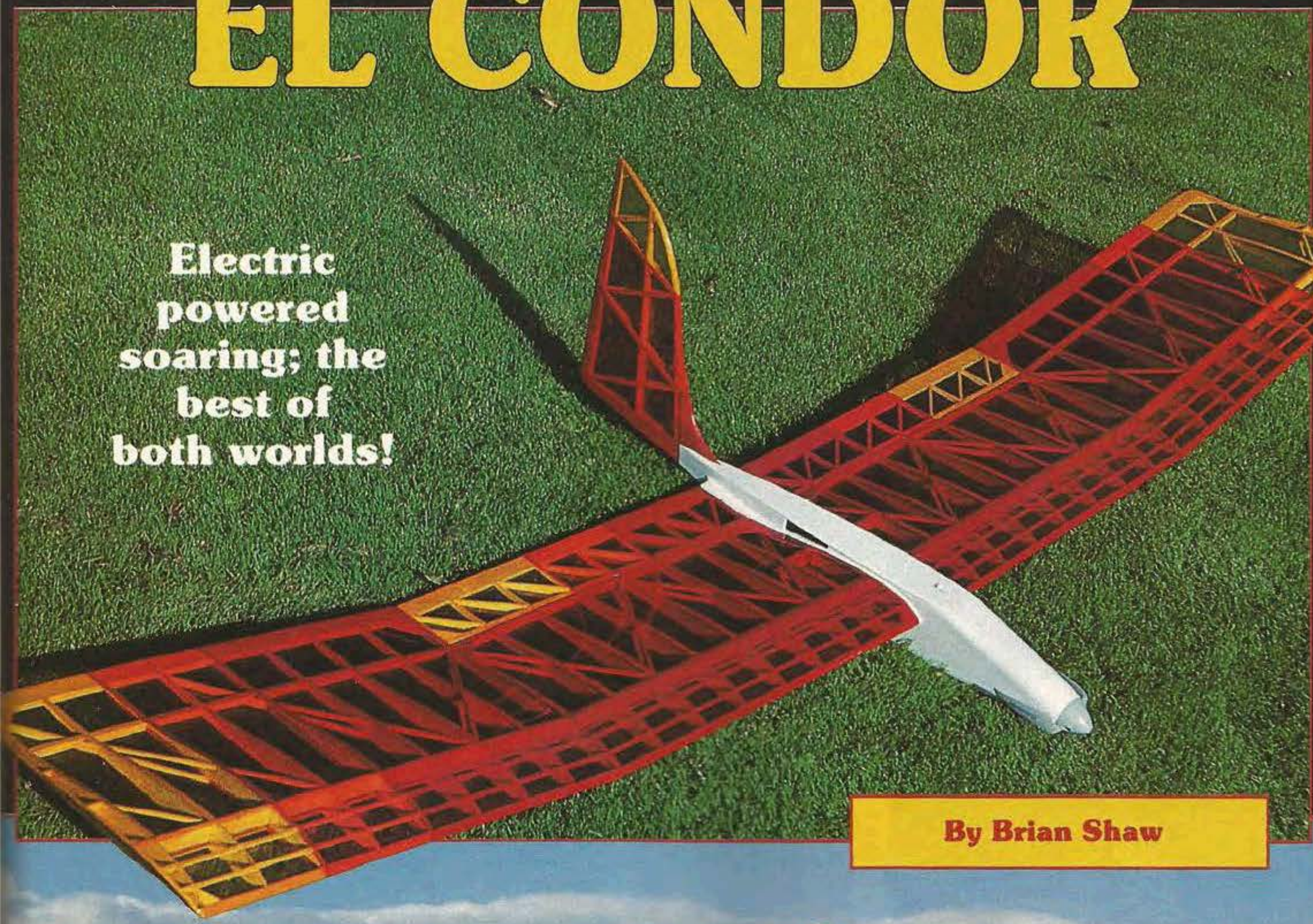
EL CONDOR



Electric powered soaring; the best of both worlds!

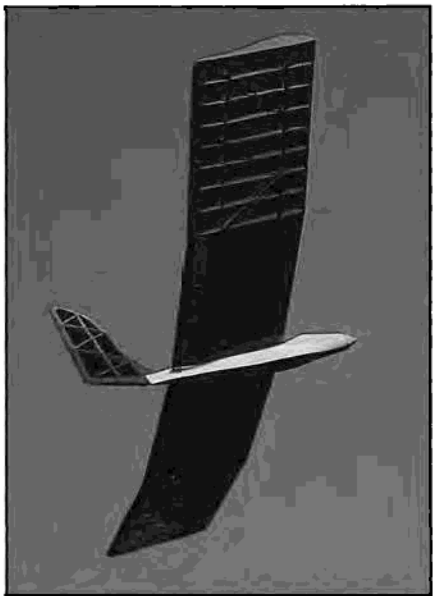
By Brian Shaw

I have been flying models for about 45 years now, and R/C since the days of valves and 90 volt batteries. I have nearly always built my own designs, and for very many years now my interest has been in gliders and sailplanes, particularly in thermal soarers. About ten years ago I began to be affected by Multiple Sclerosis and this slightly limited my activities, I then took to electric flight at just about the right time, as it happened, as electric performance was then improving rapidly.

