

**I** MUST STATE that all the ground work for this kind of model had been done by my father over a period of some fifteen years. His first ducted fan "Mig" was built in 1950 and his last model, a semi-scale design, was built in 1964. His last eight models were all single channel R/C machines. Anyone can see from this that I was at a considerable advantage as far as calculation and experience were concerned.

The main factor I learned with this type of model is that an efficient fan and ducting system is (as one would naturally assume), essential, coupled with keeping the model as light as possible. By keeping the model light I do not mean building it out of balsa stringers and tissue paper—I mean watching carefully the wing loading to power factor very carefully.

My father's ideal power/weight loading factor was 1 lb per 1 sq ft per 1 cc.

I have altered this slightly mainly due to the greater power output available nowadays; and my ideal power, weight, loading, ratio is 1 lb per sq ft per 1½-2 cc. This has proved most successful as far as I am concerned.

Now I will describe my first true multi radio-controlled ducted fan design.

I decided to choose for my model a well tried configuration in this field with plenty of wing area, clean lines and a realistic appearance. I chose a swept wing, swept tail semi-scale 'Scimitar' type design.

The model is 48" long, has a 40" span, weighs 4½ lb and is powered by an O.S. 40P. The wing area is just under 4 sq ft and it carries "Skyleader SL4" radio gear operating ailerons, elevators and rudder. I left out throttle control not because of the weight factor, but because my motor had no throttle on it and I thought this could come on my next model. The model took me three months to design, i.e. draw up rough plans, weigh radio gear, engines etc, and nine months to build, this was due to very little time available with only occasional evenings available to work on the model. The true building time I would say is probably about six weeks.

The model was first flown in November 1971 with David Runnalls at the controls (I am not a very experienced pilot). It flew "straight off the drawing board" and was one of the thrilling experiences in the field of model aviation I have ever witnessed.

Subsequent flights have been made and Dave has really put it through its paces . . . loops, slow rolls, flick rolls, hesitation rolls, stall turns etc etc.

#### **BUILDING INSTRUCTIONS IN DETAIL**

##### **1. Engine Mount/Wing Tongue Platform**

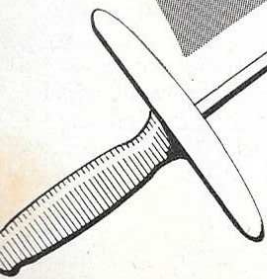
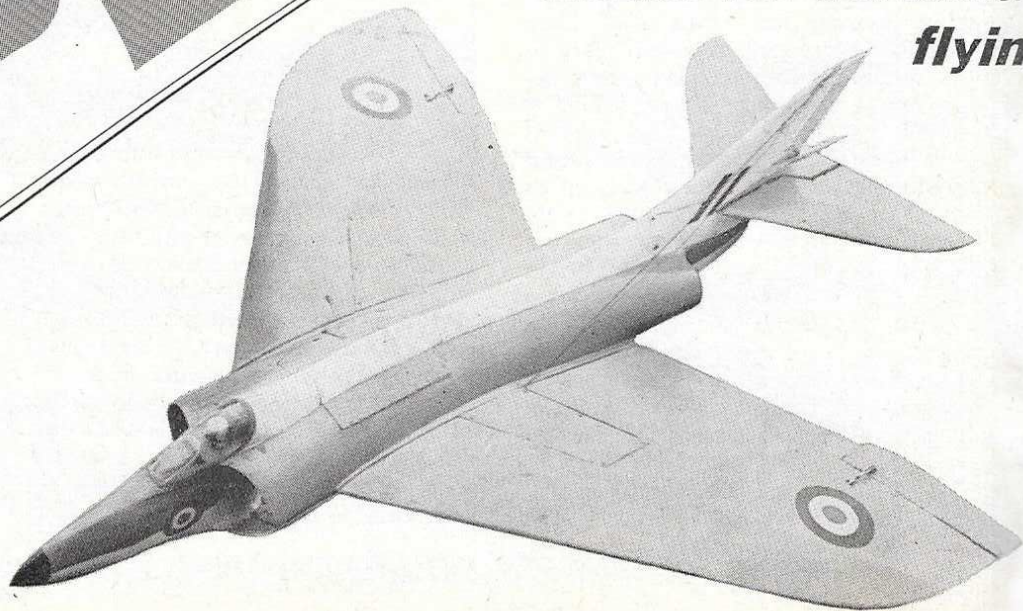
Mark the shape accurately on a piece of (resin bonded) 5 lamination ply wood ¼" thick, also the necessary cut away shapes on the centre line to accommodate the particular engine to be used (O.S. 40P on plan) and the fuel tank. With a fret saw, cut out the platform and drill engine mounting bolt holes for a screw fit.

