# FIRE

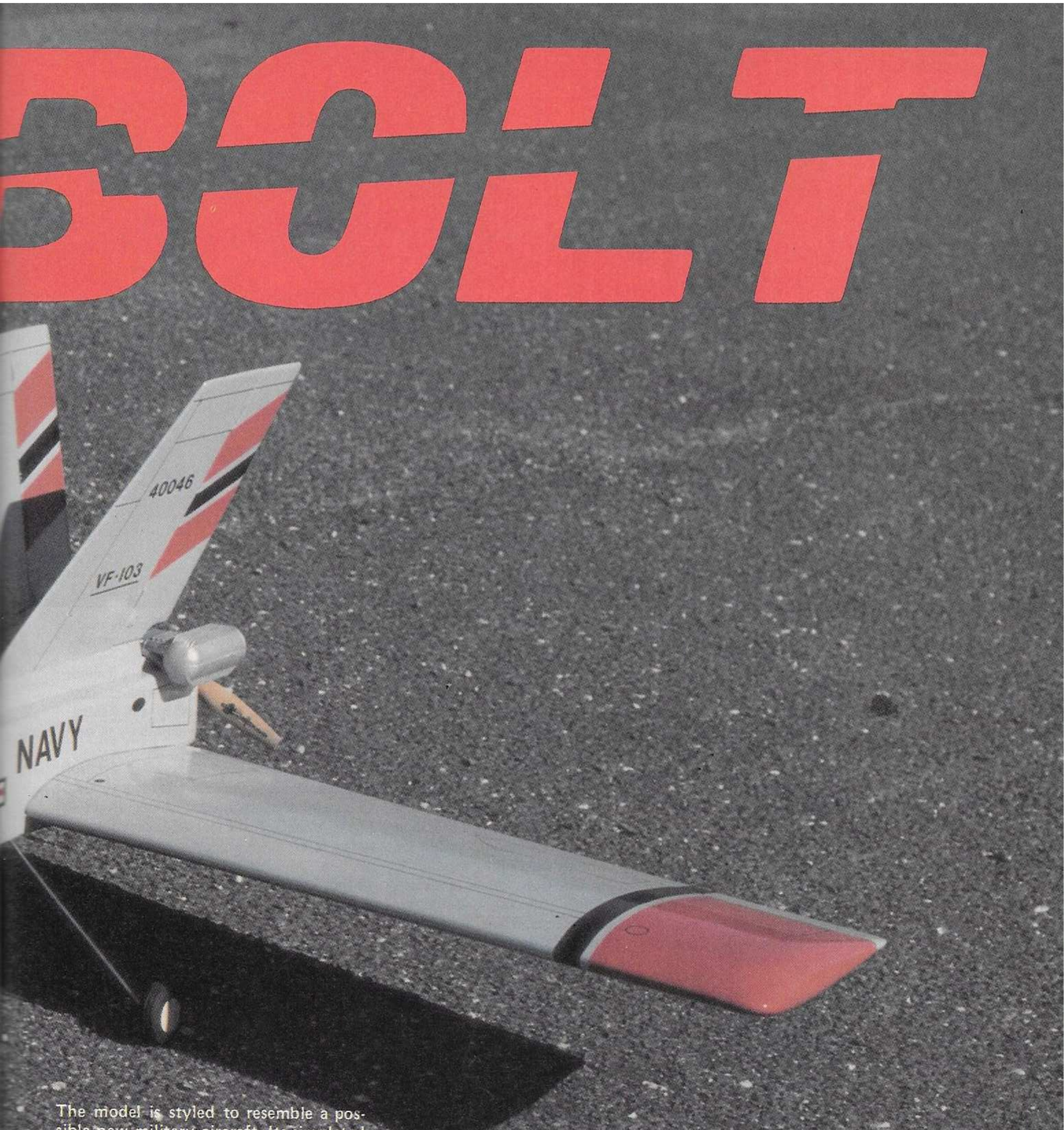
**You've heard about airplanes that look like they're breaking the sound barrier even when they're sitting on the ground. This RC pusher canard with twin fins and a swept-forward wing—for a .40 engine and four-channel controls—is an excellent example of this phenomenon. It flies and handles like a conventional Pattern/sport airplane. There's a companion article about how a computer can assist in designing canards.**


■ **Dick Sarpolus**

WHY BUILD a forward-swept wing (FSW), twin-finned, jet-styled pusher canard? Because it's modern, striking in appearance, different, fun, and best of all, it flies well. It's not Scale, and it's not optimized for Pattern flying, but it handles like a good Pattern/sport model. With a full-symmetrical airfoil, it's aerobatically capable; inverted passes, inside and outside loops, rolls, etc., are all easily handled.

This model design was inspired by the X-29 forward swept wing advanced technology demonstrator aircraft being built by Grumman for the Defense Advanced Research Projects Agency and the Air Force. FSW designs offer a number of advantages for military combat aircraft. Included are higher maneuverability, lower trim drag, lower stall speeds, improved low speed handling, spin proof characteristics, etc. The benefits of the FSW design have been

# BOLT




The model is styled to resemble a possible new military aircraft. Its simulated jet air intakes, twin fins, and military markings add much to that illusion.

known for many years, but the FSW could not be used previously because of structural limitations.

A forward-swept wing is subject to aeroelastic divergence. This simply means that air loads tend to deflect or twist the FSW and break it apart. Conventional construction and materials to make the FSW strong enough would also make it too heavy to fly well. It can be done now because of the availability of advanced composite materials for the structure. Composites such as graphite-epoxy and boron-epoxy can be made stiffer than the usual aircraft metals.

