ABOUT THE AUTHOR

Steven James Ellzey, age 24, received his B.S. in Aerospace Engineering in 1982 from Mississippi State University, and is currently working on a Masters Degree in Aerospace Engineering at Mississippi State.

Steven learned to fly R/C eight years go in Cincinnati, Ohio. Since then he has flown sport, pattern, 1/2A, glider and scale aircraft and has built and run scale R/C boats. Steven has been a flight instructor for the Greater Cincinnati Radio Control Club and the Orleans East Fly Club in New Orleans.

SPECTRE

By Steven J. Ellzey

The last time you were at the flying field did you notice how much all of the airplanes looked alike? They either look like boxes with wings, or, as my father puts it, like pregnant guppies. Well, I decided that my next airplane would not fall in either of these categories, and from that decision came the Spectre.

I had a couple of goals in mind when I designed the Spectre. The first was to have a stable yet very maneuverable airplane, and second was for the airplane to have the appearance of a jet fighter, few of which look like pregnant guppies. My design philosophy was fairly simple: To design an airplane that was big enough for a 25 size engine, the radio, and little more. Even though the Spectre turned out small, there is still quite a bit of room inside. This is because you can access the entire volume inside of the fuselage, unlike conventional airplanes where everything in the fuselage behind the wing is empty, save a pushrod or two.

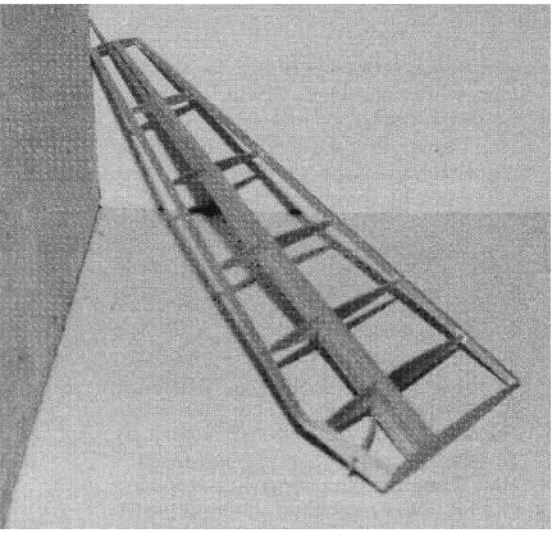
I used a pusher configuration mainly because it would look better. It allows a long tapered nose and a round squared off back, which is the way most jet fighters look. The wing was swept for looks and to push the center of pressure of the wing further aft, which helps balance the rear mounted

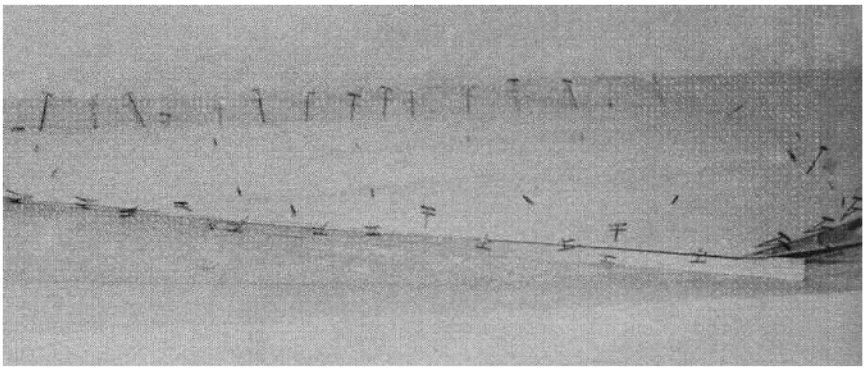
Tired of the look-alike airplanes at your flying field? Steven Ellzey has designed a sport model that takes on a jet fighter appearance. A hot .25 size engine will make this a high performance aircraft.

engine. The wing was not swept to decrease drag. As a matter of fact, sweeping the wing on a model does not decrease drag. Wing sweep is used on full scale airplanes to decrease drag near the speed of sound where an airplane runs into compressibility effects. One problem with a swept wing is that they are more prone to tip stall. This is due to a span-wise flow of air which tends to make the tip stall first. To counter this, the wing on the Spectre is twisted 4° leading edge down. This makes the tip fly at a lower angle of attack and stall after the rest of the wing. The leading edge is sharper at the root than at the tip so that at a high angle of attack and low speed, the air will separate at the root before it does at the tip. Since the airplane is short coupled and has a large amount of lateral area in front of the center of pressure, a large vertical fin area is required to provide good stability. This area is split over two fins rather than having one very large fin. This also has the advantage of tying the fins into the fuselage side where there is plenty of structure to fasten to.

