PHOTOGRAPHY: DICK SARPOLUS

The canard concept intrigues more and more modelers. Dick's *Firestar* is his experiment with a canard design aimed at pattern competition.

FIRESTAR

Canard pattern ships aren't showing up at the contests yet, but they might be in the future. Canards can fly well, and they're certainly being seen more often in full scale aviation. I can't say the canard layout offers any real benefits for R/C pattern flying, but pattern designers and competitors haven't been working on tail first aircraft to evaluate and develop that arrangement. The Wright brothers started with a canard, and the aeronautical world quickly moved the horizontal stabilizer to the rear, where it's been ever since on most aircraft. We may now be seeing a re-evaluation and a move back to the canard configuration, sparked by a brilliant engineer named Burt Rutan.

Rutan's *VariEze, LongEze, Solitare, Quickie,* and other designs, including his work on Beech's new *Starship,* have made people realize that good aircraft don't necessarily have to have the wing in front of the tail surfaces. R/C modelers are recognizing the same thing, as can be seen by the variety of canard designs appearing in the model press the past few years. I've been interested in them for years, starting with a C/L canard in the 50's. I made a large R/C canard sailplane with good results and recently did an R/C sport canard aircraft with a forward swept wing. The success of that model spurred me to try another canard, this time one aimed at pattern competition.

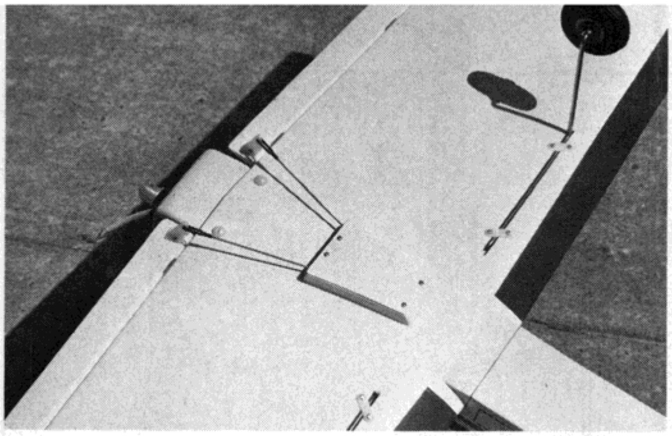
Design considerations

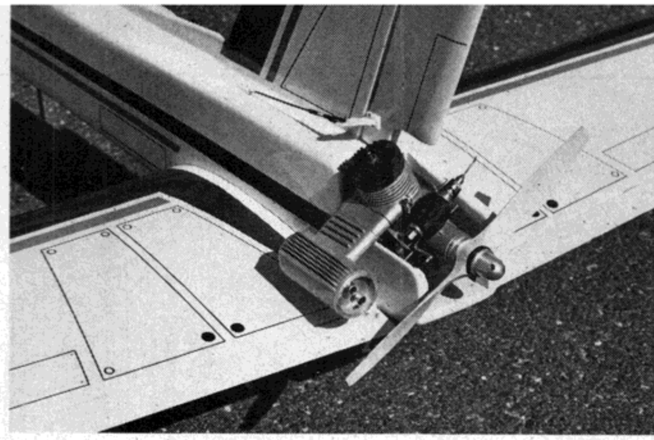
The toughest part of R/C canard design, to me, has been the mechanical considerations - primarily, how to get the aircraft to balance without requiring an inordinate amount of lead in the nose.

Other things, such as landing gear placement, adequate fuselage strength, fin and rudder placement, fuel tank, etc., are handled fairly easily. With a conventional aircraft layout, the R/C gear in the fuselage above the wing - engine and fuel tank in the nose, and an average tail moment length - the correct balance point can usually be achieved simply by moving the battery pack or adding a small amount of weight to the tail or nose. With a canard, it doesn't conveniently work out that way.