Locking nuts must be used on the underside of the mount. I used the type that are used on aircraft which have two small holes on the auxiliary wings attached to the nut. Through these small holes, drive rivets and fit them through the wing tongue making sure that the main hole is in line with the hole drilled in the tongue. Peen the rivets over. The nuts can be "epoxied" to make sure they are absolutely firm and immovable. File and sand paper to streamlined shape, the inner portions of platform between engine and where the inside of the duct will be. Make the streamlined cone from drawing paper with balsa end for fitting onto part of platform behind tank. Thoroughly dope and fuel proof inside and out. Cut aluminium or dural saddle which passes under crank shaftcase and fasten securely in position on ply platform with 6 BA nuts and bolts. (Make sure the bolts are fairly long and do not cut them off as another saddle of dural

**By Marcus  
Norman**

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**A 40 inch span  
ducted fan multi-  
model for aerobatic  
flying**



or aluminium has to be made which passes over the engine crankshaft case and fits over these same bolts forming a type of clamp.

Check engine and tank in position, and bolt engine down.

Cement tailcone in position behind tank.

Cut the hardboard fan disc template, drill centre to take crankshaft of engine, and file and sandpaper circumference to as true a circle as possible. This template must be made accurately as its job is to ensure that the engine and mount are placed accurately in the duct. Cut a 1" wide strip of 1/32" grain running the length of the strip and carefully wrap round the circumference of the hardboard disc. Mark the overlap position accurately and glue (epoxy), binding temporarily to hold until dry (when dry remove binding).

Fit the disc onto the engine crankshaft and mark where the ring touches the wing mount either side. Remove disc and ring and cut into the engine mount  $\frac{1}{8}$ " at these two places. Replace disc and ring on the engine mount and epoxy the two joints. Tighten the nut on the crankshaft to hold disc and ring in position until dry. It is important to ensure that the ring is at right angles to the engine mount. Build up in soft balsa the oval section to ring and glue, hold in position with rubber bands until dry. Carve away balsa carefully until necessary shape is obtained, carving the inside parts each side of ply ring to a knife edge.

## 2. The Fan

This type of fan which is the result of several years of experiment, is extremely efficient and not too difficult to make.

(i) Turn the hub upon lathe if possible, made either of 5-ply resin bonded plywood or as in some of my fans a 5-ply lamination of mahogany glued under as much pressure as possible with an epoxy glue. Do not drill out centre yet.

(ii) Make up a jig for cutting the blade slots. To do this in a simple way for 45° blade angles (which I find to be most successful) a perfectly simple and accurate jig can be made. Cut a square of 5 ply wood a little larger than the diameter of the fan, make sure it is not warped or distorted. Scribe a circle of the same diameter as that of the fan. Divide the circle into eight segments. Drive a small panel pin into the centre mark of the circle and remove its head. Leave it protruding approximately  $\frac{1}{2}$ ". This is a simple but accurate jig for marking your blade slots.

(iii) Place the hub over the pin, remembering not to drill out the crankshaft hole yet. Merely use a very small drill, the same size

as the panel pin, so that the hub will fit fairly tight on it. Having placed the hub onto the pin, mark the eight points on its circumference. Remove the hub and place it on the pin the other way up and mark the eight points again. Remove hub. Using a straight edge and sharp pencil, scribe a line to join the point diagonally opposite the first point you have chosen. Repeat this eight times around the hub and you now have the hub marked out for cutting. One important thing to remember is to check with an ordinary propeller the direction of the pitch. Otherwise you will end up with a reverse thrust fan (as I have twice before).

(iv) Cut blade slots with hacksaw.

(v) Cut blades from  $\frac{1}{8}$  in. Permaglass Type 22/E or Type XE6/1, making them slightly larger than necessary. This material is obtainable from the designer, Marcus Norman, 22B Lyme Regis Road, Banstead, Surrey. The manufacturer is Permali Ltd., Bristol Road, Gloucester, but we are not sure if the latter will supply direct in small quantities.

(vi) File the edges off to give an aerofoil section.

(vii) Fasten blades into hub with Araldite.

(viii) Drill small holes through the hub at each blade position, threading each hole with a 8BA tap. Screw in short 5/16", 8BA bolts. These are an added safety precaution just in case a blade comes loose. Repeat on reverse side and then drill crankshaft hole.

(ix) Mount fan on to the hardboard fan disc with suitable nut and bolt and trim off to about 1/32" under the disc diameter. Check the fan for clearance in the ring with engine in position. Remove fan and thoroughly dope and fuelproof.

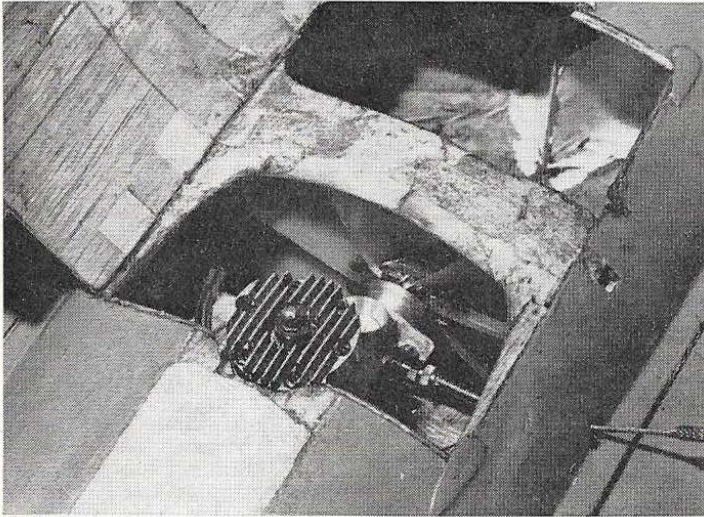
(x) Make starter pulley from fuel can top. This now completes the power plant for the machine.