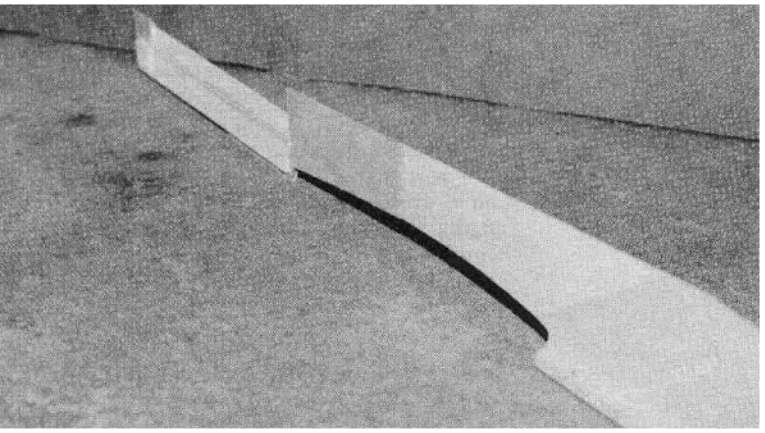
One thing notably different in the wing structure is that the ribs are not constantly spaced; the reason for this is as follows: Wing ribs have basically two functions, one to give the wing its airfoil shape, and two, to stabilize the wing skin from buckling. So, at the tips, where the loads are small, there is very little stress in the skin; therefore, few ribs are needed to stabilize it. At the root, however, the loads are at their maximum so more ribs are needed to keep the wing skin from buckling, and since the wing depends on the skin to carry part of the load, this becomes important. The leading edge extensions (those triangular pieces on the side of the fuselage in front of the wing) are functional. They increase the lift of the wing at high angles of attack by generating a large low pressure vortex that flows over the wing thus lowering the pressure over part of the wing.

At this point you're probably asking if all of this works. To which I would answer, "It works beautifully." The Spectre exceeded my expectations on all counts. She will fly straight as an arrow from one end of the field to the other hands off, turn very tight, and can roll faster than any airplane I have ever seen. The Spectre always stalls straight ahead, and when it comes time to land, the controls remain effective all the way to stall.

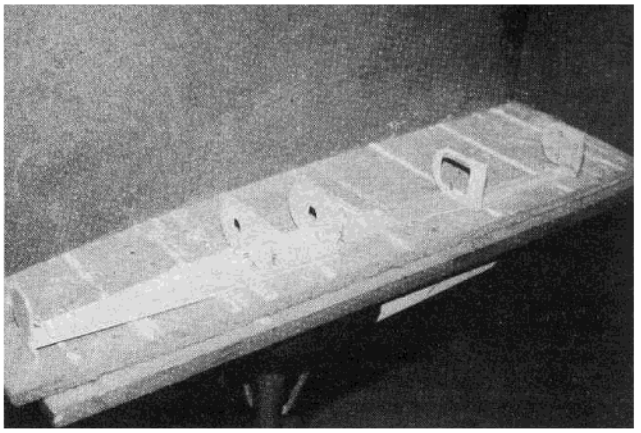




LEFT: Right wing panel ready for sheeting — antenna tube runs through wing panel.
ABOVE: Top sheeting glued in place — leading edge is shimmed with tapered balsa jig.



Right rear fuselage side has vertical tail slot sanded to bevel.



Right fuselage side with bulkheads in place. Rear firewall has blind mounting nut installed for engine mount.

The Spectre without flaps does land faster than most airplanes; however, with flaps, the landing speed was reduced to the point where she would only skid five or six feet when landed on smooth grass.

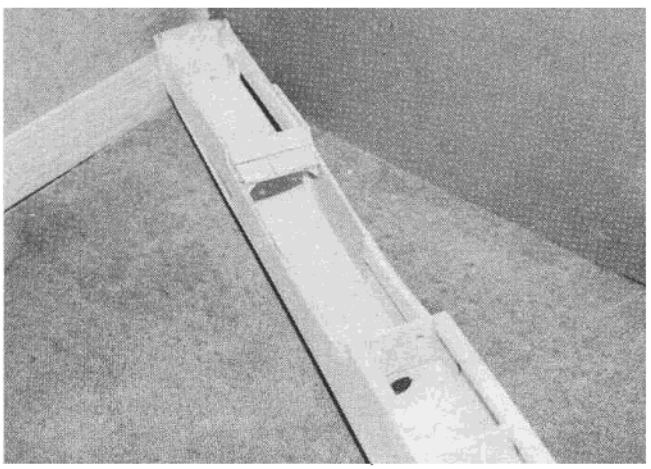
If you are a proficient pilot and want a high performance airplane that does not look like every other airplane on the field, let's start building a Spectre.

