Io

One of Sailplaning's most successful designers has once more put together his drafting table, practical contest experience, and "aircrafting" talents to give us another sophisticated competition Sailplane. This one, in the Two-Meter class, uses modern laminates for superb strength. ■Terry Edmonds

NAMED AFTER one of Jupiter's moons, this model also happens to be a Two-Meter Sailplane that's an offspring of my Standard class Callisto 82 Sailplane. However, the design presented here is constructed of composite materials, whereas the Callisto 82 was entirely of built-up construction.

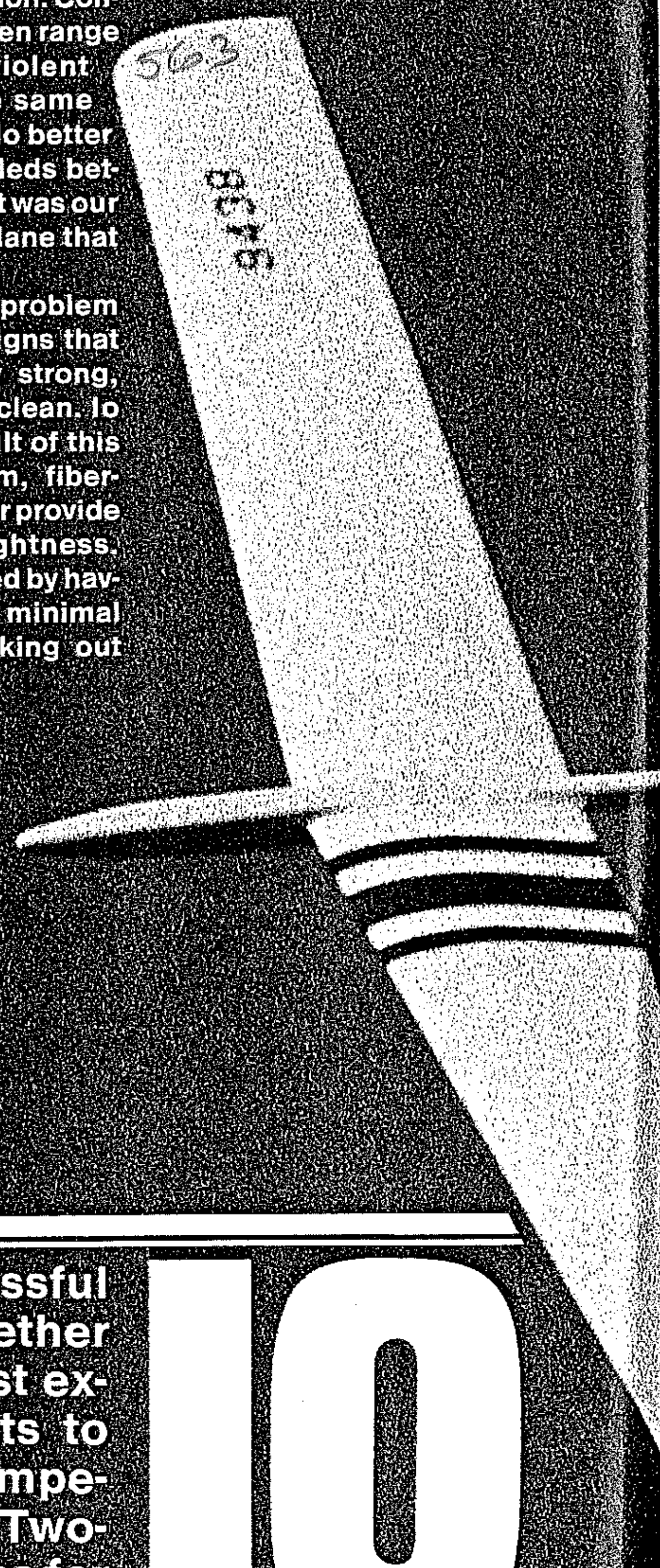
Development of this design has taken place over a three-year period during which a number of prototypes were built by myself and fellow members of the Eastern Iowa Soaring Society. In competition the Io has placed in the top four of the Two-Meter class at the AMA Nationals three years in a row (1984-1986). Additionally, an Io together with a Callisto 82 won the Lee Renaud overall award at the 1985 Nats for the best combined scores of Two-Meter, Modified Standard, and Unlimited classes.

Even though the Io is of composite construction, the components are easily obtainable. Experienced builders should not have difficulty with construction. It is definitely not recommended for beginners, though, because of the close quarters in some areas and the fitting tolerances that are required to achieve satisfactory results.

The primary design objective when we began this project was to obtain a wide range of speed while keeping the wing loading relatively light. This is an important factor in a Sailplane's ability to win in any type of weather condition. Conditions at contests often range from dead calm to violent winds, all within the same meet. Floaters may do better in light air and lead sleds better in high winds, but it was our idea to design a Sailplane that could do both.

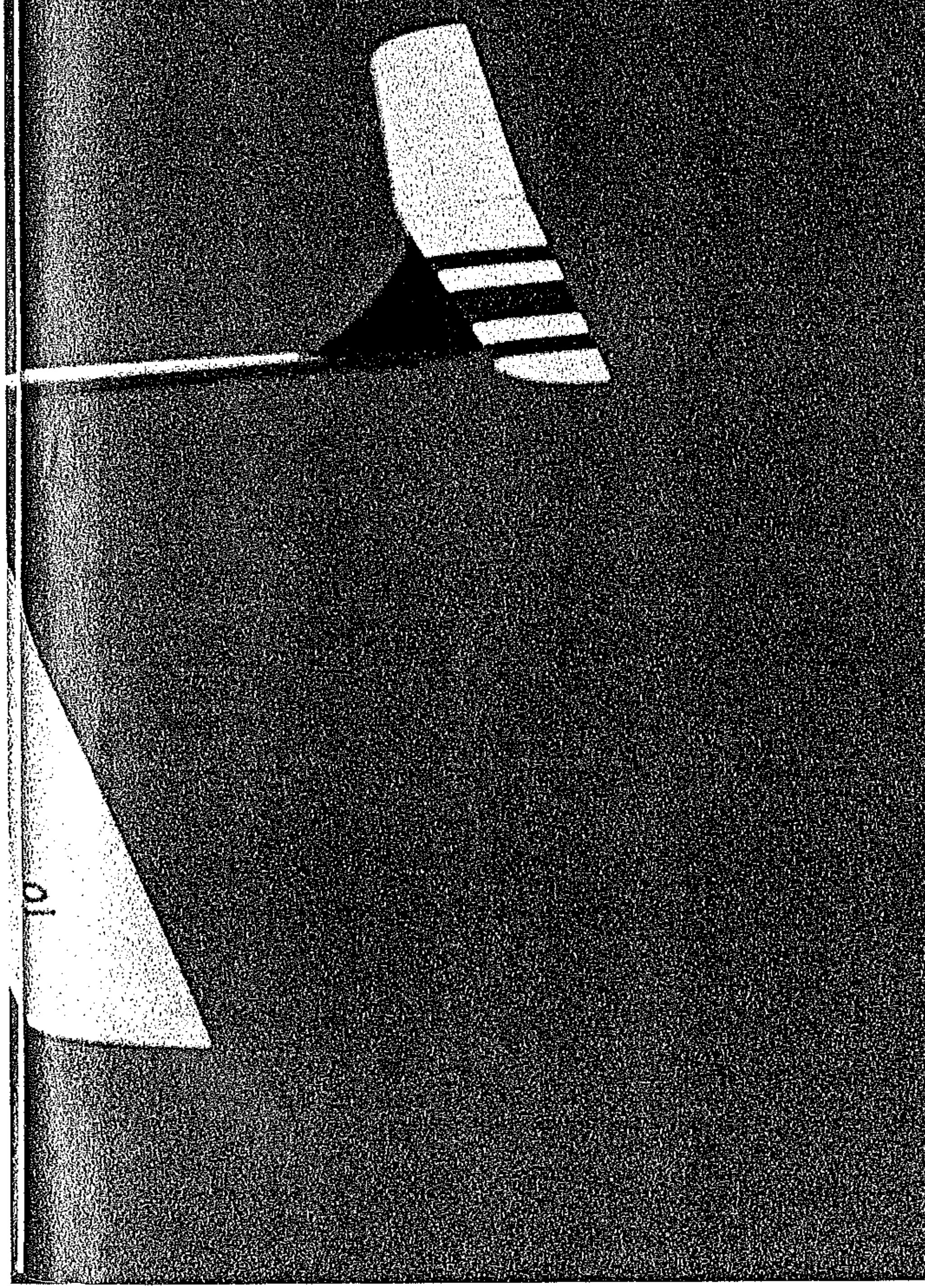
My approach to this problem was to work with designs that are light, reasonably strong, and aerodynamically clean. Io is the Two-Meter result of this philosophy. The foam, fiberglass, and carbon fiber provide the strength and lightness. Cleanliness is achieved by having low frontal drag, minimal control linkages sticking out in the airstream, tightfitting components, smooth-flowing lines, and a thin airfoil.