## 3. Lower Half of Fuselage/Duct

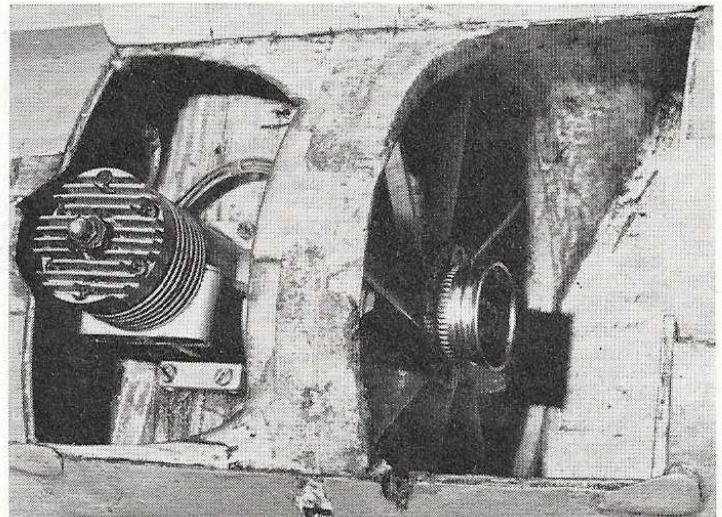
The fuselage duct is constructed entirely of 1/32" resin bonded 3 ply, formed in two halves, top and bottom. The lines are kept quite straight except for the one curve on the upper forward part of the fuselage.

Select a good quality 1/32" ply for the fuselage. Cut the lower half to the size and pattern shown with grain running lengthwise (It will be found that plywood can easily bend with the grain but not across it). Mark centre line on both insides and outside of plywood.

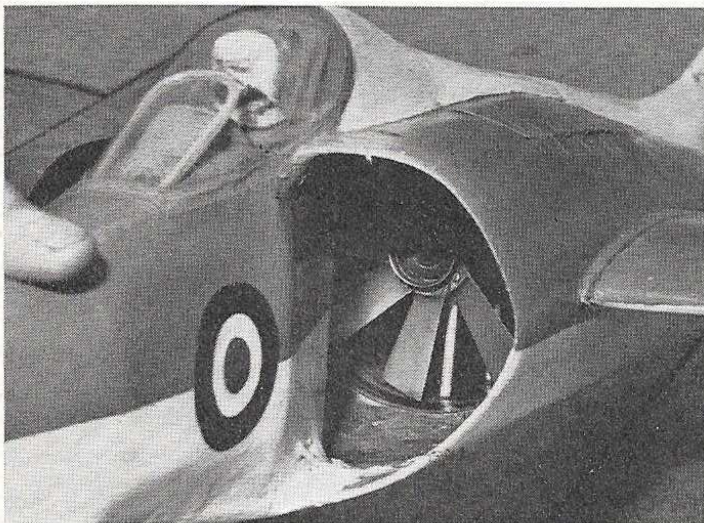
Cut reinforcing piece which extends from beyond front end to just beyond fan ring. Glue this in position inside lower half with



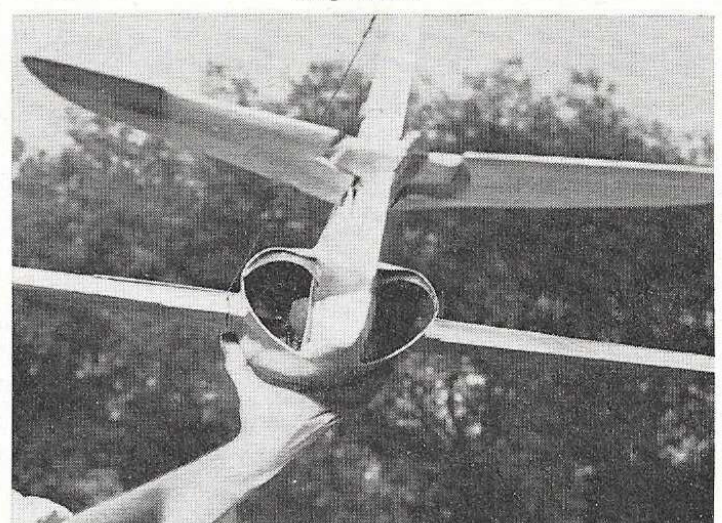
Close-up of the motor with hatch folded back to reveal engine in position with fan unit. Note needle valve extension protruding through fuselage side. Hatch is cut from basic fuselage shell.



Another view of the engine bay showing motor installation and fan unit. Note the starter pulley, a fuel can cap, O.S. 40 here is silenced, but the fuselage produces a satisfactory muffling effect.