CONSTRUCTION

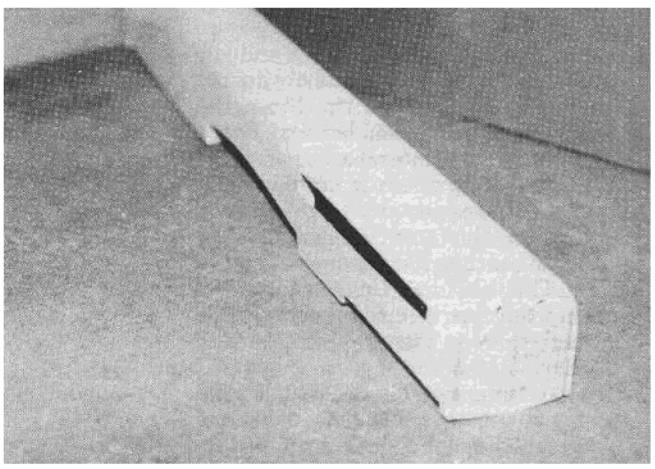
Wing:

Let's start by cutting out the parts for the wing. The ribs are made from 1/16" balsa. The main spars are cut from hard 1/4" balsa, these spars are 1/4" square at the root and 1/4" x 1/8" at the tips. The leading and trailing edge spars are made from 1/4" square balsa. The leading and trailing edge spars are oversized now but will be sanded down later. The leading and trailing edges are supported by a simple jig that is made from 1/4" balsa. The trailing edge jig goes from the root to the tip and is 3/8" tall at the root and 3/16" tall at the tip. The trailing edge jig goes from Rib 2 to the tip and is 3/8" tall at Rib 2 and 1/16" tall at the tip.

Put a piece of waxpaper over the wing plans and pin the bottom main spar to your building board over the plans. Next glue the ribs to the spar making sure that they stand up straight. You will need to trim the spar notch and the leading and trailing edges of the ribs to match the sweep of the spar and of the leading and trailing edges. After the glue has



Bottom view of fuselage with top sheeting in place. Wing hold-down plate has been added.



Rear portion of fuselage showing slots for vertical fin to exit.

dried, cut out and glue in the shear webs on top of the bottom spar. The inner four webs are made of 1/8" balsa with the grain vertical. The outer two webs are 1/16" balsa with the grain horizontal. Test fit the upper spar and trim the rib notches and/or the shear webs to make it fit, then glue it in. Glue the outer leading edge spar to the front of Ribs 3 to 7, and then glue the trailing edge spar to the back of all the ribs. After the glue on the outer leading edge spar has started to dry, cut from a piece of 1/4" balsa the inner leading edge and glue it in place, being careful not to bend the outer leading edge spar in, out, up or down.

Build the other wing half while you wait for the glue to dry on the first half. After the glue has dried, remove the wing halves from the building board marking which panel is the left and which is the right on the root rib. Sand the leading and trailing edge spars to match the contour of the ribs. The front of the leading edge spar will be getting fairly thin now but that is okay. Drill a series of holes in the right wing ribs for the antenna tube (a piece of Nyrod works well for this tube) and then install it. Sand any bumps that might keep the wing sheeting from going on smooth. Pin the wing jigs over the plans so that they overlap the drawing of the leading and trailing edge spars by 1/8". Cut out the bottom wing skin from 1/16" balsa. You will probably have to glue two pieces together to get the proper width; if so, sand the joint before sheeting the wing. Lay the balsa sheet over the plans such that its edges are resting on the jigs. Apply glue to the bottom of the spars and ribs then push the main spar to the sheeting and down to the building board, keeping the wing aligned as best you can with the plans. Pin the main spar to the building board and then pin the leading and trailing edge spars to the jigs.

Shim the sheeting up to the inner leading edge and to the front of Ribs 1 and 2 by pushing scrap wood under the sheeting. If the sheeting does not touch all the ribs, it can be pulled up by pushing a long straight pin through the sheeting at a shallow angle and into the building board. After the glue has dried, remove all of the pins and cut out another wing skin for the top of the wing. Apply glue to the top of the spars and ribs, then with the wing setting on the jigs, lay the top sheeting in place. Pin the sheeting to the trailing edge spar and jig, then to the main spar and finally to the leading edge spar and jig. Make sure that the leading and trailing edges are down tight against the jigs. Use plenty of pins to hold the sheeting down to the ribs between the spars.

After the glue has dried, remove the wing halves from the building board and sand the sheeting flush with the leading and trailing edge spars and with the root and tip ribs. The outer leading edge is sharp inboard and rounded at the tip. Using a sanding block, shape the outer leading edge.

Bend the aileron torque rods to the shape shown on the plans making sure to put a bearing on before you make the last bend. Cut the ailerons and the fixed trailing edge from a piece of 1" x 1/4" trailing edge stock. Drill and notch the aileron for the torque rod then notch the trailing edge spar for the torque rod bearing and epoxy the bearing in place. Mark the position for the aileron hinges and notch out for them. Bevel the front of the ailerons. If you plan to use flaperons make sure that the aileron can deflect 50° down and 40° up. You will not need this much throw but it is better to have too much of a bevel than not enough. With the aileron in place (not glued), notch the fixed trailing edge for the torque rod and bearing and glue in place.