A rough rule for the balance point location on a conventional model is to put it at the 25% to 30% point of the wing's mean aerodynamic chord on a design with the "usual" proportions. Most average models are similar enough so that this 25 to 30% figure is quite safe, although wing sweepback does affect it. For a canard, the balance point is located between the aerodynamic center of the wing and the aerodynamic center of the forward located horizontal stabilizer. I don't have a rough percentage location as there haven't been a lot of canard designs around to get "usual" proportions. After working with a few canard designs, a ballpark location might be 20 to 25% of the distance between the stab's aerodynamic center and the wing's aerodynamic chord, ahead of the wing a.c. There is a safer way to do things, though.

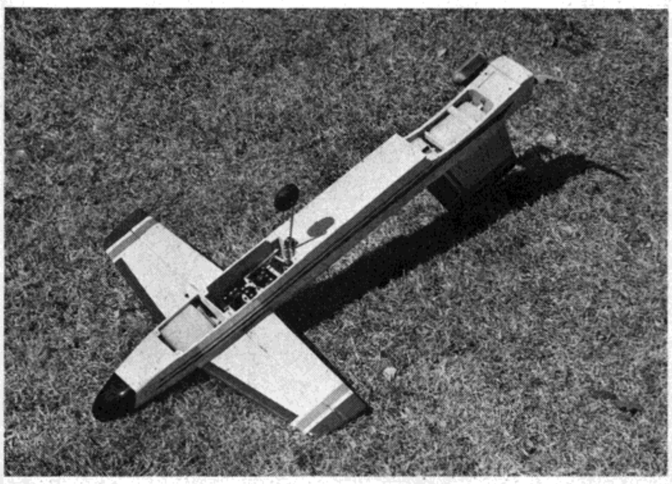
There are published formulas available to locate the balance point on a canard design, taking into account the design variables. I used such formulas during the design of the *Firestar,* attempting to get a layout that would balance without the need for extra weight in the nose. I selected a distance between the wing and stab, an area for the stab, and an equal taper wing planform that resulted in a calculated balance point location I thought would be achievable. The engine was positioned above the wing to get its weight forward, the battery pack was to go into the nose block, and the radio gear would be installed as far forward as possible. I almost made it; about four ounces of lead were needed in the nose of the prototype for correct balance. A lighter built-up wing or plastic film covering instead of a paint job might

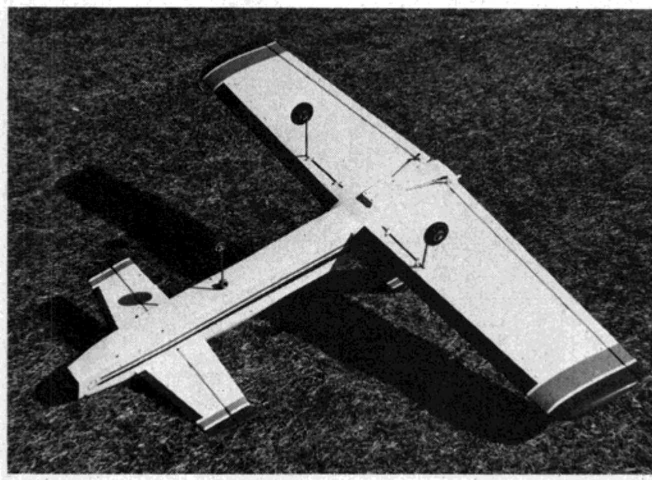




The aileron servo has been switched to the bottom of the wing (**above**) with access provided by a small hatch. With wing and hatches off (**below**), you can see placement of radio gear and fuel tank.

Pusher configurations, such as the *Firestar* (**above**), require pusher props or reverse rotation crankshafts. That's an HB .40 PDP Blitz with special short muffler. Hatches and wing on (**below**). Finish–dope and Coverite.





Plunge "tail first" into R/C aerobatics. The product of the author's wealth of canard experience. For 40's. **By Dick Sarpolus**

have resulted in no extra weight being required.

As with a conventional model, the balance point location should be varied to give the response you want in an aircraft. A more forward location and less elevator travel will reduce the model's sensitivity, but for aerobatic performance more sensitivity is desired than for a sport type model. Start with a forward balance point for safety, then try more sensitivity if you wish.