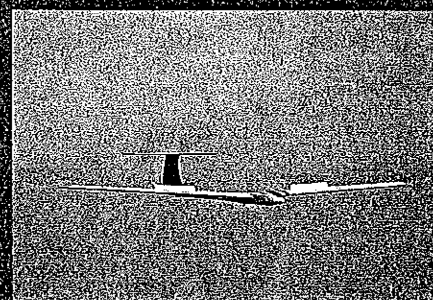
I chose the Eppler 193 airfoil because of its low drag combined with exceptional slow-



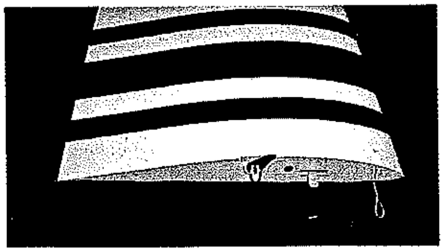
speed performance, and also because it's one of the best airfoils around for a non-flapped duration Sailplane. The Io can float on almost even par with any other Two-Meter floater design, yet with slight retrimming it can fly much faster without giving up much in sink rate. I find ballasting is not necessary until wind speeds exceed 15 mph; then I ballast at relatively small amounts to maintain maneuvering speeds. I typically find Io flying, even when ballasted, with much lower wing loadings at speeds as fast or faster than the competition.

All the earlier prototypes of the Io were entirely of built-up construction, as was the Callisto 82. I decided to try to make the design stronger with composite construction, while at the same time not sacrificing lightness. A few ounces more weight would have significantly affected the original intent of the design. The fiberglass fuselage turned out to be about the same weight as the wooden version, or perhaps a bit lighter. The foam wing came out about 1 oz. heavier than the built-up wing, but otherwise the two versions weighed about the same. In order to realize this equality, very careful weight selection of material in the wing must be done. It should be pointed out that the composite structure presented here was designed to survive flying stresses, moderately strong zoom launches, and reasonable landing impacts. It was not designed to survive

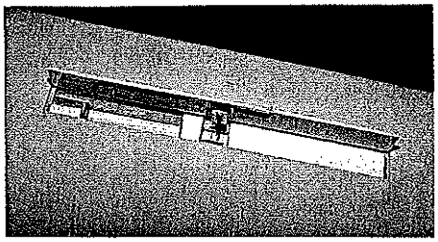




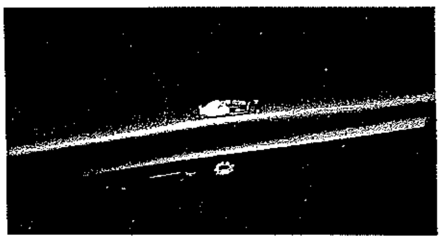
Big Picture: Captured in this sweeping turn by the quick lens of Steve Gregory, it's easy to see the beautiful fit and sleekness that have made this model a several-times major winner. Above: Io has a very thin frontal profile as can be seen even in this rather "dirty" mode with the spoilers up. Below: Construction uses fiberglass, foam, wood, and carbon fiber to give this model the lightness required to be competitive and a structure that is strong enough to go for moderate zoom launches.



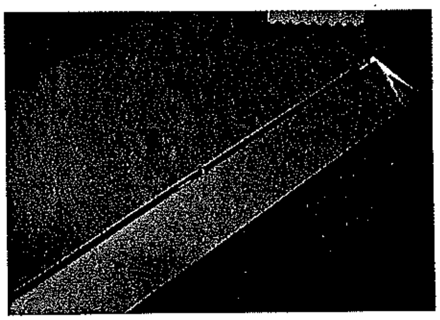
Of note in this view of the wing inboard tip are the pin tube, Ace wing lock, wing rod tube, aileron bellcrank, and the spoiler line.



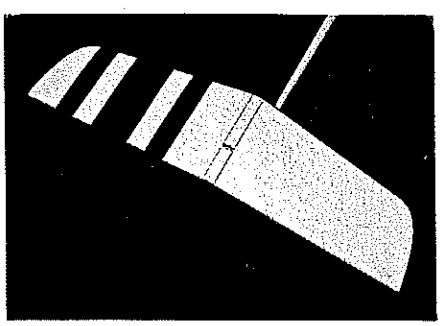
Ballast slugs are loaded through the spoiler bay and are retained by a piece of plastic foam inserted into the bay. The spoilers use a weight and magnetic latch for closing.



