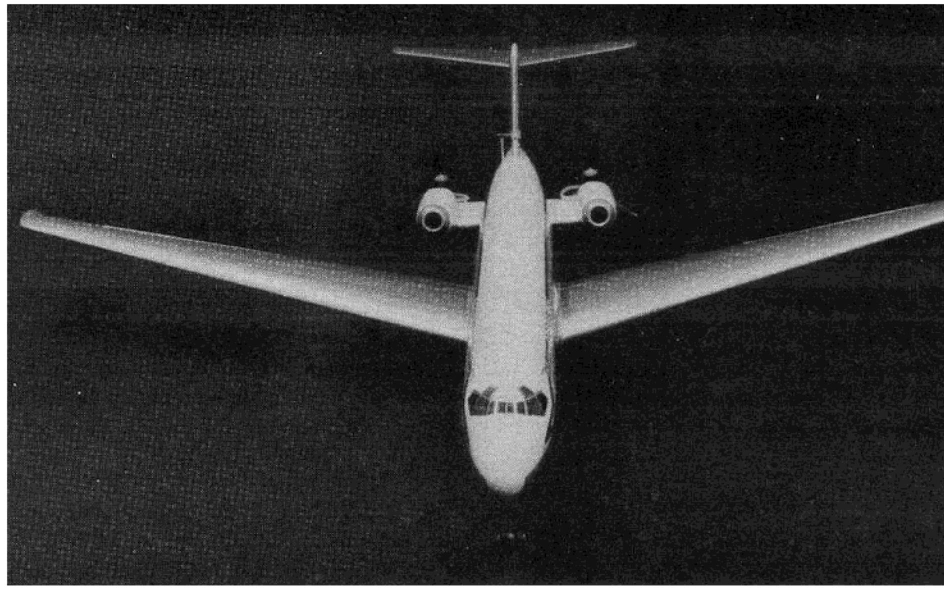
McDONNELL DOUGLAS DC-9

A high performance Stand-Off Scale twin; inexpensive composite construction that requires no special skills

By John N. & Sylvia J. Valentine

Photos by John N. Valentine



Composite — Com · pos'ite, 1. Made up of distinct parts, elements, or substances; as a *composite* structure.

This word is older than any of us, yet the meaning is as new as your next thought. We hear the word more often every day as auto makers strive to build lighter and stronger structures. Aircraft manufacturers, too, have come to realize the benefits of composite construction. Even the home-built Vari-Ease relies heavily on foam and fiberglass. Perhaps the most notable achievement of our time is the Lear fan. Constructed almost entirely of carbon fiber, glass and resin composites, it is one of the lightest, most efficient designs for its purpose to date.

One of the reasons we haven't benefited from this type of construction sooner in the R/C aircraft sport is because we have lacked a means of shaping styrofoam precisely to the shape we desire. It has been done; but only a handful of modelers have attempted to carve an entire fuselage from a block of foam successfully. As technology has a way of doing, it has thrust up past that barrier with the availability of The Great American Foam Machine and all of its companion foam-working equipment. This machine will do everything described herein & much more. The availability of composite designs and kits will do even more to advance the use of this inexpensive medium. If this plane was a kit and you purchased it at your favorite hobby shop, you would probably head for the bench with a long, narrow paper envelope in one hand and a sheet of styrofoam in the other. Yet you would arrive at the flying sight sooner! (With the extra cash you could buy a lot of fuel.)

The reasons for this savings in time and money are simple. When the fuselage sections are cut, they are at their final shape. Only a light sanding is required after assembly. Also, composite materials account for about 90% of the aircraft's structure; there simply is not that much wood involved. I expect that some day the basic balsa airplane will become a phenomena — perhaps more of a curiosity piece than a routine flying model. It will probably be built by some die-hard balsa builder who honestly believes that **balsa flies better.** A few years ago that hard-nosed balsa purist was me. I stood my ground; I turned my head in distain at the idea of plastics or foam in lieu of good old balsa wood. I can't tell you how I ever arrived at that state of mind. After all, I've never even seen a balsa tree. As far as I knew, balsa grew in boxes (although I always suspected they had to cut up trees). I never could find a balsa tree in the nursery catalogues, so just kept visiting the hobby shop when I needed some lumber. I would probably still possess that attitude but I left the hobby for several years.

ABOUT THE AUTHORS

John and Sylvia Valentine are natives of Wisconsin. John began building model aircraft at age ten — everything from free-flight to single-channel R/C in 1963. Both John and Sylvia learned multi-channel R/C flying in the mid-seventies as members of the Madison Area Radio Control Society of Wisconsin, instructed by the best friend novices could hope for, the late Bill Kettle. John later became vice-president of the MARCS.

After moving west, the couple joined the Denver Eagles and the Mile High Club, both of Denver, Colorado, as well as the Arizona Radio Control Society of Phoenix, Arizona. John, in keeping with his photographic and journalistic background, has published in this field before.

John and Sylvia collaborate on many R/C projects; each pursues his/her own area(s) of expertise.

Perhaps this interlude gave my brain a chance to air out (so to speak). Then, one Sunday afternoon, what started out as a brief shopping trip for my wife and me ended in several hours of pure bliss. Quite by accident we had stumbled onto a dazzling display of R/C aircraft demonstrated by a nearby flying club at the local mall. For hours we looked and touched, queried and listened as we exercised the patience of some of the nicest people we'd ever met. As we left that day it was apparent that the bug had bitten. In my case, that was an understatement. That invisible, infectious little varmint had sunk its teeth to the very quick. Within the year my wife and I were active participants in the greatest hobby/sport ever devised, R/C model aircraft.

One of the first things I came to realize upon re-entering the hobby was that many of the materials I had used in the past were, in fact, no longer. In their place, however, stood a gamut of new and improved products and materials that I would soon come to know and use. One of these materials was bead foam. For several years I was content to use it just in foam wing cores. But because it was such a terribly inexpensive medium I was determined to find ways to use it in other areas of my model building. It was this

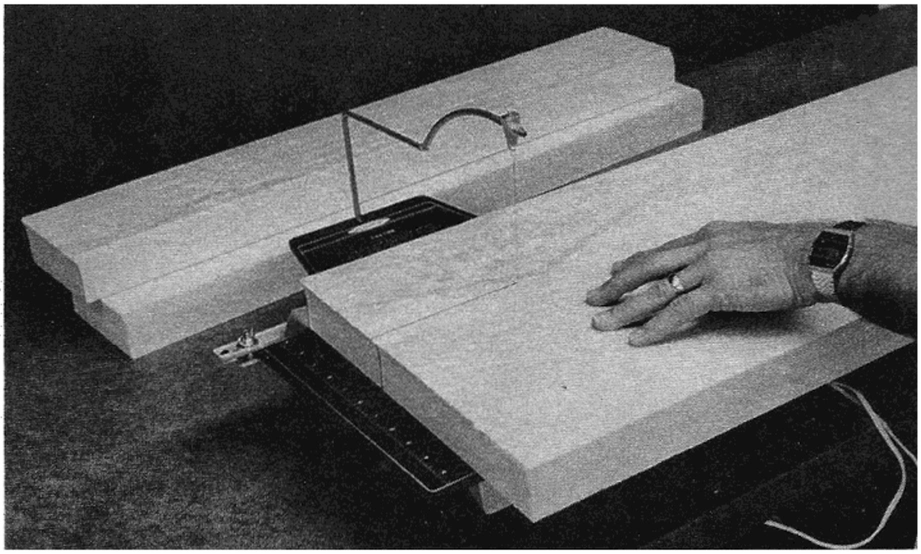


Photo #1: Cutting the rough lumberyard sheet stock down into 5" wide planks. Start with a 24" x 24" piece.

quest for economy which, after three years of research and development, led to the production of The Great American Foam Machine, the foam-cutting machine used to construct the DC-9.

At this time, I would like to point out a common misconception: Almost everyone refers to any type of foam as styrofoam when in fact that white, porous beaded stuff we use for wing cores is technically known as expanded bead poly-styrene. From this point on in this article it is **not** expanded bead poly-styrene but true styrofoam. Styrofoam is a registered trade name referring to a product developed & patened by Dow Chemical Company. This foam is light blue in color and is produced for use as a common construction insulation board. Available in thicknesses up to 2" and sheets up to 4' x 8', its microscopically fine cellular make-up is suited perfectly for our hobby purposes. It carves and sands beautifully to a very smooth finish and it is very rigid with a structural integrity rivaling that of balsa wood. Balsa wood? Ah, yes! Balsa wood; I remember that. Here is the clincher: Per cubic inch, styrofoam is over 80% cheaper than balsa. Even if you don't build the DC-9, think about using styrofoam on that dream ship you plan on building someday and read the construction portion of this article to see how this inexpensive and easy technique can make it a reality sooner than you think.

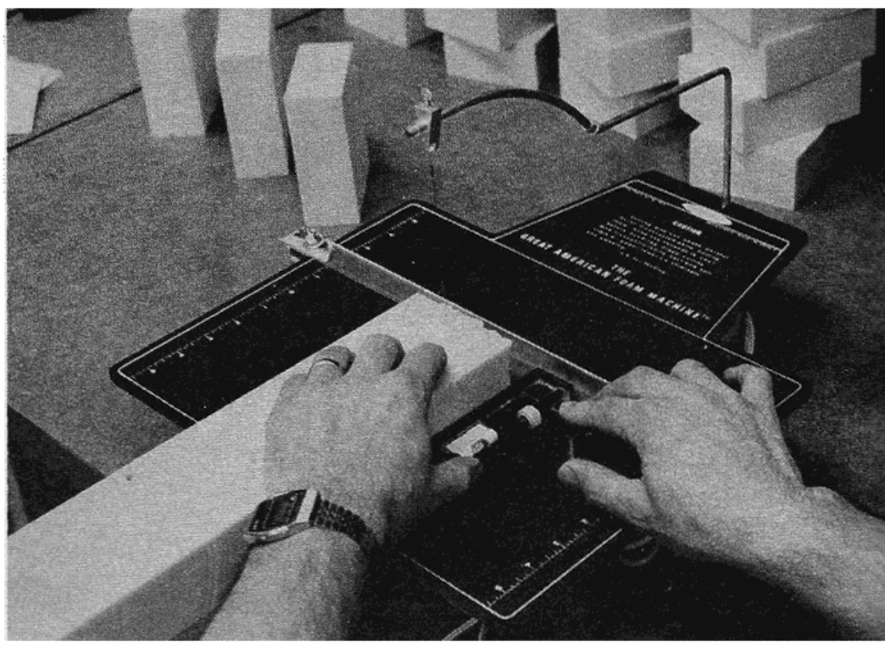


Photo #2: Squaring the plank ends is important and easy with one leg of the carpenter's square against the foam machine fence and the other leg against the foam plank.

