BANSHEE

Thoroughly proven and flight tested, this ducted fan Delta is one of the most exciting models you'll ever fly.

By Captain C. W. Peake

THE "Banshee" is designed to produce something different on the flight line, and has literally stopped the show whenever it has been flown. The basic design was produced as a free flighter using Jetex power, and a later version flew with miniature single channel radio and two Jetex 350 units, but duration was naturally limited.

P. E. Norman had been flying single channel ducted fan models in England for a number of years, but even with a hot engine, his best model weighed only 38 ozs., which would not permit multi installation. However, an American modeler named Wayne Schindler had carried out experiments indicating that Norman's practice of enclosing the fan completely within the duct gave less thrust than a fan just outside the duct inlet. This seems to be due to the fact that a fan can be designed to draw in air at the tips, rather than throwing it off, and this characteristic can be used to force more air through the duct than is possible with a completely enclosed fan. It also allows the use of side intakes, leaving the fuselage free for the installation of radio gear.

A test rig was set up, and a fan and duct unit, built along Schindler's lines, gave 22 ozs. of static thrust. Past experience indicated this should handle a model up to about 3½ lbs. weight.

The first D/F version (christened "Screaming Meemie") weighed in at 57 ozs., and while successful, was underpowered. The model shown is MK II, weighing 51 ozs., and while still requiring catapult launching, is capable of loops, rolls, and Immelmanns except in very hot weather when power output is down.

Might be possible to counteract the power loss with a good dose of nitro, but I haven't tried it yet. It normally flies on a 10% nitro mix.

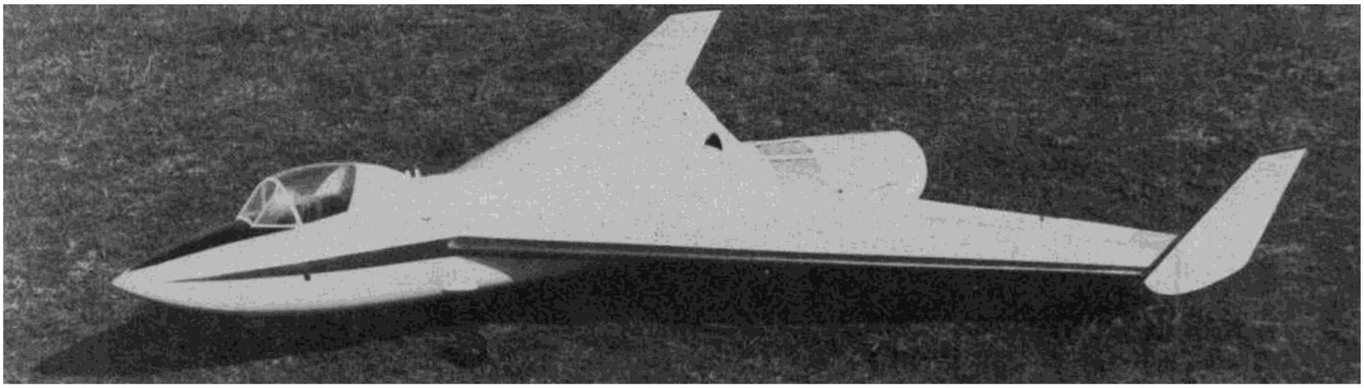
No thrust control is provided, as the Cox 15 Special doesn't take kindly to being throttled down. Some form of air flow could possibly be rigged in the duct, but this is also a project for the future.

Flying-wise, it is a reasonably docile beast when properly trimmed, but should be allowed to fly at its own speed and coaxed through maneuvers rather than forced. Elevators should be treated with caution. Don't attempt to drag it into the air with elevator, as it is likely to sink back on to the ground due to rapid drag rise as the angle of attack increases. This is known in full scale aviation as "the back side of the power curve", and is responsible for some of the changes of technique necessary when converting to swept wing jets. Aileron control also becomes very sloppy at low speed.