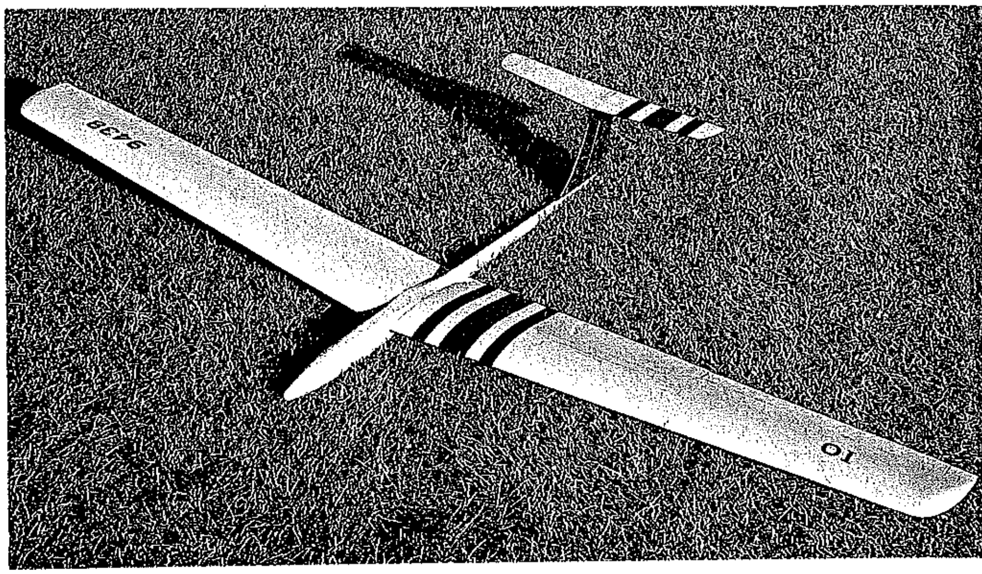
The modified Airtronics tow hook as it will be installed. The aluminum hook has to be filed down to allow tow ring clearance.



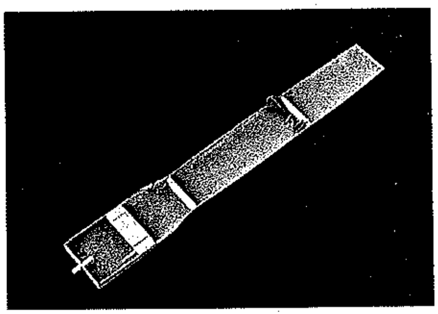
The aileron horns are internal as can be seen in this bottom view of the wing panel. The ailerons are hinged on top, leaving only this narrow gap on the bottom of the surface.



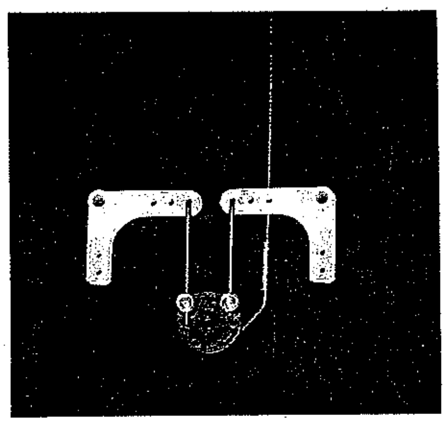
The concealed stab drive barely shows in the slot of the center faring of the stabilator.



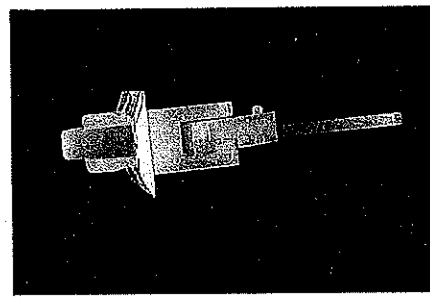
The Io is the Two-Meter offspring of our author's Standard-class Callisto 82 that was featured in the October 1982 issue of *Model Aviation* (plan #383). Io's contest track record has quickly established it as just as much a thoroughbred as the larger model that sired it.



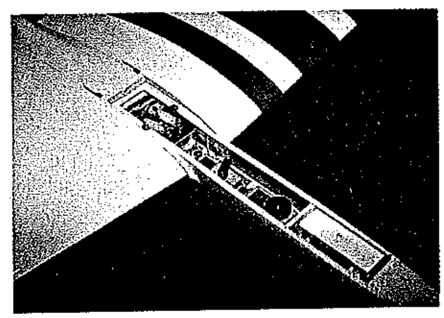
A small block fixed into the bottom of the fiberglass hatch cover retains the aileron connecting wires when in position, and a paper clip is used as the hatch-cover tie-down.



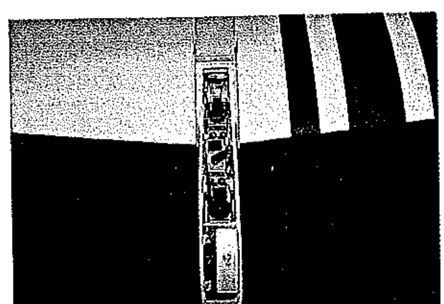
A mockup of the aileron linkage with its quick disconnect feature. The L-shaped wires are dropped into the bellcrank holes for connection. The cable is for the rudder.



The Airtronics releasable tow hook is modified (text has details) so it can be mounted inside the fuselage rather than outside.



Turnbuckles are used on this version for fine aileron trim adjustment. A section of tubing guides the tow release pull string out of the way of the aileron and rudder linkage.



The servos, starting from the front, control the stabilator, spoilers and tow hook, and the aileron and rudder. Font compartment houses the receiver and switch harness.

crashes or spear-type landings.

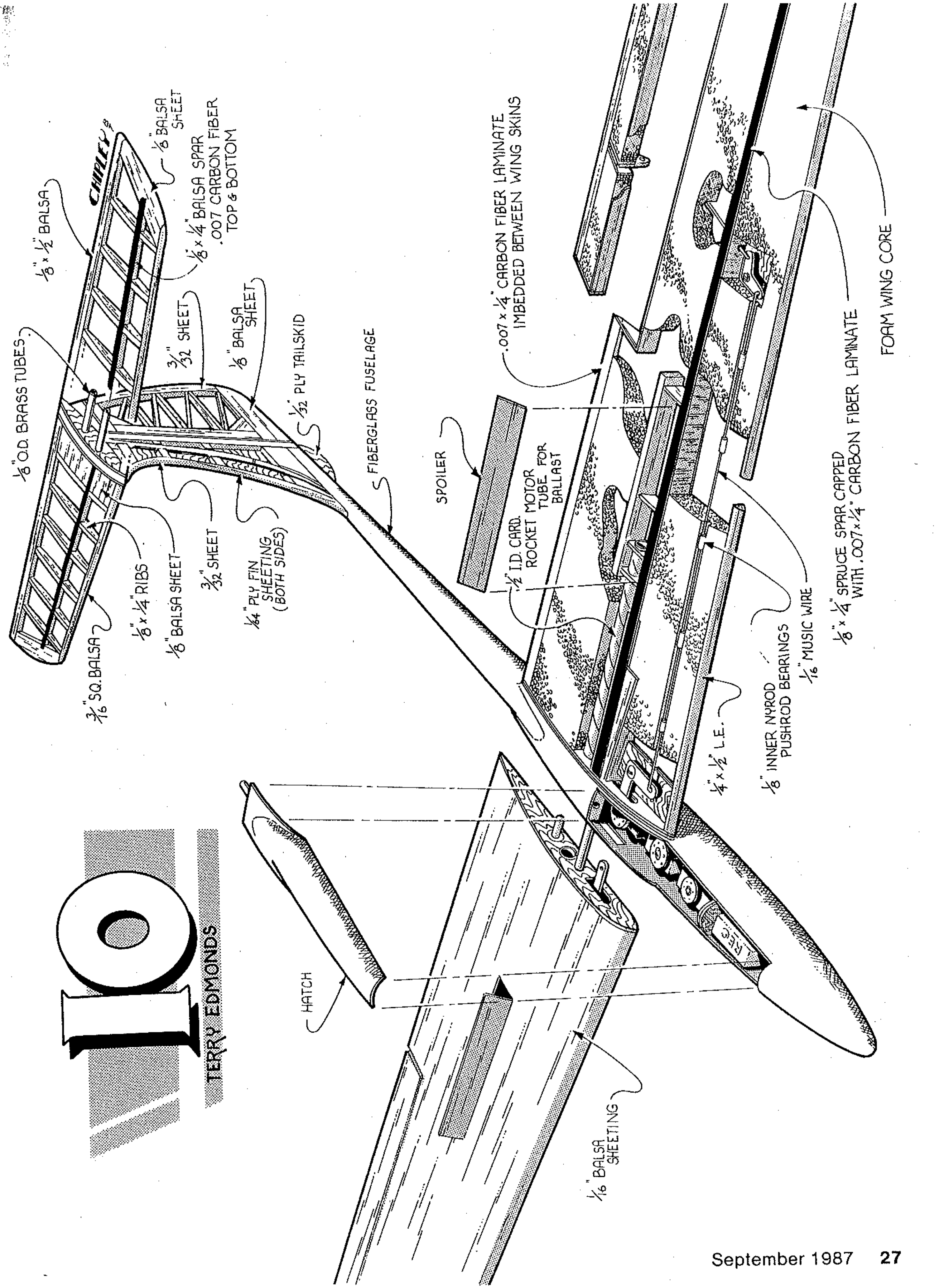
The rivalry between flat-wing and polyhedral Sailplanes seems to be leveling out
The rivalry between flat-wing and polyhedral Sailplanes seems to be leveling out
at about a 50/50 mix on the contest scene. Flat-wing aileron Sailplanes are inherently spiral-unstable and therefore more difficult to fly well. On the other hand, maneuverability of the ailerons is definitely better. I think that once the instability problem is overcome through practice, the aileron Sailplane has an edge for precision/duration events, and so I chose to go with the flat wing.