Before we begin step-by-step construction details, here are a few words about the construction techniques used on the DC-9. The wing and empennage are typical scale R/C construction techniques, nothing too far from average here. The fuselage, however, requires a bit more in-depth explanation, so bear with me while I attempt some mental imagery.

Picture your favorite aircraft without the wing and with no empennage and no canopy; it is just that cylindrical object we call the fuselage.

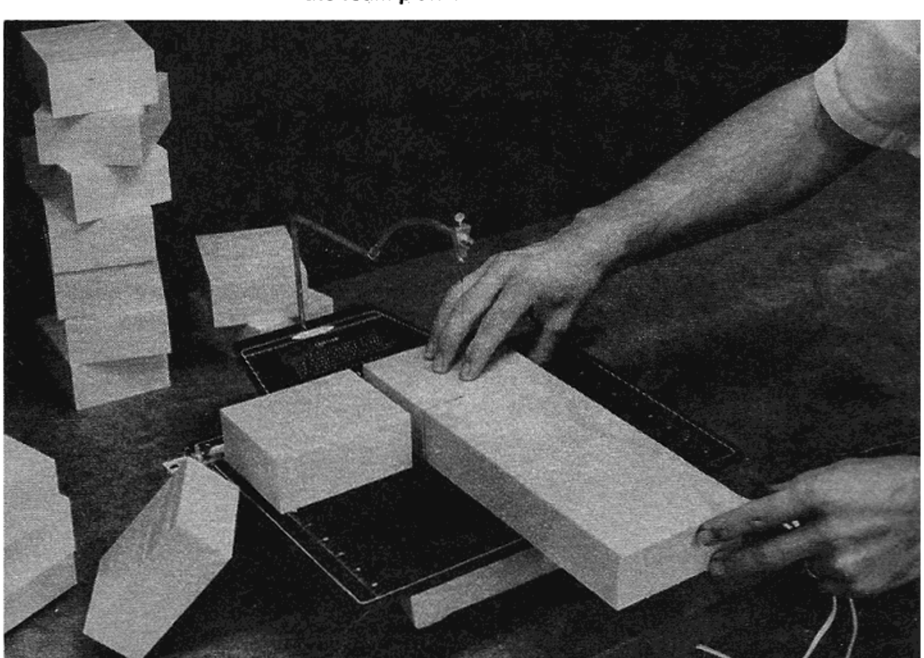


Photo #3: After squaring the ends, set the fence for a 4" cut and block up into 4" x 5" pieces.

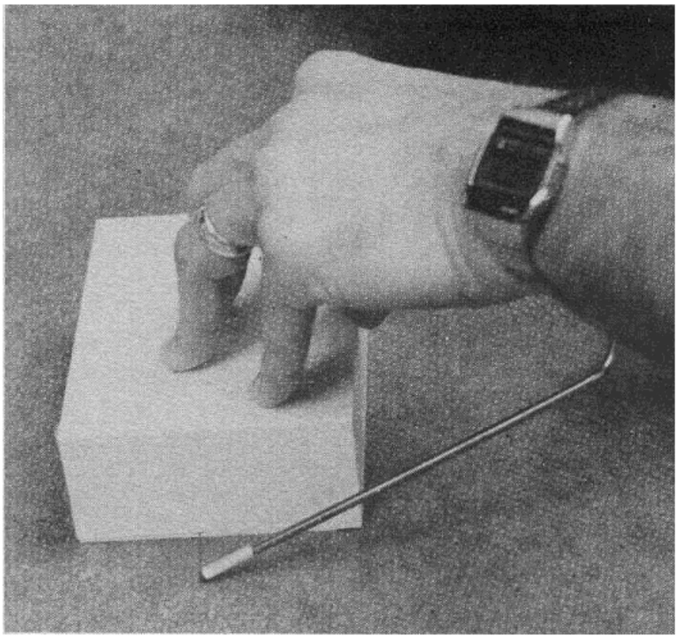


Photo #4: A thin slice from each face of the block with the hand unit removes the rough factory surface; 1/16" is sufficient.

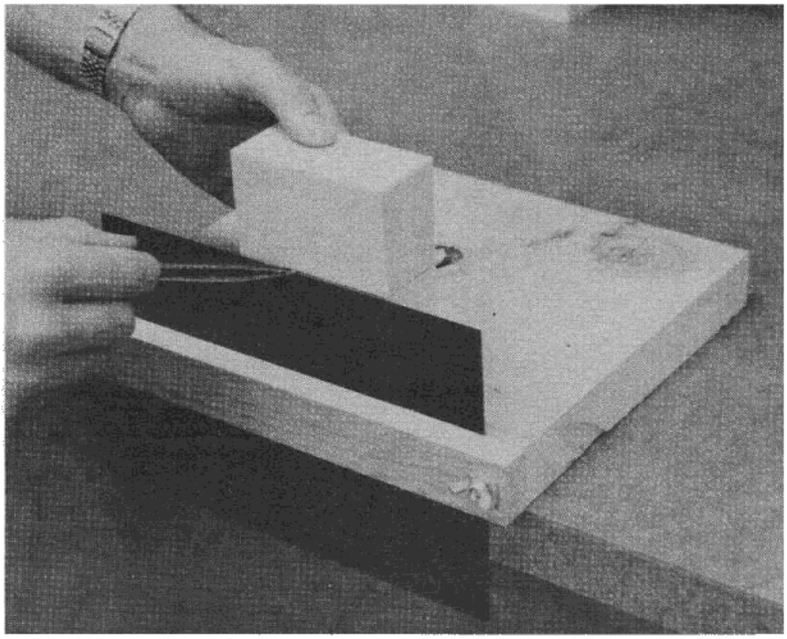
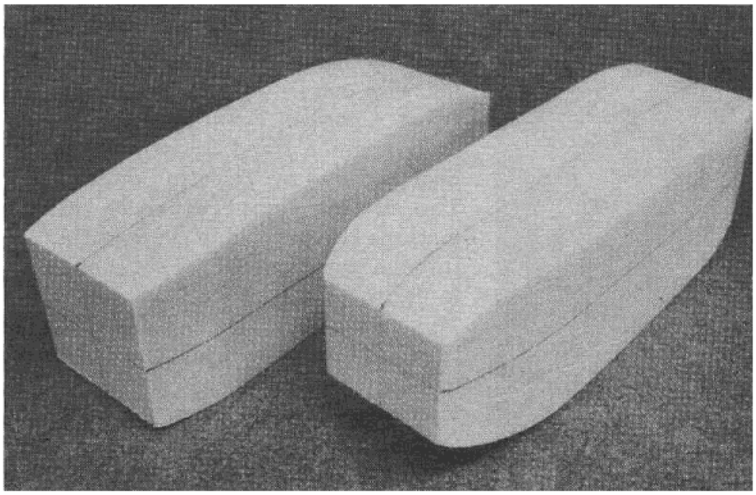
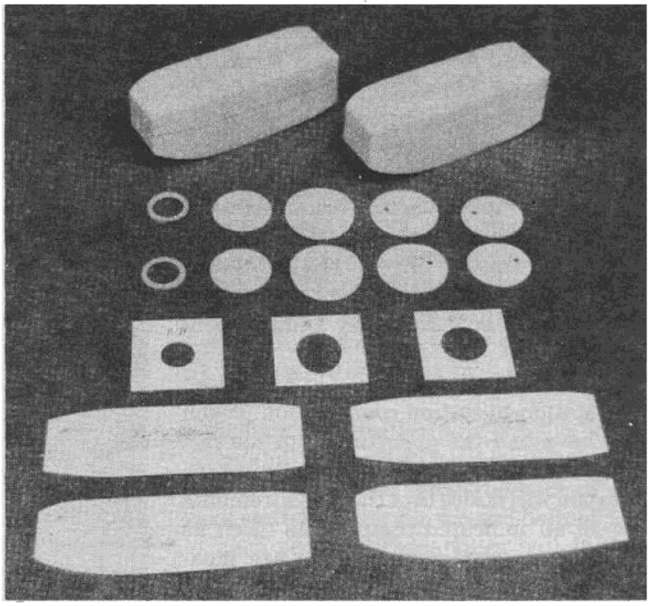


Photo #5: This simple jig made from scrap lumber and a sheet of tin improves accuracy and reduces the task of applying locator lines to only a few minutes.



ABOVE: Photo #6: After being silhouetted with the nacelle templates, the centerlines are redrawn on the nacelle blocks. RIGHT: Photo #7: Top — nacelle blocks; Row 2 and Row 3: Ply formers; Row 4: Female templates used to cut the fuel tanks and hollow out the forward section to air intake; Rows 5 and 6: Silhouetting templates.



