the washout as the dope dries. I recommend using a third coat of dope for the fuselage because of the additional handling it receives.

Fairing the cabane and landing struts is simple. Take a piece of ½-in.-wide bond paper of the appropriate length, fold it down the middle, and wrap it around the strut and a 1/32 x 7/32 balsa strip. Cement or CyA it in place, and round off the trailing edge. Dope all the struts with two coats of clear followed by two coats of Sig Fokker Red.

The lift-struts and wheel disks may also be doped red at this point. Use flat black paint to simulate the tires. I marked the tire/wheel junction using a draftsman's compass with an ink pen point filled with Floquil Locomotive Black. This made it easy to finish painting the tire.

Initial assembly. Remove the tissue covering the recesses in the bottom of the 1/8-in. center rib. Place the wing upside down on your work surface and block it in position so that it's stationary. Cut two pieces of 3/32-I.D. (1/8-in.-O.D.) aluminum tubing; slip them over the 3/32 tubing on the cabane struts.

Turn the fuselage upside down, and, while it's still on the cabane struts, fit the 1/8-in. tubing into the recesses in the center rib. Tack each piece of tubing with *a single* drop of CyA. When the glue has hardened, draw the fuselage forward, leaving the 1/8-in. tubing in the wing and correctly aligned with the cabanes. If the fuselage doesn't withdraw freely, realign the strut ends until they are parallel and at the same angle relative to the top of the fuselage before repeating the attempt. Permanently CyA the wing tubing in place.

Check the fit of the lift-struts between the wing and the fuselage; they should fit snugly without being tight. They also should not distort the wing.

Since the wing is fixed, the slot for the horizontal stabilizer is cut larger at the front than at the rear. This allows the angle of incidence of the stabilizer to be adjusted by inserting shims at the leading edge to achieve the desired glide characteristics. Cement the stabilizer in place at the spar only. Make sure the fin/rudder is congruent with the centerline of the fuselage before gluing it in. Add the tail skid. The stabilizer struts must not be installed until after flight testing and trimming.

Insert the landing gear struts in the fuselage tubing, but don't glue them. Cut a 5¾-in. length of .032 music wire for an axle. Bind the axle with thread to the landing gear struts, leaving 3/8 in. on each side for the wheels, and CyA it in place. Install a small washer, and add the wheels. Secure them with a 1/16 piece of 1/32-I.D. aluminum tubing, again using only *one* drop of CyA.

Lastly, install the motor and propeller.

Balancing. Your model should now be complete except for the battery, wiring, and switch/charging jack panel. Support the airplane on the wing lift strut fittings, place the battery on the fuselage top, and slide it forward or aft until the craft balances horizontally. Build your battery compartment precisely at this balance point. This eliminates the need for trim weight, and it's why we left the bottom of the fuselage uncovered.

Build the battery compartment in the underside of the fuselage. Follow the plans, but add additional crossmembers and structure if necessary. Mount the switch close to the charging jack panel, and install the wiring as indicated on your motor instruction sheet. Cover and dope the fuselage bottom.

Markings and trim. The only available photos and data indicate that the original HL-2 was red all over, except for a natural aluminum nose cowling. The HL-2 lettering and a sketch of Harold Lloyd's horn-rimmed glasses were done in black on each side of the fuselage. No registration numbers or other markings are evident.

As is typical of open-cockpit airplanes, the cockpit edges were padded to save wear and tear on both the passengers and the airframe. A piece of split black tubing CyA'd around the edge of each cockpit nicely simulates the padding. I stripped the plastic insulation from a piece of 12-gauge automotive wire, then slit it with an X-Acto blade. Add the windshields as shown.

Flying. Wait for a day with almost no wind. Check the balance point again. The model should balance at or immediately (1/16 to 1/8 in.) aft of the main—i.e., upper—spar.

Remove the propeller, and test glide the model over the proverbial tall grass. Adjust the stabilizer shims until the model glides to your satisfaction. Reinstall the prop, and attempt a powered flight on *no more than* quarter charge. Increase your power run gradually, adding right or left thrust as desired. With 1° of right thrust and the rudder tab bent approximately 1/32 in. to the left, the prototype climbs and glides in a large left circle.