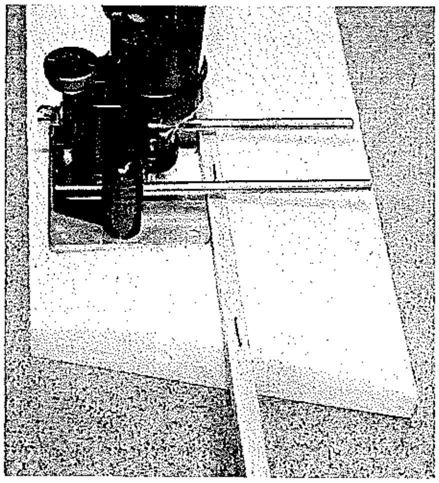
Construction. It is assumed that builders of this Sailplane have at minimum built other Sailplanes, and have a good understanding of the basic model building skills. Therefore, rather than give step-by-step instructions, only important and unusual points will be addressed.

An Io fiberglass fuselage can be obtained from either of two sources: Viking Models

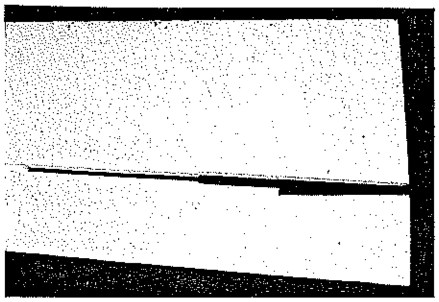
IO

TERRY EDMONDS

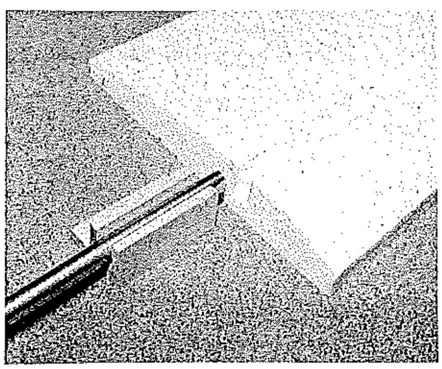




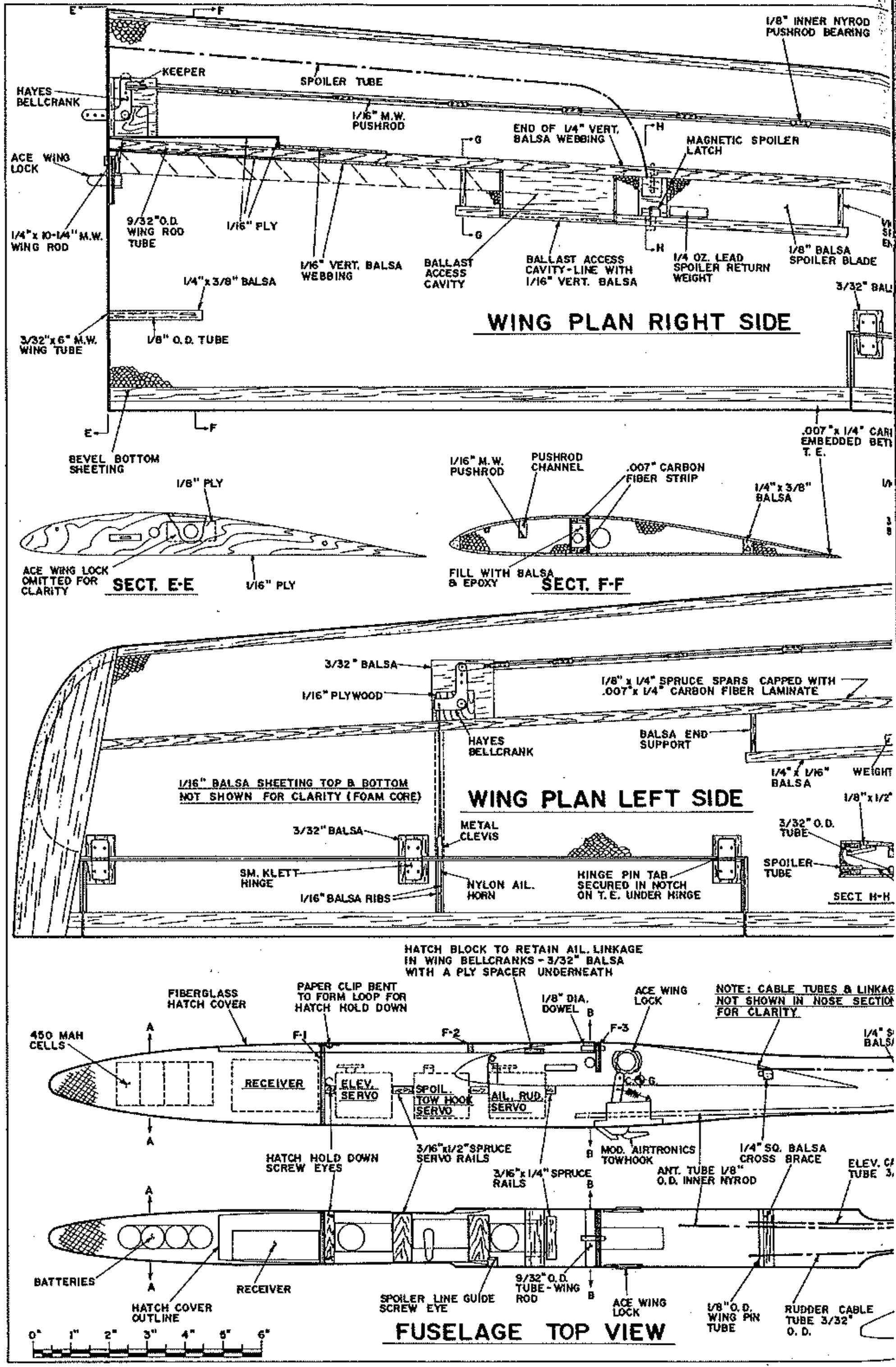
A Dremel router tool run along a temporary guide is used to cut out the spar notches. The curved notches are best done freehand.