The front air intake ducts are large to provide the fan with enough air to drive the model. Note the blades of the fan, clearly visible here.



Rear view of model showing the shape of the jet efflux and the thrust deflector tabs.

epoxy, or P.V.A. white glue. Hold in place with pins or clothes pegs.

Measure positions of wing platform edge exactly on ring and disc, place ring disc and platform in lower half and mark off platform position accurately.

Cut slots in ply shell so that platform ring and disc fit accurately in position. When satisfactorily aligned, glue platform unit in position. Bind with rubber bands and string and leave to thoroughly dry. Place rubber bands round front and rear of sheet, to maintain curvature until set. Cut intake and efflux templates from hardboard. Make and fit metal tie rods from underside of platform to inside of lower half shell. The engine will have to be removed to carry out this operation, but it is advisable to leave the disc in position in ring to maintain dead central position of crankshaft in ring. Remove any surplus glue, smooth off reinforcing pieces, and pieces round ring into duct sides.

#### 4. Pattern for Upper Half of Shell, Methods i and ii

i) Carve the complete upper shape of fuselage from a block of hard balsa, allowing about an inch more than the actual depth required. Ensure that the front section, section at the fan, and rear section are accurate. Sand to smooth finish and cover front portion with grease-proof paper held in position with gummed strip. This is to prevent plywood shell from sticking to this portion of the pattern when gluing.

ii) Make silhouette shape of fuselage top half from 1" hardwood, i.e. Deal: cut front section, fan position and rear section from  $\frac{1}{2}$ " hardwood. Cut two bottom strips from  $\frac{1}{2}$ " x  $\frac{1}{2}$ " hardwood, glue whole together firmly and cover upper front portion where curve occurs, with greaseproof paper held with gummed strip paper.

#### 5. Forming the Upper Half Shell of Fuselage by Shaped Mould Method

i) Cut the resin bonded  $\frac{1}{32}$ " to pattern shown (this is slightly oversize to allow trimming to shape when forming is completed). Mark centre longitudinal line on both sides with pencil. Cut centre line with sharp point back to point indicated.

ii) Soak ply in hot water and lay centrally on mould. Drive pin through ply into mould at centre rear end, and just beyond central cut in ply, wrap this portion with rubber bands or string to hold it to the mould.

iii) Run glue (epoxy or P.V.A. wood glue) over the upper side of the ply alongside the central split.

iv) With strip rubber or tape, firmly bind the split portion onto the mould, letting one side pass over the other, and, starting at the middle portion, (fan position) securely bind the split together along the ply until the other end is reached. Drive in a pin or two if necessary to hold the overlapping portions in position. Try to get the wood as even as possible, free from lumps. However do not be unduly worried if a few occur, as there is a reinforcing piece to be fitted inside and in any case the finished joint is sanded and filled and eventually covered by the cockpit and spine.

This operation is not as difficult as it sounds providing the wood has been well soaked beforehand. Allow to dry, then remove binding and carefully remove shell from mould. The shell will open out, but this does not matter as it will be formed again during assembly with the lower half of fuselage.

Cut the reinforcing piece as indicated on plan, glue inside shell and hold in position by placing back on mould and bind or pin as before. While this is setting, mark the exact position of the engine access hatch, and make a small pin hole through each corner to transfer position of hatch to inside of shell.

When dry, remove reinforced shell from mould.

## 6. Forming Upper Half of Fuselage Shell by Built-up Mould Method

- i) Cut ply as for method No. 1 etc and soak in hot water.
- ii) Apply centrally to mould and bind round rear and fan formers.
- iii) Drive pins in along both lower sides.
- iv) Carefully coax in and overlap the split section of the plywood driving in pins and/or shoe brads through plywood into mould, and commencing at central former, work on a short portion at a time until the front former is reached, when rubber strip or string binding is applied tightly round ply and former.

The glue is applied as for the other described operation before the retaining pins are driven in.

- v) Allow to dry thoroughly, then carefully remove from the mould. The shell will open out, but this again forms correctly during assembly process of the upper and lower halves.

## 7. Assembling Upper and Lower Halves of Fuselage

Cut two lengths of hardwood or hard balsa from 1" x 1" stock (length from back of mount, to about 2" larger than lower half of fuselage shell). Slightly curve off one face and wax to prevent gluing to inside of shell. Insert into back end of lower fuselage half on each side and position flush with top edges, and hold tightly in position with pins. Cut another piece of similar material and fit snugly between the engine mount ends of the two lengths. Position the hardboard efflux template former between other ends of wood and hold with rubber bands.

Place upper half of shell in position over lower half, and mark position of engine mount. Trim shell carefully and neatly away at this point, until shell fits snugly over fan ring, mount and down to efflux template. Run glue (resin or epoxy) along top faces of lower shell. Carefully position upper half and slip rubber bands over to hold two halves together at mount and efflux position. Drive in steel dressmaking pins along two sides through the two shells and into hardboard lengths inside. Rubber bands may be added also, to ensure that both sides make thorough contact for glue. Put aside to dry when this part of the operation is complete.