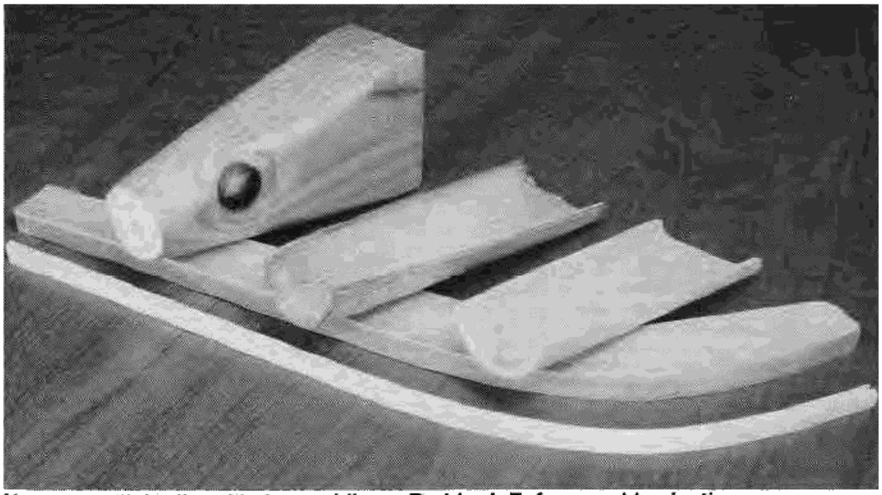
My first success was with a Jabberwock (RCM Plan #932) reduced to 60" span and this still flies regularly. I went on to design a series of three conventional electric soarers of increasing performance.

Before describing El Condor, let me say to anyone who is not as mobile as they might wish, electric flight may be ideal for you, as it is for me. Near silent climb to soaring altitude without the hassle of winches and tow lines is, of course, wonderful for all.

In October and November 1978, RCM published a construction article by Roger Sanders for the flying wing sailplane Windfreak (RCM Plan#743). At that time this was a breakthrough in performance for this type of model which had suffered from mediocre performance. If at all possible, I suggest you read the article as it contained, in my opinion, very sound thinking. I found myself in such close agreement with Roger Sanders that I wanted to investigate the potential of this layout for electric power.



EL CONDOR
Designed By:
Brian Shaw
TYPE AIRCRAFT
Flying Wing,
Electric Powered Sailplane
WINGSPAN
80⅝ Inches
WING CHORD
12¼ Inches
TOTAL WING AREA
985 Sq. In.
WING LOCATION
Shoulder
AIRFOIL
Special Reflex
WING PLANFORM
Constant Chord
DIHEDRAL, EACH TIP
4¼ Inch
OVERALL FUSELAGE LENGTH
29 Inches
RADIO COMPARTMENT SIZE
(L) 14" x (W) 2" x H 2¼"
STABILIZER SPAN
NA
STABILIZER CHORD (incl. elev.)
NA
STABILIZER AREA
NA
STAB AIRFOIL SECTION
NA
STABILIZER LOCATION
NA
VERTICAL FIN HEIGHT
12 Inches
VERTICAL FIN WIDTH (incl. rud.)
5 Inches (Avg.)
REC. MOTOR SIZE
05 Electric
BATTERY SIZE
6 Cells, 1200 mA
LANDING GEAR
NA
REC. NO. OF CHANNELS
3
CONTROL FUNCTIONS
Rud., Elev., Throt.
BASIC MATERIALS USED IN CONSTRUCTION
Fuselage .... Balsa & Ply
Wing .... Balsa, Ply & Spruce
Empennage .... NA
Wt. Ready To Fly . 43 Ozs. (2 Lbs. 11 Ozs.)
Wing Loading .... 6.28 Oz./Sq. Ft.



Nose cone "plug" and balsa moldings. Rudder L.E. form and laminations.

For readers who are unable to get hold of the original article, the two most important points were:

(1) Use a conventional and well proven airfoil as the starting point, and adapt it for stability (as a flying wing) by adding a surprisingly long and gentle reflex.

(2) For the purpose of calculating wing area, wing loading, and C.G. position, consider only the basic airfoil (neglect the reflex portion). This implies for El Condor an effective chord of 9", not the full 12¼".

Now for electric soaring there is a further most important variable — weight. When soaring with motor off, weight is of only minor importance, indeed too light a wing loading would be a disadvantage, but when climbing to soaring altitude, weight is critical. Our motor batteries store only limited energy, and most of this is used lifting the total weight up to altitude, so weight must be kept to a minimum. A final weight of 43 ozs. giving an effective wing loading of 6.28 oz./sq. ft. is the target to aim for. Because of this, I recommend the use of microservos and a 250 mAh battery pack for the receiver. Good flying requires minimal use of the controls, and I find that an hour's flying only uses about 30% to 40% of the rx battery's capacity. If in doubt, take a second pack out to the field.

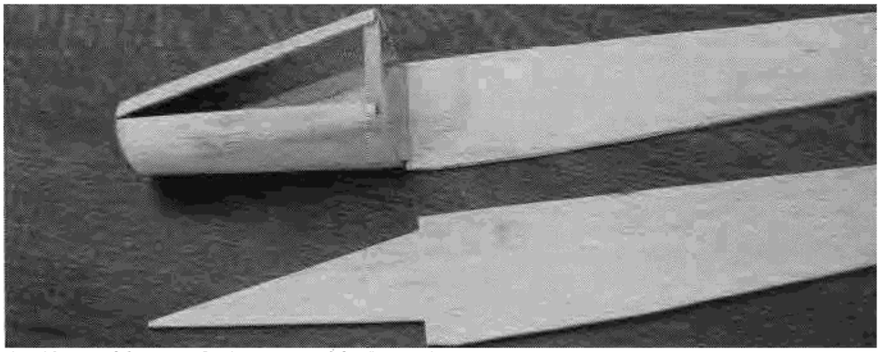
El Condor is my second version of this design, I was so impressed with the first that I wanted to build a second and present it for others to experience. The changes I made for El Condor were small, the main ones being a slight reduction in span from 86" to 80", and the adoption of polyhedral in place of curved dihedral. The latter looks very nice but is a real pain to build and cover, and the change has had no effect on performance or handling.