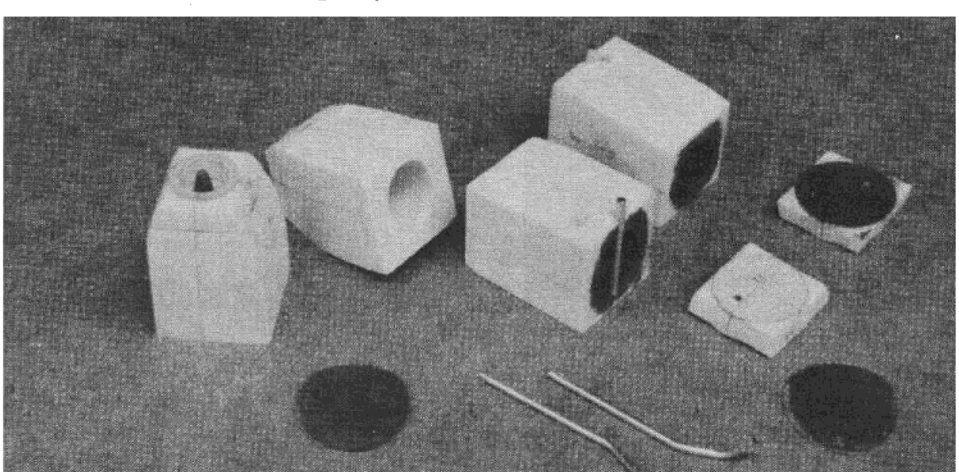
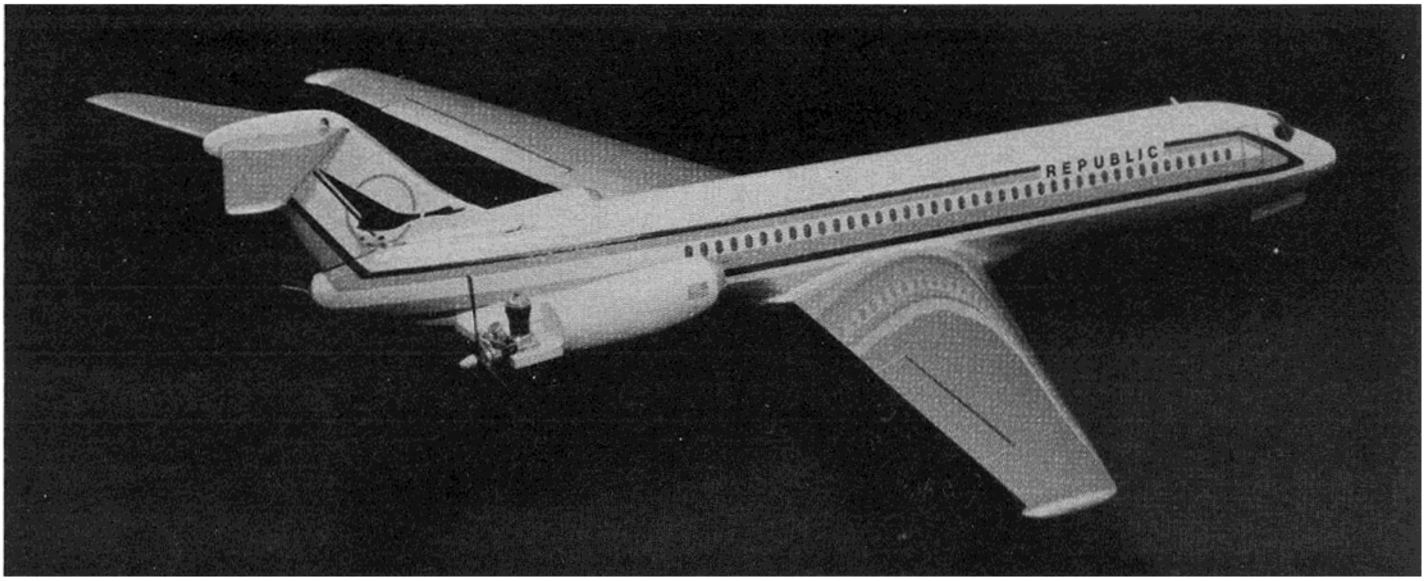


Photo #8: Nacelle forward sections reassembled with intake rings and turbine cone in place. Vent tubes installed and internal portion of tank section as well as facing side of tank formers have been painted with epoxy. Tinted here for clarity.

Let's start at the front of the cowl. With a tape measure, put a mark every 2" from the tip of the cowl to the tip of the tail. Now keep in mind these are only brush strokes in a mental image, not a recommended construction process. Let's take a saw and cut completely through this fuselage at each 2" increment. What we have now is a pile of oddly shaped rings, some wider than tall and some tapered more than others but all of them 2" thick.

We can now stack these oddly shaped rings together in many combinations, but only one combination will result in the original fuselage shape. This stacking of rings is where we stop with this example and where we start with the fuselage of the DC-9.



We simply stack up these styrofoam rings that we have cut precisely to the shape required for the fuselage at any given section. When complete, we have a hollow styrofoam fuselage almost ready to glass. The marriage of glass and foam produces a structure that is hard to beat for strength, finish and lack of weight.

The real beauty of this building method is its ability to reduce even the most complex fuselage to a simple construction project. Whether it's the clean, smooth lines of the DC-9 or a sophisticated ducted fan jet, construction will be quick, easy and inexpensive.

I call this method of construction station-to-station construction. If you have had the opportunity to see factory drawings of full-scale aircraft, you will notice that the measurements of all indicated components (such as wings, gear, canopy, etc.) are measured from the most forward part of the aircraft. Therefore, if the wing leading edge was located exactly 12' from the tip of the spinner, we would see that indicated on the drawing as wing L.E. located at Station 144 (the stations are usually given in inches). The main gear may be located at Station 187. We would then know that the main gear is mounted at a point 15' 7" back from the tip of the spinner. This information is relative because I chose to use this same method in the design of the DC-9. As you look at the plans, you will note the station callouts along the top right side of the fuselage top view. Of course, there are an infinite number of stations in any fuselage; however, we are only interested in those which tell us the location of a particular part.

In the case of the DC-9, the stations indicate the point at which two fuselage sections are joined. The sections are either 1⅞" or 3/4" long, depending on how complex the fuselage shape is at that point. Rapidly changing contours must be cut in shorter sections to accommodate these changes, while gentler contours or straight sections can be cut in longer sections.

My method of cutting is the simple hot wire cutter — in this case, The Great American Foam Machine and its companion Hand Sculpting Unit, manufactured by Valectro Company. The cutting temperature of this machine is regulated to cut smoothly through styrofoam but not hot enough to destroy the card stock templates. This makes the entire fuselage structure possible with only two major tools, a pair of scissors to cut out the templates and the foam cutter.

The material used on this project is Dow Styrofoam insulation. This is available through most building suppliers. Call your nearest Dow Chemical representative and ask for the nearest distributor if your building supplier doesn't stock it. This material couldn't be better suited for our hobby and this type of construction. Dow Styrofoam is light blue in color, runs about six pounds per cubic foot, is very rigid, sands to a very smooth finish and carves like soft balsa and it costs about 80% less than balsa.

Bill Of Materials

Dow Styrofoam:
2" x 24" x 30" (5 sq. ft.)
Glass Cloth:
1 sq. yd. light (.6 oz.)
Balsa:
6 Sheets 1/32" x 3" x 36" (Wing Skins)
1 Sheet 1/4" x 3" x 36"
1 Sheet 1/16" x 3" x 36"
3 Sticks 1/4" x 1/4" x 36"
2 Sticks 1/8" x 1/4" x 36"
1 Stick 1/4" x 1/2" x 36"
Spruce:
1 Stick 1/4" x 1/4" x 36"
Plywood:
1 Sheet 1/32" x 6" x 48"
1 Sheet 1/8" x 3" x 6"
1 Sheet 1/4" x 1½" x 3"
Hardware:
1 — 1/8" x 12" Brass Tube
1 — 3/16" x 36" Aluminum Tube
1 — 7/32" x 36" Aluminum Tube
2 — 3/32" x 36" Piano Wire
2 — 3/4" Wheels (Williams Bros. or Perfect)
2 — 1⅜" or 1½" Wheels
Miscellaneous:
(2) Small Klett Hinges, (2) No. 2-56 Socket Hd. Bolts, (3) 1/8" Nylon Gear Retainers, Scrap Kydex or Nylon Plastic, (11) No. 2-56 x 1/2" Bolts with Blind Nuts, (3) 3/32" Wheel Collars, (1) 1/16" Wheel Collar, (2) Ball Links, (1) Small Elevator Horn, (1) Small Steering Arm, (1) Sheet 24" x 30" Card Stock, MonoKote, Paint, Pushrod Material, 3M 77 Adhesive.

CONSTRUCTION

To begin construction, cut off about a 2' x 2' piece of styro. Set the foam machine fence for a 5" cut and slice off five 2" x 5" x 24" planks, as shown in Photo #1. Now check **one** end of each plank for square. If these ends are not square, use the method illustrated in Photo #2 to square up the planks. Now set the foam machine fence for a 4" cut and slice the planks up into nice square 4" x 5" x 2" blocks (Photo #3).

The factory surface of the styro is irregular and varies from glossy and smooth to pitted and cracked. For our purposes we want a perfectly flat and consistently smooth surface to work with. So plug in the hand unit and lay the blocks on a smooth surface. With the tines of the hand unit, guided by the smooth surface of the workbench, draw the cutting wire through the foam block. This will remove about 1/16" of the surface of the block and yield a smooth flat surface with which we can begin to work (see Photo #4).

In the next step we must apply the locater lines referred to on the plans sheet to our foam blocks. It is very important that these lines be located accurately adjacent to each other on opposite sides of the foam blocks. A simple jig as illustrated in Photo #5 makes this task a snap. Slice three of the blocks to a 3/4" thickness, apply locater lines to these as well. Locater lines must be applied vertically as well as horizontally.

Use a sheet of stiff cardboard about the thickness of the cardboard on the back of a writing pad, but with a smooth, hard surface receptive to pen and pencil. Using carbon paper, transfer the template patterns to the cardboard. Be sure to transfer all locater lines as well. Use sharp scissors to cut the templates out; it's best to rough cut about 1/16" from the line and then go back and cut on the line. Inside cuts are easier with an X-Acto knife. Keep all cuts smooth and continuous without burrs or fuzz. When finished you will have a group of paper templates resembling that in Photo #11.

Let's start by cutting a relatively straight section, namely the one just after the cockpit. Locate Template #4.75 and Template #6.625. Spray Template #4.75 lightly with 3M 77 Adhesive and, while still wet, apply to one side of a 1⅞" foam block. Take care to align the locater lines on the template with the locater lines on the block. Now repeat this procedure with Template #6.625 on the opposite side of the block. Be sure to use the same set of horizontal locater lines (top, middle or bottom) on both templates. Now plug in the hand unit. The machine can be used if you don't have the hand unit but the hand unit allows more maneuverability. Hold the block vertically and rest the hand unit blade on the top of the block at the vertical locater line. Step on the foot switch and slice down through the foam until contact is made with both templates. Now draw the blade along the templates while rotating the block slowly. Very little pressure is required to keep the blade against the templates. On a simple section such as this, cut one-half of the way around and then cut outward away from the template to remove the scrap portion of the block. Now reposition the block in your hand and repeat the procedure for the other half of the cut. The outside cut is now complete.

Using a foam borer, also available from Valectro Company, or a screwdriver, bore a hole in the center of the section large enough to get the cutting wire through. Release the cutting wire from one of the tines and pass it through the hole. Now reconnect the blade to the tine and make the inside cut to hollow out the fuselage section.

Slide the blade keeper back, and once again remove the cutting wire from the tine. Remove the blade and center section scrap from the section. Now carefully peel off the templates. You now have one of 19 sections which comprise the fuselage. Using this method requires little practice and you can cut an entire fuselage in one short evening's work.