Flight characteristics

Two prototype *Firestars* were built; my friend Nick Nicholson made one in Alabama while I was constructing mine in New Jersey. Nick's was ready to fly first and I learned via a phone call that a crash was the first flight result - due to a too sensitive pitch response. Nick moved the balance point forward, reduced the elevator throw, and his model was flying well on the next day. I should have learned, but my first flight almost ended in disaster for the same reason. I added a few ounces of lead to the nose, cut down the elevator travel, and the subsequent flights were successful.

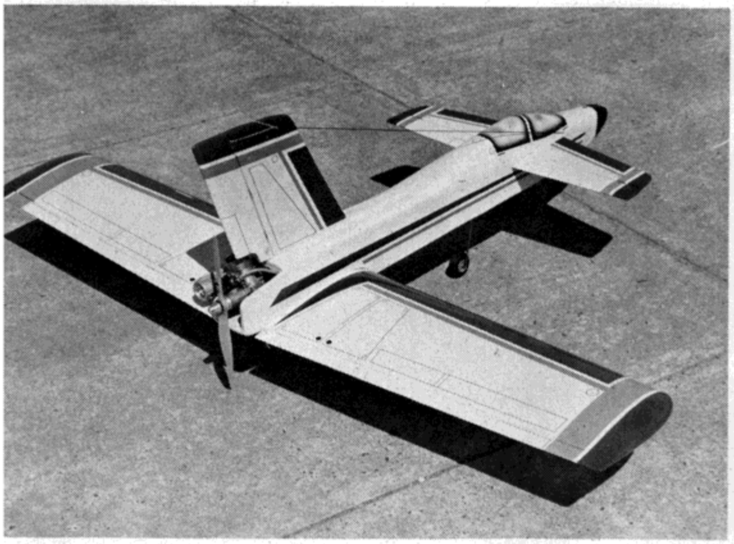
A characteristic noted on my previous canard repeated itself here; when power was cut, the nose went up, and down trim was needed for the landings. This time, the action was stopped by shimming the engine mount to tilt the thrust line up several degrees. When trimmed for level flight under full power, there was now no trim change when the power was cut.

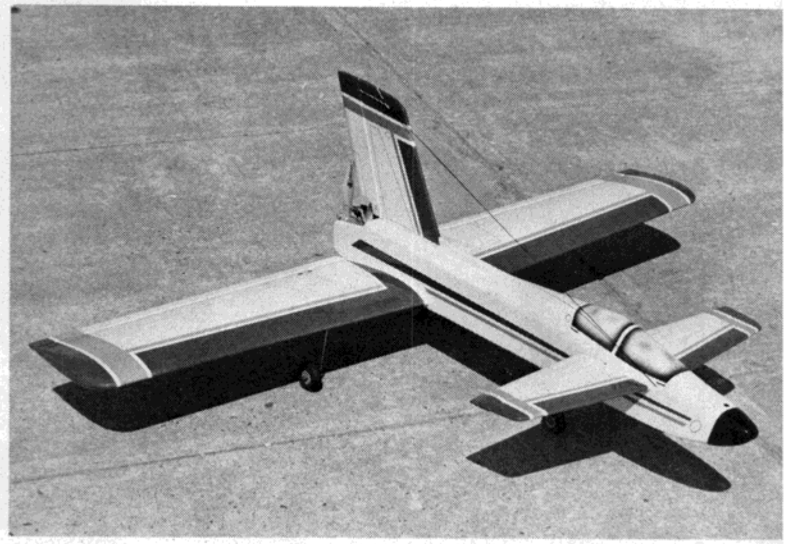
Some full scale canards are said to be stall proof. I'm sure this would also be true of the *Firestar,* if the elevator control available was limited. When stalled with limited up elevator, engine at idle, the nose will drop straight ahead with no tendency to fall off, and this action will be repeated as the up elevator is held. However, with more elevator control and rudder movement, the plane will definitely snap. I have been reluctant to spin my canards after reading about the difficulty of recovering from a spin - but Nick reports that his aircraft has been spun a number of times and with application of full opposite control and down elevator, the plane comes out of the spin. Here's where more elevator control is necessary. Honestly, at this time I still haven't tried it with mine.

