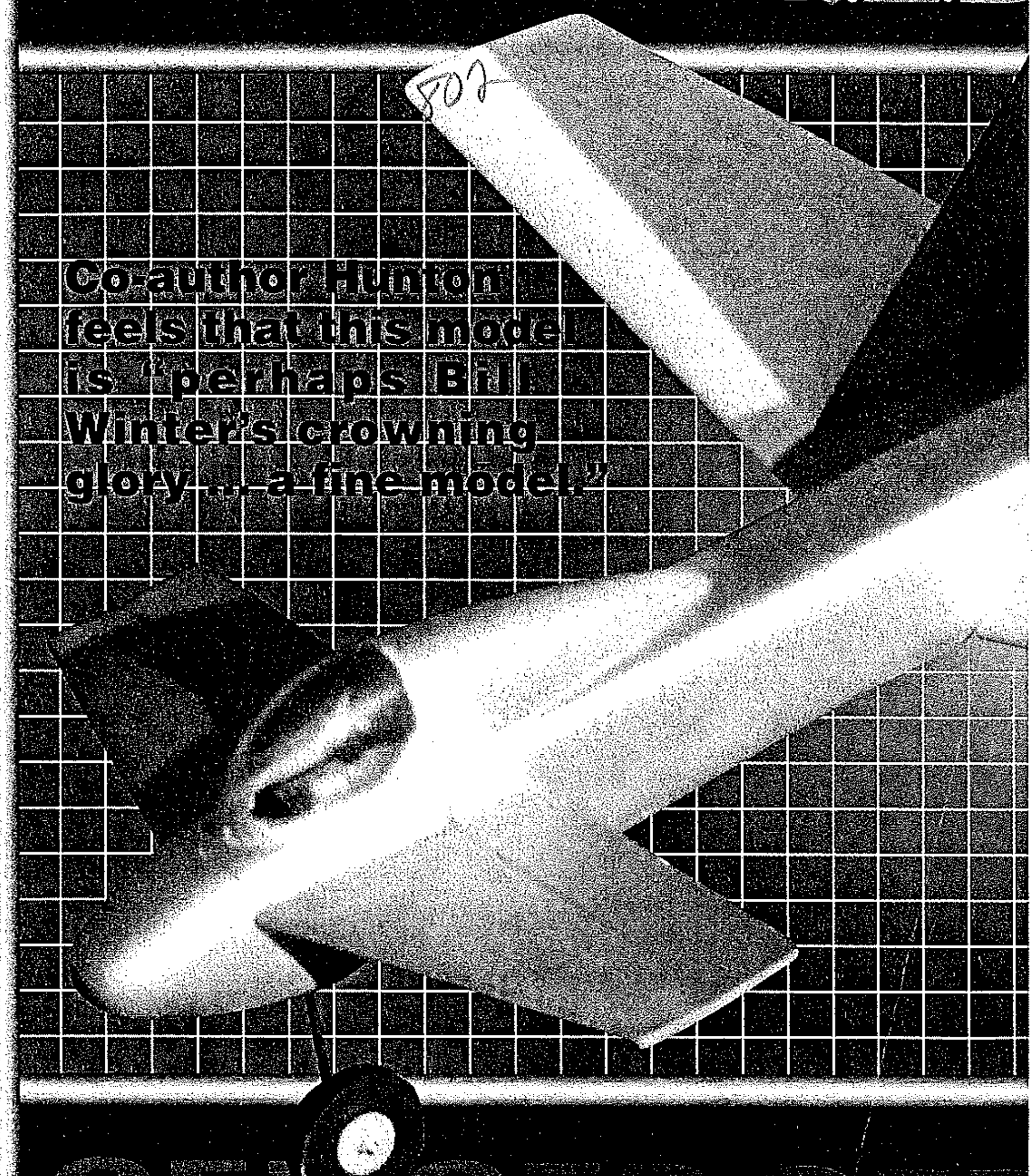
Q.E.D.



Co-author Hunton feels that this model is "perhaps Bill Winter's crowning glory ... a fine model."