The only section which deviates even slightly from this method is the section containing the cockpit windshield. Before affixing the fuselage templates to this block, the profile templates "cp" are affixed to the sides of the block and the top portion of the block removed (see Photo #12 and #13). Now proceed as with all other sections. After all the fuselage sections have been cut, stack them up in the proper sequence (see Photo #16) and check them for fit and alignment. The finished fuselage will require very little sanding if care is taken at this stage of construction.

Engine Nacelles With Integral Fuel Tanks:

The engine nacelles are cut from solid blocks of foam and the fuel tanks are built as an integral part of the nacelle. This eliminates the weight of two, one-ounce fuel tanks as well as the expense. A clunk can be used if desired and when constructed as shown on the plans will produce a 1¼" ounce tank.

Cut two 2" x 2" x 5¼" blocks. Draw the locater lines on all six sides of the blocks. Using a light application of Scotch 77, glue all four templates to the block, top and bottom, right and left. Cut the side view silhouette first, then temporarily glue the top and bottom scrap sections back in place and cut the top silhouette. Now remove the top and bottom scrap pieces. After the nacelle blocks have been silhouetted, redraw the locater lines (see Photo #6). Photo #7 shows the silhouetted nacelle blocks, ply formers and all cardstock templates used to make the nacelle tanks. Cut the nacelle block into sections at the locations of FT-2 and FT-3. Use Template AA and BB to hollow out the forward section. Use Templates BB and CC to hollow out the rear section. The section between FT-3 and FT-4 remains solid. Now cut the forward section at the location of FT-1. (See Photo #8.)

Paint the inside of the rear section as well as one side each of FT-2 and FT-3 with a thick coat of Formula 2 epoxy. When bending the brass tubing for the pick-up tubes, remember to make one left and one right. Reassemble the nacelles using 5-minute epoxy. Use enough epoxy at the tank joints to insure a fuel-tight joint. Carve and sand to final shape and apply one layer of light glass cloth and Formula 2 epoxy. After curing, sand out, apply one coat of thinned epoxy and set aside.

Cradle Assembly:

Before beginning the actual fuselage assembly, construct the styrofoam cradle using the template supplied on the plan. The cradle not only provides protection from cosmetic damage, but it is also used as an accurate reference for locating wing and pylon positions as well as alignment of wing and empennage.

Fuselage Assembly:

Carefully extend all vertical locater lines located on the front and back of each section, along the top and bottom of each section. These lines will be used as references throughout the construction process. Use the card stock templates to trace the formers on the 1/32" ply. Be sure to include the areas indicated by shading on the plans. Trim the formers slightly undersized to allow for sanding after assembly.

When gluing the fuselage sections together, apply 5-minute epoxy sparingly with a toothpick to prevent it from squeezing to the outside of the fuselage. Any excess can cause problems when it comes time to sand out the assembled fuselage. Glue the fuselage sections together in the following four groups (Photo #17): With the first five sections, beginning with Station 0.625 through 6.625, be sure to include the ply former at Station 1.375. Next, begin with the ply former at Station 6.625 through Station 16. Then begin with the former at Station

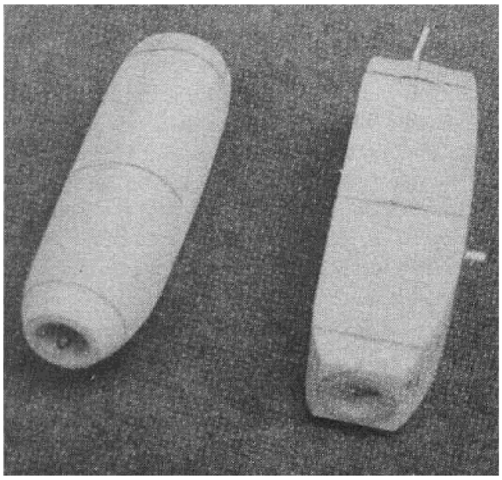


Photo #9: Reassembled nacelle fuel tank before and after carving to final shape.

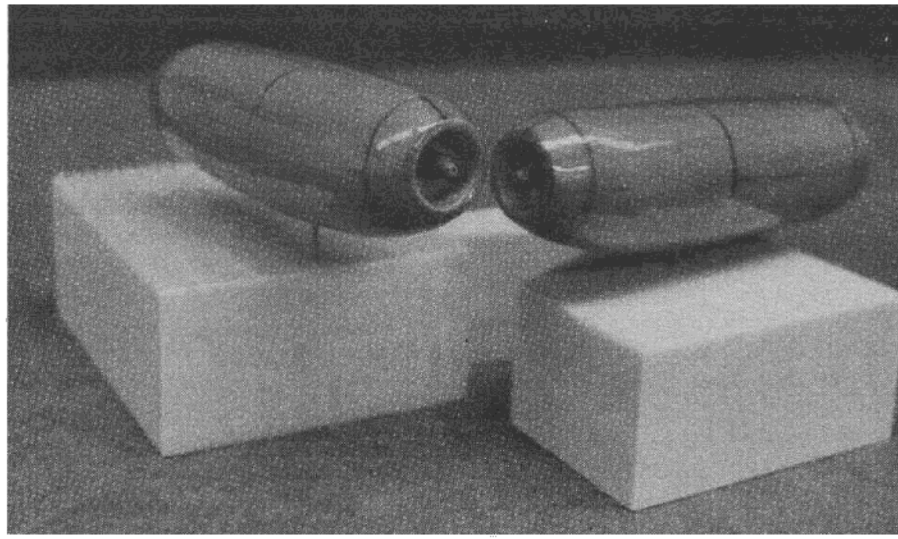


Photo #10: Finished nacelles with integral tanks, after glassing.

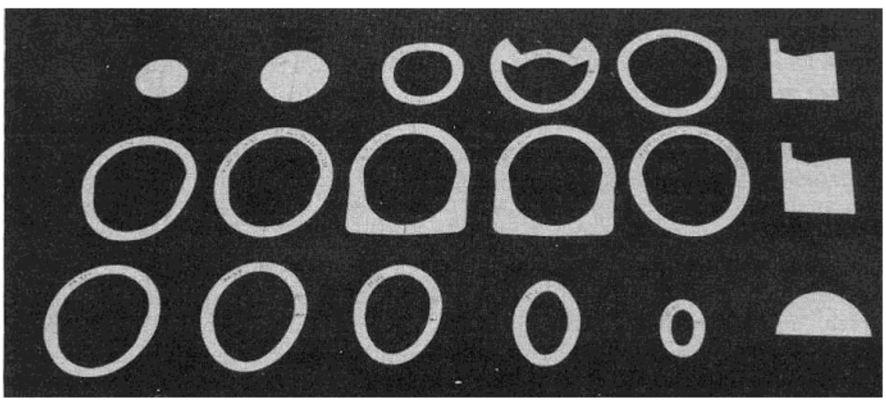


Photo #11: Card stock templates used to cut all the fuselage sections.

16 through Station 29.375. Include the ply formers at Stations 16, 22.75 & 29.375. Next, begin at Station 29.375 through 35.875, including formers at 30.25, 32.125 and 35.875. Stand each section on end and use about a two pound weight on top to keep the joints tight. Locate the section containing Stations 16 to 29.375 and insert one end of the 1/16" x 1" x 23½" balsa liner until it butts the former at Station 29.375. Now hold it up against the inside of the fuselage and mark the point of exit at Station 16. Paint both liners from this line to the end with Formula 2 epoxy as well as the inside flat areas of the fuselage section. Install the balsa liners and hold them firmly in place until cured by blowing up a child's balloon inside the fuselage (Photo #18).

Next, slide the section beginning with Station 6.625 and ending with Station 16 down over the protruding 1/16" balsa liners and mark them where they exit at Station 6.625. Use the same paint and balloon method to secure the liners in this section. Use 5-minute epoxy at Station 16 to glue the foam and former together.

Install the 1/4" sheet gussets at Station 29.375 using 5-minute epoxy,

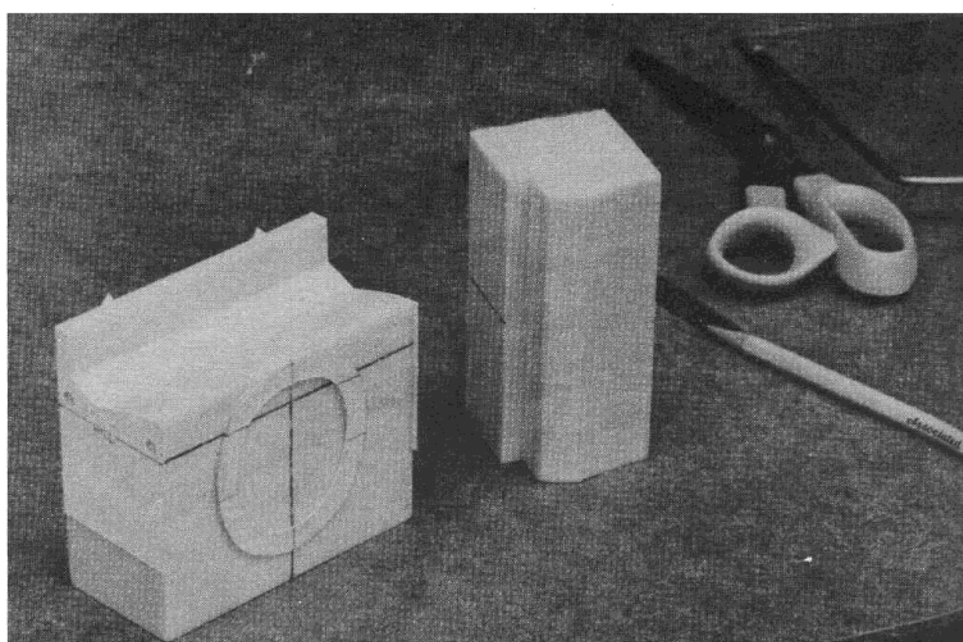


Photo #12: Here the cabin silhouette has been cut using two CP templates on the left and right edges of the block. Template #2.125 and Template #4.0 are in place and ready for the circumferential cut.

then glue the tail section on. Check all three sections for alignment with the extended top and bottom locater lines. Last, glue on the nose section. Glue the nose and tail cone blocks on and carve to shape.

Sand the entire fuselage smooth using a long sanding block. Any nicks or dents may be filled with spackle and sanded smooth. Use an X-Acto knife to open up the cockpit area and install the cockpit roof (Photo #19).