Cutouts in the wing for the offset wing tube box and webbing are done with hand tools.



A special cutter and jig are made to cut out the cavity for the cardboard ballast tubes.



USA, 2026 Spring Lake Dr., Martinez, CA 94553; or Bob Sealy's Quality Fiberglass, 521 96th Lane N.E., Blaine, MN 55434. (Bob Sealy's Quality Fiberglass also markets Io foam wing cores.)

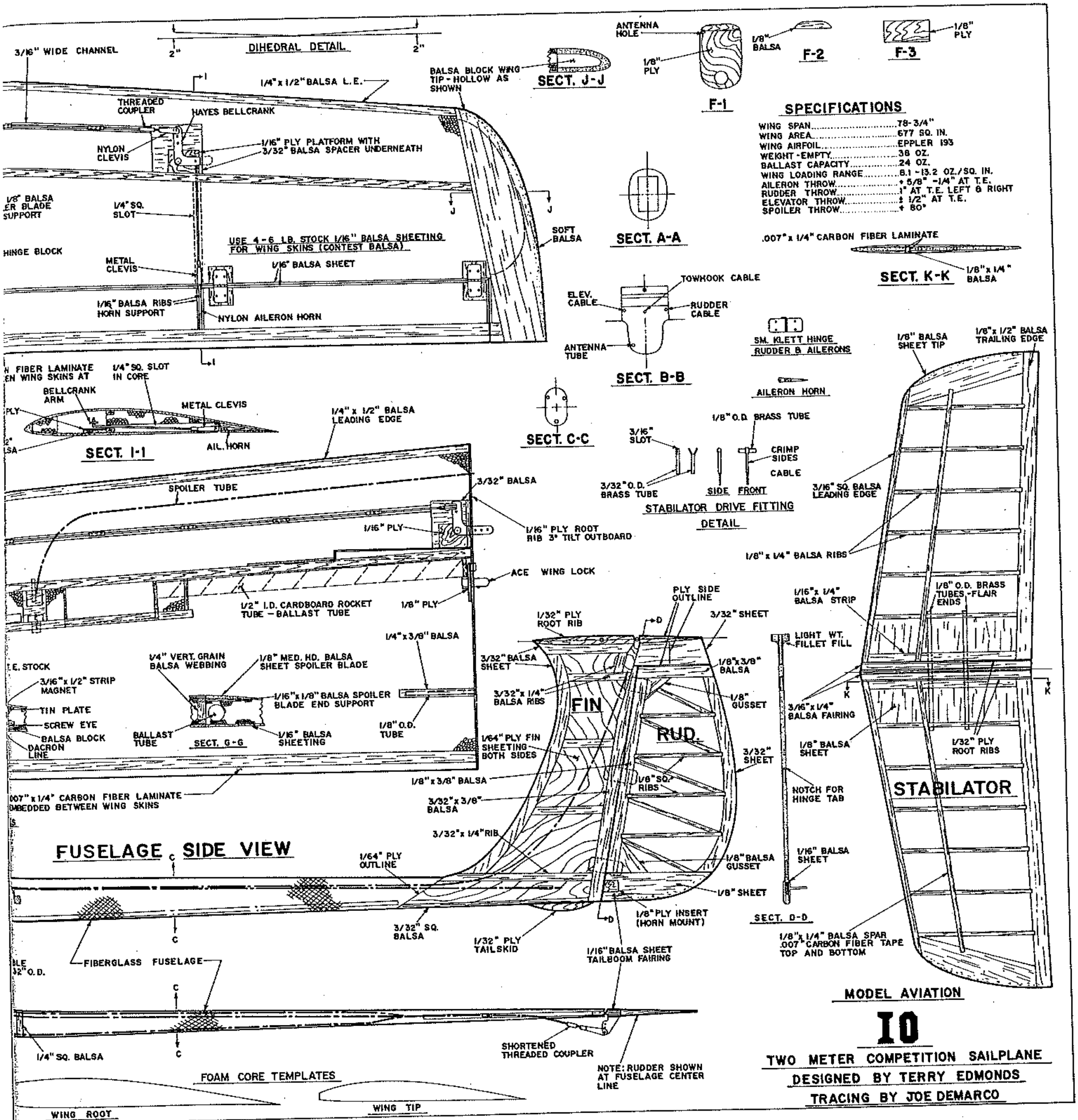
The carbon fiber material used in the Io is all .007 x ¼-in. laminate. The laminate consists of one layer of unidirectional carbon fibers embedded in a thin sheet of epoxy. This material is available from various sources and can even be bought in ¼-in.-wide strips from Bob Violett Models, 1373 N. Citrus Rd., Winter Springs, FL 32708. Buying it this way avoids having to strip it yourself. All other materials in the Io are common items available from regular hobby sources.

The wing cores are cut with the usual hot-wire method. The tic marks on the templates take into account leading-edge wing taper. Be sure to line these up on the centerlines of the foam block. Failure to do this will cause a twist to be cut into the wing panel. Bevel the core roots 3° so that the root rib will fit flush with the fuselage. One method of doing this is to first prop up the core to the correct dihedral angle so that the root is even with the edge of the building table, and to then make a few passes over the edge with a sanding block. Another way is to use a hot wire across two 87° templates.

Spar notches are cut into the core with a Dremel router tool. This method produces a good-fitting spar—a necessity when portions of the shear webbing are actually the foam core. Pin a balsa strip to the core for a router guide. Cut out portions of the core for the offset wing tube box and wood webbing. Try to cut this accurately so that the parts will fit well. I use a razor-saw blade removed from the holder for the rough-cut and a flat Permagrit sanding blade for finish.

Cutting an accurate cavity for a round ballast tube in a foam core can be challenging, to say the least. I have had the best success with the method shown in the photos. Make a cutter out of a 17/32 x 12-in. brass tube. Using a file, sharpen one end of the tube and then cut teeth into it.