This is not a beginner's model, and no attempt has been made to cover all construction steps in detail. However, the sequence given should enable an experienced modeler to reproduce what has proved to be a most spectacular airplane.

Select balsa carefully to keep weight down. Hard ¼" sq. for the spars and spar joining triangles, and soft for the rest. (Not "pulpy" soft.)

Fan and duct assembly provide a good starting point. Steps in fan construction are detailed on the plans. Make sure all nicks, scratches and tool marks are polished out, and the fan carefully balanced. Also shown is the method I use to keep



the fan in place on the Cox 15. If you use another type of engine, make sure to lock the fan securely, as the ordinary method of attaching a propeller may not hold the fan at the high RPM.

Use whatever construction method you can dream up to produce a reasonably even duct of 4 1/8" inlet and 3 1/2" exit (inside) diameters. My own method was to use two 1/8" balsa discs of the appropriate diameters joined by a piece of straight 1/4" dowel about 3/8" longer than the duct. This was planked in the ordinary way with 1/8" balsa, the ends cut off with a razor saw, and the dowel and discs removed.

If you use this method, it is useful to take two pieces of cardboard about 7" square, cut a 4 3/4" diameter hole in one and a 3 3/4" hole in the other, and slip them over the outside. This will hold the duct in shape while you sand the inside. Fill with thinned Hobbypoxy "Stuff" and paint the inside black with Hobbypoxy enamel. The smoother the finish inside the duct, the more thrust you will get. Leave finishing the outside until the cone assembly is installed.

The cone is carved from soft balsa and hollowed. Six flow straighteners are spaced at equal intervals around the cone just inside the duct inlet. From edge is 3/8" from the inlet. Four flow straighteners are fitted with rear edges at the duct exit. All straighteners are cut from 1/16" balsa, are 1 1/4" wide, and sanded to streamline section. Cut slots in the cone and glue flow straighteners in place. When dry, cut a slot at the base of each of the forward ones, and damp and mold them to an angle of about 30° into the direction of fan rotation. These act as guide vanes for the air leaving the fan. Trim the ends so that the whole assembly may be inserted in the duct. Fill, sand, and paint black, and glue in place. The duct will now be rigid enough for you to work comfortably on sanding the outside.

Airframe.

The heart of the airframe is the 1/8" plywood crutch. If you use a different engine, adjust the engine space and bearers to suit. Place the engine in position on the crutch and outline the mounting lugs. Cut away so that when installed the engine rests on the bearers, not on the crutch.

Your building board should be large enough to accept the entire wing (at least 36" square), and an outline drawing of the top view is required. Place the drawing on the board, cover as usual with waxed paper, and lightly nail the crutch in place with three or four fine nails.

Butt join enough sheets of 1/16" balsa to cover complete wing outline. Grain runs parallel to leading edge. Draw and cut two outlines to exact size for bottom sheeting, and two oversize for top sheeting. Note that top sheet must overlap R1 far enough to meet fuselage planking.

Cut all ribs to shape. R1 is 3/32" thick, R2 through R5 1/16", and R6 is 1/8". No spar cutouts are shown, as the angle of the spar is such that cutouts are in a different place on either side. Place rib in position on edge over plan, mark spar position on each side, draw lines at right angles to lower edge of rib, and cut to spar depth at angle shown by vertical lines. Notch bottom only of tip rib, as rib is not deep enough to take two notches. Top spar is butt joined to tip rib.

Lay bottom sheeting on plan and glue to edge of plywood crutch. Lightly draw spar and rib locations on sheeting. Glue 1/4" sq. lower spar in position on sheeting. Glue filler strip along trailing edge, bevel rib edges to match, and glue ribs in position. The filler strip serves to fair the top sheet down on to the plywood crutch, and a piece of 1/16" balsa cut to the shape of the rear prong of the crutch is glued in place after the top sheet to produce a smooth transition from top sheet to crutch.