An important thing to keep in mind when flying a pusher canard is that there is no prop blast across the control surfaces to provide control force at low speeds. Until the aircraft is up to some speed, there will be no control response - so, don't yank the plane off the ground; let it accelerate to a good flying speed, then take off. And when the aircraft is stalled in the air, remember that there will be no control until airspeed again builds up, from a dive. This is similar to ducted fan model flying, the same situation.

The *Firestar* knife edges well, probably due to the fuselage side area up front, making four point and slow rolls easier. For wingovers, obviously the kick over should be started before all airspeed is lost - again, there's no air blast over the rudder. The plane tracks well, and if control sensitivity seems too great, reduce the surface throws and/or shift the balance point forward.

Another canard design characteristic is the necessity for a large fin/rudder area. Double fins could be used on the fuselage, or dual fins could be installed part way out on the wing panels. I wanted to do this but didn't want the added complexity of installing rudder linkage out through the wing panels. The fin area could be cut down if another fin was added below the wing. If you modify this design I suggest you maintain ample fin area in one way or another. With the fin and rudder necessarily located so close to the engine, vibration is a factor to guard against. The fin must be well anchored to the fuselage and sufficient rudder hinges used to resist the





Canards seem to require much larger vertical stabs (**above**). Note how the bottom of the rudder is notched for engine clearance. Dick Robbins holds as author/pilot Dick Sarpolus pre-flights for maiden flight (**below**).

The fuselage of the plane is a basic box construction with some balsa blocks in the nose and canopy to allow for shaping (**above**). Paula Nicholson (**below**) holds her dad's, Nick, *Firestar.* His was the first to fly.

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structure vibration.

Regarding the engine installation, there is no prop blast to assist engine cooling on the ground so watch for overheating. A pusher prop is necessary (I use the Zinger 10-6 pusher on a .40) or a reverse, right hand crankshaft is available for some engines which would permit use of a standard propeller. I install the fuel tank as usual, clunk toward the rear, and run the vent and fuel lines back over the top of the tank to the engine. Despite the long fuel lines, using muffler pressure, I have had no engine operating problems. A fuel pump would insure a steady running engine.

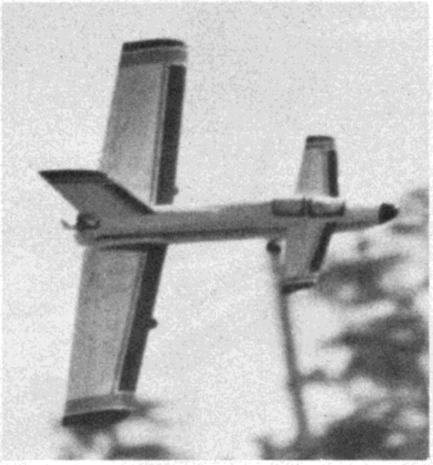
The design specifications are as follows: the wingspan is 57 inches, an equal taper planform from $11\frac{1}{2}$ inch root chord to a 9 inch tip chord, for 580 square inches. The usual full symmetrical airfoil is used. The horizontal stab area is 125 square inches, 21% of the wing area. The vertical fin and rudder area is 90 square inches, 15% of the wing area, and I would go no smaller than this size. The overall fuselage length is $41\frac{1}{2}$ inches. The weight of my *Firestar* with a good painted finish and some lead weight is exactly six pounds - it could certainly be built lighter, but flies well at this weight. The wing loading calculates to 24 ounces/square foot but since, for a canard, the stab area is included when calculating the loading, it works out to 20 ounces/square foot.