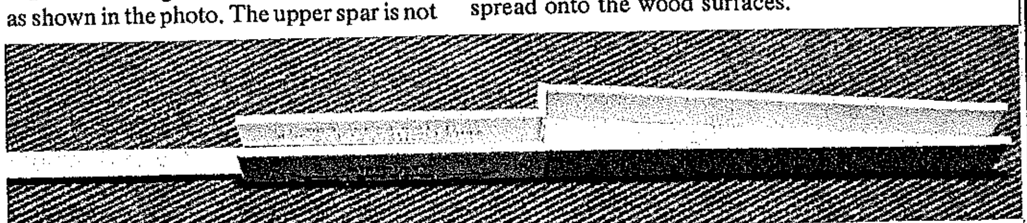
Make a jig to guide the brass tube cutter



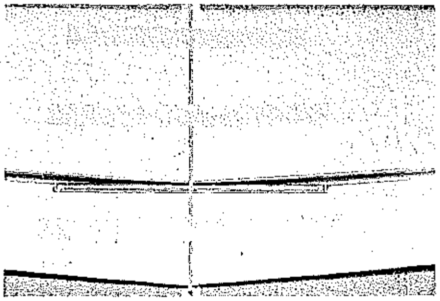
into the core at the proper angle. To cut the hole in the core, twist the cutter by hand while applying a slight inward pressure. After the cutter penetrates the core a short distance, a piece of cylindrical foam, which you must remove before proceeding, will break off inside the cutter. Try it on some scrap foam—it works.

The spruce spars are capped with .007 x ¼-in. carbon fiber laminate. I clean the carbon fiber with alcohol, then bond it to the spars with slow-set cyanoacrylate (CyA) glue. Handle the laminate with care, as the carbon fiber has very wicked splinters. Be sure the carbon fiber strip gets total glue coverage. Any bond voids could cause the carbon fiber to separate from the spar under compression stress.

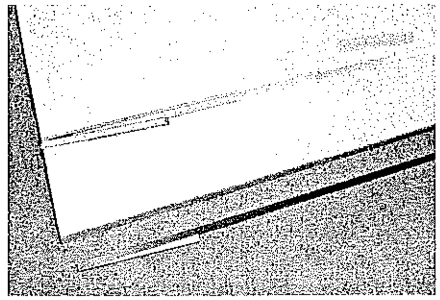
Build the wing tube box on the lower spar as shown in the photo. The upper spar is not installed until later. Use epoxy and clamp the assembly together with the upper spar used as a spacer. Epoxy this assembly into the cores with a very thin layer of glue spread onto the wood surfaces.



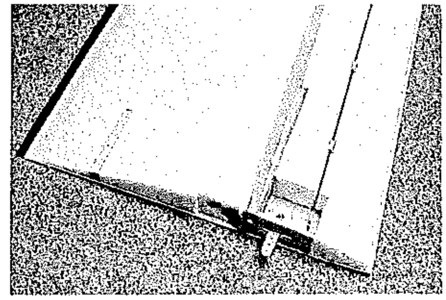
The wing tube box is built up on the lower spar, then put into the wing core. If CyA glue is used, be sure it has cured before placing in foam. The upper spar will be installed later.



The core halves are temporarily taped together with the ply root ribs in between to locate the wing tubes. Fit and accuracy are paramount; make sure everything is right.



The wing tube-box filler, webbing, and top spar are epoxied into place in one operation. Allow the core to cure in the foam beds.



The long aileron pushrod is music wire with Nyrod bearings spaced along for stiffening.

Temporarily fit the left and right cores together as shown in the photo. The wing tubes are installed with a short wing rod while ply root ribs are used as positioning guides. The tubes are tack-glued in place, and then the core halves are separated. Fill the wing tube box with a mixture of hard balsa filler strips and microballoons/epoxy mix. Before the mix sets up, epoxy the webbing and top spar in position, then place the cores into the beds and weight everything down until the glue cures.

Make the remaining cutouts in the cores for linkages, spoilers, etc., using a router and razor-saw. Route out the pushrod channels in the same way as the spar channels were done. Route out the spoiler tube channel freehand because of its compound curves. The hinge block cavities are also cut out with a router. I pre-notch the hinge blocks prior to putting on the sheeting, to simplify this chore later on.

To achieve satisfactory operation of the ailerons in the Io, a few points should be observed regarding the wing linkages. Only one small servo drives both the ailerons and the rudder. This makes it important that the wing linkages be absolutely free-moving. The root bellcrank mount should be beveled so that the arm protruding from the root is perpendicular to the root (at a 3° angle with reference to the wing bottom). The pushrod bearings must be carefully aligned so as not to cause any mechanical drag. Pushrods should pivot easily in the bellcranks without slop. The clevis in the long pushrod is adjusted so that the inner and outer bellcranks operate parallel to each other.

The internal aileron horn is inherently short-coupled and makes the throw sensitive. This is compensated for by throw reduction at each bellcrank. This arrangement tends to magnify linkage slop, though, so it is important that actual slop be kept to a minimum. Because proper installation of the linkage is necessary to produce proper throws and attain tolerable rigidity, the plans are quite detailed on this matter. If you do not feel comfortable in coping with this problem, an alternative would be to install standard external horns on the bottom of the ailerons, with short pushrods

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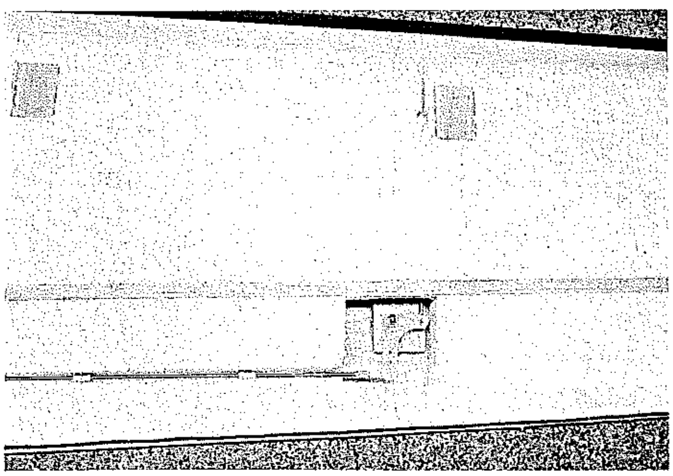
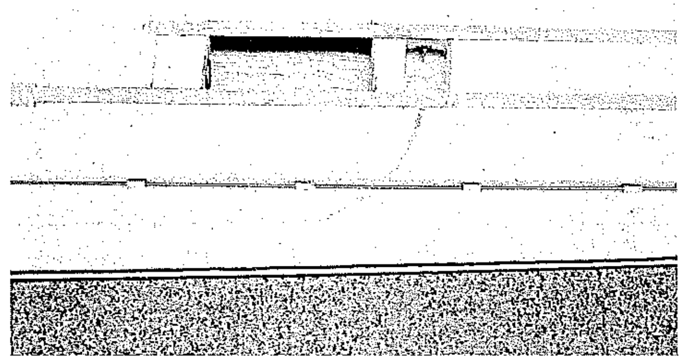
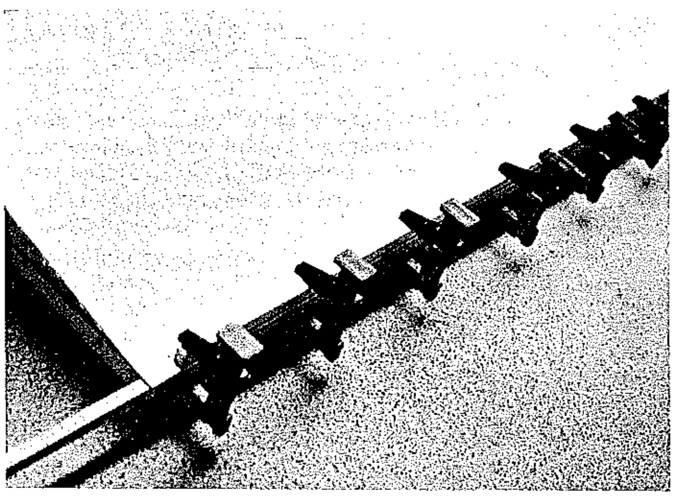
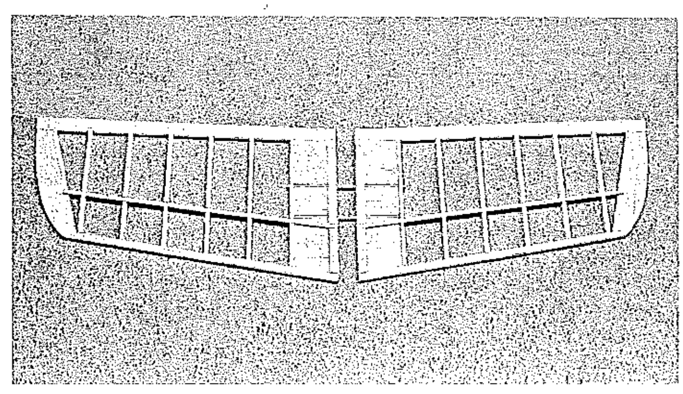