The benefits of the FSW design don't apply to our RC aircraft, at the speeds and performance levels we have. I wanted an FSW model for its appearance, and I felt that with a limited forward speed and a rigid sheeted foam-core wing there would be no structural problems.


**Canard designs require a large vertical fin area for stability. The twin fins of the Firebolt provide more than enough area as was accidentally made plain when one of the fins/rudders was lost while the model was flying. More details in the text—and do look at the companion computer article.**

RC canard designs are becoming more common. I believe a real breakthrough was the Zonker design by Air Force aerodynamic engineers Milt Sanders and Charlie Bair, published in the March 1977 issue of *Model Aviation*. I met Milt and saw him fly the Zonker in Pattern competition at the 1976 Dayton Nats. It was quite a sight. More recently, *Flying Models* had two canard designs by Dan Reiss in the May 1982 and December 1983 issues, and *RC Modeler* ran an interesting canard in the September 1983 issue; just last month *Model Aviation* published a simple ½A RC canard. I think we'll see more RC canards in the future; there will be trainer versions, super-stable sport types, and all-out Pattern designs.

Canards do have some benefits for RC use; compared to a conventional design, the horizontal stabilizer does more work, creating lift just as the wing does. The wing and stab work together for greater efficiency. Aerodynamicists say that the lack of high-speed propeller wash over the aircraft decreases drag. I know from flying the Firebolt that, at 7 lb. weight, it handles like a much lighter model, and it appears to be faster than an equally-powered conventional model. Of course, there's no exhaust oil to wipe off.

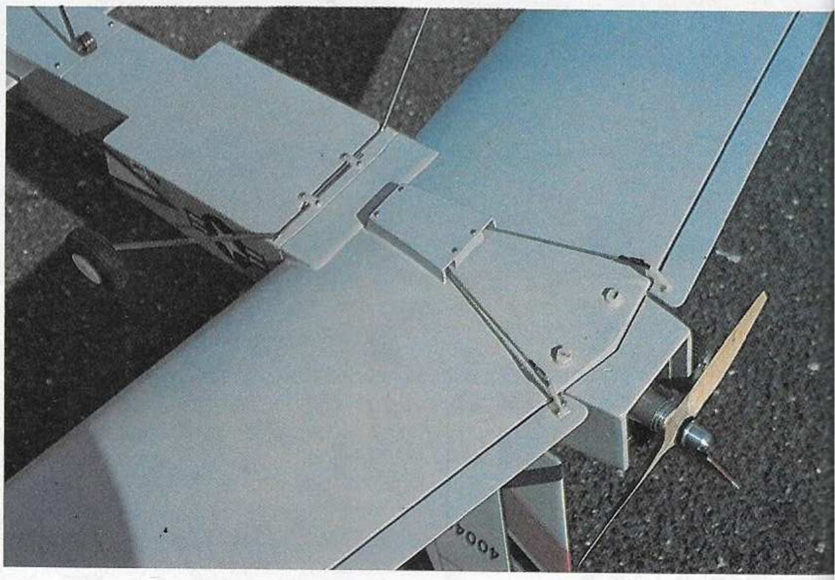
In full-scale aviation, most modelers know of Burt Rutan's success with his canards, the Vari-Eze series. There are a lot of look-alikes to Rutan's designs now flying; imitation is flattery. Two new twin turboprop seven-passenger business aircraft have recently been introduced by Beechcraft and Gates Learjet. In the aircraft big league, with millions of dollars being risked, note that the new Beech Starship and Gates-Piaggio GP-180 are both canard designs with pusher engine installations.

I built my first canard model, a Control Line type, back in the 1950s and had another CL canard design published in the July 1977 *Flying Models*. I still feel a CL canard has a lot to offer for Precision Aerobatics competition. Another canard project was my 10-foot RC Sailplane in the June 1975 *FM*. With this canard model background, I wanted to try again with an FSW version.

The Firebolt design owes a lot to the Sanders-Bair Zonker, which I knew to be a well-proven aircraft. I laid out a wing with a 57-in. span, 580 sq. in., tapered from an


**Left: Rear view presents an unusual appearance. Wing has a fully-symmetrical airfoil with strip ailerons and 584 sq. in. area. Forward canard surface has area of 138 sq. in. Right: Canards aren't new to the author. The twin-boom CL Stunt model on the left was published in Flying Models magazine. He's also had a canard RC Sailplane. With further development, Dick feels a canard design would be ideal for CL Precision Aerobatics.**