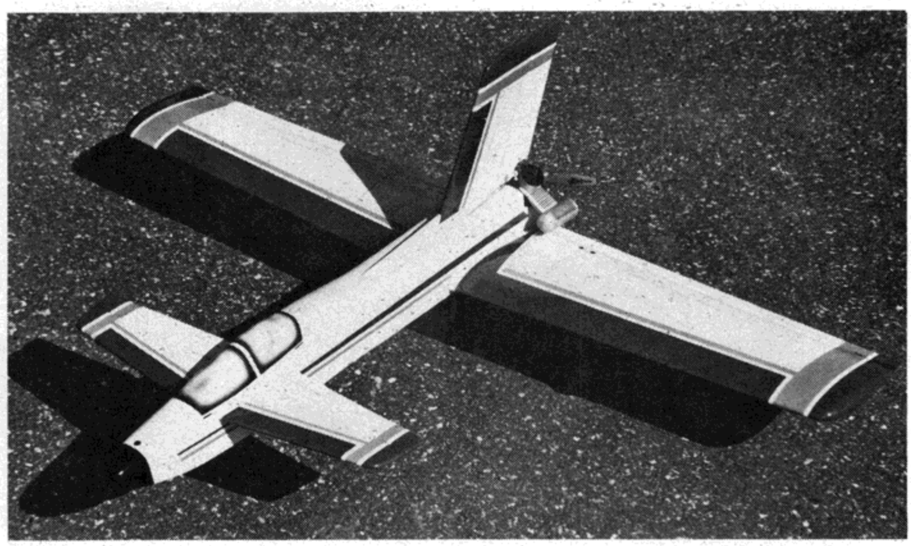
Construction of the model is, as usual, as straightforward as I could make it. The wing is foam cored, but could be built-up if you believe that would be lighter. The tail surfaces are sheet balsa and the fuselage is a basic box construction, with some angled pieces and blocks up forward to allow shaping of a streamlined canopy area.

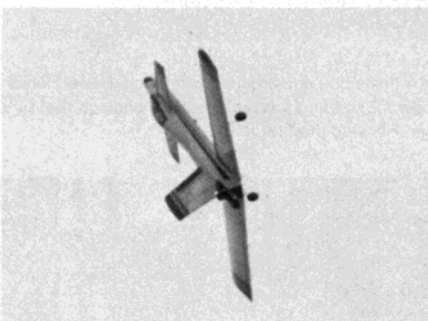
Starting with the wing, if you don't have a local source for foam cores, I suggest Ken Marcheselli, Ryerson Ave., Newton, NJ 07860. The core is skinned with $\frac{1}{16}$ inch balsa, and although I used a modeling contact cement, I agree with FM's Editor, Bob Hunt, that use of epoxy glue to attach the skin would result in a lighter wing. Bob applies the epoxy only to the prepared balsa skin, using a minimum of glue to do the job. The skins are held in place on the core with the foam blocks the cores were cut from, and weighted overnight to allow the epoxy to cure.

The grooved hardwood landing gear blocks must be installed in the foam core before it is sheeted. I use two sections of $\frac{3}{4}$ inch dowel epoxied to the gear block extending up through the foam core for reinforcement, or install partial ribs of $\frac{1}{16}$ inch plywood into the foam, cut to retain the gear blocks. Leading and trailing edges and tip blocks are added after the skinning, and sanded to shape. I use heavy fiberglass cloth and epoxy around the center joint for reinforcement.