Glue a block on the tip rib to shape the tip from. Holding the tip of the aileron to neutral, mark the outline of the end of the aileron on the tip block. Remove the aileron and carve and sand the tip to shape.

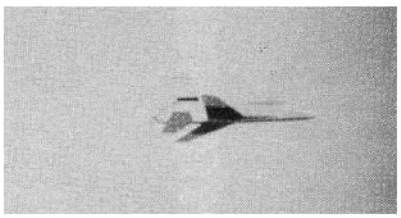
With both tips blocked up 1/4" and the center of the trailing edge blocked up 3/8", epoxy the wing halves together. Cut the leading edge brace from 1/16" plywood and epoxy it on, then sand it flush with the inner leading edge. Glass the entire center section except for the leading edge brace with a 2" width of 4 ounce cloth.

Fuselage:

Cut the fuselage sides out of 3/32" balsa. Mark on the inside of each which is the left and right. Draw a line 1/4" from the top on the outside, the entire length of the fuselage. Using a sanding block, bevel the top of the sides to the line. This is where the top sheeting will glue to the sides. Cut the fuselage doublers from 1/32" plywood and laminate it to the fuselage side with contact cement or 5-minute epoxy. Glue the 1/8" balsa tail supports to the plywood doubler 1/4" from the back. Using coarse sandpaper and a sanding block, bevel the tail support, plywood doubler and the fuselage side to the shape shown in the plans. Glue a 1/4" square balsa stick to the inside bottom of the fuselage in front of the wing cut-out.

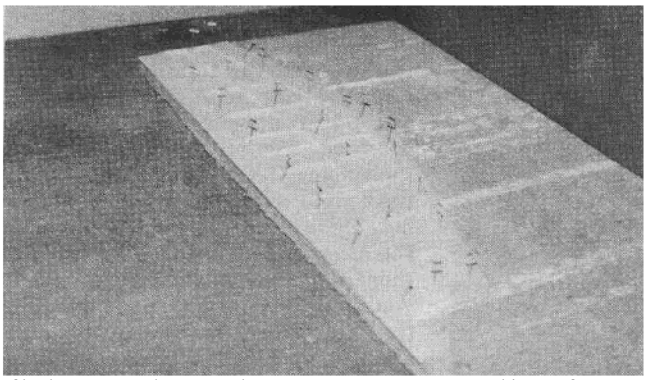
Cut the firewall out of 1/4" plywood. Drill the holes for the engine mount, throttle cable and fuel lines, then install the blind nuts for the engine mount. Cut the rest of the bulkheads from 1/8" balsa with the grain vertical. The #4 bulkhead has a 1/16" balsa doubler with the grain horizontal at the top and bottom. This bulkhead must also have a hole in it large enough to pass the fuel tank through.

Using the plans, mark the position of the bulkheads on one fuselage side. Glue and pin the #2 bulkhead in place. Make sure that the fuselage is pinned down tight to the building

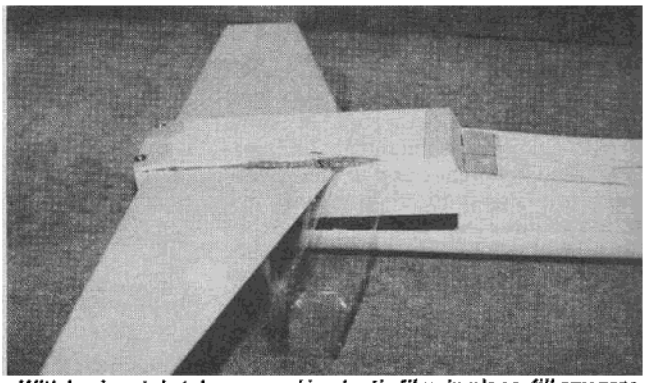


SPECTRE
Designed By:
Steven J. Ellzey
TYPE AIRCRAFT
Sport
WINGSPAN
37 Inches
WING CHORD
6½" (Avg.)
TOTAL WING AREA
244 Sq. In.
WING LOCATION
Low Wing
AIRFOIL
Symmetrical
WING PLANFORM
Tapered — swept 25°
at 25% chord
DIHEDRAL EACH TIP
None
O.A. FUSELAGE LENGTH
37 Inches
RADIO COMPARTMENT SIZE
(L) 22" x (W) 2½" x (H) 2¾" (Avg.)
STABILIZER SPAN
18¼ Inches
STABILIZER CHORD (incl. elev.)
5¼" (Avg.)
STABILIZER AREA
96 Sq. In.
STAB. AIRFOIL SECTION
Symmetrical
STABILIZER LOCATION
Bottom Of Fuselage
VERTICAL FIN HEIGHT
8½ Inches
VERTICAL FIN WIDTH (incl. rud.)
5 Inches
REC. ENGINE SIZE
Hot .15 — Hot .25
FUEL TANK SIZE
4-6 Oz.
LANDING GEAR
None
REC. NO. OF CHANNELS
4-5
CONTROL FUNCTIONS
Rud., Elev., Ail., Throt.
or Flaperons
BASIC MATERIALS USED IN CONSTRUCTION