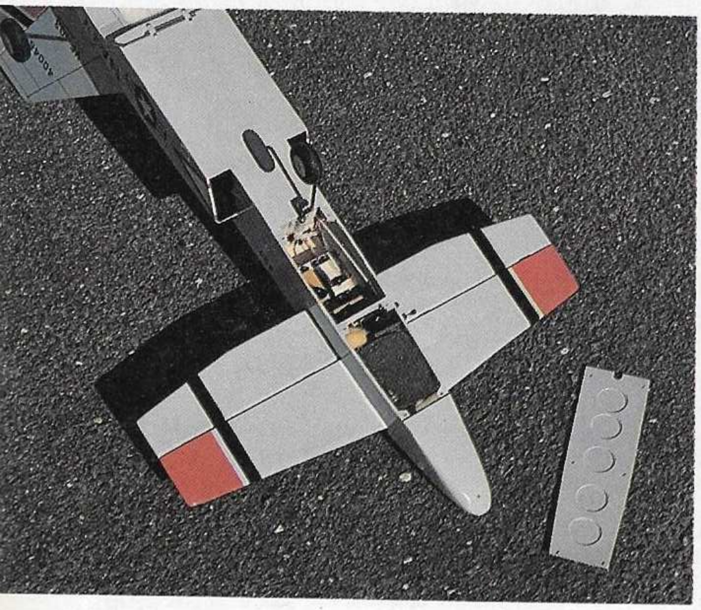
Left: Nick Nicholson, left, finished his Firebolt in an Air Force paint scheme based on the Grumman FSW aircraft now under construction. The author, right, chose a Navy scheme for his. Nick's model was the first Firebolt to fly; all the "bugs" were worked out on his model before the author's model was flown. Right: Two ¼-in. nylon bolts anchor the wing in place. The tricycle landing gear is mounted in the fuselage.

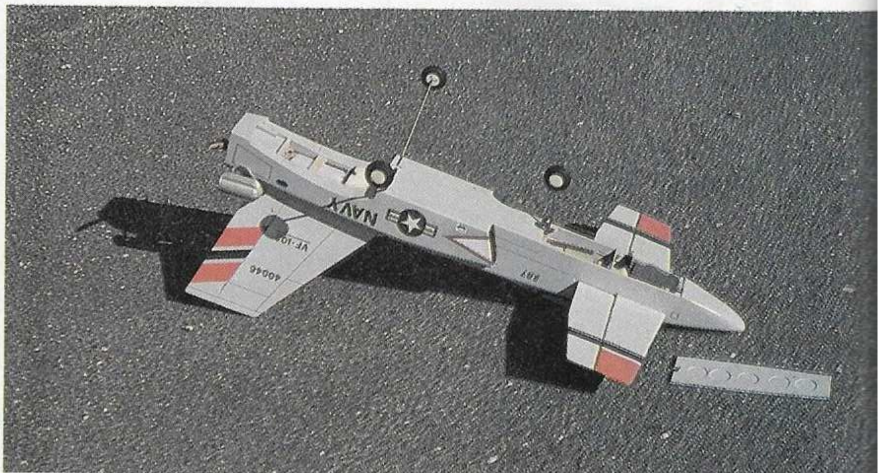



Left: Power comes from an HB .40 PDP Blitz engine and Zinger pusher prop. Read the author's comments in the text about props for pushers. A special muffler is available from HB that is ideal for a pusher installation. Right: Conventional strip aileron linkage couldn't be used inside the fuselage due to the engine location, so the servo was installed under a removable hatch with linkage direct to the ailerons. It works well.

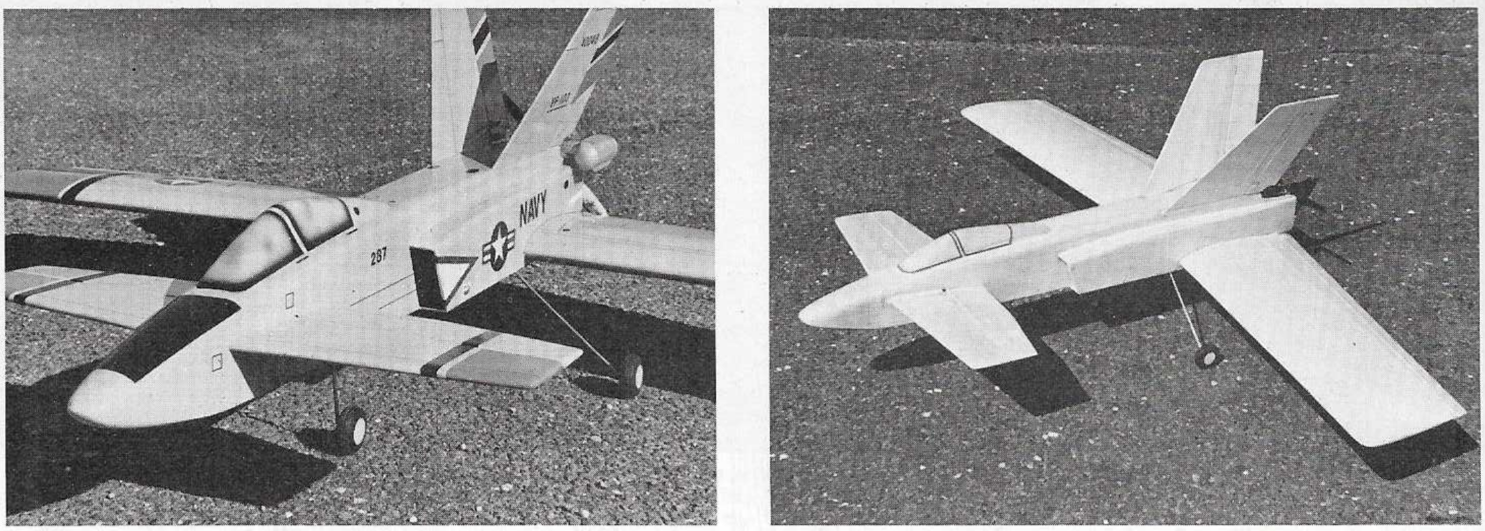
11½-in. root to a 9-in. tip, with a 16% root thickness to a 17% tip thickness, and a typical full-symmetrical airfoil. The leading edge was swept forward with the tip 4 in. ahead of the root. The horizontal stabilizer area is 138 sq. in., 23% of the wing area. I wanted two vertical fins; I like the appearance and knew a lot of vertical fin area would be necessary, as the fins are so close to the balance point. The total area of the two fins is 145 sq. in., 25% of the wing area—really more than is necessary. Later, I'll cover how I found that the plane will fly with only one fin, so if you prefer single fin styling, it should be safe to go with one fin.