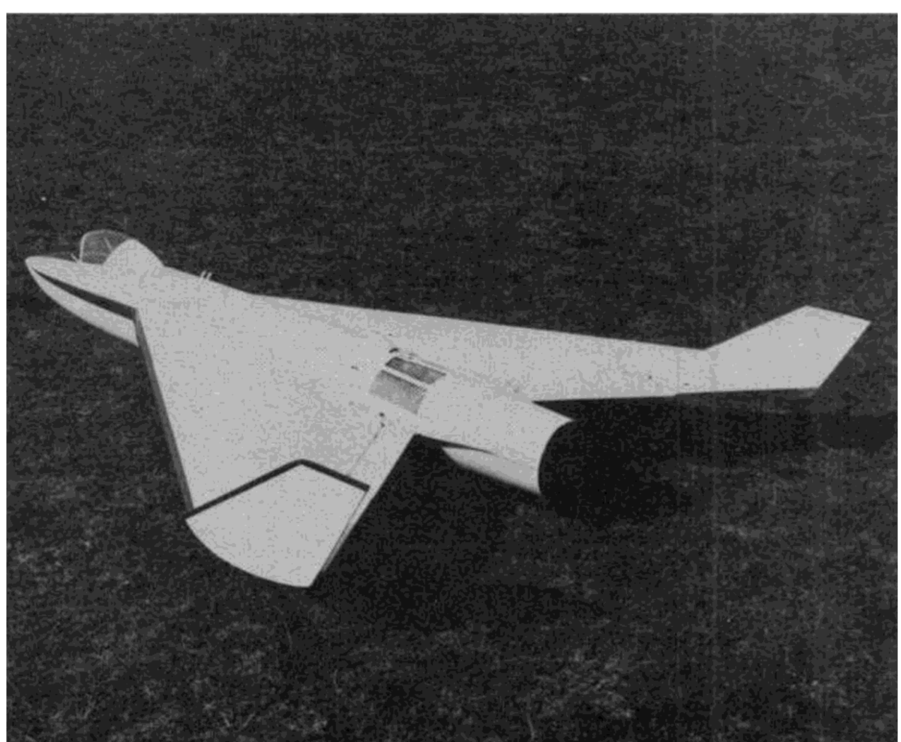
Bevel front ends of ribs to correct angle to butt firmly against leading edge, which is cut from 1/4" balsa, and tapers from 9/16" at root end of 3/8" at tip. Glue leading edge and top spar in place, and bevel top of leading edge to receive top sheeting.

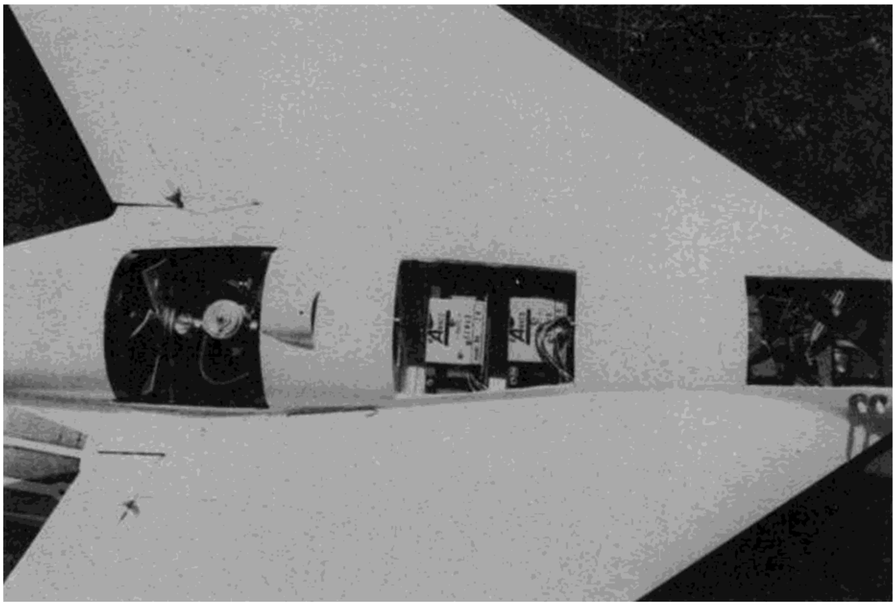
Repeat for other wing. Note that spars and leading edges extend across fuselage and are joined in the center with a triangle of 1/4" hard balsa.