For sport flying I see no need for expensive equipment. El Condor uses, as have all my previous electric models, a relatively inexpensive motor much used by the car people, a Kyosho Spirit 600. I run these on six Sanyo cells of 1200 mAh capacity and, except for my geared Jabberwock, they turn the Graupner 7¼ x 3 folding prop at 11,300 static rpm and give between four and five minutes running time in the air, depending on how the motor is used during a flight.

While it is clear that larger props with gear reduction is more efficient, the light weight, simplicity, and streamlined nose that is obtained with the small prop has a great deal to commend it. Further, this small folder does fold when the motor is cut without provision for motor braking.

I use a motor control system utilizing two microswitches actuated by the motor servo, giving off half speed and full speed. I really only use the half speed position to give a soft start and stop for the motor; this arrangement has been described in these pages on several occasions. Simple on/off using a single microswitch would be satisfactory.

The handling qualities of El Condor are docile and should not present any problems to someone with a little experience at soaring. I would not recommend it as a first



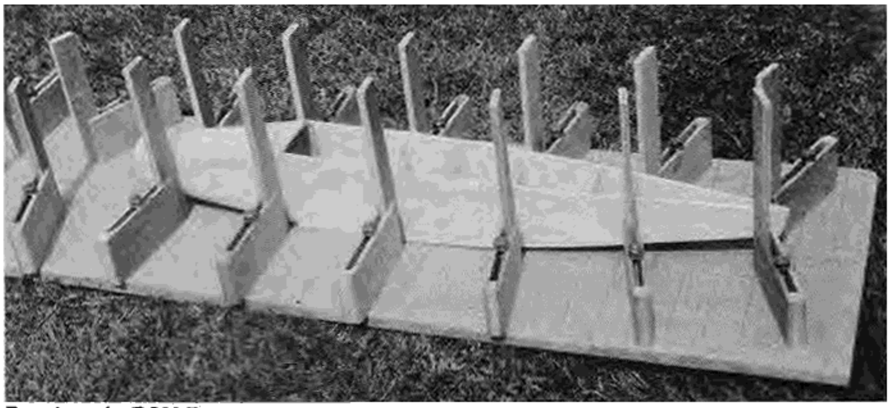
Fuselage sides ready for assembly to nose cone.

electric soarer if for no other reason than the shape is unusual and disorientation in the air could easily occur.

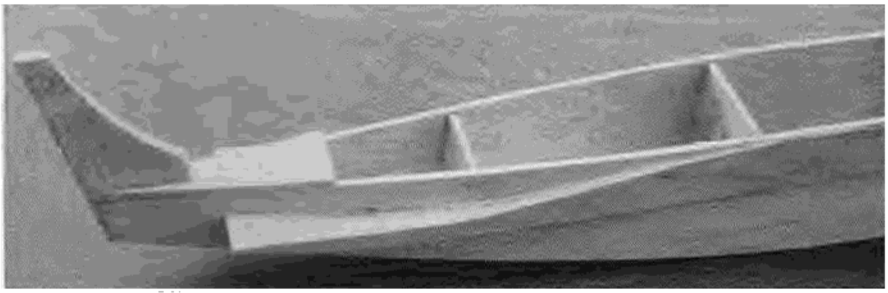
I learned a lot from the prototype (still in excellent condition), and the first flight of El Condor was uneventful. Apart from a small change in elevator trim and the shifting of the C.G. slightly forward, nothing else was required on the first day out. The first flight was deliberately ended after eight minutes for these adjustments, and the following flight clocked up 18 minutes. Flights of over 20 minutes are common.

The prototype had insufficient down thrust resulting in large trim changes between power on and off, trim had to be moved as motor speed was changed. This has been corrected on El Condor, and now elevator trim is used in a relaxed way to adjust glide speed as with any conventional glider.

These flying wings easily out-perform my conventional powered gliders, and although you might expect them to be difficult to handle, they are not. Steep turns at low altitude are just as safe, if not safer, than with conventional models, due largely to the low aspect ratio I suspect. After a season's flying with both models, I can say that I enjoy flying these wings more than my other models.



Fuselage in RCM jig.



Fin and root fairings added. Formers are temporary.