A problem with model canard design is achieving the proper balance point without adding any more nose weight than is neces-






Left: Removable plywood hatch provides access to the radio gear. Battery fits into hollowed-out nose block. Throttle, rudder, and elevator servos are mounted far forward to help with balance. Right: A 24-in. aileron extension cable goes from the receiver back to the wing opening, where the servo is plugged in. Despiite the forward radio installation, additional weight is necessary in the nose for balancing.




**Left: The model is finished with Sig butyrate dope. Panel lines are drawn with a drafting pen, numbers and letters are rub-offs, and the canopy area is airbrushed. Kraft wheels, with no protruding axles, give a clean appearance. Right: Completed, but before applying the finish, the all-balsa exterior can be seen. The foam wing is sheeted with 1/16 balsa. The fuselage is basically a balsa box section that requires only a little shaping.**

sary. I tried hard to do this by locating the engine above the wing trailing edge, installing the radio gear far forward, and putting the landing gear in the fuselage. Even so, about 10 or 12 oz. of lead had to be added to the nose. This can be helped by keeping the wing as light as possible and using a light engine/muffler. A forward-swept wing requires a balance point location farther forward than a straight or swept-back wing.

Conversations with Bob Hunt, *FM* editor and foam-wing expert, have convinced me that attaching the balsa wing sheeting with epoxy would have been lighter than the usual contact cements. Plastic film covering instead of my painted finish would also have helped. The plane flies well at 7 lb., but if you can save weight in the rear of the model, do so; this will help avoid carrying lead weight in the nose.

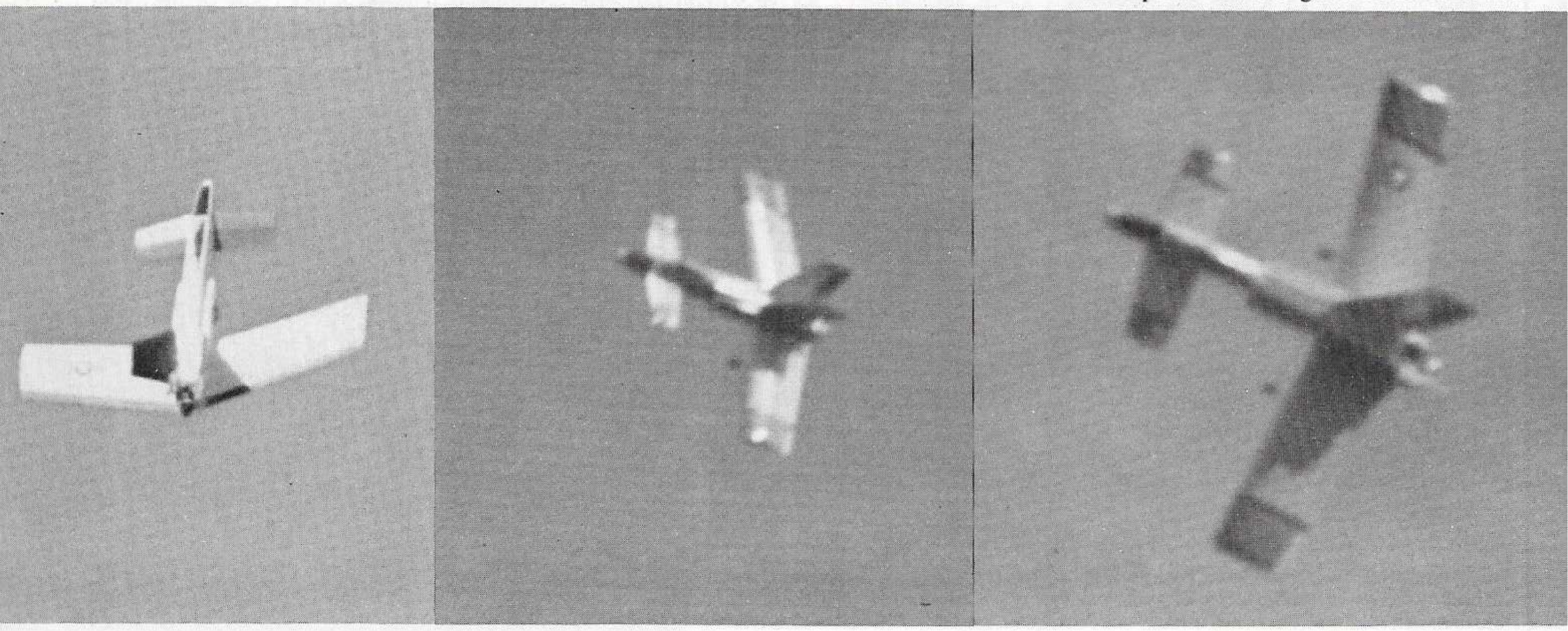
The fuselage is a basic balsa and plywood box structure with added jet air intakes for styling. The lines are rather square, but they do have a modern jet appearance. The stab and fin surfaces are simply sheet balsa. A plastic canopy could be used, but I prefer the all-balsa construction. Retracts could be used with the wing units installed close to the leading edge, but I didn't want the weight penalty.