Assembly at this stage should be firmly pinned to board. Install aileron and elevator bell cranks, noting that elevator cranks must be arranged so that both elevators move in the same direction. Install push rods of 3/64" diameter wire. Light wire is adequate since there is little or no "push" function — mostly "pull". Plywood guides should be glued to each rib.

Where push rods extend through trailing edge, cut small grooves in the filler strip, deep enough to allow top sheet to be glued along filler strip over the rods. After fitting top sheet a slot is cut to enable the push rods to be lifted enough to align with control horns. A small piece of nylon or plastic tubing is slipped over the rod and glued into the slot to form a guide, and the slot below the guide filled with a balsa strip.

If you prefer to sheet the top in sections, it is possible to start at the trailing edge





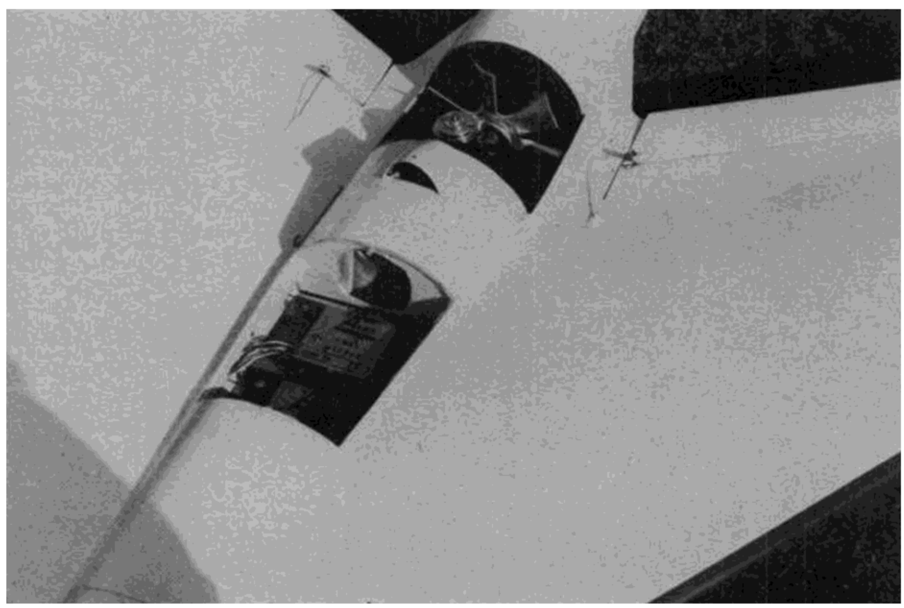
The works. Note switch location. Annco servos now replaced by Mr. Bonner's "real small" control muscles. Pressure line vent to left of engine.

and install the guides as you go, without notching the filler strip. The push rod and bell crank assembly shown was designed for use with reed equipment and Annco servos, but thanks to the ingenuity of Mr. Bonner, the Banshee has now gone proportional with a Digimite 4-RS, and the same linkage works well. The ship was designed before flexible cable and nylon guides were readily available, and the whole installation could be easily changed to lightweight flexible cable and guides.

The important point is that whatever system you use, it must all be securely in place before the top sheet goes on. This includes having the push rods between bell cranks and servos cut to correct length, as once the top sheet is on it is difficult to find the bell crank neutral. While the top is open and accessible servos can be placed in position and rods cut to length without difficulty.

The leading edge should now be pinned down with pins angled in from the front so that top sheet can be placed over them. All inside pins should be removed. Double check for pins inside, as it is most frustrating to get your top sheet nicely fitted and find you're still pinned down *under* that top sheet you have just put on so carefully!