CONSTRUCTION

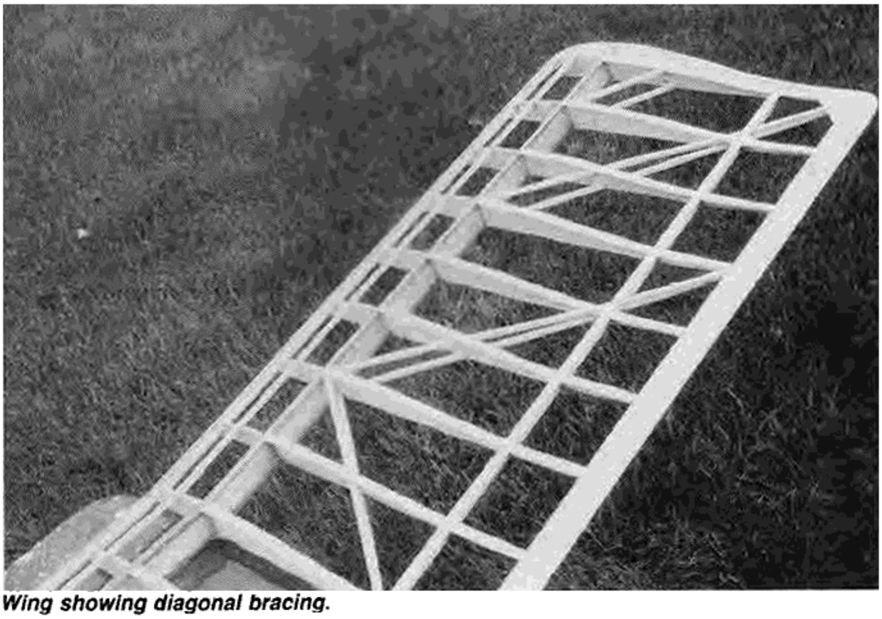
Now to the building, again this is not for the beginner, but for anyone with some experience at scratch-building there should be no problems. The structure is a little complex and I think the main requirement is patience. I hope most information can be read off the plan, so building notes are fairly brief except where something a little unusual arises.

I used mainly aliphatic resin adhesive, but the use of thin CA in some areas greatly speeds construction. Choose wood carefully to keep weight down to a minimum, consistent with adequate strength.

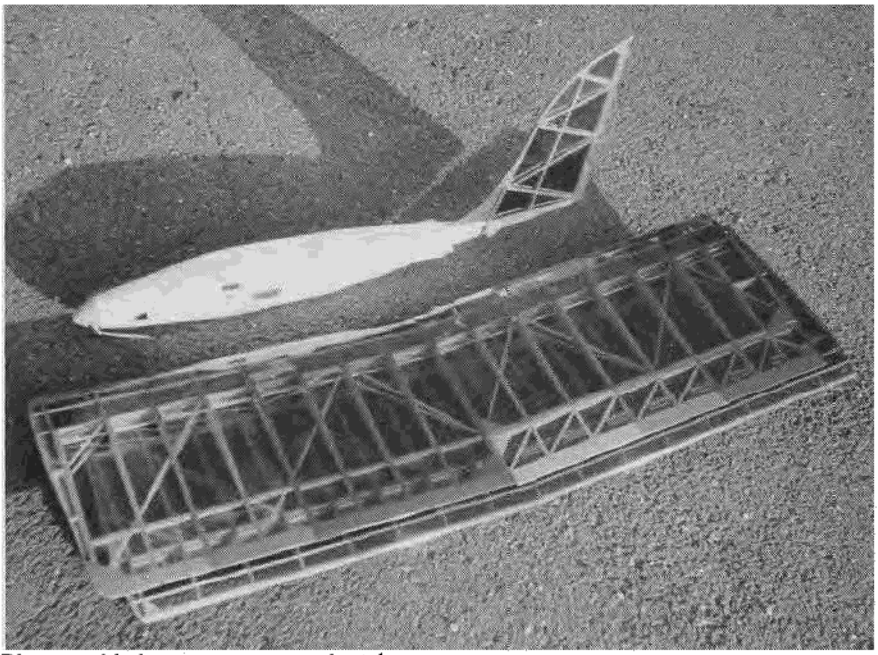
Fuselage:

Let's start with the fuselage. The only unusual part is the nose cone. With small folding props like the Graupner, it requires considerable care to produce a nose sufficiently close fitting around the front of the motor to allow the prop to fold back completely, and is most important that it should do so to eliminate prop drag. The nose cone is formed from two laminations of 1/16" sheet balsa molded over a wood block or "plug," the dimension of which are on the plan. Before carving the plug, make sure your motor is the usual 1⅜" diameter at the front; if not, adjust the front diameter of the plug accordingly. Carve the block to the shape shown and note how the four flat triangular surfaces meet at the circular front surface. Before molding over the block, cover it with thin plastic food wrap to prevent sticking. The nose cone is ultimately formed from two identical moldings for the top and bottom and the triangular front ends of the fuselage sides. Note that although you have carved the complete plug, both balsa moldings are made over the same section of the plug; just use whichever surface of the plug seems the better shape. You will now need five yards of 3/16"-1/4" strip rubber as used for rubber-powered models. Cut four pieces of medium 1/16" sheet balsa large enough to well cover the top of the plug. Soak two pieces in boiling water for five minutes, shake off the water and set aside for a moment. Cut a piece of thin nylon cloth (as might be used for covering a model) and coat it with white glue. Brush a coat of glue also onto one surface of each piece of balsa. Place the gooey mess over the plug, a pin on the centerline at the front and rear will prevent it sliding about. Now, starting at the front, wind the strip rubber around the plug and laminations, stretching the rubber as you go. Use moderate tension but do not bruise the balsa; the first turn or two will not bring the balsa into contact with the plug, but as more turns are applied, the balsa will conform tightly. Take your time, wind steadily with the turns almost touching until the laminations are covered. Wipe off surplus glue and set aside in a warm place for at least 24 hours. When you're sure that the glue has completely hardened, remove the rubber strip and take the balsa off the plug. Carefully remove any of the plastic used to cover the plug which may have stuck to the balsa.