The fuel tank could be located over the balance point if you use a fuel pump. This would be a good thing to do. With the tank back close to the engine, filling it with fuel moves the balance point ⅜ in. to the rear, and this must be considered when balancing the model.

The engine I used is a real powerhouse, the new HB .40 PDP Blitz. It runs very well with the 10-6 Zinger pusher prop. Conveniently, HB offers a special short muffler which will clear the prop when installed in the pusher configuration. HB also has a muffler spacer which was used on my Firebolt. A rugged engine, this HB .40 required a .60-size engine mount; I used a molded Kraft unit.

Pusher props are available from several manufacturers now; Zinger offers a full line of pusher props, and I like their good quality. I might mention that a pusher, or right-hand, prop *is* necessary. Many modelers have commented when looking at the Firebolt that a conventional prop mounted backwards could be used for a pusher installation. That's not correct; only if you use an engine converted for opposite, clockwise rotation can you use a conventional prop mounted backwards. Many engine manufacturers offer a reverse-ported crankshaft to convert to clockwise running; I felt it was easier to use a pusher prop. The right-hand prop appears to be mounted backwards in a pusher installation; remember that the front curved surface of the prop faces forward in the direction of flight whether it is in a pusher or tractor configuration.

A balance point range is shown on the plans for the model without fuel in the tank. The Firebolt has been flown at the forward and aft locations, and in between. I suggest you start at the forward location and then try moving the balance point to the rear. The pitch response will change, and the final balance point location will depend on your preference; elevator throw will also affect the response. I would guess that a radio with



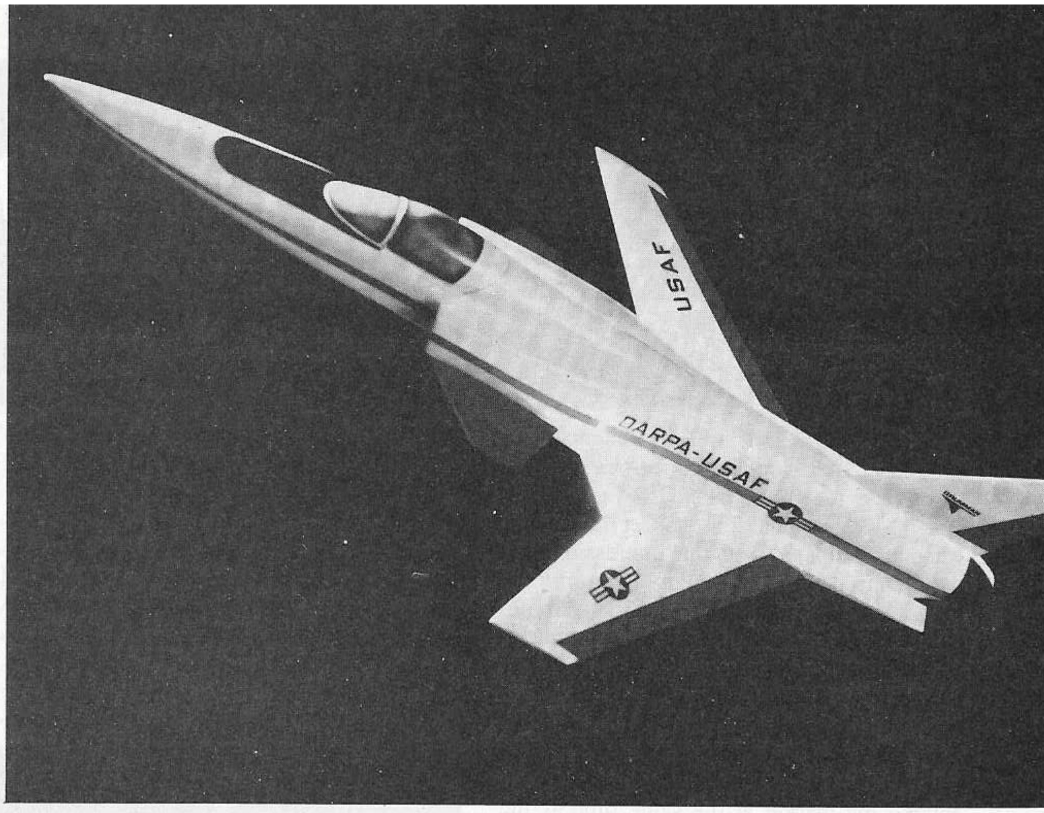
**Flight shots show the full aerobatic capability of this design. Author and others who have flown the Firebolt report that it handles like any capable Pattern/sport model. Nick Nicholson notes that the pilot must remember that "the little end is in the front." Initial trouble with orien-**

exponential elevator control would handle a more-aft balance point.

The balance point location on a canard is important. The first flights with the rear location were overly sensitive to elevator inputs, although it was flying well otherwise. Moving the balance point forward dampened the pitch response and made the handling much more "groovy." Experiment to get the response you like.

I established the initial balance point for flight tests using the formulas published by Ron Van Putte in his Sport-Aerobatics column in the June 1980 issue of *Model Aviation*. Later, my friend Bernie Raad incorporated these formulas into a computer program to make the job easier. This was done after the Firebolt had been designed; it would have been a great help earlier in the project. For those interested in the computer program, it is described in a separate, accompanying article.