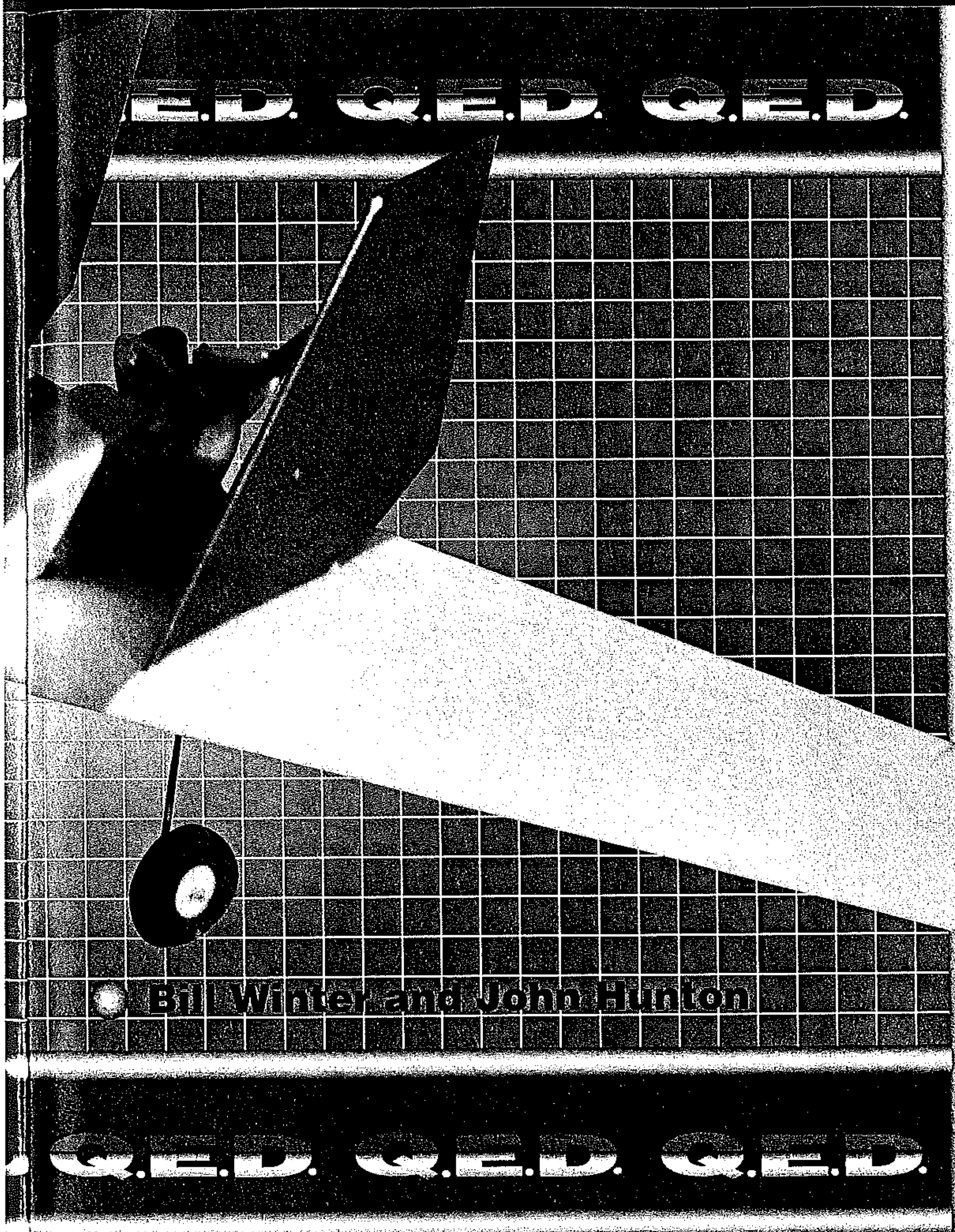
IF I HAD KNOWN that RC canards flew so well, I would have built them long ago! Nor would I have designed this one, had it not been for the scuttlebutt about mysterious problems and odd "musts" that supposedly bedevil the tail-firsts.

Q.E.D. (*quod erat demonstrandum*) is Latin for "[that] which was to be demonstrated" and refers to the proposition that a "conventional" model and an equivalent canard have the same geometric design code, however different their appearance.

Why should a good canard pusher be any more difficult than a conventional tractor? Both designs must obey the same aerodynamic laws.

To use a Flintstonian approach, consider a see-saw with two

Q.E.D.

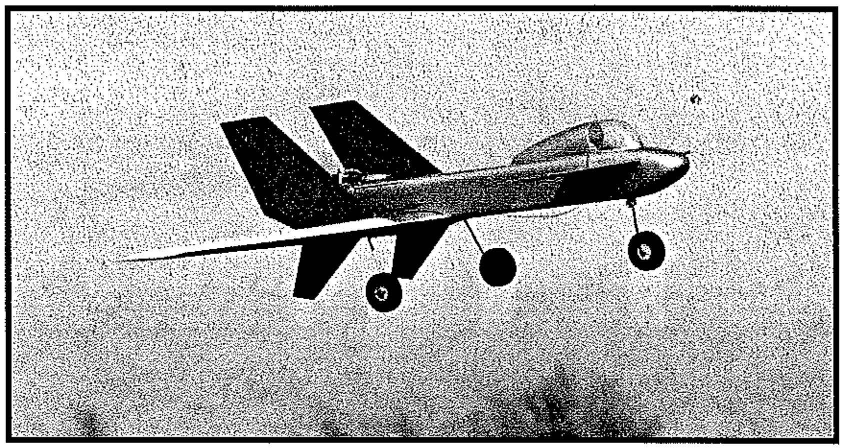


children of greatly different weights. We don't reinvent the see-saw; we place the children at proportional distances from the pivot according to their weights. For a canard, the mainplane and foreplane areas must similarly be located—proportionate distances from the center of gravity.