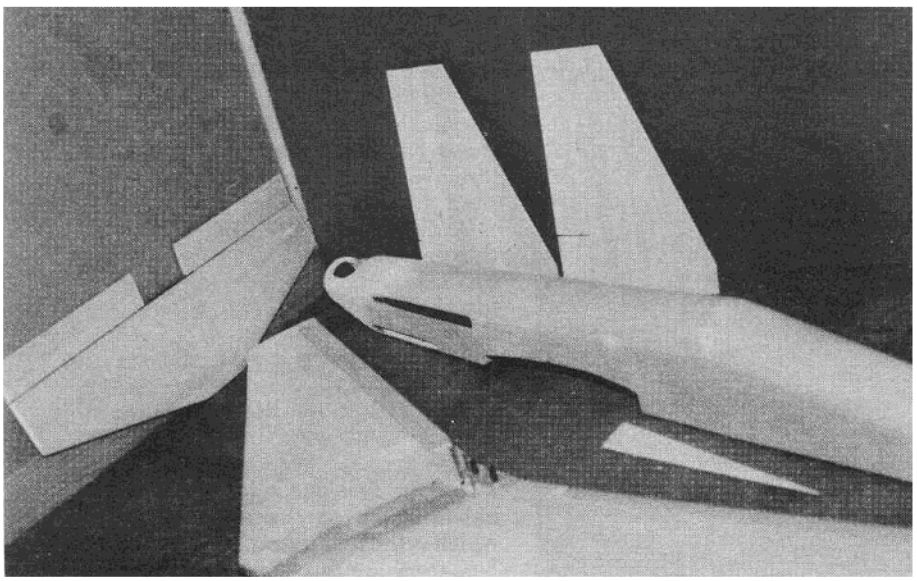
Fuselage	Balsa & Ply
Wing	Balsa & Ply
Empennage	Balsa
Wt. Ready To Fly	**44 Oz.**
Wing Loading	**26 Oz./Sq. Ft.**



Horizontal stab being built up. Leading and trailing edge are shimmed with 1/32" balsa.



With horizontal stab wrapped in plastic film, in place, fill any gaps with favorite putty.

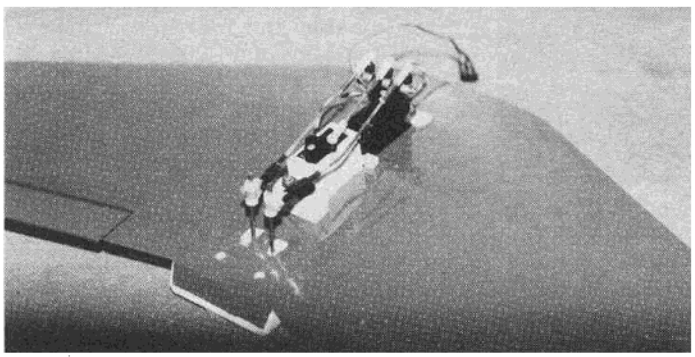


All components complete and ready to cover.

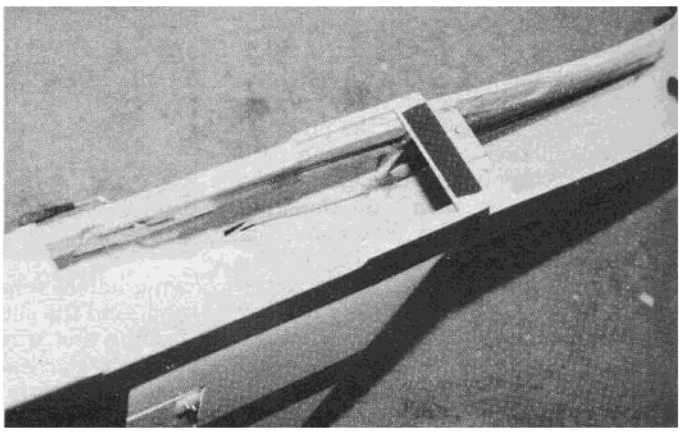
board at the #2 bulkhead. Shim up the front of the fuselage 1/4" with a piece of 1/4" balsa. Glue on the rest of the bulkheads making sure that they are vertical, and epoxy on the firewall using a triangle to keep it square. After the glue has dried on the #4 bulkhead, glue on the lower part of the bulkhead. Apply glue to the side of the bulkheads and epoxy to the side of the firewall, then lay the other side in place and place enough weight on it to hold it down tight.