Now repeat the whole process for the

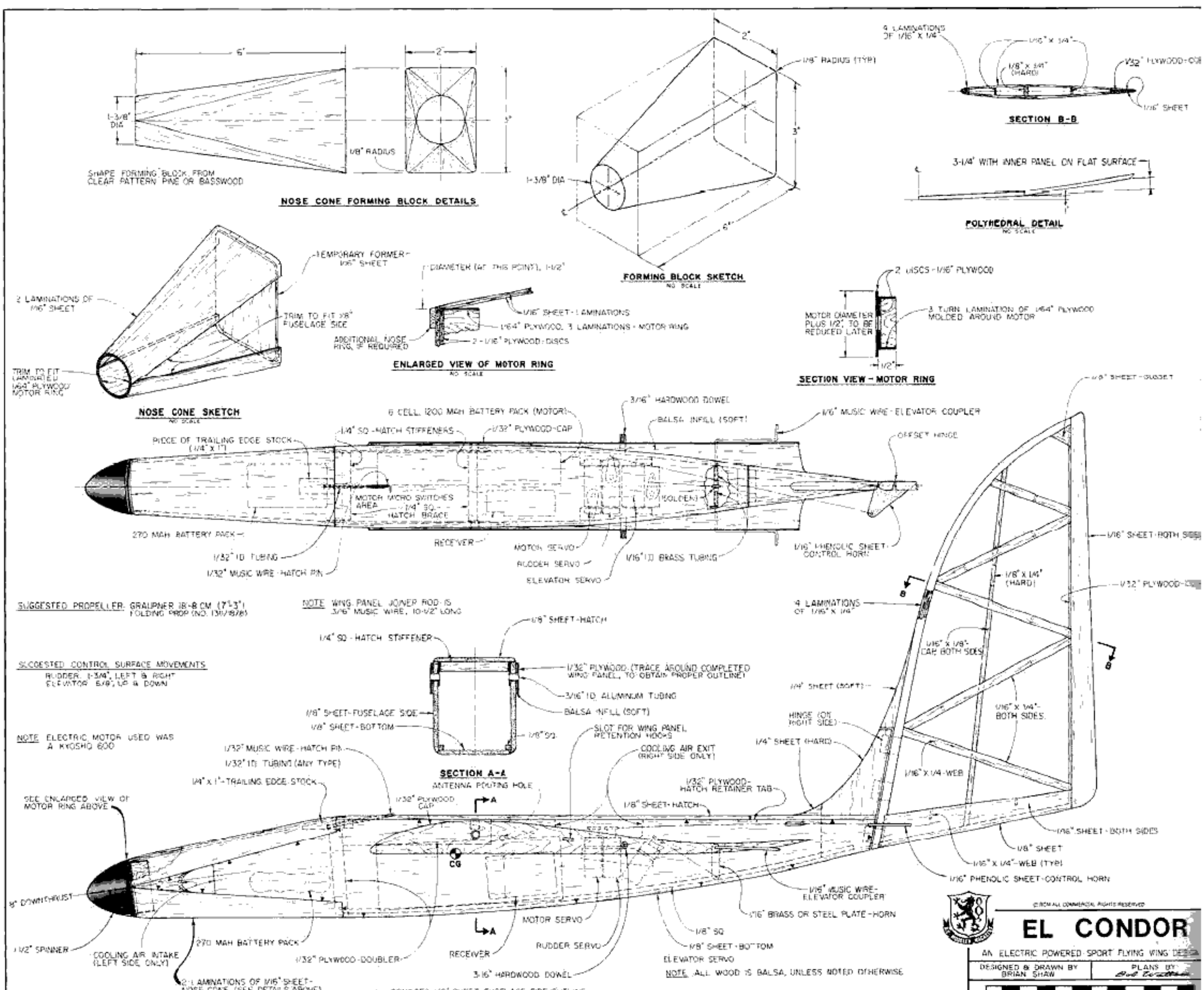


Wing showing diagonal bracing.

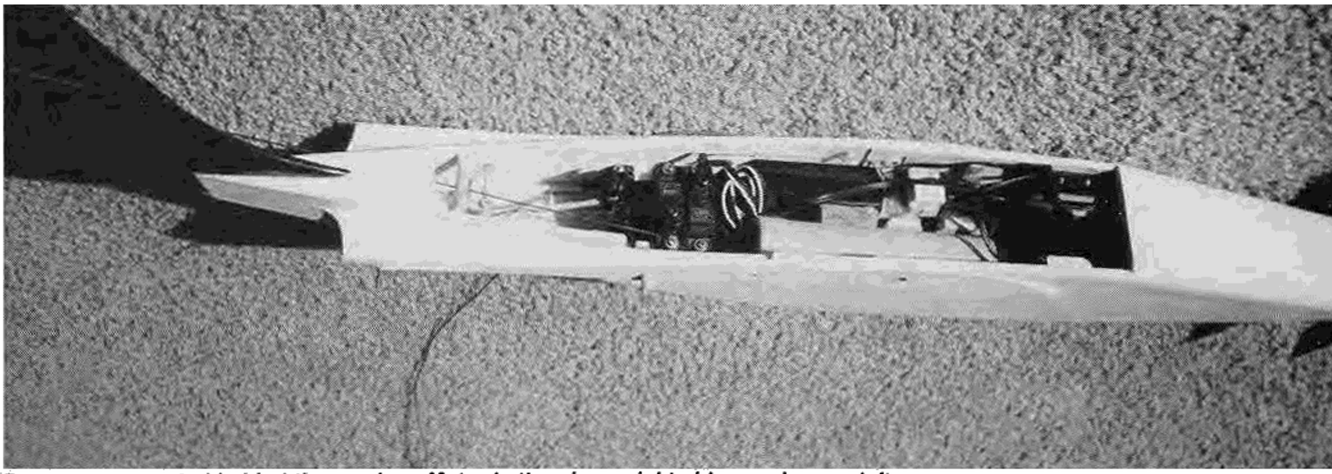


Disassembled — a very compact package.