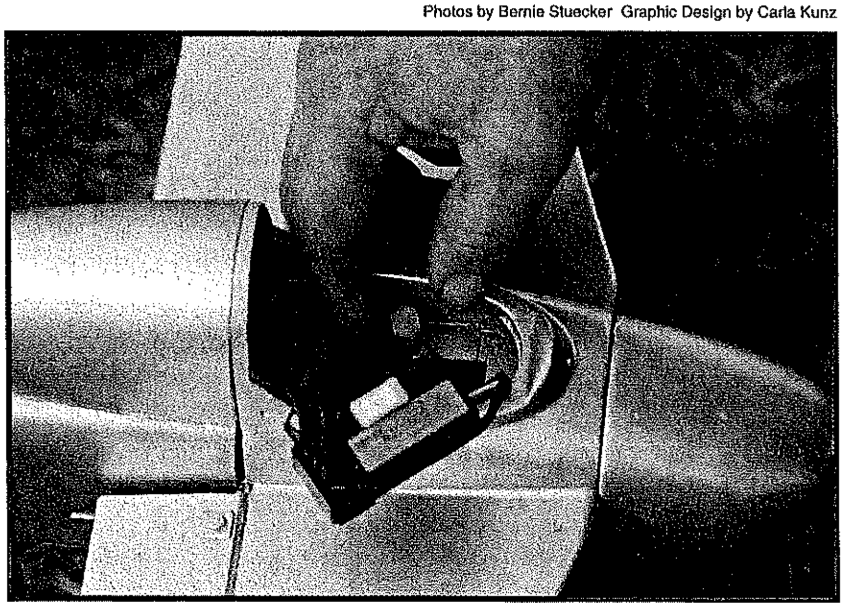
A conventional airplane's wing must stall before the horizontal stabilizer for positive stability; with a canard, the foreplane must stall first. In both cases, the forward surface must stall first. If this seems like a gross oversimplification, it is really just a matter of having a positive (recovering) pitching moment for the entire airplane as the angle of attack progresses to a stall.

Q.E.D. has wing and horizontal "tail" areas, dimensions,

Q.E.D. Q.E.D. Q.E.D. Q.E.D.



Photos by Bernie Stuecker Graphic Design by Carla Kunz



Winter (L) and Hunton. Big inboard fins probably help channel airflow over engine while fencing off spanwise airflow.

Above right: High-speed flyby reminiscent of Air Force's XB-70 canard. Big red fins make it obvious it's going *thataway.*

Right: Receiver mounts on Velcro patches between bolts, lifts off so that individual leads are conveniently exposed.

airfoils, and decalage that are identical to a fine-flying cabin design.

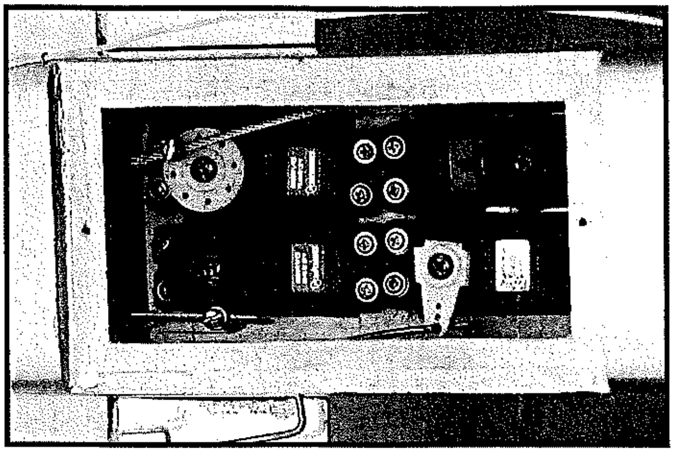
The Q.E.D. configuration evolves from the truism that form follows function. One does unavoidably indulge a degree of cosmetics in any package, but this was not among the objectives. The Q.E.D. planform was generated as shown in Figure 1 and the accompanying sidebar.

A ⅓-scale 3-view was worked out using the stated procedures (none of these were my invention; they are merely ABCs to an engineer) to arrive at a natural balance without the use of ballast. A ⅓-scale sheet balsa glider was made with the proper design CG location, and checked by hanging the glider with thread and a straight pin. The glider was ballasted to the design CG *before* flight—it is a fine flier.

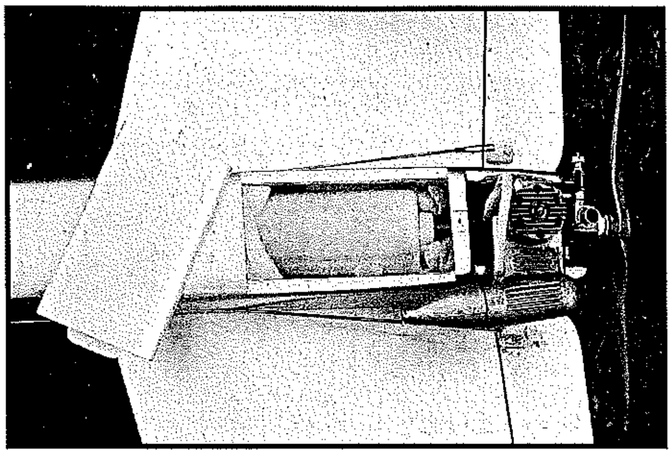
The arrangement of components reflects tried-and-true concepts used in conventional design that have produced good results. The canopy and twin fins were arranged to raise profile area forward and lower it aft. Mass was distributed in the same way: high at nose, low at tail (these things contribute to good turn and bank characteristics).

The model has a double-tapered low wing with tricycle gear and an NACA 00-series symmetrical wing section, parallel to the ground, with 3 degrees positive in the foreplane (resulted in excellent takeoffs, approaches and landings).

The twin fins may look massive, but originating from the low wing the center of vertical tail area is rather close to the CG (short moment); they also compensate for considerable forward fuselage



Nose wheel and engine servos top, left; aileron servo bottom, right; elevator servo with short pushrod to horn outside fuselage.



The six-ounce Du-Bro tank, fully accessible by a typical hatch, is retained on all sides by pieces of foam.

profile area with the large (12-inch) canopy, which contributes to turn excellence.