While you are waiting for the glue to dry, find a piece of soft 3/32" x 4" balsa and a 3' long tube between 2" and 3" in diameter. Wet the balsa sheet with ammonia and wrap it, grain parallel to the axis of the tube, around the tube. This will be the top of the fuselage. After the ammonia has dried, pin the fuselage upright on your building board. Place scraps of 1/4" balsa under the nose to keep it from twisting. Glue a piece of the precurved balsa on the top of the fuselage between bulkhead #2 and the firewall using plenty of pins to hold the top sheet to the sides, but be careful not to bow in the fuselage sides. Trim the top sheet flush with the #2 bulkhead, and then glue on the #2 bulkhead doubler. After the glue has dried, trim the remaining piece of curved balsa to fit the front of the fuselage, and glue it on. Sand the edge of the top sheet smooth with the fuselage side; and trim the opening for the vertical fins so that a piece of 1/8" balsa will fit in.

Epoxy in the 1/4" plywood wing hold-down plate and the 3/8" triangular balsa braces above it. Glue on the 1/8" balsa wing saddles. Out of a piece of 1/16" plywood, cut a 2½" x 2" plate. Mark the center of the plate and, on the long axis, drill a 1/4" hole 1/2" from the center on both sides. On the wing leading edge brace, mark the center and drill one 1/4" hole 1/2" from the center for a wing hold-down dowel. Push a 1" long piece of 1/4" dowel through one of the holes in the plate and half way into the hole in the leading edge. Using the second hole in the plate as a guide, drill a second hole in the leading edge for the other hold-down dowel. Remove the plate and push another piece of dowel in the second hole. Drill two holes in the #3 bulkhead for the wing dowels. Open these holes up as necessary to get the



Wing flaperon linkage.



Detail of the flex rod exits.

wing to set in the wing saddle. Trim the plywood plate so it will fit on the front of bulkhead #3. With the wing in place, and using a small amount of epoxy, attach the dowel plate to the bulkhead and the 1/16" plywood load transfer plates to the fuselage sides and to the dowel plate. Epoxy a 1/16" x 2" x 2" plywood pressure plate to the wing. Carefully align the wing with the fuselage and drill for the wing hold-down bolts. You can either tap the wing hold-down plate or use 10-32 tee nuts, which work very well.

Epoxy in the 1/8" plywood forward hatch hold-down plate. Glue the 1/4" x 2½" x 3/4" balsa piece to the front bottom of the fuselage. Cut the forward hatch out of 1/4" balsa and glue a 1/32" plywood tongue to the front end. Mark the position where the hold-down screws will go through the hatch, and then recess that area for a 1/32" x 1½" x 3/4" plywood pressure plate then glue the plate in. Holding the hatch in place, drill through the pressure plate and the hold-down plate and install 4-40 blind nuts on the back of the hold-down plate. The rear hatch is made in the same manner except you use 1/8" balsa, wood screws going into the firewall, and the area around the screws are glassed. Use fairly hard balsa for the rear hatch. Sand the forward and rear hatch so that their edges are well-rounded.

Tack glue a balsa block to the nose and rough carve it to shape. Remove the block and hollow it out, then glue it on and finish shaping it. The rear tail cone/engine cowl can be either carved from a solid block of balsa or built up in the following manner. Install the engine, and then cut the spinner ring out of 1/32" plywood. Cut out the side pieces from 1/4" balsa and bevel their top and bottom edges. Epoxy both sides on at the same time using the spinner ring, centered around the engine shaft, to space the sides at the back. Glue and pin the bottom pieces on and then mark the position of the spinner ring on the ends of the bottom and side pieces. Remove the engine. Glue and pin on the upper side pieces. After the glue has dried, sand the top edges flat on top and glue on the top piece. At this point the back will be a bit uneven but, using the spinner ring, draw a circle on the back. Rough shape the tail cone, but do not get too close to the circle, and then sand the back smooth. Open up the top of the tail cone for the engine; make sure that the needle valves, throttle arm, and muffler have plenty of clearance. With the engine in place, epoxy on the spinner ring making sure that it is centered around the engine shaft. Remove the engine and finish shaping the tail cone.

Tail Surfaces:

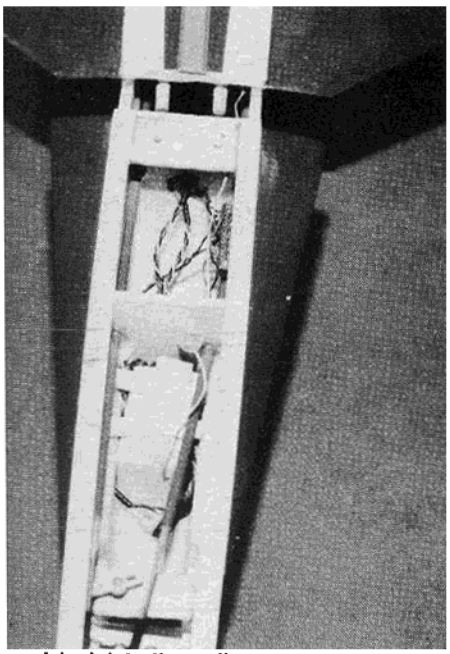
The horizontal fin is built up to keep the weight down and the torsional stiffness fairly high. Start by cutting a 1/16" sheet to the shape of the horizontal fin. Glue and pin the 1/8" x 1/4" balsa spar down then glue the 1/16" x 1/4" balsa leading and trailing edge spars on. Shim up the leading and trailing edges with scrap 1/32" balsa. (You do have some scrap 1/32" balsa somewhere, don't you?) Mark the position of the ribs on the main spar. The ribs are cut from 1/16" balsa, have straight sides and taper from 1/8" to 1/16". Glue all of the ribs in place. Cut the fin top sheet from 1/16" balsa and then glue and pin it in place. When the glue is dry, sand the leading edge round, cap the tips with 1/8" balsa and round them. The elevator is made from 3/16" balsa and tapers to 1/16" at the trailing edge. Bend the elevator torque transfer rod out of 1/8" music wire. Drill and notch the elevator for the torque rod. Notch the elevator and the fin for hinges and bevel the front of the elevator.

Lay a piece of plastic wrap on the horizontal tail saddle and wrap another piece around the center of the horizontal fin and pin it in place. Apply some type of putty (I like micro-balloons and resin) to the bottom inside edge of the aft hatch and then fasten it in place. This will fill the gap between the fin and the hatch. After the putty is dry, remove the fin and sand the putty smooth.

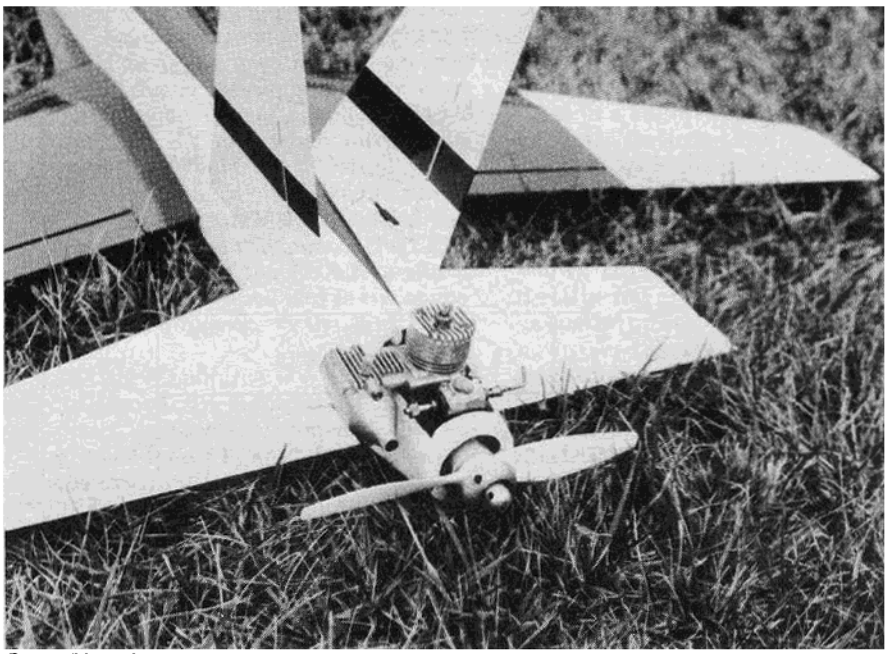
Cut the vertical fins from hard 1/8" balsa. Sand them to shape and cut out the rudders. Notch the rudders and the fins for hinges.

Belly Pan:

Bolt the wing in place. Cut out the sides for the belly pan from 1/4" balsa and glue them in place. Remove the wing. Fit and glue a piece of 1/8" balsa to the inside of the front and back of the belly pan. Make two wing bolt passage blocks from scrap 1/4" balsa. Make sure that the hole is large enough for the bolt head and a screwdriver or a nut driver to pass through. Epoxy the blocks to the plywood pressure plate on the bottom of the wing, centering the holes around the bolt holes. When the epoxy



A look into the radio compartment.



Super Tigre S25 ABC powers the prototype. Muffler tip has to be cut for prop clearance.

has set, sand the bottom of the blocks flush with the bottom of the sides. Sheet the bottom of the belly pan with 1/8" balsa. Use hard balsa since this is where most of the landing loads go. Cut out a hole in the 1/8" balsa for the bolt passages. Bolt the wing back in place and sand the belly pan to match the shape of the rest of the bottom.

Leading Edge Extension (LEX):

From the top view on the plans, cut a piece of 1/32" plywood to the shape of the LEX. Check the fit of this piece to the side of the fuselage and to the leading edge of the wing and trim as necessary. Using epoxy, glue a piece of 1/4" balsa to each side of the plywood piece. Epoxy is used here to prevent any warping that might occur with regular glue. One of my planes had a warped LEX and when pitched up sharply it would try to roll slightly. With the wing in place, hold the LEX in place and mark the shape of the leading edge on the back of the LEX. Carve and sand the LEX to a sharp edge on the plywood and to the shape of the leading edge at the back.