Glassing:

Before beginning the glassing operation, experiment with a mixture of Formula 2 epoxy thinned with Methyl Ethyl Keytone (MEK). MEK alone will destroy styrofoam; however, when it is combined with epoxy it is tamed considerably and a brushing consistency similar to that of resin can easily be achieved. Brush a heavy coat

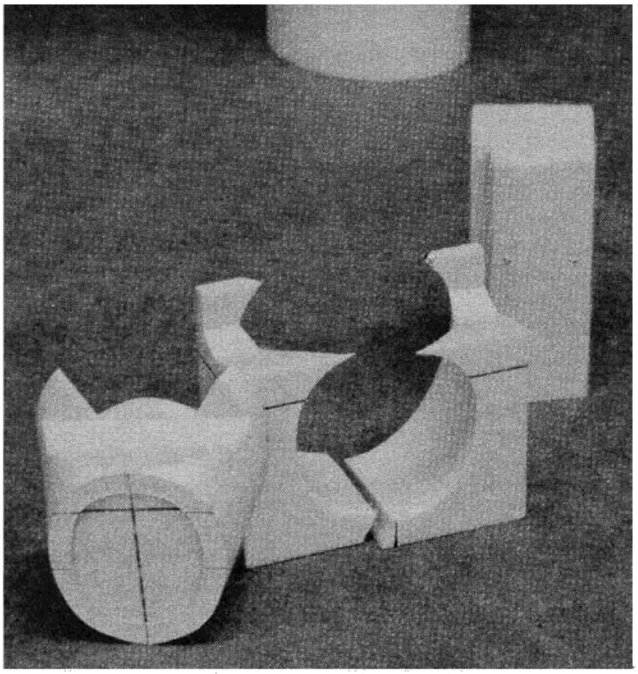


Photo #13: Cabin section after the circumferential cut. Internal cut to hollow out is all that remains.

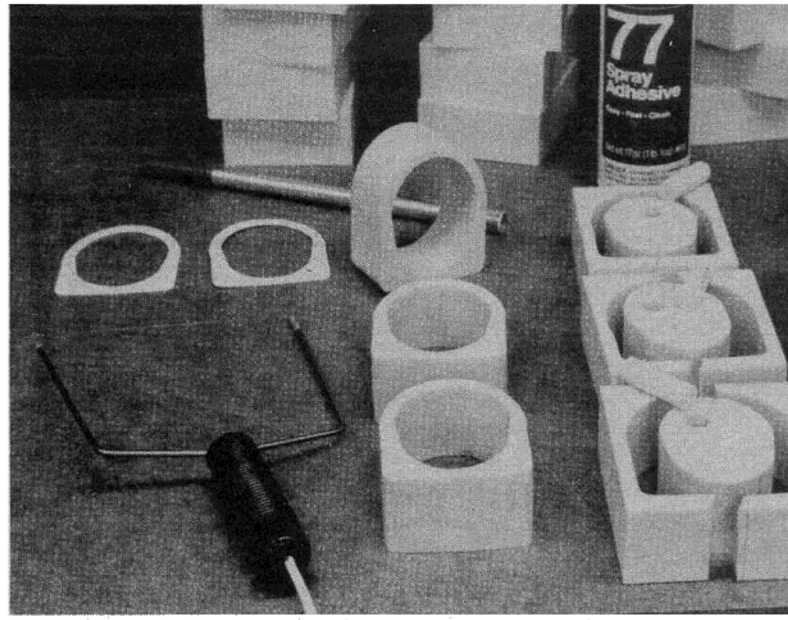


Photo #14: CENTER: Three fuselage sections (scrap on the right). LEFT: Foam Bore, templates and hand unit used to cut sections.

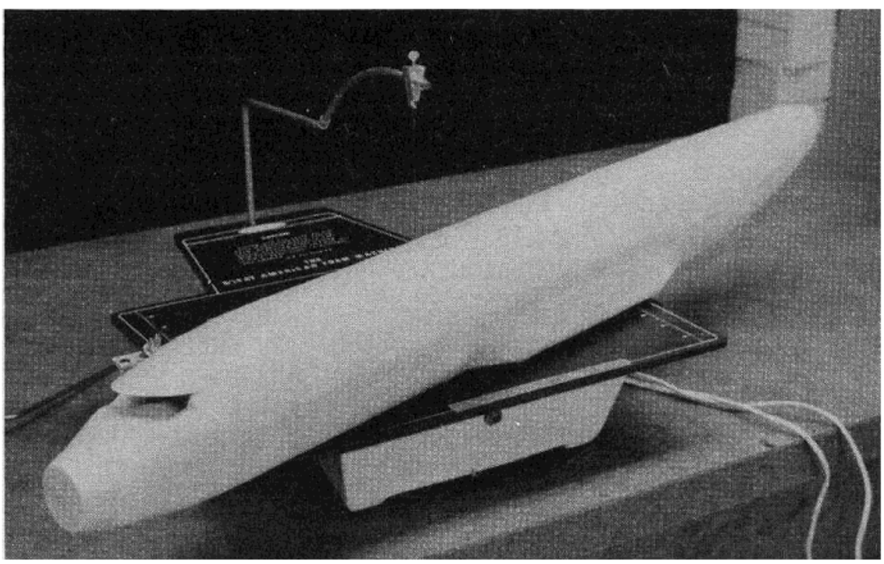


Photo #15: Held together with transparent tape, the entire fuselage weighs less than 2 oz. at this point.

Place the assembled fuselage in the cradle with the rear end resting at Station 24.625 and align the bottom locater line with the centerline mark on the cradle upright. Run a piece of masking tape over the top of the fuselage and down the cradle's upright sides to maintain this position. Locate the wing cut-out by placing the wing locating template on the base of the cradle and aligning the Station 16 mark. Trace the airfoil shape on the fuselage side through the template. Repeat for the opposite side. Use this same procedure for locating the pylon cut-out, only this template will rest on the workbench and align with Station 29.375. Cut all the plywood parts for the vertical fin, engine pylons and the nose gear mount.

of this mixture onto one side of a scrap block of foam and allow to stand for 15 minutes before determining if it is safe. A one ounce batch should do the entire fuselage.

With the fuselage in the cradle, drape a piece of glass cloth over the entire length of the fuselage with the weave running spirally around the fuselage (see Photo #20). Brush a wide stripe of epoxy down the top of the fuselage from the cabin to the tail cone to hold the glass in place. Brushing in the direction of the cloth weave will eliminate any wrinkling that may occur. Support the fuselage with a dowel through the windshield opening when finishing up the last areas to be glassed. Lap the cloth about 1/2" at the bottom of the fuselage. After curing, sand out any irregularities with fine sandpaper of the white, non-loading variety. Apply the second layer of glass cloth using the same method. After sanding out the second layer, apply a thinned-out mixture of epoxy to the entire fuselage. Put aside to cure.

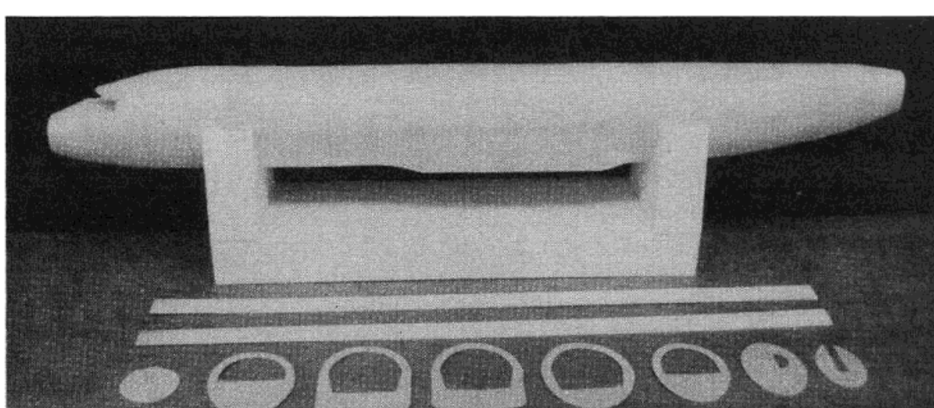


Photo #16: Template cut sections are held together with tape to check for fit and alignment before permanent assembly. Note areas on ply formers not included on cutting templates.

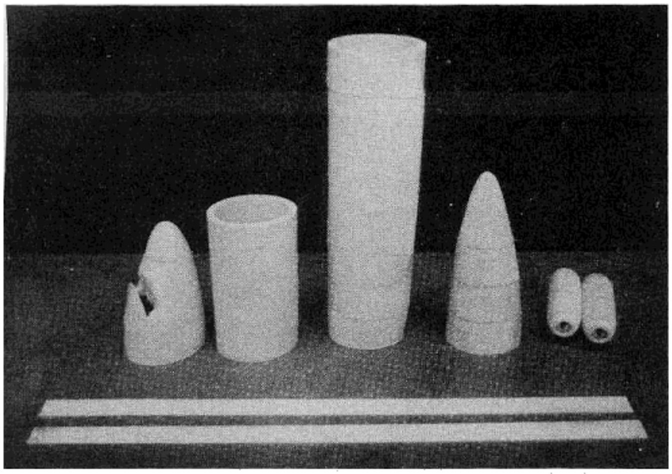


Photo #17: Four fuselage sub-assemblies with ply formers installed, ready for assembly.

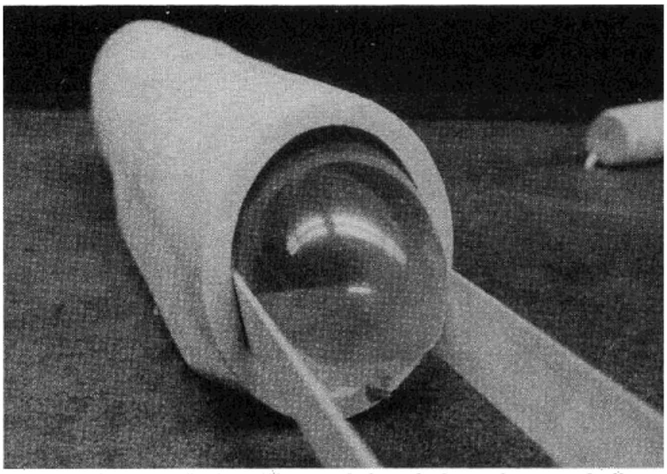


Photo #18: Installation of internal sheet balsa using a toy balloon to apply pressure.