Tests of the hand-launched glider confirmed that the vertical area could not be reduced without a reduction in stability. Fins that "fenced" the propeller were preferred over tip fins to place them closer to the centerline and make them less subject to damage.

For simplification, rudder control was not used (and has not been missed) but the nosewheel is steerable. Downthrust of 3° is identical to my cabin model.

A balsa-skinned foam wing was used for good airfoil accuracy, strength, and easy building. The remainder of the model is conventional built-up balsa.

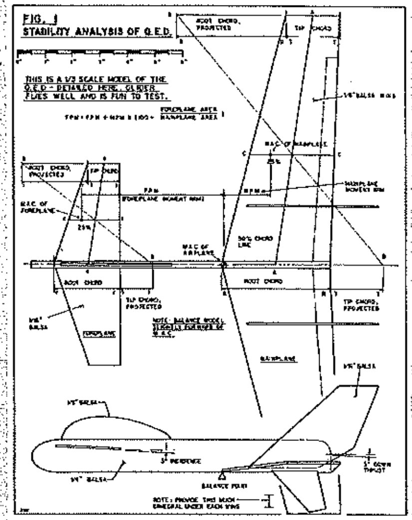
Making the model balance at the design CG was an anticipated problem because of the weight of the pusher engine and fuel tank. This is why modest wing sweep was used (approximately 15° for the LE and 3° for the TE). A center-wing cutout for the prop was rejected as too complex. With the airplane still on paper, the battery pack was placed in the nose and a group of four servos was placed immediately behind the foreplane. This proved to balance the system perfectly.

At this juncture Sig Manufacturing introduced the Tri-Star canard. Struck by similarities in methodology, I compared notes with designer Ray Satterlee and obtained an advance kit (it's an ingenious design that flies very well). Roy's experience confirmed my approach and provided confirmation for building the Q.E.D. prototype.

Figure 1 illustrates the sequence of steps used to develop Q.E.D.. The drawing is also arranged to enable building of a quickie ⅓-scale sheet balsa test glider. It should not be thrown hard like normal hand-launched gliders; rather, it must be released gently, dead ahead, at a velocity gauged to duplicate its natural glide angle.

Figure 1 does not imply that a canard is different by requiring determination of the Mean Aerodynamic Center and its relation to the

Layout Development for Q.E.D.



To locate the Mean Aerodynamic Center of the wing (main plane): Extend the tip chord line T-T forward by the length of the root chord line R-R. Extend root chord line R-R rearward by the length of the tip chord line T-T. Draw half-chord line A-A from the midpoint of the root chord to the midpoint of the tip chord. Draw diagonal line B-B from the endpoint of the extended tip chord through the extended end of the root chord. Through the intersection of lines A-A and B-B draw the Mean Aerodynamic Chord line C-C.

Locate the 25% (quarter chord) point of line C-C. Extend a line at 90° through this point to the centerline of the aircraft. This is the Mean Aerodynamic Center (MAC) of the entire main plane.

To locate the MAC of the foreplane, repeat the process. Corresponding symbols for the foreplane are given in the lower case (a-a, b-b, c-c, t-t, r-r). Again, project the MAC to the aircraft centerline.

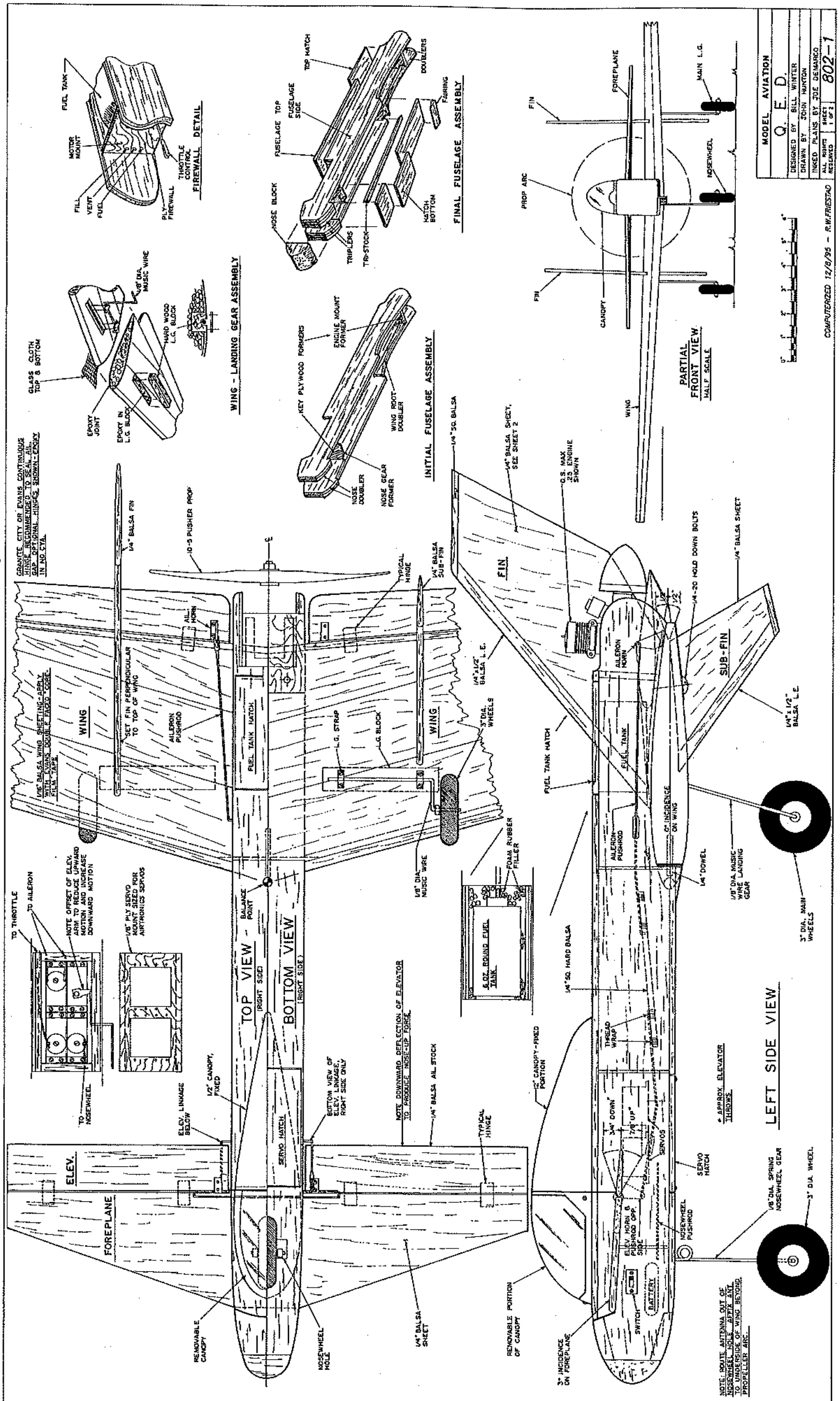
To locate the design balance point (CG) the effective moment arms of the mainplane and foreplane MACs must be factored in. This is simply accomplished by dividing the foreplane area by the mainplane area (for the Q.E.D. the result is 25%). Label the foreplane moment arm FPM and the mainplane moment arm MPM. Measure the distance between the foreplane MAC and the mainplane MAC (= FPX + MPM). Multiply this dimension by 25% to locate the MAC of the system. The foreplane moment arm is therefore 100% less the 25% or 75% of FPX + MPM.