The HL-2 is an excellent flier—in fact it's really *too* good. I've almost lost it twice in thermals. The little $3\frac{1}{2}$-oz. ship flew eight to 10 minutes on only one-third charge, and I had to chase it nearly a mile each time. I've *never* charged the battery pack more than 40 percent of capacity. Normal—that is, nonthermal—duration ranges from 1:45 to 2:15.

This is the first Scale or semiscale model I've built that begs for a dethermalizer.

In closing, I wish to thank James R. Smith for reviewing the construction sequences and making a number of helpful suggestions.

References

Cynk, Jerzy B. *Polish Aircraft 1893-1939.*

Hannan, Bill. *International Peanuts & Pistachios*, vol. 5.

Fly Electric!

FF Duration/Murphy

Continued from page 62

design is highly dependent on the ability of the wings to handle tremendous bending loads without failure. Two-piece wings compound the problem by placing the joint at the maximum load location which is obviously at the center of the wing.

Since $\frac{5}{32}$ music wire wing joiners had been utilized with good success for the past decade, a bench test goal was established to fabricate a spar that would successfully bend the $\frac{5}{32}$ wire before the spar itself might fail. Initial tests indicated that glues alone would not accomplish the requirement, and ultimately a technique for spiral wrapping the structure with Kevlar thread was developed which transferred the loads to the thread making the type of glues used basically unimportant.

The next step was to tailor the weights and thicknesses of the various materials to arrive at an optimum-strength to lowest-weight determination.

An inadvertent field test came about when one model nosed into a full power dive from 1,000 ft. up and smacked into a concrete runway at WPAFB. The wing did not flutter or fold under the stress of the dive, and an examination of the remains yielded an unscathed spar. The spar was even removed from that wing, rewrapped with Kevlar thread, and used in a subsequent wing.

The sketch showing a double tapered spar fabrication should be rather self-explanatory with actual root and tip dimensions depending on the particular wing panel length and airfoil used. Note that the carbon-reinforced basswood sides are to be only 12 in. long (they help make up the joiner box on the inboard end of the fabricated spar), so a calculator is a handy tool to compute these dimensions at the various tapered locations. A step-by-step recommended procedure would be to first determine the required dimensions of all components including those for the balsa core. The inboard end of the balsa core is to be 2 in. shorter than the top and bottom carbon plates to permit a pocket to receive the brass tube for the joiner wire.

The initial construction step is to epoxy a 4-in. length of .007 carbon onto one end of a 12-in. long, 3-in. wide sheet of $\frac{1}{32}$ basswood from which is to be cut four 12-in. long strips of the now carbon-reinforced basswood to the width of the desired root dimension. These are to become the sides of the spars. Now cut the tapered balsa core from straight grain 6-7 balsa which can be sanded to shape from initial $\frac{1}{4}$ in. square or oversized $\frac{3}{16}$ in. sq. stock depending on the required dimensions. The top and bottom caps are tapered strips of .021 thick carbon sheet.

With all components trimmed to shape, the spar is assembled using cyanoacrylate cement (CA). After a final sanding, spiral wrap the assembled spar using Kevlar thread to a pitch of $\frac{1}{64}$ in. at the root increasing to a $\frac{3}{16}$-in. pitch at the outboard end and cement coat to retain in place. Norm states that a pair of finished joiner spars, using this technique, should tip the scales at 10 to 11 grams. The completed spar is then used in the construction of the wing panel where upon completion a 2-in. length of $\frac{5}{32}$ in. I.D. brass tubing is potted in place into the previously hollow carbon box end using a mixture of epoxy and microballoons.

Obviously, the foregoing is a condensed version of "how-it's done," and if you care for more detailed instructions send a SASE to Norm and he will gladly send you a copy of a formal uncondensed article on the total process which we do not have the space to relate word-for-word. Norm's address is found elsewhere in this column, and we certainly thank him for this quite informative building tip.

FF Publications. The 1990 edition of the National Free Flight Society *Symposia*, which is a 129-page collection of design, theory, plans, and photos of interest to Free Flighters worldwide, is still available. The *Symposia* has been published without fail annually by the NFFS since 1968. Each issue covers various aspects of both Indoor and Outdoor Free Flight as to state-of-the-art competition as well as sport flying.

Among other items and features, the current issue contains power articles on hi-