Canopy:

A Sig 7" bubble or WW 2 canopy will look good. To shape the bottom to match the fuselage, wrap a piece of 80 grit sandpaper around the nose where the canopy sits and move the canopy back and forth on the sandpaper until it sits correctly. I like to use a deck for the canopy to glue to. This is made by wrapping a piece of 1/16" balsa (dampened with ammonia) around the nose where the canopy sits. After the ammonia has dried, set the canopy on this sheet and trace its outline on the sheet. Cut this piece out and trim it so that the canopy will fit over it without bowing the canopy sides out.

Finishing:

Sand the entire airplane smooth and fill any dents with putty. Cover the model with your favorite covering and color. You will notice that the ailerons do not seem to match the tip and center at the same time; remember that the wing is twisted so the aileron will need to be twisted also. After covering the aileron, just twist it and reheat the covering, and the aileron will hold the twist.

Epoxy in the hinges and control surfaces. Fasten control horns to the rudders and elevator.

With the wing bolted in place, hold the LEX in place (its tip should be 1/4" above the bottom of the fuselage side with the forward hatch removed) and mark around its base on the fuselage. Remove the covering to within 1/32" of the line, then epoxy the LEX in place being careful to position it properly. Repeat this for the other side.

Epoxy the vertical fins in one at a time making sure that the top sheet is glued to the side of the fin.

Put the fuel tank in place and glue a piece of balsa in behind it to keep the fuel tank from shifting aft. Bolt the engine, muffler, prop and spinner in place, fill the fuel tank, lay the horizontal tail in place and fasten the rear hatch down. Lay your radio inside the fuselage and find out where it needs to sit to balance the plane. Mount the servos by whatever method you like best, but remember that the throttle servo will probably need to be mounted higher in the fuselage than the other servos.

I used pushrods in my first Spectre, but due to some of the strange bends that were needed, there was a good deal of play in the system. So, I used flex rods after that. However, I use them in a slightly different way than normal. Rather than exiting the fuselage with the outer tube a little way, I ended the outer tube inside the fuselage and finally exit with a threaded pushrod. One of the photos shows this clearly. The rudders, throttle and ailerons or flaperons can be hooked up easily now. The elevator, however, takes a little more work since the elevator is not in place. After you are happy with the elevator linkage, glue a piece of soft foam to the inside top of the fuselage between the rudder flex rods, and another piece to the top center of the horizontal fin for the fuel tank to rest on. Put the fuel tank in and hook up the fuel lines. You will notice that I have the tank facing forward and use long fuel lines to hook it up. So far, after six months of flying, I have had no fuel draw problems. Epoxy the horizontal fin on.

Hold the canopy deck in place and mark all the way around it on the fuselage covering. Remove the covering under the deck and glue it on. At this point the edge of the deck is bare wood; if you wish you can go around the edge with a felt tip pen to hide the wood. Carefully rough the bottom inside edge of the canopy where it touches the deck edge with 220 grit sandpaper, and then wash and dry the canopy. Put a small bead of 5-minute epoxy around the edge of the deck, then push the canopy in place. I prefer epoxy to super glue here since super glue can fog the canopy. Some of the epoxy will squeeze out but do not wipe it off. When it starts to harden you can peel it off very neatly, but you have to work fast.

In order to protect the bottom of the airplane I installed a rubber sailplane skid. After landing on some rather rough fields I feel that the skid was a good idea.

Flying:

Make sure that the airplane balances with a full tank of fuel on or slightly ahead of the Center of Gravity mark on the plans. Set the control throws as shown on the plans. I recommend that you wait until a clear sunny day for your test flight. If it is hazy or overcast you might find out where the name Spectre came from.

Throwing the Spectre is not as hard as you might think. Just grab the fuselage between the wing and horizontal tail with your first two fingers and thumb, and support the fuselage with your other fingers. Throw the airplane straight ahead, slightly up and fairly hard. She might fly nose up until she has built up speed. Do not let the prop bother you. Even though I have never watched the prop on launch I have been told by friends who have watched, that the prop never gets close to my hand or arm. Once in the air the Spectre looks more like a jet than any model I have ever seen, save a few fan jets. The Spectre will perform most any maneuver you wish. The only maneuvers that are difficult to perform, that I have tried, are stall turns and snap rolls. This is because there is no prop blast over rudders. But then, again, how many jets do you see doing stall turns and snap rolls.

You land the Spectre like you would any other airplane that you skid in. Some up elevator is required to get a good glide, and on the final flare the nose will come up fairly high. If you have flaperons you will need to put in some up elevator trim when you drop the flaps, so you will want to drop them before you turn final so you have time to retrim. With flaps down you will find that you will need more power to fly level and you will need to use less elevator on landing.

If you build a Spectre I hope that you enjoy it as much as I do.

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