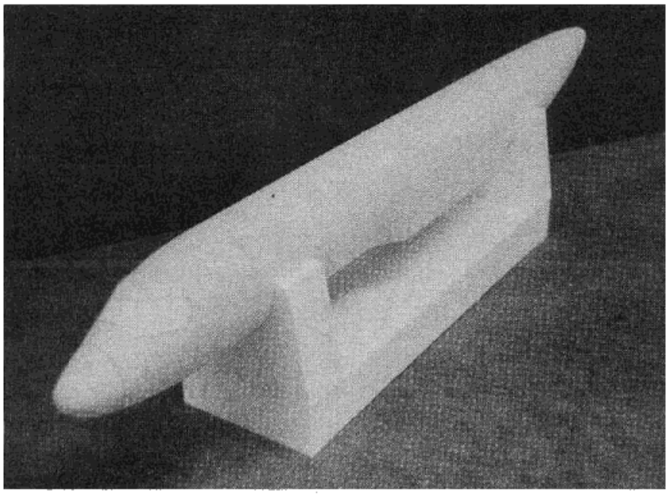


Photo #19: Assembled and sanded fuselage ready for glassing. Windshield template is removed before glassing.

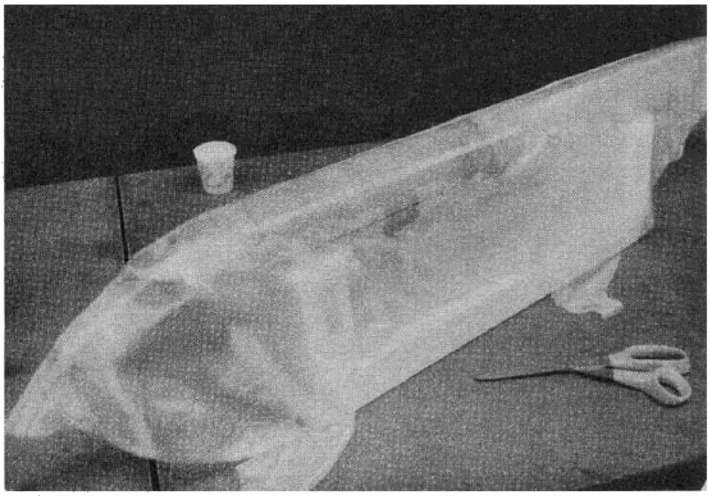


Photo #20: Glassing operation begins with 1/2 oz. glass cloth and thinned Hobbypoxy Formula 2 Epoxy.

All of these components are assembled flat on the bench on one side of the 1/32" ply parts with CA. Apply the second side with 5-minute epoxy and plenty of weight to cure flat.

Before closing up the engine pylons, decide on the type of engine control system you wish to use. You may wish to run the linkage inside the pylon. The author used the "kiss" method here. A piece of carpet thread is guided through the pylon inside a small NyRod tube. When the throttle channel is retarded, the fuel lines are simply pulled off the carburetors. Crude, but very effective.

When assembling the vertical fin, care should be taken to keep the elevator linkage free from excess play. Harden the holes in the 1/16" ply bellcrank with CA. A 2-56 x 1/2" bolt is

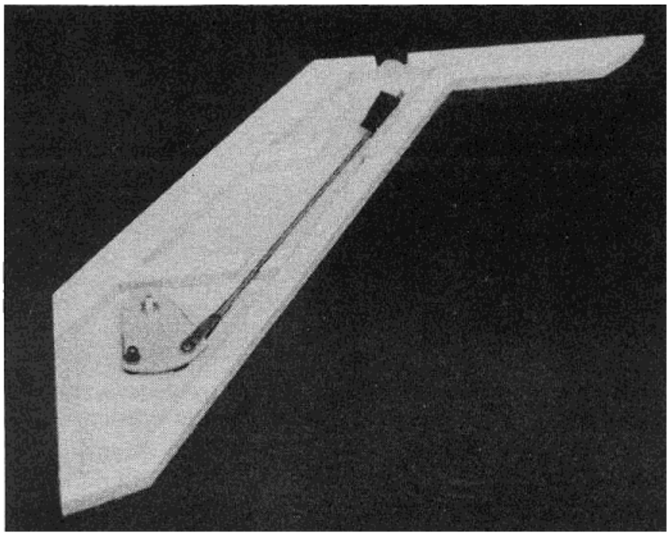


Photo #21: Vertical fin assembly showing elevator bellcrank and pushrod installation.

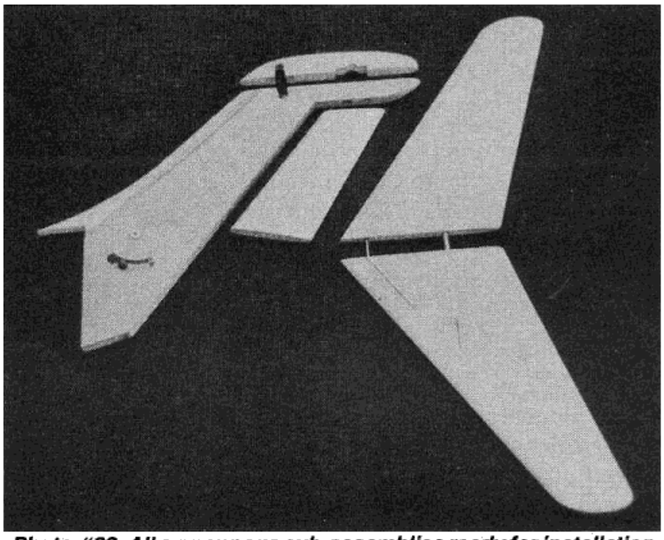
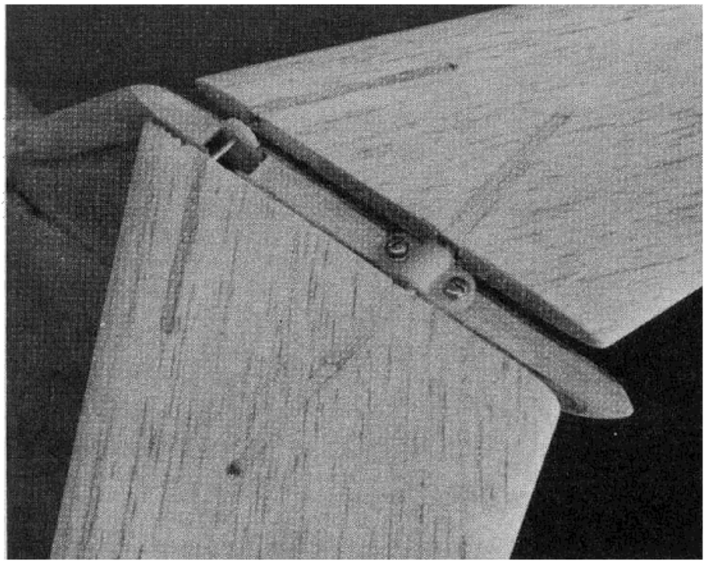
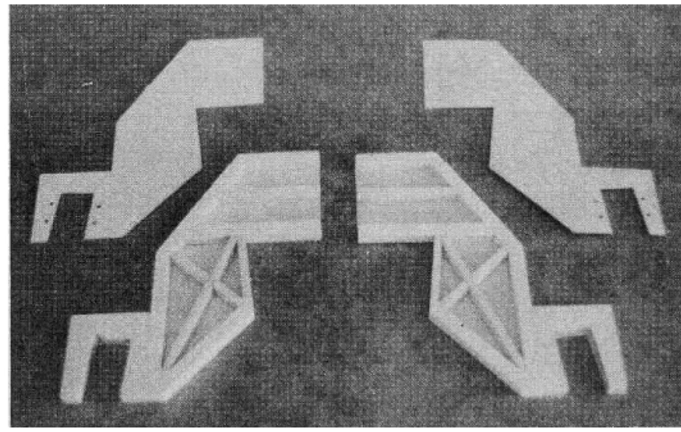
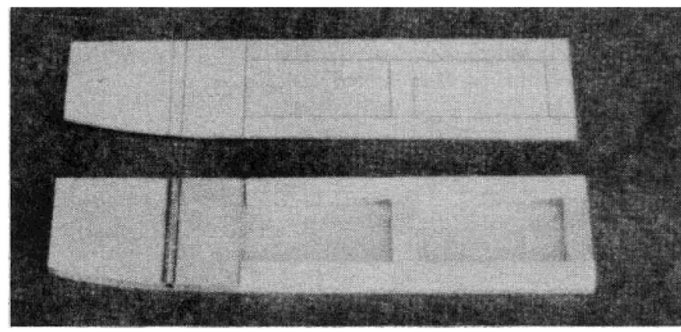


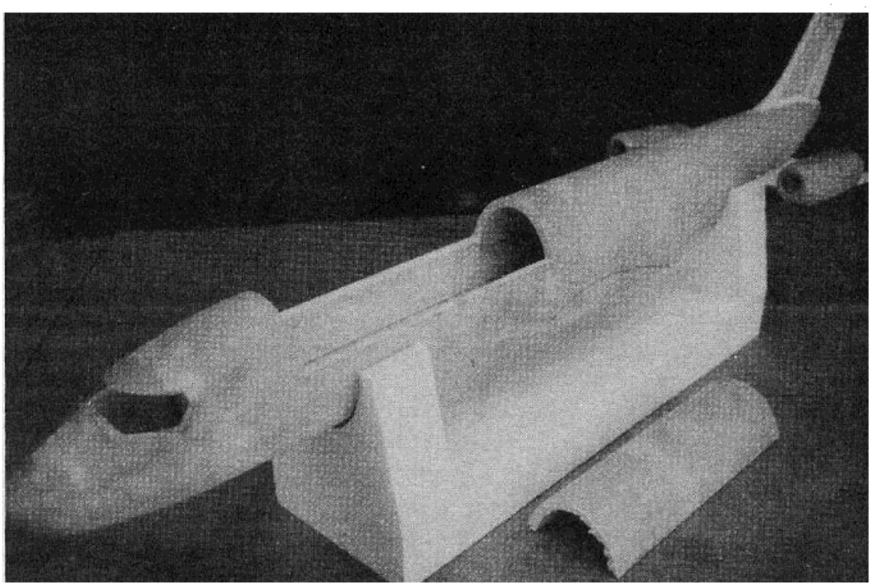
Photo #22: All empennage sub-assemblies ready for installation and final assembly.







ABOVE: Photo #23: Elevator installation and pushrod detail. ABOVE RIGHT: Photo #24: Engine pylon assemblies ready for installation of control cables or system of your choice. RIGHT: Photo #25: Nose gear support with 1/8" brass tube installed and ready for 1/32" ply top sheet.