Top sheet can now be affixed with a fairly slow drying glue, plus pins, weights, fingers, thumbs, toes, etc., to bend the sheet to conform to upper rib shape. Start at the trailing edge and work forward. A slow drying glue gives you a bit more time in case you have to rip it all off and start again! This is one of those points at which you swear off models forever.



Cooling air scoop, fuel tank installation. Note engine cover clip lying on wing root. If hatch cover tends to sag in middle, 1/16" dowel pegs hold it up. Old lid serves well as starting pulley.

P. S. If you have used my trailing edge grooves, don't glue the push rods in 'em!

After you have stopped cursing model planes in general and ducted fan deltas in particular, cut the bulkheads to shape. F1 through F7 from 3/32" balsa, F8 top from 1/8" ply, and F8 bottom from 1/8" balsa.

Glue two strips of 1/8" balsa 3/8" wide on edge against the leading edge immediately above the points where L. E. and fuselage planking meet. These two strips should project forward so that they can be bent to conform to the forward shape of the fuselage, and they form, in fact, the first of the fuselage planking. The top halves of

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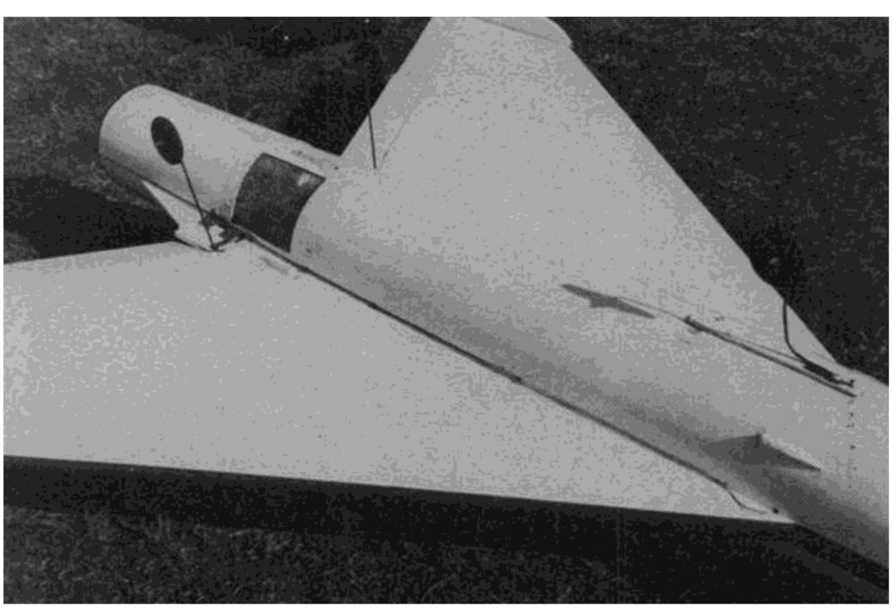

Underworld secrets revealed! Undercarriage, lower intake screen, blocks for take off dolly. Also antenna for reed receiver. Put proportional antenna to top of left fin, away from servos and engine.

F1, F2, and F3 are pinned in place over the plan, and the two strips bent as described and glued to these bulkheads. If your building board is 36" square like mine, this nose section will have to be supported on a separate piece of board.

Glue remaining bulkheads in place between root ribs. Remove nails from crutch, and plank top of fuselage with 1/8" balsa from F1 to F8. This is largely a "cut and try" operation to fair planking smoothly into wing. Cracks can be filled with "Stuff".

The moment of truth has now arrived. When dry, the whole assembly can be unpinned and lifted from the board. (I told you to take *all* the pins and nails out from underneath.)

Glue servo rails in place. If you were smarter than I was when I built mine, the rails could actually be included in the plywood crutch.

Epoxy engine bearers in place underneath crutch. A couple of screws behind F8 will strengthen the joint and hold the bearers in place until the glue dries. Remember that the whole engine and duct area becomes fairly saturated with fuel, and glue and fuel proof accordingly.