second molding. While this is drying out, the motor ring can be made. Protect the motor with thin plastic tape, then wind at least three turns of a 1/64'' thick ply strip about 1/2'' wide around the motor having coated one side with epoxy. Bind the laminations tightly with string while the epoxy sets. Trim the front of the ring to be true with the front of the motor. Carefully cut and sand a 1/16'' ply disc to fit inside the motor ring and epoxy in place, making sure that there is no excess epoxy left on the inside. When set, use a flat surface to sand off any epoxy on the outside and to get a flat surface on the front of the motor ring assembly. Now with white glue, add the second ply disc of approximately 2'' diameter onto the front of the assembly, it will be sanded to size later. Drill and file out the hole to accept the motor bearing boss, and the two holes for the motor mounting screws. The motor can now be screwed in place for a trial fit. Next make a ply ring of approximately 2'' outside diameter and inside diameter to just clear the screw



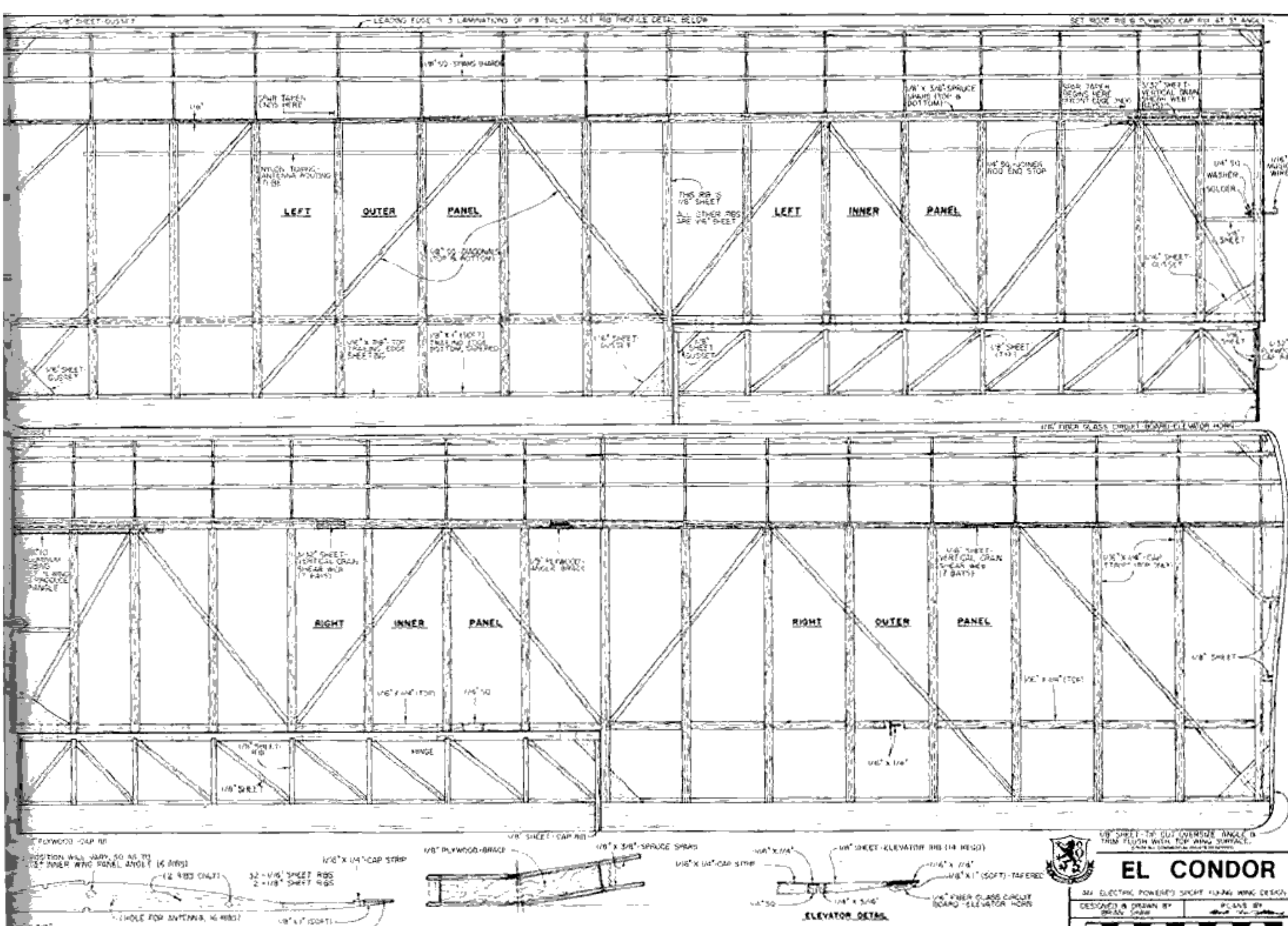
FULL SIZE PLANS AVAILABLE — SEE PAGE 209



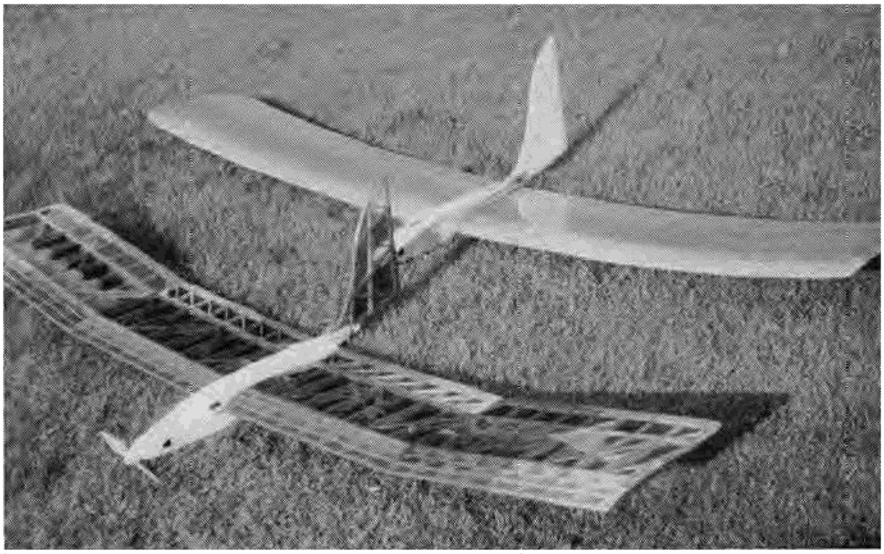
Servos are mounted behind the receiver. Motor battery is on right side, receiver on left.

heads. This not only gives a little clearance for the screw heads but also allows for a little more contouring to fair in the nose behind the spinner, but this is done at a later stage. The balsa moldings are now trimmed to fit the motor ring. Sand the inner balsa lamination almost through to the nylon cloth at the front so that the laminations fit snugly against the motor ring. The overall diameter, after final sanding, must be kept down to about 1-9/16" behind the spinner to ensure correct folding of the prop.

It is helpful to temporarily glue a false balsa former to the rear of the moldings to hold things in place and allow accurate trimming of the laminations to fit the motor ring and give the correct down thrust, this is important. There is no side thrust. Glue the moldings to the motor ring with white glue and bind in place with rubber bands while the glue sets. When dry, remove the false former and trim the moldings to accurately fit the fuselage sides, these having been cut from quite light 1/8" sheet to the outline indicated (▼) on the plan. I use and recommend the RCM fuselage jig (*Editor's Note: RCM F.J. appeared in February '92 issue. Copy available for $2.00 U.S. funds*) which makes alignment easy as everything can be squared-up and held while CA is applied. All this is almost more laborious to describe than the actual work is to do. Just think through each move before you do it and you will be rewarded with a very light fuselage. If you do not have the RCM fuselage jig (why not make one?) then a couple of temporary formers spaced down the fuselage will help keep things square and straight. Where the fuselage sides and bottom join the balsa moldings, the joint is covered on the inside with 1/32" ply strips about 3/8" wide. The remainder of the



LL SIZE PLANS AVAILABLE — SEE PAGE 209



El Condor, with the slightly larger prototype behind.