Two prototype Firebolt models were built. My friend Nick Nicholson saw the plans and wanted to build one right away—he had confidence. Nick's plane was ready to fly much earlier than mine, and as it turned out, all the test flying and experimenting with different trim, surface throw, etc., was done with his model. He finished his in the early color scheme of the Grumman X-29 experimental aircraft, and mine received a scalelike Navy paint scheme.




Grumman photo of the X-29, the plane which provided the ideas for the Firebolt. This FSW aircraft is scheduled to be flown in 1984 in an Air Force technology demonstrator program.

The first test flight was rewarding—down the runway and up into the air with very sensitive ailerons (Nick had used wider aileron stock) and sensitive elevator control, as discussed earlier. On the first flight I tried rolls, loops, inverted flight, and did enough to feel good about the model. We found that when the engine was cut to low throttle, the nose tended to come up, and down-elevator trim was necessary. This tendency lessened when the balance point was moved forward, but you may find some down-trim desirable for landings. I suspect less positive incidence in the stab would eliminate this completely. The plane can be brought in very slowly with no tendency to stall, and good landings are easy.

One maneuver we have avoided is a spin, as I have read so much about canards not coming out of spins. On the second flight, not thinking about this, Nick put the plane into a high-speed snap roll, and it went into at least a two-turn spin—and came out, very low. With the excitement, we don't know what controls got it out of the spin and haven't yet tried it again. One crash did occur on a landing approach, which Nick acknowledges as pilot error when he simply became disoriented due to the canard configuration. Almost no damage was done, and as Nick now says when flying the Firebolt, "You have to remember that the little end is in front." After several flights this is not a problem as you get used to the canard configuration and its appearance in various flight attitudes.

Both prototypes had the vertical fins and rudders made of 3/16-in. balsa. This weight-saving idea was a bad one; Nick's plane lost one complete fin during flight, and mine lost one rudder. New fins and rudders were made of firm 1/4-in. balsa to solve the problem. I had a situation where the plane went into the weeds off the runway; the prop broke, and the engine over-revved briefly; all four nylon hinges (two on each rudder) broke off from the vibration while the plane was sitting there on the ground. Sounds impossible, but it happened.

I have read of several other RC canards having flutter problems with the fin and/or rudder, and I believe it is due to the fin and

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tation lessens with each flight until it becomes no trouble at all. One maneuver that the author has avoided is the spin, as canards have the reputation for not pulling out. However, Nicholson put his in a spin and recovered, but in the excitement they don't know what controls were used.

some beautiful landings. He said it handled very well, much more like a good Pattern ship than he would have thought. He found it to be stable, particularly so on the landings. I plan to work on another canard design directed more toward Pattern performance, and it looks like we will be building a pair of them.

## Firebolt/Sarpolus

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rudder being so close to the engine that they are subject to a lot of vibration. Use firm ¼-in. balsa for the fins and rudders and plenty of hinges; we have had no further trouble. Nick's Firebolt handled okay coming in with a dead engine after one fin had broken off in flight, so I assume one fin provides sufficient vertical area.

In addition to the flight experience Nick and I have accumulated with our Firebolts, Lance Schneider also has had some stick time on it. Lance is one of the best local RC fliers, and I value his opinions about any new aircraft. I watched him fly the Firebolt through a variety of maneuvers, noticing his axial rolls, round loops, inverted passes, and

**The construction notes** will be brief, as the Firebolt structure is simple and can be built very quickly. I prefer to cut out all necessary parts before beginning assembly, and get my own kit ready to go. If you don't have a local foam wing cutter, I can recommend as a source Lou Wolgast, 40 Castlewood Trail, Sparta, NJ 07871. The wing is skinned with 1/16 balsa, and I suggest applying the balsa skin with epoxy glue to make the lightest wing. To do so, edge-glue 1/16 balsa to prepare the wing skins, and lightly sand the foam cores. Vacuum them to get rid of all loose foam dust. Use slow curing epoxy, which can be heated with warm water to make it flow better. Apply the epoxy only to the balsa skin, spreading it on the wood and leaving a minimum of glue. Place the skin on the core, and place the skinned core back

*Continued on page 142*

to accept the two 5/32-in. wire landing gears side-by-side, is epoxied in place across the fuselage bottom just ahead of the wing opening. Vertical pieces of hardwood are glued inside the fuselage to take the landing gear end pieces. Before adding the fuselage bottom planking, cut the necessary holes in the fuselage bulkheads, and install the two nylon tubing control linkages to the rudders, plus the flexible throttle cable linkage back through the firewall to the engine. Make provisions for feeding through the aileron servo extension cable. Hardwood pieces are drilled and tapped to take the two 1/4-20 nylon wing mounting bolts. The forward radio compartment hatch of 1/8 plywood can be held in place with six #4 × 1/2-in. screws into small hardwood blocks. The balsa canopy can be assembled and shaped before gluing it to the fuselage top.

I used a Kraft molded engine mount and a Sullivan SS-8 fuel tank. The fuel tank is positioned ahead of the firewall in the same direction as in a conventional model. The fuel and vent lines are bent back over the top of the tank to run back through the firewall to the engine. The long fuel lines do not cause a problem; the engine runs fine through all maneuvers. We did use muffler pressure to the tank vent. The HB muffler was ideal for this model, exhausting directly to the rear. On Nick's Firebolt he used a conventional long muffler, which had to extend forward; one flight showed plenty of exhaust mess over the side of the airplane. He then plugged the exhaust and drilled a same-size hole in the front end of the muffler, which now points to the rear of the aircraft. Works fine.