Glue bottom halves of bulkheads in place, and plank bottom of fuselage. If you use 3/32" planking forward of F5, and 1/8" aft of F5 except for a 2-inch wide strip along the bottom, a layer of fiberglass can be nicely blended into the thicker planking.

With engine and fan in place (use blind nuts on mounting bolts) insert the completed duct between crutch prongs. Duct inlet should be 3/16" to 1/4" behind rear edges of fan blades. Center duct behind fan, align with reference line, and glue securely in place.

Recess planking and outside of duct inlet 1/32" to accept intake screens. (Upper intake screen is also the cover for engine and fan area.)

Cut screen frames from 1/32" ply and epoxy screens inside. Support in approximate semi-circular shape until glue dries to prevent glue cracking when screen is bent over intake area. Exact frame shape may vary with individual construction techniques and varying material thicknesses, and you may find it easier to make the screens first and then cut the recesses to fit the screens.

Paint and finish inside of lower screen and underside of engine area before gluing lower screen in place. Upper screen is held by the two aluminum strips epoxied to fuselage sides and upper wing surface. The edges of the screen frame slip down inside the strips, and a wire clip inserted through the cooling air scoop holds the screen in place. The screen is readily removable for engine starting. With the Cox 15, a small hole is necessary in the top of the screen to clear the tip of the glow plug.

Engine may now be removed until model is complete.

Cut cooling air slot in top of planking. Line cooling air passage with 1/16" balsa to prevent fuel entering the fuel compartment. Some oil will find its way through the feed line and pressure line holes, but if the cooling air passage is not lined, the fuel compartment quickly becomes oil soaked. Make a small scoop from 1/32" aluminum and epoxy in place. Exact scoop shape is not particularly important as long as some air is directed down on to the cylinder head.

Round off leading edges. Cut fins from 1/8" balsa and add 1/16" ply doublers to lower portions. Control surfaces are also cut from 1/8" balsa, and 1/16" fibre control horns glued into slots. The rather odd control horn shape provides the necessary differential movement. The 1/32" ply strips prevent the surfaces from splitting in the vicinity of the horns.

After wing, fins, and control surfaces are sanded, hinge surfaces to wing trailing edge, and lightly glue fins to wing tips. Light gluing recommended here, as in a hard landing the fin will simply separate from the tip, whereas if heavy gluing is used it takes half your wing tip with it.

Sand, fill, and finish as desired, always with weight in mind. No tissue or silk covering is used on the model shown, which was filled with "Stuff" thinned to brushing consistency, and sprayed with white Hobbypoxy enamel. The fuselage forward of F5 below the line of the wing lower surface is covered with very light fibre glass, and a two inch wide strip of the same material extends along the bottom from F5 right to the rear of the duct. This enables the model to be flown without undercarriage if desired.

Detachable undercarriage details are shown on the plans. A single 4-40 bolt holds the forward leg and six small wood screws with three aluminum clips hold each rear leg. Wheel size is not important, but use thin wheels rather than balloon wheels to reduce drag. The undercarriage shown is surprisingly unobtrusive, and detracts little from the appearance in flight. It is readily removable by loosening the bolt and sliding the forward leg out, and unscrewing the screws on the rear legs. Removal of undercarriage weight and drag results in a corresponding increase in performance. The plywood strip carrying the catapult hook is retained by re-tightening the bolt, and four small streamlined blocks (two of which are clearly visible in the underside photo) serve to prevent fore and aft movement of the dolly used for take off.

Carefully cut hatches from receiver and servo compartments with a razor saw. I find that finishing before cutting hatches results in better fitting hatch covers. Strips of 1/4" x 1/32" balsa glued along the inside edges of the hatch covers form small flanges or lips which can be gently sprung into place under the planking, and the covers will then remain in place without external fasteners.