When set, place intake template (hardboard) in position and hold into lower half shell with one or two pins. Run glue along side of shells, slipping over rubber bands and pinning as before. Inspect for thorough contact of glue and then put aside to dry. All pins and rubber bands may now be removed, also the disc, nose and tail formers. The lengths of wood are carefully prised out and the complete shell is cleaned up with fine sandpaper. Next, the hatch may be finally cut through and removed and the engine compartment inspected. Hinge the hatch with  $\frac{1}{2}$ " wide nylon ribbon as shown. Make hatch fastener as shown from a piece of clock spring and fasten to hatch with small 10 or 8 BA nut and bolt. Cut a small slot in the fuselage at the point where the fastener makes contact and check that the hatch locks securely when closed. At the corners add two blister type pieces for edge of hatch to also slip under when closed (see plan).

## 8. Nose and Tail Blocks

Build the nose and tail section as shown on plan, cutting out respective formers as indicated and building up using conventional construction techniques. Make sure that these are built accurately as they have to be fitted into the fuselage duct.

Coat the top and bottom faces of the nose block with glue and also the inside of duct at proposed area of contact. Insert nose block in position and hold firmly with 3/16" lengths of tapered wood dowel pegs, driven through previously drilled holes in duct and nose block. Now tightly wrap with string or rubber bands the extension pieces on duct to nose block, checking that the latter is lined up dead true to duct.

Repeat the same operation for tail block piece. When the whole structure is dry, all the binding etc may be removed, and the fuselage cleaned up with fine sandpaper. The front and rear ends of the duct are now strengthened by wrapping with 1 $\frac{1}{2}$ "-2" nylon ribbon, glued and doped. Also, the nose block and tail block can be covered with lightweight nylon.

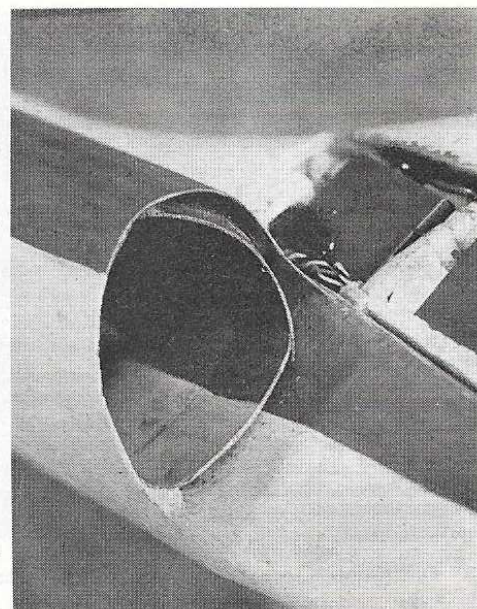
The whole unit is now complete except for drilling the needle valve hole for the engine (the needle valve will need to be extended). The down thrust vanes are made from 1/32" ply and fitted at rear end of duct, as shown (a very important item).

Now cut out the sheeting at the battery compartment in nose. Line the edges with a suitable hardwood. Cut out the compartment cover to fit flush over the space and drill holes for 8BA screws as shown. The switch for your batteries goes in this panel.

You require extension leads for your radio gear as shown on plan. Run the battery leads from the compartment as shown and bring them out forward of the ring where they will eventually pass through the wing root into the wing panel which carries the radio receiver. Where the leads pass round the duct, cover with 1" nylon ribbon and thoroughly dope.

Take the aileron extension lead and pass it straight through the duct over the top of the wing platform. Cover with nylon ribbon where it crosses the platform and thoroughly dope. It is essential that where leads, etc pass through the duct, the holes

Another close-up of the jet efflux, here showing the shape and angle of the deflector plates.



must be thoroughly sealed afterwards. (Silicon bath tub sealant will be useful here).