As far as finishing the model, a plastic film covering would, of course, be the lightest method. Nick MonoKoted his wing and tail surfaces and painted the fuselage with Hobbypoxy. I painted my Firebolt with Sig butyrate dope. As a base for a butyrate paint job, I prefer Silkspun Coverite for the wing and tail surfaces; it's easy and neat to apply, goes on well, sticks permanently, and is easy to fill. I frequently use only Sig sanding sealer on the fuselage as a base for the finish.

## Firebolt/Sarpolus

*Continued from page 139*

into the lower section of the foam block it had been cut from. Apply the top skin promptly, add the top foam block section over the sheeted wing, and hold everything in place with plenty of weight on top. *(Editor: See Joan Alyea's article in the April issue.*

The following day, the edges of the sheeting can be trimmed flush with the core, and the leading and trailing edge stock added and shaped. Balsa tip blocks are added and shaped, and the wing halves epoxied together at the proper dihederal angle. Use heavy fiberglass cloth and epoxy around the center-section joint.

Standard strip aileron linkage can be used, or nylon horns can simply be bolted on the inboard ends of the ailerons. I made a small removable hatch over the servo, as it protrudes from the lower wing surface. If this appears cluttered, the servo and typical bellcrank linkages could be installed inside the foam core for a cleaner appearance.

Fuselage construction starts by gluing the plywood doublers and triangle stock to the basic side pieces. The sides are then joined with the bulkheads. Alignment is easy, as the sides are parallel from the firewall up to the second bulkhead. Next, the outer bulkheads and 3/16 balsa strips are added to the basic fuselage to accept the outer fuselage sides. The fuselage top is added, back to the double fin location. I tack-glued the nose block in place, rough-shaped it, removed and hollowed it to accept nose weight and battery pack, then glued it in place for the finish shaping.

The horizontal stabilizer, shaped from 3/8 balsa, is glued in place on the fuselage. The wire elevator horn should be inserted first, before the stabilizer is added. To accept the double vertical fins, the fuselage sides are cut and sanded on the inner top edges to position the fins at the proper angle. The fins are epoxied in place, and then the fuselage top planking is completed between the fins. A piece of 3/8 × 3/4 hardwood, grooved

**Flying.** There's not much to say regarding test flying this canard, other than to remember that the little end is in front. For suggested control surface travel, aileron throw should be set at about ¼ in. each way, elevator throw about ⅝ in. each way, and rudder about ¾ in. as measured at the trailing edge of the surfaces. As on any model, the amount of surface movement should be adjusted to suit your style of flying.

Don't pull the plane off the ground too quickly, for several reasons. Too much rotation might cause the prop to hit the ground (although we've never had this problem), and the controls will not be effective until flying speed is reached. Remember, there's no air blast from a propeller going over the control surfaces, so forward speed is needed for control. This also means that if you slow way down while flying and then go to high throttle, the elevator may not be effective until you get some airspeed again. For a landing approach go-around, apply the throttle gradually.

Landings are easy; the plane will settle in slowly, nose high, and is very stable on the approach. Wingovers can be done, and they look good, but hit the rudder control before all your airspeed is gone. Again, no air blast on the rudders to help. If you want to try snap maneuvers or spins, you're on your own; let me know what happens. It may be a while before I try them.

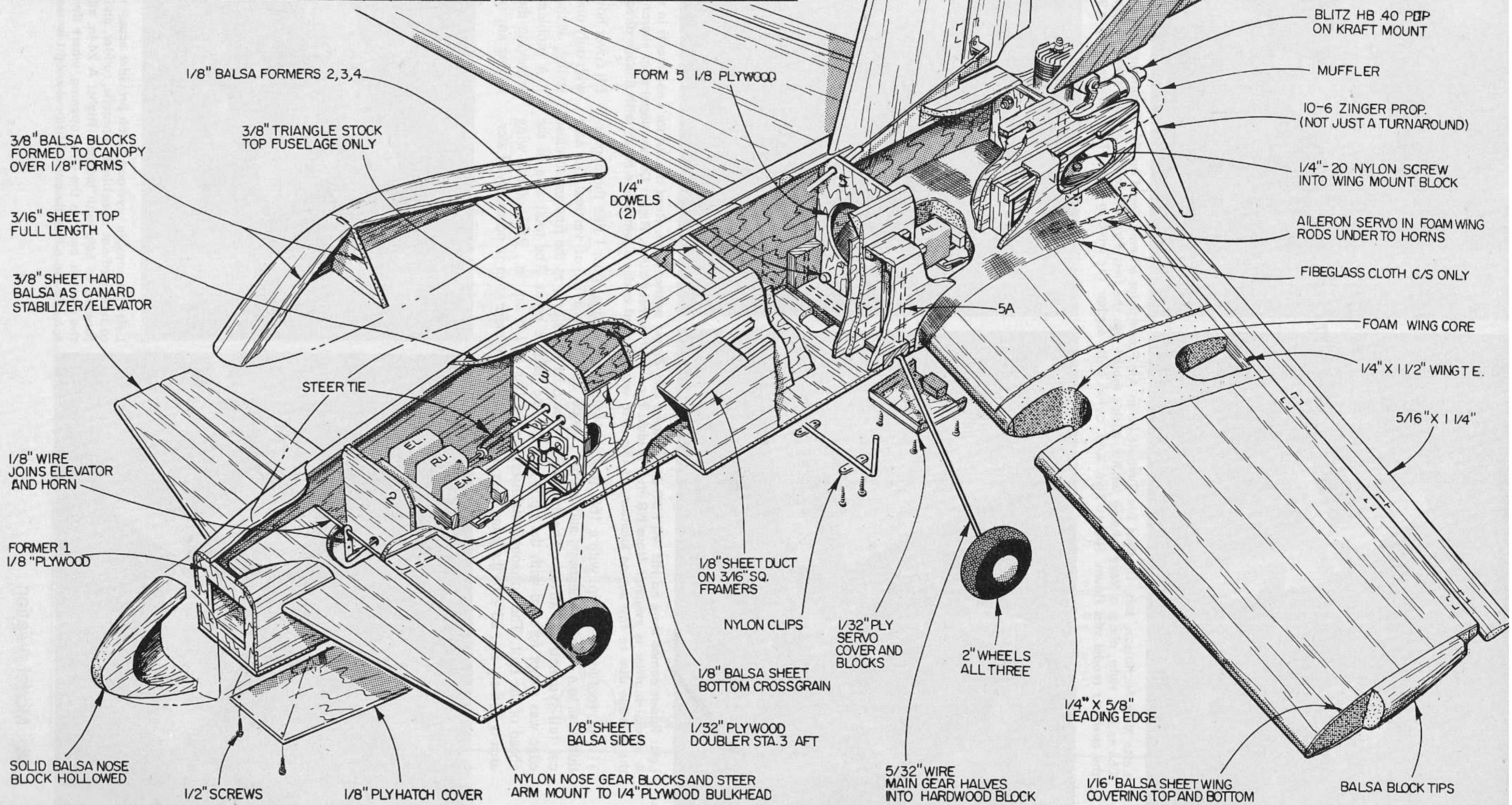
If you experiment and change the design, calculate the balance point location carefully, and don't fly a tail-heavy airplane. Keep plenty of vertical fin area. A ducted-fan version of the Firebolt would be interesting, and with the fan unit mounted in the fuselage above the wing, the correct balance point would be easy to achieve.