Hatch covers should be as large as possible. The outlines shown provide sufficient access to the receiver compartment to enable the inside hardwood strip for the undercarriage to be installed without difficulty, and the hole for the fuel tank can be cut in F7 through the servo hatch. The tank can then be installed through the servo hatch without requiring a third hatch above the fuel compartment. A two oz. tank provides duration enough to leave my nerves in tatters.

Use pressure feed for consistent running. I put an old free flight cut-off valve in the pressure line to vent the line quickly in case of a false start. This prevents filling the crankcase with fuel.

Mount servos on 1/32" plywood plates, which are then glued or screwed to servo rails. Receiver and battery pack go in the front compartment, wrapped in foam. Holes must be cut in F5 and F6 to enable plugs and wiring to go through between the two compartments. Plugs will probably finish up inside the intermediate compartment, and I push strips of foam through the holes in F5 and F6 into this area to stop the plugs rattling around. Pictures show reed gear installed (Orbit receiver, 5 pencell size 450 MA/HR Deac batteries, two Annco servos), but as mentioned earlier the Banshee now flies on Bonner 4 RS proportional. The only changes in installation necessary were to modify the servo ends of the push rods for the center output arms of the 4 RS servos, and move the antenna from the underside of the left wing root, as shown in underside photo, to the top of the left fin. Too many funny metallic noises for proportional in the original location.

Final Thrust Adjustment.

Re-install engine and fan, install fuel tank, and connect push rods to control horns. Note the small v-shaped bend in the push rods, which provides a ready external adjustment of the reflex angles. Make sure wheels roll freely, and stand model on a flat smooth surface.

In case you haven't handled a ducted fan before, my starting sequence is as follows:

Fill tank through feed line. The cutoff valve mentioned earlier also vents the tank for filling.

For initial starting, leave this vent open. Connect feed line to engine, and prime through exhaust ports. Don't prime through air intake. Because of the tank position, which is slightly above the engine when the model is standing on the ground, the tendency is usually to get too much fuel in the crankcase. If you have too much trouble with flooding, get someone to hold the rear of the model up a bit, or make a cradle to do this.

Set needle valve to approximate starting position.

Put knotted string in notch in fan hub, turn fan backwards over four or five compressions.

Connect starting battery to plug. If you use alligator clips, it is useful to have a small lug under one of the mounting bolts for one of the clips.

Pull string smartly. (Don't run away — it always makes a noise like that.)

Adjust needle for maximum RPM — literally maximum noise!

Close vent. RPM will drop off, as tank is now pressurized and mixture therefore richer.

Lean out again for maximum RPM.

For subsequent starts with the Cox 15, the needle valve should be left in the pressurized running position, and the vent closed before starting. If you have a false start, vent the line as quickly as possible to prevent flooding. If it floods, you will have to blow the fuel out of it, and possibly start again with the vent open.

If you can, talk to someone with pressure feed experience. Free flighters and speed men often have more experience of this than radio controllers. It takes a little time and patience to get used to a pressure fed D/F.

Now connect a scale or spring balance to rear of model. Start engine, and check thrust reading. At normal temperatures, you should get 20 to 22 ozs. on straight

FAI fuel mix. Adjust blade angles in very small amounts for maximum thrust. **Not** while it's running, stoopid!

Incidentally, the rear end is designed so that if you become too discouraged with the fan set-up (and it **is** more patience testing than a prop) the whole duct assembly can be cut off straight across between the elevator hinge lines, and a 7" pusher prop installed in place of the fan. Undercarriage would need to be moved forward also. This feature was built into the design deliberately in case fan thrust proved insufficient. The fan has proved so successful, though, that it hasn't been tried.

Trimming and Flying.

Check center of gravity position. A slightly forward CG is permissible, but an aft CG may produce violent instability. Most of the test procedure here is designed to guard against the possibility of getting into the air with the latter condition, which would result in a rapid write-off.

Adjust aileron reflex angle (see plans) to about 8°, elevators to 4°. If the aileron trailing edge is raised ¼", and the elevator ⅛", it will be fairly close to desired angle.