For positive stability the MAC must be on or slightly aft of the CG.

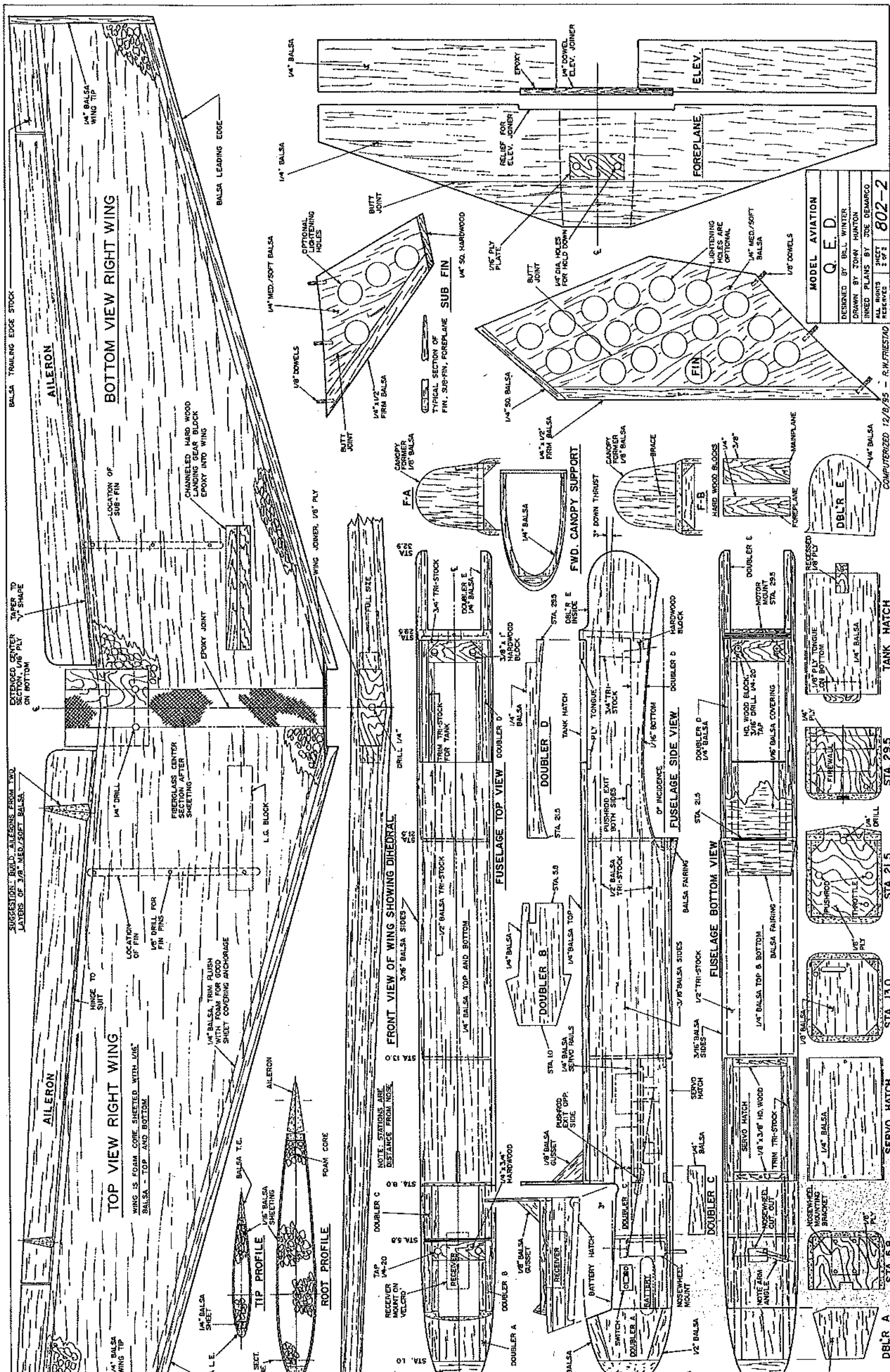
For good lateral stability, vertical stabilizer area was proportionately enlarged from the cabin model in ratio to its moment arm from the CG and eyeballed an extra bit to compensate for the significant forward profile. Adequate fin area was confirmed on a test glider.