fuselage is quite conventional. The oversize ply discs are now sanded down to meet the contour of the nose and to blend with the contour of the spinner. Round off the fuselage corners. The wing root fairings are very soft balsa behind the ply facings. Take care to drill accurately for the elevator drive arms, the holes are hardened with CA to give a hard bearing surface. The drive arms are soldered into a brass tube which is in turn soldered into the brass or steel elevator horn. Note how the servo rails are angled at the rear to tilt the elevator servo. The holes for the short pieces of aluminum tubing which accept the wing joiner must be positioned very carefully, but this is best done after the wing is built; the same applies to the alignment dowels for the wing root.

Vertical Fin/Rudder:

The rudder is straightforward. The L.E. is laminated from four strips of 1/16" balsa, then cut and sanded to 1/4" wide. The T.E. has a core of 1/32" ply. The rest of the rudder goes together quickly with CA. "Top hinges" are used on the right side of the fin.

Wing:

I used the NACA 4309 as the starting point for the airfoil. This 9% thick section was used for my prototype, but I increased the basic thickness to 10% for El Condor as I reasoned that since I was reducing wing area a little, I would increase the lift coefficient slightly. As Roger Sanders proposed for his Windfreak, a fairly gentle reflex was blended onto the basic 9" airfoil. It really surprises me how easily stability is obtained by such a simple procedure. The double turbulator spars obviously cause a departure from the original NACA airfoil, but a very well behaved airfoil results. Unlike Roger's Windfreak, I find no need for washout, just be sure the wings are warp-free.

Construction of the wing presents no particular problems, it just takes a little more time than a simpler structure.

You will see that the T.E. is laminated from 1/16" sheet on top of a 1/8" x 1" T.E. stock. This is probably thinner than you will find in stock, if so sand it down from 1/8" sheet. This is easily done if you make a small sanding jig which can simply be a short length (4"-6") of 1/8" thick metal epoxied parallel to, and spaced 1" away, from the edge of a second piece of sheet metal. A flat sanding block will then produce an accurate 1/8" x 1" T.E. section. After laminating the T.E., weight it down to prevent warps. Do not forget to leave the step which will accept the capstrips, which are on the top of the ribs only. Cut some wedges from scrap to raise the T.E. above the building board so that it is in correct alignment with the ribs. The spruce spars are cut and sanded from 1/8" x 3/8" stock, note where the taper begins and ends. The rear of the spar is straight. Splice the spars to give the correct polyhedral angle. I do **not** recommend CA for spruce. If the spliced joints are very good, there is, I feel, little need for a dihedral brace, but if you have any doubts, a ply brace is shown on the plan. The ribs are all produced with 1/8" wide notches for the spar, these are then enlarged forward to fit the spar on assembly. Do not forget to drill the left ribs for the antenna tube.