## 9. Fin and Dorsal Spine

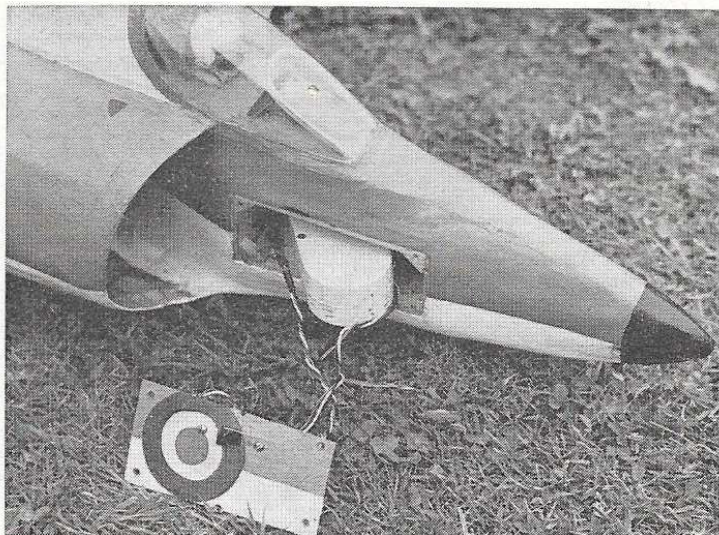
The fin is constructed as an integral part of the fuselage. Cut the Mainspar from  $\frac{1}{4}$ " thick medium hard balsa. Insert into tail block as shown, checking for alignment with trailing edge which has been incorporated during the building of the tailblock. Cut leading edge of fin, which also forms the top of the spine, from one piece of  $\frac{1}{4}$ " medium balsa about  $\frac{1}{4}$ " deep. Where this piece has to bend, cut notches in it and soak in hot water. Then gradually ease to the correct shape over plan. Having done this, glue in position as shown. Cut rib as per plan from  $\frac{1}{8}$ " medium balsa and glue in position; ensuring that your servos will fit the servo compartment. I built the machine for Skyleader S.L.4 equipment, but obviously some servos are different—slightly longer or wider or higher so at this point one must use his own discretion to alter accordingly. Make the tail attachment point suitably strong and insert tailplane pivot tube as shown, ensuring that it is horizontal and well epoxied in place. Now place servo extension leads along the spine as shown, through the duct at the point indicated and out again through the wing root passing into the wing compartment carrying the RX. Again, cover the leads with nylon ribbon where they run inside the duct. Place the spine formers in position as shown. Sheet in with light 1/32" balsa as shown on the plan. Now form the rudder hinge spar as shown but do not cut out the rudder yet. Sand fin and rudder over to ensure a good surface for sheeting. The fin can now be sheeted and the servo compartment hatch made. This is done, as with the battery hatch, in 1/32" ply.

## 10. Cockpit Fairing and Spine

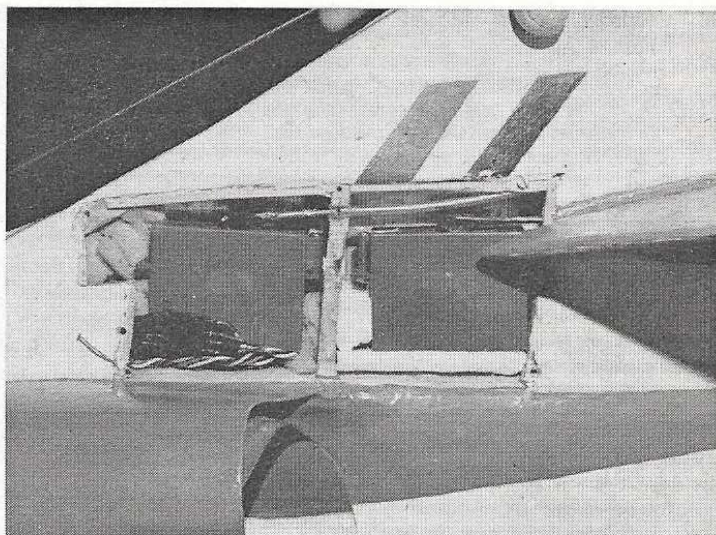
Build up with formers as indicated. Use 3/16" for top and sheet in with 1/32" soft sheet. The cockpit on my machine I moulded myself, but I am sure there is a suitably shaped one on the market one could use.

## 11. The Tailplane

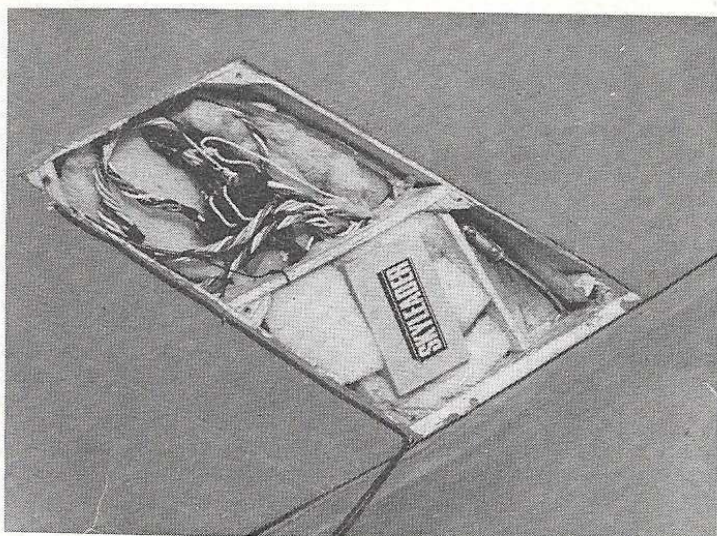
This is constructed over the plan in a conventional manner. It is made in two identical panels. The leading edges are cut from 3/16" x 3/16", trailing edges from 3/32". The centre ribs are 3/16" while all the other ribs are 3/32" sheet. The mainspars are also cut from 3/32" sheet. Press the mainspar down into position on ribs. Cement and allow complete frame to dry. Repeat for the second panel. Sand off tail section to streamline airfoil, leaving slightly more camber on upper surfaces than lower ones. Check frames to make sure they are free from warps. Cover the leading edge back as far as mainspars with 1/32" soft sheet. Now mark position of hinge points on both tail sections. Insert into both panels a length of tube at these points as per the plan. The actual pivot pin should be a fairly tight fit in the tubes. I used duralamin rod of size shown on the plan. The pivot passes through the fin and into both tail sections. Drill a hole through the tube and pivot in tail section. Tap an 8 BA thread in each hole and insert a 3/16" 8 BA bolt in each. The tail plane is now linked on both sides of fin but is able to pivot through the fin. Fit the fairing strips either side of the fin as shown with a negative incidence of 2 $\frac{1}{2}$ -3°, this is the flying position of the tailplane in level flight. The tailplane control horn is made from a commercial one cut down and shaped and glued to the face of the root rib as shown. I made the tailplane removable for easy transport. While performing this