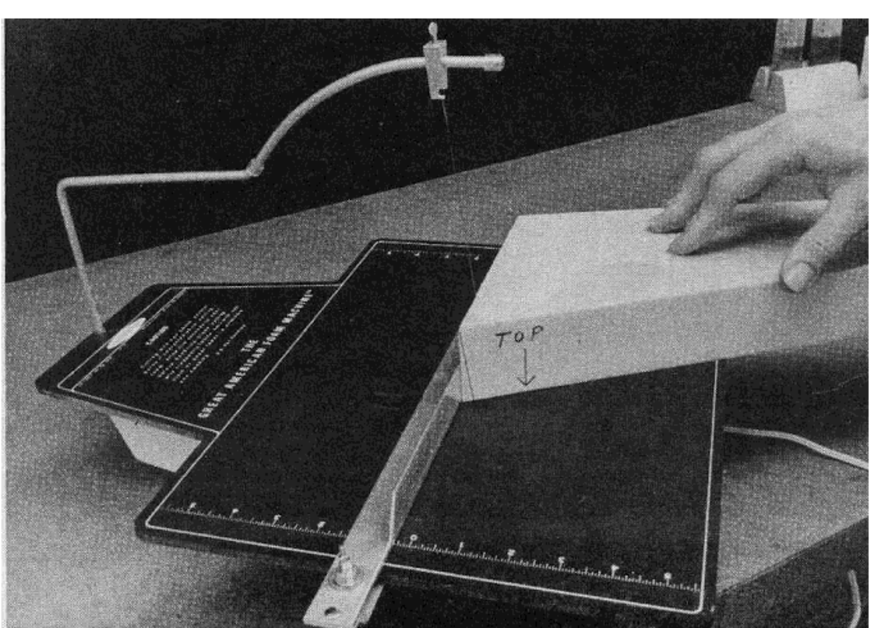


used as the bellcrank shaft and provides adjustment for centering the bellcrank. Be sure to allow the ball to protrude far enough through the fin to accommodate the socket link clearance.

After the left side has been epoxied in place, a #2-56 nut is snugged down and both the nut on the left side and the bolt head on the right side are glued with CA. Cut off any excess bolt flush with the nut.

When assembling the elevator, use two pieces of 1/4" x1/2" scrap to space the left and right sections 1/2" apart.

Photo #26: Opening up the hatch section is a dramatic moment. Size of hatch can easily be altered to suit your needs.



Care should be taken when capping off the recessed elevator bearing tube. The center section of brass tubing must remain free to turn on the 3/32" shaft. Sand to shape and test-mount it on the vertical fin to check for square. A little sanding on the 1/4" square spruce mount will level it.

Tack glue the vertical fin tip block and carve to shape. Add the 1/4" balsa fairing and sand the entire vertical fin to shape at this time. Remove the tip

Photo #27: The Great American Foam Machine is set for a 6° miter and the dihedral angle is cut into the wing core block before the core is cut.

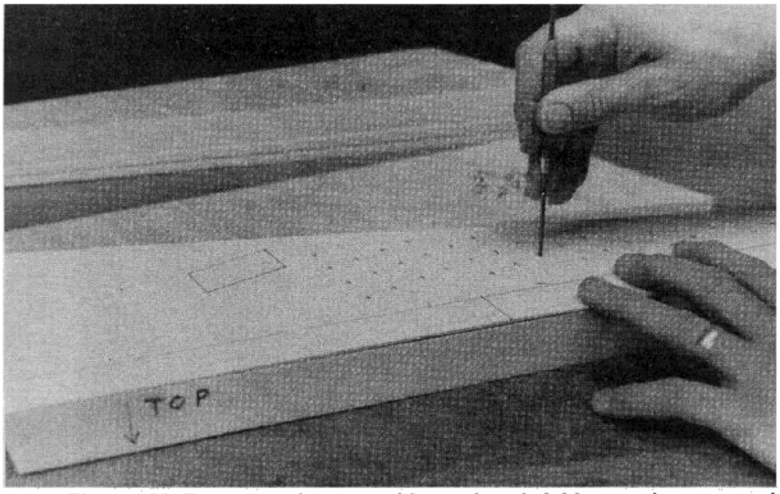


Photo #28: Paper template traced from plans is laid over wing core and pierced to mark location of all lightening holes.

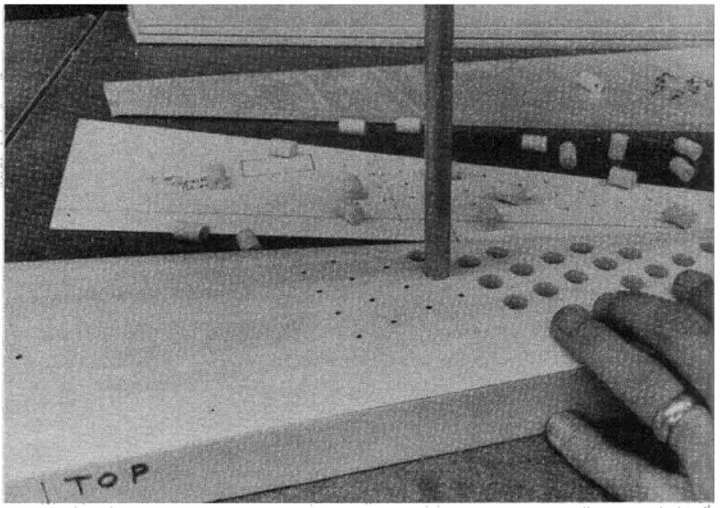


Photo #29: A 1/2" Velectro Foam Bore is used to cut the lightening holes after marking with paper template.

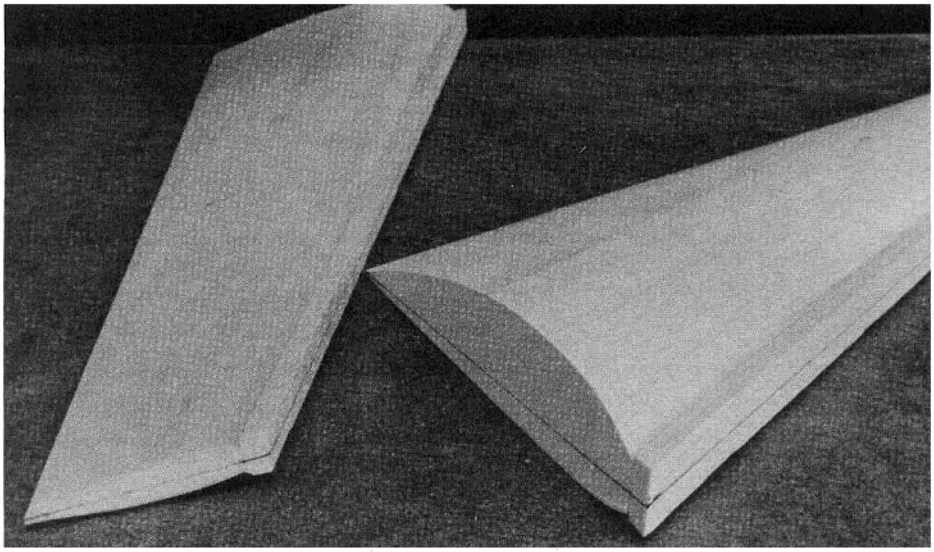


Photo #30: Installation of leading edge to sheeted wing cores. Note airfoil at root and tip.

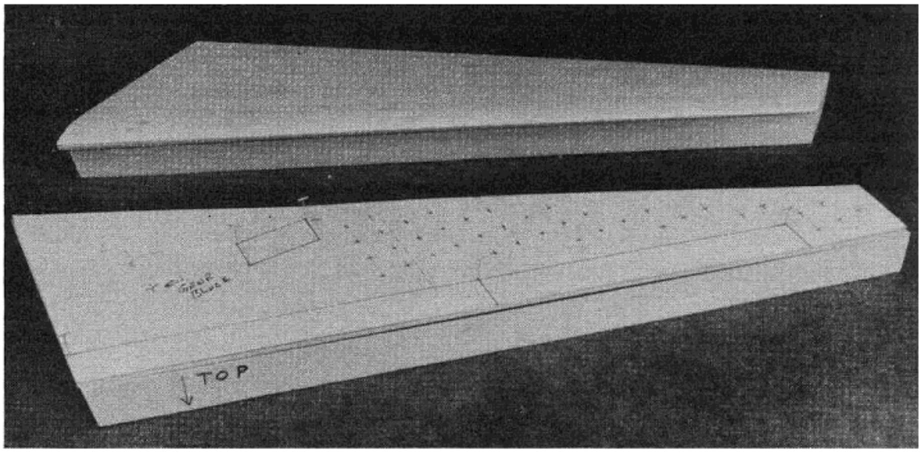


Photo #31: After sheeting, the same paper template is used to locate exact position of aileron bay, gear plate and gear dowel.

block and hollow out for pushrod clearance; cut and remove the wood in the area of the nylon gear mount used to secure the elevator shaft. Locate the vertical fin opening in the fuselage by measuring back from the former at Station 32.125, 3" back and 5/16" wide centered on the top locater line. Cut and remove the glass and foam in this area and test-fit the vertical fin. You may have to relieve a small area for the bellcrank bolthead and nut but keep the fit snug. With the fuselage taped in the cradle, check the vertical fin for alignment and square.