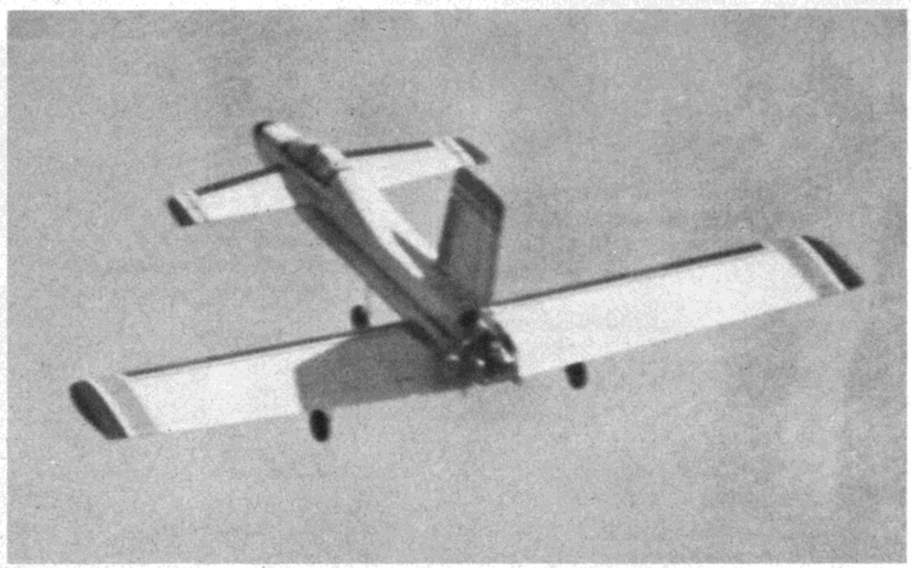
There is no room inside the fuselage to permit a standard aileron servo linkage arrangement, so I install the servo into the bottom of the wing with a small access hatch. The linkage can then be run directly to the ailerons - it's easily accessible for adjustment and







The biggest problem is orientation as you may guess from these flight shots (**at left**). Reflecting his contro-line interest, Dick used a #3 Leroy drafting pen to ink on the panel lines (**above**). The absence of air blast over the control surfaces reduces their effectiveness so obtain some speed before lift-off (**below**).



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doesn't look bad.

Construction

First step for fuselage construction is to epoxy the 1/32 inch plywood doublers to the 1/8 inch balsa sides. On my models I extended the plywood doublers all the way to the nose block for extra strength, figuring that the slight amount of added weight would be needed in the nose anyway. The sides are joined by the fuselage bulkheads, followed by the top planking. The canopy area side pieces must be trimmed to fit with the correct angles block sanded on the edges. The forward block and top pieces are added and then should be well sanded to a rounded contour on top. The nose block should be hollowed out to accept the battery pack before it is permanently glued in place.

Before closing in the fuselage bottom, install the throttle cable and rudder pushrod. The fin should be notched and fitted into the top block for maximum strength. Provide holes in the fuselage bulkheads so the aileron extension cable can be fed through later. Since several degrees of engine upthrust are needed, you may want to tilt the top of the firewall forward 3/32 inch when installing it so you won't have to shim the engine mount. Hardwood blocks are installed and later drilled and tapped for the nylon wing retaining bolts.

The horizontal stab surfaces are cut out and shaped out of 3/8 inch balsa. A 1/8 inch wire control horn must be made to tie the two elevator halves together for control; be sure the horn assembly is brazed for strength, not soft soldered. A commercial horn may be found for use. The radio gear access hatch, 1/8 inch plywood, can be held in place with small screws into hardwood blocks.

I finished the project with my usual materials - silkspun Coverite over the balsa followed by acrylic lacquer automotive primer and then Sig butyrate dope, sprayed on. The canopy area was airbrushed with white, blue and black dope. After the color trim areas were painted, panel lines and details were added with a number three Leroy drafting pen. Four or five coats of clear were sprayed on top for gloss and protection.

There are a number of short mufflers on the market which will clear the propeller and allow the exhaust to go out toward the rear of the aircraft. One benefit of a pusher canard engine installation is the lack of exhaust oil on the airplane to be wiped off. Very neat. I used an HB .40 PDP Blitz engine, with the HB short muffler and a muffler extension piece.

Test fly with some caution; you must remember that the little end flies in front and it takes a while to get comfortable and oriented to the canard's appearance. Keep the balance point forward and restrict the elevator travel to about 1/4 inch each way at first; later you can adjust things to get the response you are comfortable with.

Try the *Firestar* in your club pattern competition; I think we'll be seeing more canards in the future. Be the first in your area with a tail first pattern model, and enjoy it!