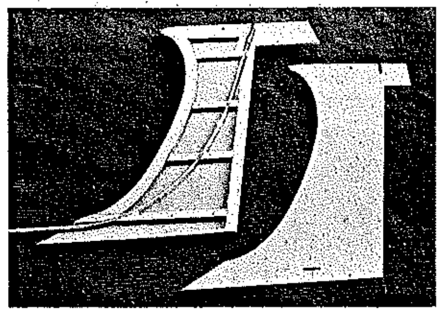


Left: The notch for the long pushrod is cut into the top of the core; the notch for the short aileron horn pushrod into the bottom. Right: The spoiler bay has a cavity for ballast access and another for the linkage. Route a recess in the remaining foam for the spoiler blade.

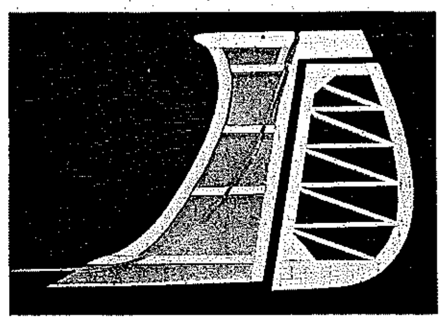




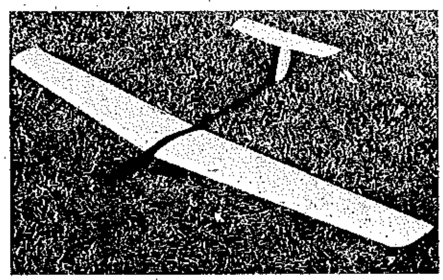
Left: Carbon fiber laminate is epoxied between the wing skins at the trailing edge. Spruce strips are clamped on the T.E. to keep it straight while curing. Above: Carbon fiber laminate (or similar substitute for strengthening) *must* be applied to the stabilator spar-sides. The joiner tubes are built as one piece, then cut in half.



The fin is constructed of a balsa frame sandwiched between two 1/64 plywood sides.



Rudder is of conventional built-up construction with a ply-insert control horn mount.



lo quickly established a proven contest record both on the Midwest and National Contest circuits. This one built by John Cyr placed in a meet a week after it was built.

exiting the bottom of the wing.

Any kind of wing-skin adhesive can be used; but remember, it is important that it add the absolute minimum of weight. I use Supertape, because it weighs practically nothing. However, I have had some minor problems with small areas delaminating.

For additional trailing edge strength, a strip of carbon fiber laminate is embedded between the wing skins at the trailing edge. This is glued in with epoxy as the top sheeting is put on. Clamp the trailing edge between spruce strips until cured, to ensure a straight T.E.

The stabilator is of conventional built-up construction. The leading edge, trailing edge, and tip need to be shimmed-up off the building board for proper height. The spars have carbon fiber laminate strips bonded to both the front and back sides. This makes for a very strong, lightweight stab. Do not eliminate the carbon fiber or some other reinforcing; earlier stabs which did so have experienced structural failures during strong zoom launches.

To ensure perfect alignment, the jointer tubes are initially installed as a one-piece unit in the left and right stabs and then cut in

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Editorial/Waterman

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tip speed below a finite value."

Taking that bull by the horns at the club level won't be a picnic. Ninety percent of your club will know what must be done and will be willing to do it whether it means banning the go-fast type of contests until 90 dB is achieved (for openers) or whatever. It is that other 10% who won't take it lying down. They will be your club's most aggressive, uninhibited, and verbose members (being competition-oriented), and they have their own network (sort of a club within a club) that knows how to pack a meeting whenever a crucial subject is to be discussed or voted on. The competition aspect of our hobby is all that they have any concern for, and they will be well prepared and have many ways to bat down you and your arguments.

If you kid yourself into thinking that you can reason with grown men who surely must have the best interests of our hobby at heart, maybe we had better listen to the words of Duke Fox, a prominent engine manufacturer, upon returning from a contest in Florida:

"I have been spending quite a bit of time exploring ways to make slightly quiet, a bit quieter, and really quiet two-cycle model airplane power plants. One of my purposes for making the trip was to find out whether interest in quieter airplanes is real, or whether it is just lip service. I am sorry to report that of over 150 modelers I talked to in Orlando, not one single modeler wanted to hear any more about it. I amy be slow to catch on, but I am not going to spend any more time or money promoting quiet. In case you might feel differently than I, I have compiled my findings on sound in a report that I will send to anybody who desires it if they will send me a self-addressed envelope with two stamps on it."

Of course, it will not be necessary for you to remind me that there are some other competition fliers besides Don Lowe who do not have tunnel-vision, do not have their heads in the sand, will not shrug and say "It can't happen to us," and do sincerely have the best interests of aeromodeling as a whole in their hearts. Even my own club has a couple of these more compassionate, responsible, or farsighted competitors, and I have a few more as pen-pals, so jumping on me for stereotyping or generalizing does nothing but cloud the issue. If this hobby that we love is to survive, we have no choice but to impose quieter engines on the only group standing in the way of quieter engines—or else curtail their contest activities.

Safety/Preston

Continued from page 22

hand, if no pins are used, there is distinct likelihood that the entire prop will be thrown off the shaft should the engine backfire for one reason or another. I have previously published letters from readers that suggested using a prop nut with a locking insert to prevent the prop from being ejected entirely off the shaft. Another solution is to drill a small hole through the end of the prop shaft so that a cotter pin can be inserted to prevent the regular prop nut from spinning entirely off the shaft. If the shaft has been hardened, such a hole cannot be drilled with a conventional drill, but there is a process (mentioned by a reader whose letter I'm unable to find) whereby a hole can be etched through the shaft by an electric arc process. Maybe four-stroke-engine manufacturers might consider drilling holes in the ends of prop shafts to accept cotter pins?

Have a safe month

John Preston, 2812 Northampton St., N.W., Washington, DC 20015.