Have fun flying tail first!



"But Pop! You said yourself I oughta get into the hobby."


CHUCK WOOD by Hank Clark
'FLIP CHIP'
CAPTAIN! IT'S ME CHIP! I'M GETTIN' REAL IMPATIENT WAITIN' FOR YOU ON THESE LONG TRIPS! I GOT A LOT OF 'MISSIONS' TO DO ON 'X' AMOUNT OF TIME!
BOY, YOU'RE SOUNDING LIKE AN OL' WOMAN!!
TURN ON! NOBODY'S LOOKIN'!
YOU FIND OUT ANY MORE ABOUT FF?
GANDER CHASE! I FLEW OFF TO FIND THOSE GALS! THEY'RE NO WHERE IN SIGHT!!
-SO THEY WENT HOME!-AND HOW DID YOU FIND ALL THAT FUEL I HID AWAY FROM YOU?!
MY 'SUPER VISION'!! REMEMBER?
SOME TIMES I'D LIKE TO FORGET!
QUIT FUSSIN' WITH THAT NOSE GEAR! IT'S ALL O.K! CAN SEE THRU IT! -NOW- LISTEN TO ME CAPTAIN!- THERE'S THREE MYSTERY FEMALES, MY SIZE, LOOSE ON THIS PLANET!
YOU HELP ME FIND THEM-OR I DON'T 'SHOW UP' FOR YOUR R/C WORK ANY MORE!


USE LOTS OF HINGES
1/4" SHEET HARD
BALSA RUDDERS-FINS
BLITZ HB .40 PDP
ON KRAFT MOUNT
MUFFLER
10-6 ZINGER PROP.
(NOT JUST A TURNAROUND)
1/4"-20 NYLON SCREW
INTO WING MOUNT BLOCK
AILERON SERVO IN FOAM WING
RODS UNDER TO HORNS
FIBEGLASS CLOTH C/S ONLY
5A
FOAM WING CORE
1/4" X 1 1/2" WING T.E.
5/16" X 1 1/4"
1/8" BALSA FORMERS 2,3,4
FORM 5 1/8 PLYWOOD
3/8" TRIANGLE STOCK
TOP FUSELAGE ONLY
3/8" BALSA BLOCKS
FORMED TO CANOPY
OVER 1/8" FORMS
1/4"
DOWELS
(2)
3/16" SHEET TOP
FULL LENGTH
3/8" SHEET HARD
BALSA AS CANARD
STABILIZER/ELEVATOR
STEER TIE
1/8" WIRE
JOINS ELEVATOR
AND HORN
FORMER 1
1/8" PLYWOOD
1/8" SHEET DUCT
ON 3/16" SQ.
FRAMERS
NYLON CLIPS
1/32" PLY
SERVO
COVER AND
BLOCKS
2" WHEELS
ALL THREE
1/8" BALSA SHEET
BOTTOM CROSSGRAIN
1/4" X 5/8"
LEADING EDGE
1/8" SHEET
BALSA SIDES
1/32" PLYWOOD
DOUBLER STA.3 AFT
SOLID BALSA NOSE
BLOCK HOLLOWED
1/2" SCREWS
1/8" PLY HATCH COVER
NYLON NOSE GEAR BLOCKS AND STEER
ARM MOUNT TO 1/4" PLYWOOD BULKHEAD
5/32" WIRE
MAIN GEAR HALVES
INTO HARDWOOD BLOCK
1/16" BALSA SHEET WING
COVERING TOP AND BOTTOM
BALSA BLOCK TIPS