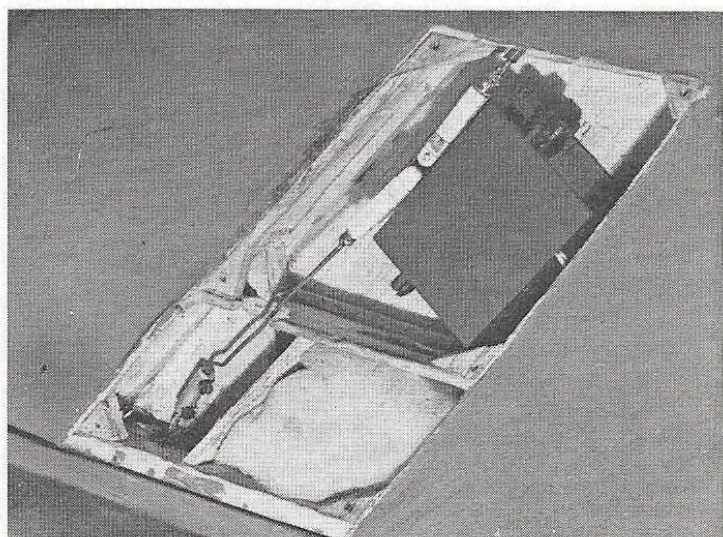
The nose section of Epee, showing the battery compartment with hatch removed. Note switch fitted to hatch cover.



The rudder and elevator servos, installed in the thick sectioned rudder assembly. Hatches remove to reveal control runs to surfaces.



The receiver installation compartment in the wing. Receiver is sensibly kept apart from the mass of wires and extension leads necessary for this installation. Note attachment for aileron linkage.



Aileron servo installation in one wing panel seen here with hatch removed. Aileron linkage is via 'snake' type flexible drive.

operation, do keep an eye on the plan. Alignment of both tail panels has to be very carefully done. The actual linkage from the tail to the servo can now be worked out and fitted to make sure it operates correctly. (The servos in this model should all be mounted using tape) to absorb any vibration through the airframe when the engine is running. The linkages on the tail section and servo should be as tight as possible without overloading the servos.

## 12. Wings

These are constructed over the plan. Cut the trailing edges from  $\frac{1}{8}$ " medium sheet and the leading edges from  $\frac{1}{4}$ " x  $\frac{3}{8}$ " medium hard balsa. Cut ribs 4-9 as per plan from  $\frac{3}{32}$ " medium. No. 1 rib (root rib) is  $\frac{1}{4}$ " medium hard and is cut to correct shape as per plan. No. 2 (a, b, c) and 3 are from  $\frac{1}{8}$ " medium hard and are again cut out as per plan. Measure off the depth of the slots for the leading edge and trailing edge for each individual rib, which is placed temporarily in position on the plan.

Cut the slots in the ribs. Slip ribs into position and cement. Add built up wing tips and cement.

Cut mainspars as shown from  $\frac{1}{8}$ " hard balsa. These must be cut accurately according to plan.

Place mainspar in position, onto wing frame and hold temporarily with pins. Cement mainspar in position, ensuring that the bottom edge is flush with the underside of each rib. Allow to dry and then, using a sanding block, carefully sand over.

Cut the aileron spars as per plan from  $\frac{1}{4}$ " medium sheet and place in position as shown on plan using the same methods as for the mainspars. Cut the aileron leading edges as shown and place these in position taking care not to glue them on the face that meets the spar. Cut and place in position the aileron sub ribs as shown on the plan. After drying, sand over lightly to ensure an evenness of surface, then cut out the ailerons as shown

from the servo box and radio box, one in each wing as shown on plan. Lay aside wing frames to prepare wing boxes. Fit wing root fillets (see section 20).

## Wing Boxes

These are made from  $\frac{1}{32}$ " ply and hard balsa strips corresponding in thickness to wing tongues ( $\frac{1}{4}$ " approximately) and are best constructed on the wing tongues themselves. Cut the four pieces of plywood, place the lower piece under the wing tongue and mark edges of tongue with pencil. Cut the hard balsa strips and glue (epoxy or resin), in position ensuring tight fit to tongue. Hold in position with pins or clothes pegs.