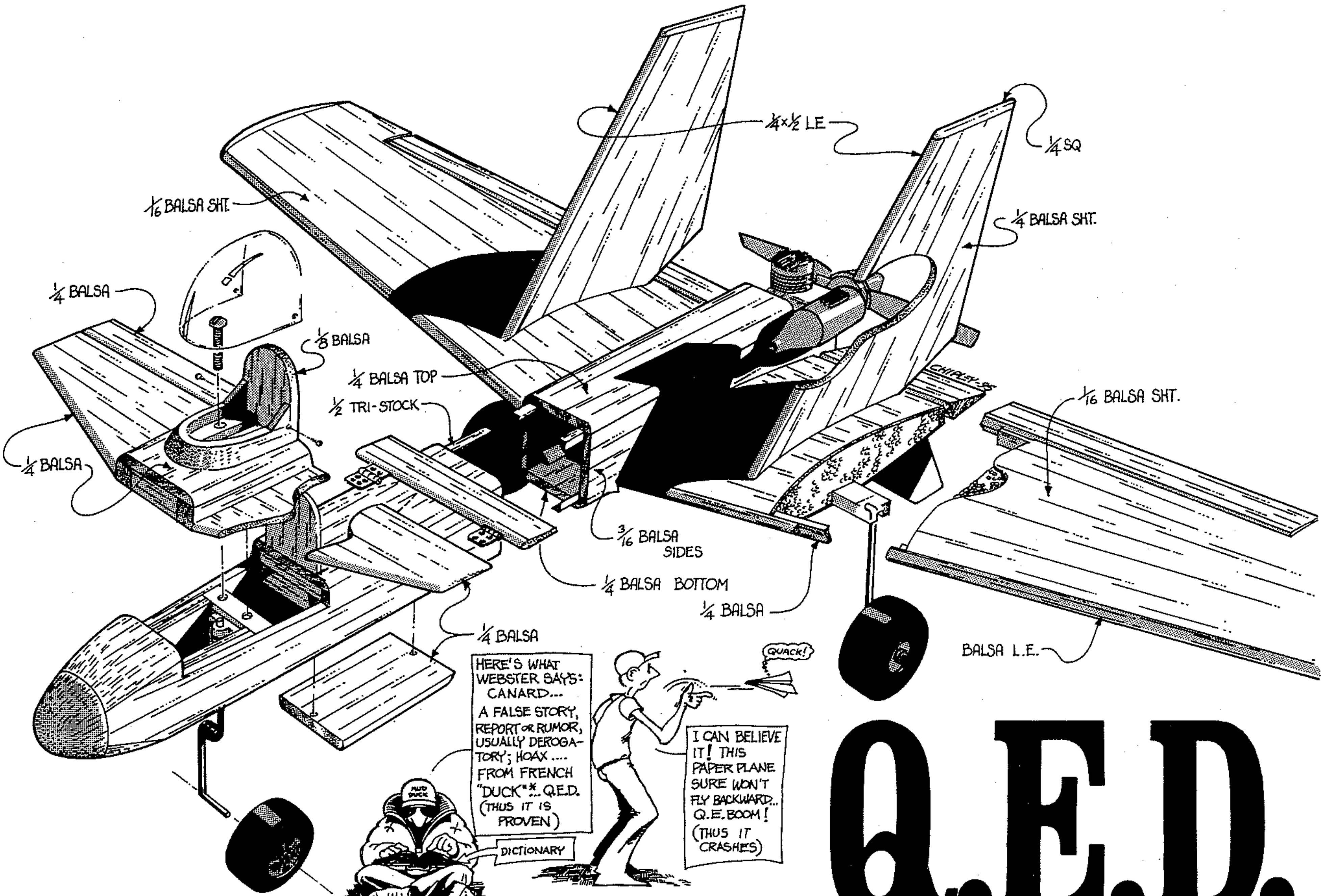
Q.E.D.