Drive a small peg into the ground, and tie together the ends of a 30-yard length of ¼" flat rubber to form a loop 15 yards long. One end of the loop goes over the peg, and a round wire loop about an inch in diameter is attached to the other end. Again using the scale or spring balance, stretch the rubber to obtain 3 to 3½ lbs. of pull. The wire loop is placed over the catapult screw just in front of the nose wheel.

With all radio on and checked, and an experienced flyer on the transmitter, release the model. It should just lift off, glide a few yards, and land. If it does not, increase pull to 4 lbs. in small increments. If it still won't lift, begin increasing elevator reflex until it does. If it doesn't lift by the time the elevators are up level with the ailerons, the CG is probably too far forward. Aileron and elevator reflex can both be increased up to about 10° to overcome this.

If at any time it shows any tendency to sit back on its tail, hit down elevator. It will do much less damage to thump it in on the nose than to allow it to stall and squash back on the fins. If it shows any tail sitting tendencies, the CG is too far aft, and this must be remedied before it is flown.

Any turning tendencies can be taken out with aileron adjustment, remembering to adjust **both** ailerons, as one aileron alone will also affect longitudinal trim. Do not adjust ailerons to the point where the fully down aileron goes much below the chord line of the wing. If your CG is right and construction is true, they should never approach this point anyway.

Adjust ailerons and elevators to produce a straight fast glide. If you take your time and go through the above procedure carefully, it will ensure that your model is stable in the air and will also help to give you the feel of an unfamiliar type.

When you are satisfied with the glide, use exactly the same technique for a powered launch, with 3¼ to 3½ lbs. of pull. Climb will be fairly shallow, but don't drag it up too much with elevator, as explained before. Takeoff should be simply a continuation of the glide launch.

You may find during the glide tests that the front undercarriage leg bends back rather readily. Mine does, but I just bend it forward again. ⅛" wire may be an improvement, but I haven't got around to trying it yet.

If you aren't shaking at the knees by the time it gets off, you should be! The noise is indescribable (I started to write unbelievable, but couldn't spell it), but when you see this thing howling across a blue sky, you'll forget all the qualms and frustrations.

But hey! We still have to get it down. The Cox usually gives fair warning before it dies — blurp, blurp, blurp! Let it glide at its own speed, don't try to slow it down too much until you get close to the ground. Give yourself plenty of room — it can cover a lot of sky on the glide. Hold it just off the ground and keep that stick coming back until it sinks on to the rear wheels. It's down — what happened to those rosy cheeks?

Do's and Don'ts.

Do use a high speed engine to ensure sufficient thrust. The Cox turns about 25,000 RPM.

Do use pressure feed for consistent running at high RPM.

Do be careful when installing the upper intake screen with engine running. You could finish up with a couple of very short fingers. Also watch that the rear edge of the frame is not drawn down into the fan.

Do your glide tests with all radio operating and someone controlling the model. This is a fairly radical design, and until you are used to it, it is difficult to pick control alignments. An experienced flyer can keep it out of trouble unless it is badly out of trim.

Don't omit the cone and flow straighteners in the duct. This is an important feature of the design.

Don't try to throw it around like a Class III Stunter. Especially on proportional, coax it, don't bully it. A nice long shallow dive and plenty of speed for aerobatics.

Don't neglect to clean oil and dirt out of the duct after each flight. A clean smooth duct gives maximum thrust. Keep intake screens clean, too.

Don't use heavy weight radio. About 10 or 11 ozs. of radio is the maximum. The lighter the model is, the better it will perform. Properly trimmed on the glide tests, it could be flown on single channel if you can dream up a suitable aileron linkage. Don't put rudders in the fins.

Don't write to me (or Don Dewey) and say it won't fly. It has, it does, and it will, if built and handled as described. My apologies for lack of in-flight pictures, but I just haven't got around to getting 'em.

Well, I've done my part. Now you do yours. Build it! Good luck.