When dry, remove pegs or pins and glue upper surface pieces in position. Allow to dry and then trim away surplus wood at edges. Remove from tongues. Drive shoe brads through edges, about three per side, and two along the tip (see plan) and bend them over, making sure the heads are resting on something hard i.e. metal block.

## 20. Fitting Boxes into Wing Frames

The wing root fillets should be fitted over the tongues at their correct angle of incidence and in the correct position (see plan detail). The angle of incidence should be about  $2^\circ$  to the centre line. It is fairly easy to determine the centre line if, on assembly, to the fuselage, the wing tongue-cum-engine-mount has been placed correctly. The tongue should be the centre line. Place the wing boxes on the tongues and set up the wings in their correct position but on top of the boxes.

Carefully mark the position of the wing boxes on the underside of each wing. Cut away the wing where marked so that it fits down over the wing box and is correctly aligned with the

## EPEE

root fillet. When this is satisfactory, glue the boxes into the respective wings still in position on the model. There is no dihedral set flat on bottom surfaces. Pin well, so that the whole model is set up, put aside to dry. Make good the undersides of those ribs which were cut away for the wing boxes and sand over lightly to regain section. Replace wings on model for screw fittings to be added.

**21. The Wing Retainer Bolts**

There are two of these to each wing tongue. (6BA bolts, brass or nylon). Drill two holes through each wing box and tongue with the wing in position. Drive the 6 BA bolts through from the underside of the wing and add Simmons locking nuts. Having determined the correct positions, epoxy the locking nuts in place. These are the only fittings required for each wing. Now sheet the leading edges back as far as the mainspar on both wing panels.

This completes the wings and fittings. The aileron drive is a 'flexi-type' that can be bought from your model shop. Fit the drive in with the wings assembled to the fuselage. The aileron drive runs as one piece from one aileron in a gentle curve through the fuselage just behind the engine and on in another gentle curve, to the other aileron, running through the compartment which carries the aileron servo and through the box that carries the RX.

Glue the aileron drive in position and allow to dry. Cut the cable at the position where the servo is to be placed and make the necessary linkage for connection to the servo. Also cut the cable where it passes through the RX box and make up the linkage so that it can be undone when the model is disassembled (see sketches). Glue a 1" nylon strip over the cable where it passes through the fuselage over the wing tongue and make sure it is firm. When dry the wings can be removed and the model is ready for covering and finishing.

**22. Covering**

I *strongly* recommend covering in lightweight nylon.

**23. Fitting Engine, Tank and Fan**

Place the tank in position and retain in place with a spring clip made from piano wire as shown. Place engine in position and bolt in place. Position the invented saddle over the bolts in front of the carburettor and screw the nuts on the bolts in position. Now drill a small hole in the fuselage side just above wing root to correspond with needle valve position. The needle valve will have to be extended so that it protrudes through the duct to facilitate engine adjustments when the hatch is closed and the engine running. This is important because the engine cannot

be adjusted correctly with the hatch open as the closing of the hatch will alter the setting slightly. I reverse the needle valve assembly so that it protrudes through the fuselage on the starboard side of the fuselage.

Install the radio gear. The servos are attached in my machine with servo tape as this absorbs a certain amount of vibration. Pad the receiver and battery pack well with foam rubber and check operation of the system. Replace all access hatches and panels.

My model weight is 4½ lbs all up with *Skyleader* equipment (3 servos). It is very important that the weight is maintained at 4½ lbs as that is the design weight of the machine. A bigger engine cannot be fitted once the model is complete. Of course if your model weighs less than this fully laden, then you will have a very very good performance.

Fit the down thrust vanes in the tail pipes as shown. These are very important, and it is better to have too much than too little to start with. I have a Dolly undercarriage for my model which I made up for R.O.G.s.

**24. Balancing and Test Flying**

The C.G. should be at approx 45% of the wing root chord. If the model has been built correctly according to the plan you will find no ballast weight is needed to bring the model to correct balance. Slight nose heaviness is permissible but not tail heaviness as this will have disastrous results especially in the case of hand launching. I did not test slide this machine but set the engine four stroking for initial exploration of flight characteristics. The model should be tested in a slight breeze, launching directly into wind, always fairly fast and dead level with no tendency to a nose up attitude. If a swept wing is pulled up too sharply with this type of propulsion it will stall very quickly. So I suggest keeping the model very low and straight for the first few seconds to ensure a good built up of speed (acceleration is slower on this type of model than with a conventional prop). When the speed has built up, a gentle climb can be initiated. After some experience you will find that the pulling up into the climb can be quicker.

My test pilot, Dave Runnalls, finds the model quite pleasant to fly but a little tricky. This model has an all movable tail-plane and if the movement is too great then you can be in trouble. The correct throw movement for this control surface is indicated on the plan. The model will not spin. We have tried everything, but a true spin is just not possible. When executing loops and rolls, it is advisable to build up a bit of speed first.

It also flies well inverted. Make sure you know approximately how long the tank run is. When the engine cuts, although the glide is good, it is fairly fast and so the model needs to be in a position up wind for a good circuit on the glide, to set the machine up directly into wind for a smooth belly landing.