Type: RC Sport Canard
Wingspan: 54 inches
Flying Weight: 4 lb. 12 oz.
Engine: O.S. .25
Functions: Throttle, aileron, elevator, nose wheel
Construction: Built-up
Covering/finish: Coverite 20th Century film and paint


MODEL AVIATION
Q.E.D.
DESIGNED BY BILL WINTER
DRAWN BY JOHN HUNTON
INKED PLANS BY JOE DEMARCO
802-1
COMPUTERIZED 12/8/95 - R.W.FRIESTAD
PARTIAL FRONT VIEW
HALF SCALE
FIREWALL DETAIL
WING - LANDING GEAR ASSEMBLY
FINAL FUSELAGE ASSEMBLY
INITIAL FUSELAGE ASSEMBLY
TOP VIEW - (RIGHT SIDE)
BOTTOM VIEW (RIGHT SIDE)
LEFT SIDE VIEW
WING
FIN
SUB-FIN
FOREPLANE
ELEV.
FUEL TANK HATCH
SERVO HATCH
FUEL TANK
BATTERY
SERVOS
10-5 PUSHER PROP
O.S. MAX 25 ENGINE SHOWN
6 OZ. ROUND FUEL TANK
NOTE: DOWNWARD DEFLECTION OF ELEVATOR TO PRODUCE NOSE-UP FORCE
NOTE: ROUTE ANTENNA OUT OF NOSEWHEEL HOLE. AFFIX ANT. TO UNDERSIDE OF WING BEYOND PROPELLER ARC.
NOTE OFFSET OF ELEV. ARM TO REDUCE UPWARD MOTION AND INCREASE DOWNWARD MOTION
1/8" PLY SERVO MOUNT SIZED FOR AIRTRONICS SERVOS

Full-Size Plans Available—see page 157





Q.E.D.

BILL WINTER & JOHN HUNTON

models that we fly we generally know from experience where the CG and MAC must be located.

CONSTRUCTION

Proper selection of wood can provide for easier construction and considerable weight savings. There are several balsa supply houses that offer selected light wood at a small additional fee. Be sure to order more wood than you actually need so that you have an ample supply to select from. Wood thicknesses are noted on the plans and are not addressed in the text.

Use cyanoacrylate (CyA) glue for general assembly and Titebond where slow-drying glue is needed.

Fuselage: The fuselage is of basic box construction from front to rear. Pin the sides together while cutting foreplane and wing slots so they will be identical.

Lay out the positions of all formers on the sides. Install the triangular strips on the sides. These triangles run straight from the firewall to the nose. Cut out all formers, being careful to tailor them to the actual size of the triangles. Cut out the firewall and nosewheel mount, drill them to suit, and install blind nuts.

Install the firewall and nosewheel mount to one fuselage side, using a small triangle to align the parts. Attach the other side. Install all formers, doublers, servo tray rails, and hardwood hold-down blocks.

Block-sand the fuselage top and bottom flat. Install the servo tray with servos, routing wires to the battery compartment, then add all linkages. Cut out all hatches and install the remaining top and bottom sheet parts. Trim the triangles in the hatch areas.

Install the remaining nose parts, including a tacked-in foreplane blank (3 inches wide). Tack-glue the hatches back in. The fuselage can be rough-shaped, then sanded to final shape. Install canopy formers and supports. The wing mount bottom sheeting is placed cross-grained.

Assemble the fuel tank with the flexible (silicon) tubing *looped back* so that the pickup is in the rear of the tank (nearest the engine). Trial-fit the fuel tank into its compartment, complete with tubes. Remove the tank and seal all surfaces in the tank compartment and engine areas with epoxy .Install the tank and engine. Trial-fit the nosewheel strut. Set the nosewheel arm at the proper angle, remove the strut, and file a flat where the screw bears. Do not drill and tap for mainplane or foreplane hold-downs yet.

Wing: Have the wing cores cut to the required airfoil shape. We ordered from Bill Evans Aircraft (454 Wildrose Ln., Bishop CA 93514). Keep the pieces that the cores come in; lay the wing into these parts on a flat surface to work on them.

Vacuum the cores thoroughly. Install the leading edge doubler, trailing edge spar, and landing gear blocks with Titebond.

Use Evans core-film double-faced tape or 3M spray adhesive to adhere the balsa covering (test any proposed substitutes, which may melt the foam). Prepare the balsa skins by butt-gluing the sheets together before applying them. The balsa covering extends over the leading edge doubler and the aileron spar for good adhesion (glue with Titebond here). Use foam-friendly CyA through pinholes to fix any sheeted areas that do not stick down completely. Press the skins down firmly while inserting glue.

Sand the leading and trailing edges and wingtips of the sheeted wing panel flat with a long sanding block (12 inches recommended) and install the balsa LE, TE, and wingtips with Titebond. Rough-shape these parts, then sand the wing halves to shape with fine sandpaper on the long block.

Match the width and basic airfoil shape at the root of the panels. Prop the wingtips up with a balsa block pinned into place. Use the flat sanding block along a table edge to trim the wing roots to the proper dihedral angle. Check the fit to make sure that there are no large gaps in either the top or bottom when the panels are fitted.

To join the panels, anchor one panel flat on the bench over waxed paper, then block up the other panel twice the dimension called for on one panel. Join the wing roots with epoxy.

Install the front plywood dowel support. Add the trailing edge root parts. Wrap the wing center section with 1½-inch-wide (minimum) medium-weight fiberglass (see plans) using CyA to wick it down.

Fins and foreplane: Cut the parts from sheet and butt-join as required for the foreplane and fin widths. Keep the fins light with proper balsa selection and by drilling optional lightening holes.

Sand the surfaces smooth, taper the trailing edges of the fins and elevator, and round off all leading edges. Join the elevators with a dowel, positioned on its center of rotation to keep the fuselage clearance hole small. Use a straightedge to check for good alignment of the elevators.

The ailerons can be fabricated from two layers of light material. Sand to tapered shape. If you use the iron-on I-type hinges, apply them before covering.