Io Sailplane/Edmonds

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half after the framing is done. The stabs are held on the fin by the common kinked-jointer-wire method. Check that the bends in the jointer wires do not throw the stab halves out of alignment with each other.

The fin is built up of a 3/32 balsa frame with 1/64 ply sides. The stabilator control tubing is embedded in the frame. Experiment for the best tube location by putting the cable in the tube and trying different curvatures for smoothest operation. The stab-drive fitting is fabricated from two simple brass tubes as detailed on the plans. The 3/32 tube has a 3/16-in.-deep slot cut in one end with a cutoff wheel to form two tabs. The tabs are flattened and bent outward in a Y-shape and then formed around the 1/8-in. horizontal tube. The cable is crimped into the 3/32 tube and the whole assembly soldered.

Final assembly is begun by fitting the fin into the fuselage. The fiberglass fuselage tail boom will have to be shortened approximately 1 in. to the length shown on the plans. Cut a slot for the fin in the top of the fuselage tail boom and slide the control tubings and fin into place from the rear. Position the fin so that it is parallel with the sides of the wing-root fairing.

The control tubings should be glued to the fuselage side walls at as many places as possible. Thick CyA glue can be gravity-fed down from the hatch opening and a long stick used to hold the tubes in place while the glue cures. If the tubes are not substantially secured along their length, temperature variations can affect trim just as with a Nyrod.

Fit the stab fairing to the fin. Adjust it and the pivot tube to position the stab perpendicular to the fin. Make sure the stab fairing is at 0° incidence to the fuselage centerline. The design is set up so that normal stab trim will be very nearly even with the fairing at 0°.

The wing is fitted by tack-gluing the wing tube into the fuselage so that the wing rod is perpendicular to the wing fairing both vertically and horizontally. Trial-fit the wings to the fuselage. At this point the wing and tail alignment should be correct. If not, make adjustments to the wing rod tube inside the fuselage to compensate. Fit the ply root ribs to the wings. By careful shimming, a tight fit between the wing and fuselage (very critical for optimum performance) can be achieved. The 1/8-in. wing pin tubes are installed to make final alignment of wing incidence.

Tack-glue the wing pin tube in the fuselage. Use this as a guide to drill the wing pin tube holes in the wing panels. Make adjustments of the tubes to get equal incidence of the two wing panels. This can be checked easily by supporting the plane with two matched blocks under the wings next to the fuselage. If the incidence is not equal, the

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trailing edge of one panel or the other will be up off the block.

I modified the Airtronics releasable tow hook to allow it to be mounted on the inside of the fuselage rather than the outside. This reduces the amount of drag produced by the tow hook. Bevel the lower frame edges with a Dremel grinder as shown in the photo. Cut a slot in the bottom of the fuselage to allow the hook to protrude from the inside. Sand down any fiberglass bumps on the inside of the fuselage in the area of the tow hook. The idea is to let the tow hook set as low in the fuselage as possible. Next, file the aluminum hook down to a point that will allow adequate tow ring clearance. Screws and nut-plates are mounted as usual. If you use the capture feature, a 1/16-in. wire pin has to be added to the capture latch to fill in the gap made by filing down the hook.

I use Super MonoKote for the finish on all surfaces except the fuselage, which is painted. Whatever finish is chosen, be sure to keep weight buildup to a minimum. Weight of the paint on the fuselage is not likely to be a problem, because of its small surface area.

Even with the carbon fiber laminate, shrinking the covering on the wing can cause ripples to develop in the trailing edge. The carbon fiber produces a sharp, ding-resistant trailing edge but does not prevent it from becoming wavy on a thin airfoil. I have been somewhat successful in rectifying the problem by clamping the trailing edge straight between balsa strips and then reheating the covering with a heat gun.

Radio installation will have to follow the procedure shown on the plans and in the photos fairly closely. There is not much room for variation because of the small space. Aileron connect and disconnect is accomplished by L-shaped wires from the servo engaging the wing bellcranks. To connect the ailerons, the wires are simply dropped into the bellcrank holes. The wires are retained in position by a block in the bottom of the hatch.

The hatch, in turn, is secured by a couple of rubberbands stretched from one screw eye through the paper-clip loop to the other screw eye in an inverted V-shape. In some of my planes I have used small turnbuckles in the L wires to get very fine trim adjustments of the ailerons. Unfortunately, the nylon turnbuckles shown are no longer available. Metal turnbuckles could probably be adapted to do the same thing.

Proper aileron differential is achieved by selecting the correct point of connection at the servo wheel. Start by attaching couplers to the wheel near the spot shown in the photo. Fine-tuning of the differential is done by trial-and-error drilling of holes in the wheel until the right spot is found. Expect to ruin a couple of wheels in the process.

The spoilers are hinged with a strip of MonoKote ironed on the top side. Spoiler lines are made from Goldberg ½A control line with loops tied in the end that slip over a spindle on the servo arm. The spindle is made from an eyelet attached to the servo arm. The lines are threaded through a screw eye to guide them directly to the servo. At the spoiler end the lines are attached to the horns with round toothpicks. The spoiler servo also pulls the tow hook release. A nylon tube is formed to route the line out of the way of the other linkage.

Ballast is made up of ½-in.-O.D. x 2-in. brass tube sections filled with lead. Lead shot can be epoxied in the tubes or melted and poured into the tubes. If lead is melted, take proper precautions—molten lead fumes are **deadly!** Do not attempt this if you are not absolutely certain what you are doing.

Trimming and flying. It is recommended that control surface throws be set initially as per plans, although the throws may be a little sensitive for some pilots. Test fly the Io as you would any Sailplane. Give it some hand tosses to get the feel, and then put it up on the line. Launches can be high-speed, with moderately strong zoom releases if desired. Experiment with different trim settings to find various usable speeds for thermal searching, thermal turning, and getting out of sink.

Try out the spoilers at altitude, as they are very effective. Be aware that Io has a very thin frontal profile and tends to disappear when coming directly at you or going directly away, even at distances that are not too great. This can be a little unnerving when the model alternately appears and disappears during thermal-turning at certain positions way out. It simply takes some getting used to.

Io is also at home on the slope, capable of riding the smallest of hills or when ballasted, of flying in strong lift. It is highly maneuverable and just plain fun to fly.

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farm, with permission of the owner. Flying stops for a few weeks each year when the field is being planted or harvested, which is a small price to pay for the ideal conditions they enjoy in the rest of the year.

A major attraction of this field is that it is near Spadaro's airport, which includes the Long Island Skydiving School. As Tommy describes it, "There is a continuous air show, what with airplanes taking off and landing, parachutists floating down all over the place, and quarter-scale models in continuous action." He's right.

Then we come to the GMAS field (a.k.a. the Grumman Athletic Association field), where Bob Aberle, Tom Hunt, Ron Farkas, I, and others do our lunchtime flying. We share the space with baseball diamonds, soccer fields, dogs, and golfers. Fortunately, most of the "other activities" take place after work, which doesn't affect us.

As the Grumman Corporation keeps building things on the field, it keeps getting smaller and smaller. As the field diminishes in size, we keep restricting the size of the models to smaller and lighter packages. That is what has prompted the delightful .20-engined models you have seen in this column from time to time. It is also what has prompted Tom Hunt to design the Consortium,