The 1/8" sq. diagonal braces are important as they increase the torsional stiffness of the wing tremendously. The bottom braces are flush with the wing bottom surface — there are no capstrips on the bottom surface. The upper braces are set into the ribs below the capstrips. Cut into the ribs sufficiently for the braces to take a straight-line path. Insert the upper braces first, with the wing panels held flat on the building board. Where these braces cross the ribs close to the T.E., cut half into the rib and half into the brace. This allows the brace to follow the reflex curve, and does not weaken the rib too much. The lower braces are inserted with the wing panels inverted over the board and weighted down with the T.E. raised 1" off the board. When the braces are in place, the structure will be remarkably stiff. Note that after fitting the lower braces they will have to be sanded almost completely away in the area close to the T.E. to match the bottom contour of the ribs. The tube for the wing joiner is best assembled into the wing as one 10'' length. Raise both polyhedral breaks 1'' above the building board and ensure that the root ribs are parallel to each other and flat on the board while the epoxy securing the tube hardens, then cut away the unwanted tube. The cut-off piece can be used for the short sections in the fuselage sides, these can be epoxied into position while the fuselage and wing are supported in correct alignment.

Controls:

The elevator horn is set vertical when the elevators are in line with the wing T.E., this gives some slight differential action in favor of up elevator. Use your favorite clevis arrangement, just be sure to allow for trim adjustment and keep slop to zero. The Futaba microservos I used are mounted by a single screw at each lug, this allows them to rock slightly; you can prevent this by sticking a small scrap of wood to the fuselage floor. For rudder control I simply use a .036'' diameter wire pushrod supported by a close fitting guide halfway along its length. I use Z-bends at both ends and find no need for a clevis — just get your bends in the right place. Likewise for the pushrod to the microswitches, here .025'' wire was sufficient, again guided at the halfway point.

Batteries and Balance:

The approximate position of the motor battery is shown on the plan. Start test flights with the C.G. 1/8'' in front of the wing spar. Position the batteries fore or aft when the model is completely finished to achieve the correct C.G. Leave the battery location temporary so that it can be adjusted as flight tests proceed.

Covering:

Be sure to use a lightweight covering for the wings as there is a lot of area. I used transparent Solarfilm for the wings and SolarTex for the fuselage.

Flying:

The control movements measured at the T.E.'s are as follows: rudder 1¾'' left and right, elevators 5/8'' up and down. I suggest you start with these movements and for the first few flights have rates set at 60% in case you need them. My preference is to avoid test glides and to go straight into full power flight; one can always cut the motor in an instant if necessary, but power to climb away from trouble is very useful. Set the elevators in line with the wing T.E. at neutral trim; then for the first flight, set elevator trim slightly up with T.E. raised between 1/16'' and 1/8'' above the wing T.E. Get someone to launch for you, fairly fast and horizontal. Have a finger ready on elevator trim so that the up trim can be removed very quickly if necessary. The chances are that the up trim will not be required, but anything is better than an initial dive towards the ground. Over elevation is not disastrous and like the Windfreak, El Condor does not stall in the normal way, she may rear nose-up into wind at an alarming angle but a stall followed by the expected dive does not follow, she merely ''nods'' and tries to climb again. I have found with both models that there is time to get down trim in before serious trouble develops. Provided there are no warps, no rudder trim will be required, but a very small quantity of lead should be added to the left wingtip to ensure lateral balance if necessary, after all, the motor battery is on the right side. If all goes reasonably well, let the motor run for about 45 seconds by which time you will have adequate height to cut the motor and check the glide. When you have the trim right you will find that a one minute motor run should give about 400' altitude. Try not to completely exhaust the battery, but leave a little power for the landing phase in case you need to go round again. The glide is very flat with a wide speed range depending on trim settings. When the wing gets close to the ground, ground effect comes into play and you are likely to overshoot the landing spot by a considerable distance. Finally, locate the C.G. such that the elevators are in line with the wing T.E. when gliding normally; any further up trim will only give rise to additional drag which will adversely affect the glide angle. It is convenient to bear in mind that moving the motor battery 1/4'' will move the C.G. about 1/16'', and I would suggest you move it in these increments for final trimming. Be prepared for powerful rudder action when the motor is on; this is due to the prop blast on the large rudder. You may wish to use reduced rate on rudder when climbing, on the glide the rudder action is still quite powerful, but just as I like it.

It is worth mentioning a useful technique I have adopted after re-reading Roger Sander's article. If when approaching the landing area you are too high and are set to overshoot, do one or two quick stalls by suddenly applying full up. The loss of height will be very small but the drag increase will steepen the approach almost as if spoilers had been deployed. The stalls are over so quickly that you will not lose heading.

When the C.G. and trim are adjusted, I find the normal use of elevator trim is as follows: neutral trim during hand launch, then as the model accelerates into the climb, feed in some down trim to maintain flying speed and a reasonable angle of climb. When the motor is cut, El Condor will enter the glide without need for trim change, just use trim at your leisure to set up the glide speed you require for the prevailing conditions.

Take your time setting the trim and C.G. and I believe you will find El Condor to have very good performance and also be great fun to fly. The unusual appearance will undoubtedly give rise to considerable interest wherever she appears and, hopefully, will encourage further developments of this type.

Finally do remember that El Condor is designed for thermal flying, not aerobatics, the wing structure is light and is not intended to be put under severe stress. If anyone is thinking about converting it to a pure glider, don't, the wing structure would not stand the launches. In any case, for high performance pure gliding, the original Windfreak, which was the inspiration for El Condor, is what you need. ☐

From RCModeler May 1994