Covering: We used Coverite's 21st Century film and spray paint to finish the model. We used film on the wings and fins and paints on the fuselage and foreplane, but you may cover the entire model with film if you wish.

It is essential to follow the directions that cone with the film. It is also recommended that, if possible, you get an iron with a thermometer (also Coverite) to set temperatures with. With the thermometer you can set the iron to just melt the adhesive for initial positioning and covering without shrinking the material, then set it higher later for sealing and shrinking. Cover the top with a light color and the bottom dark for good recognition when flying.

Final assembly: Drill a "sloppy" hole in the wing for the leading edge dowel. Epoxy the dowel in place. Slip a piece of waxed paper over the dowel and slip the wing into place for curing.

Check that there is an equal distance from each wingtip to the nose, then drill 3/16 holes for the hold-down screws. Re-drill the wing 1/4 for clearance, then tap the fuselage block 1/4-20.

Mount the foreplane similarly, checking for squareness. Install the landing gear and nosewheel. Install the engine and fuel tank. Install the control horns and all linkages.

Remove covering material where the fins are to be installed. Use a balsa triangle (with the "toe" cut out to clear the glue joint) to align the fins while affixing then.

Check for control throws shown on the plans. Before flying be sure to check the balance point carefully, and add ballast if necessary.

While the forward-pointing exhaust may look incongruous, we found no apparent performance reduction with this simple installation. We later installed a 1/2-inch copper L that deflects the exhaust upward, but the model seems to fly the same.

Flying Winter's Q.E.D.: These notes should serve to allay any reservations that you may have about building this "unorthodox" design. Actually, the model is completely orthodox to fly except for the way it looks, and some additional benefits that the design brings to the table.

This is a "conservative" canard. All of the features that produce excellent flight characteristics are included in the Q.E.D. As with all of the Winter designs that I have had the privilege to test, Q.E.D. flew right off the field in perfect trim ("Just lucky," Winter says—every time).

In the air, Q.E.D. handles as well as any other model. There are some subtle differences in flying Q.E.D. compared to a more conventional model; these are discussed in the format of a typical flight.

Many modelers perform an engine check by having the engine run up at full speed and holding the nose up, to make sure that the engine does not go lean during the takeoff acceleration phase. This is necessary because the fuel tank is behind the engine.

Q.E.D.'s fuel tank is ahead of the engine; the engine will tend to richen up slightly during takeoff. You can set the needle valve "right on" and the engine will not sag. The plan shows how the clunk and tube loop to what is now the rear of the tank.

This canard has no rudder control. How good is steering during takeoff? No problem. There is no prop blast over the elevator during takeoff, so there is no premature rotation and nose liftoff. The nose wheel stays in good contact with the ground until the foreplane lifts, at which time the model is ready to fly. This characteristic also provides a margin of safety; the canard will not take off prematurely.

During the climbout it is best to keep up good airspeed to keep the pusher engine cool as a precaution in hot weather, and in case of lean-side settings, but there is no danger in overrotating and stalling because of the excellent stall characteristics inherent in the canard configuration. The foreplane stalls before the main wing, making it difficult or impossible to stall the main wing.

You will find normal control responses in all phases of flight. This canard has a snappy roll rate, inverts well, will loop, Immelmann, snap, do Cuban eights, etc., and spin.

The only anomaly is in spinning. With no rudder control the spin is induced at stall (power on or off) with up elevator and aileron to one side. With full up elevator the spin starts slowly, then the turn rate increases until the spin abruptly flattens out after about three turns. The wingtip that the model is spinning from has stalled and the spin stops.

You can stay in the spin by holding less up elevator or aileron after the spin has started. When experimenting with spins, leave plenty of space above the ground until you get used to what the model does.

The only caution that we can give you when flying this canard is that its appearance is very different in the air than a tractor model, particularly when viewing the wing edge-on. Get used to flying the canard at altitude so that when it's low you can make quick decisions without becoming disoriented. *(Winter: As a less-gifted pilot, this did not trouble me!)*

As you level off for cruise, the lift-to-drag ratio becomes very high and the model becomes more efficient than a conventional model.

This canard can be soared at low power

settings for extended flight. When varying power during flight you will find some very pleasant things:

There is very little, if any, pitch change if power is adjusted slowly and smoothly (due to the downthrust, if power is reduced suddenly the foreplane will rise slightly).

There are few, if any, torque effects.

There are no surfaces in the propeller slipstream. These characteristics provide for an excellent landing profile as well as exceptional tracking.

The most pleasant surprise is landing. I have never flown a model that is easier to land. The fact that you can add power and go around at any time with no pitch or torque changes gives you an added measure of confidence while landing.

It is possible to get Q.E.D. flying too slowly because of its excellent stall traits, and have insufficient airspeed to flare properly, so keep some speed on it. It also has a tendency to float (but not balloon) when the mainplane encounters ground effect, so just fly it down to the runway with slight forward stick and let the speed bleed off; then you will feel the complete mastery and control that you have over the landing profile. It is very easy to grease-on landings with this canard.

Q.E.D. is an exceptional model to fly. While it is very easy to fly, it is relatively small and rather aerobatic. It is not intended for beginners, but a moderately experienced pilot will have a great time with. it.

The Q.E.D. is a distinctive and unusual looking model, but it flies as normal as apple pie. Enjoy! ✈

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