When you are satisfied with the fit, remove the fin assembly and apply 5-minute epoxy to the leading edge where it butts Former 32.125 and along the bottom where it butts the inside of the fuselage and re-install. Allow time for alignment. Bore a 1/2" hole in the fuselage adjacent to the ball link for later installation of the ball link socket. Install the elevator and vertical fin cap. Cut the openings for the engine pylons and test-fit them. Use some 1/4" scrap for alignment tongues. You may want to do a little trimming to get a snug fit. Be sure the forward edges of the pylons butt squarely up against the former at Station 29.375, as this sets the correct

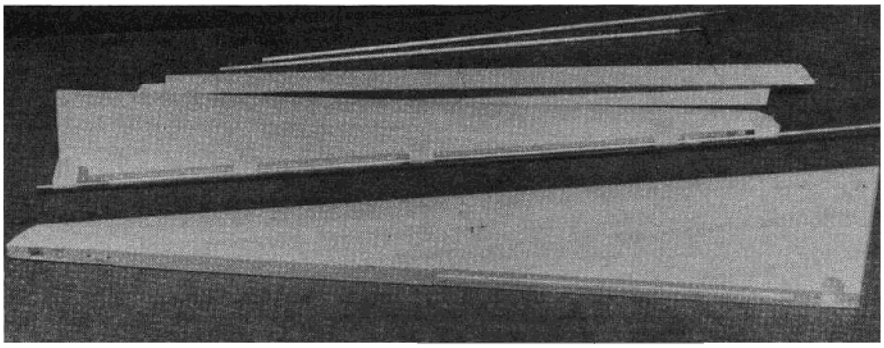
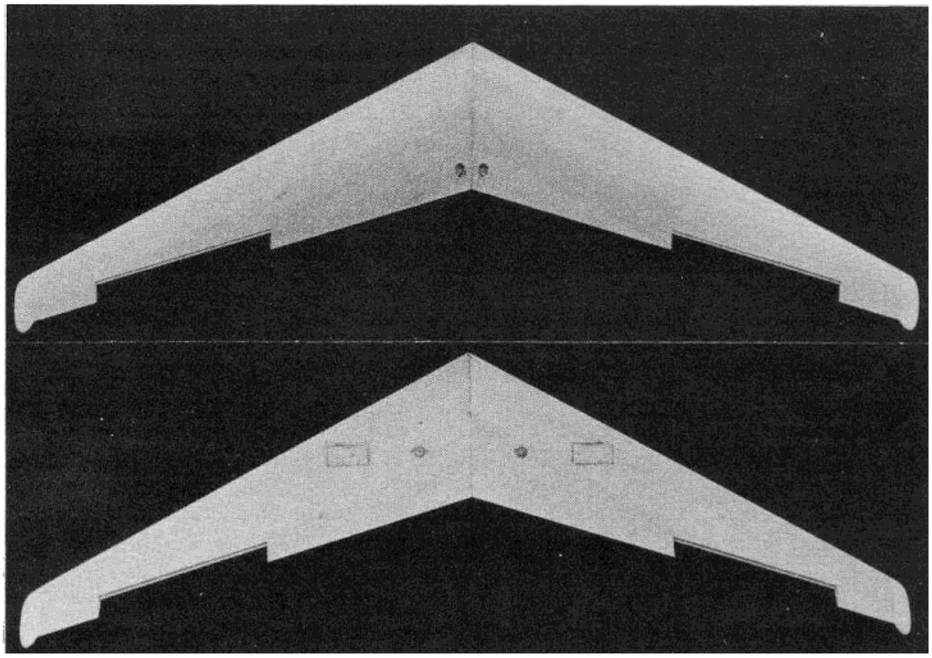


Photo #32: TOP: Torque tubes and cutaway trailing edge sections. CENTER: Right wing trailing edge detail showing installation of torque tube bearings. Note piano wire used for alignment of bearings. BOTTOM: Left wing trailing edge showing installation of aileron bay facing and 1/32" shim strips to support torque tube bearings. Note lightening holes at wingtips.

Photo #33: Top and bottom view of assembled wing. Note exposed torque tubes. Ailerons are added after MonoKote is applied to aileron bays.

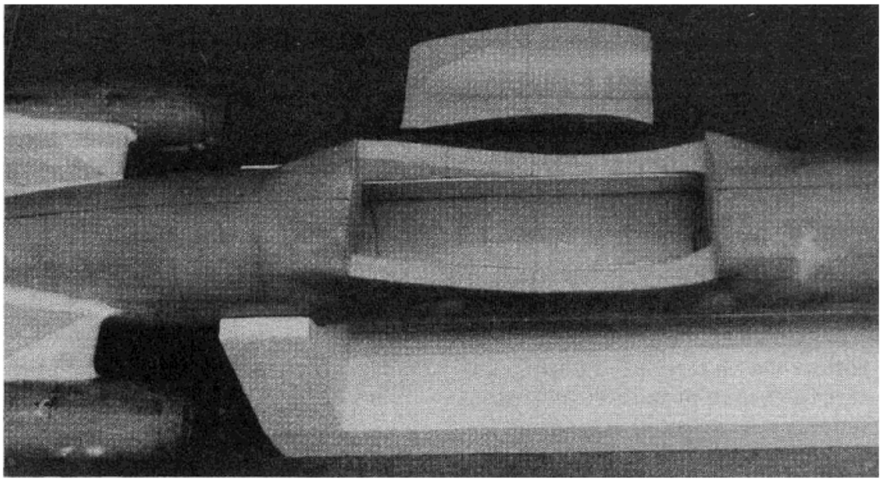


engine thrust offset.

When you are satisfied with the fit, remove the pylons and glue in permanently with 5-minute epoxy. Next, glue the engine nacelles into position, making sure to get left and right positioned correctly. Install the triangular styrofoam filler pieces at the leading and trailing edges of the pylons. Use micro-balloons and epoxy to fillet the pylons in with fuselage and the nacelles. Locate the parting line for the hatch by measuring up 4⅝" from the top of the cradle base. Use a straightedge taped to the side of the fuselage to cut the opening of the hatch. Be sure to cut behind the former at Station 6.625 and ahead of the former at Station 16 when cutting the hatch opening. Remove the hatch section and construct the hatch hold-down assembly as shown on the plans. Drill and tap the two hardwood pieces at each end of the hatch to accommodate the 2-56 hex-head hold-down bolts. Remove 1/4" of excess material on each side of the hatch cover and line it as well as the hatch opening with 1/8" x 1/4" balsa.

Cut the opening for the nose gear mount assembly and test-fit. Install with epoxy between Former 1.375 and Former 6.625. Install the 1/4" triangle stock at Former 1.375 and epoxy to the foam along the bottom of the fuselage.

Install the 1/16" subfloor sheeting from 1/2" behind the nose gear bearing back to Station 10.375 (or 8.5 if you need the room for your radio gear).



ABOVE: Photo #34: When cutting the wing opening in the fuselage, first cut through the fiberglass with a knife, then use the Velectro Hand Unit to cut through the foam and epoxy.

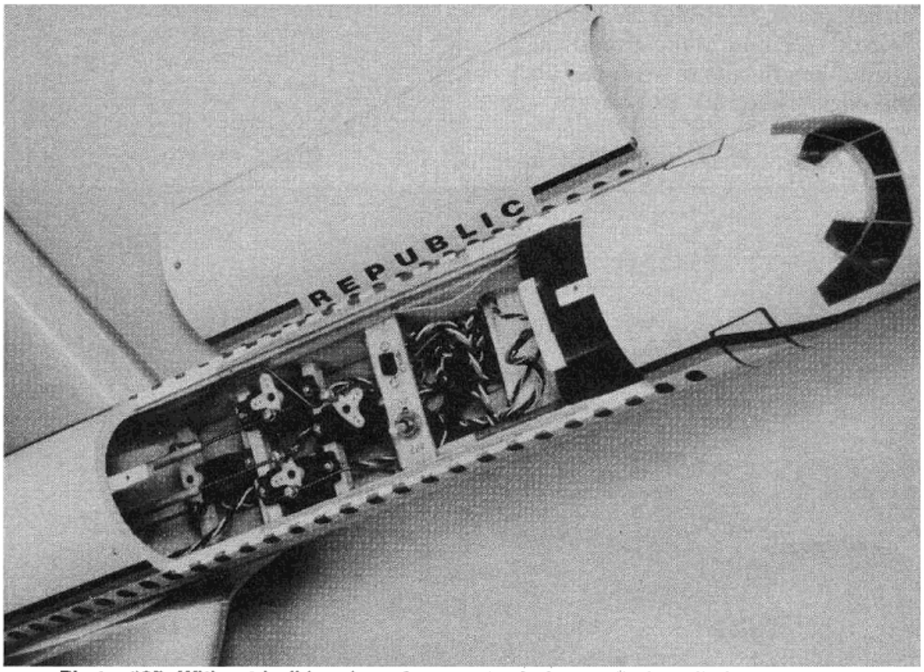


Photo #35: Without bulkheads or formers to dodge, radio installation can be neat and easy to work on. Note where antenna wire enters antenna wire guide tube.

Wing Construction:

The wing cores are cut from the same blue styrofoam as the fuselage. On the No. 2 prototype I used white bead foam for the cores and for several reasons I prefer and recommend the blue styro. Primary among these reasons: Blue styro cores are much stronger and warp resistant than bead foam cores.

Cut the core blocks to the exact outline of the wing core. Use Scotch 77 to fix the templates to the ends of the core blocks. Cut the core with a conventional bow cutter. Because of the extreme taper, it's a good idea to reduce the temperature of the cutting wire some-

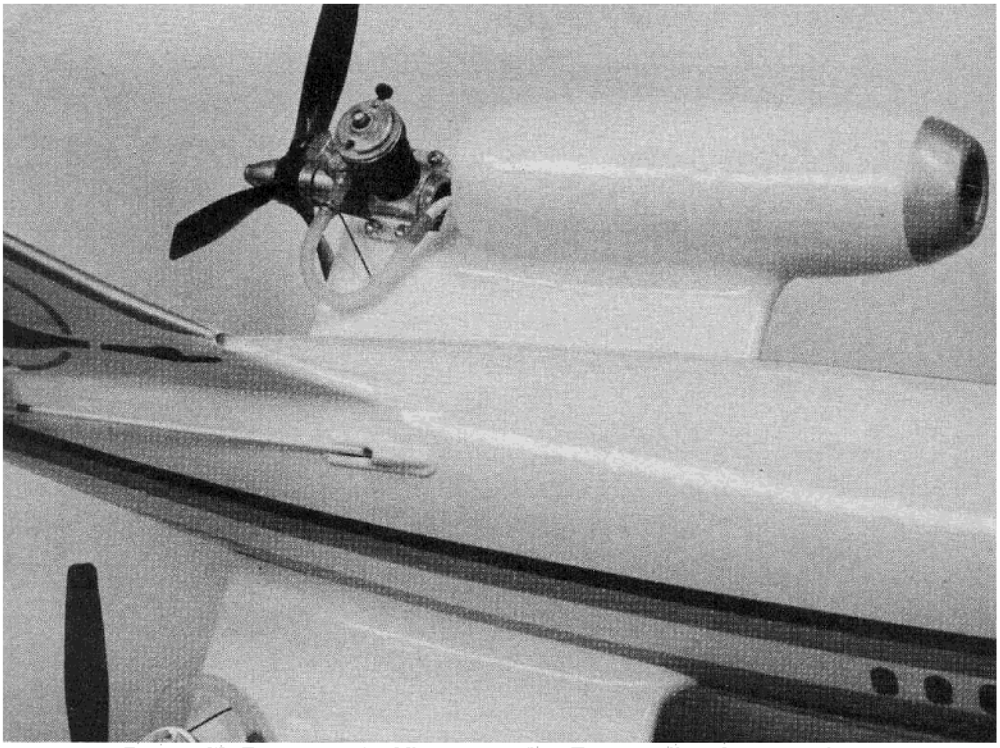


Photo #36: Engine and fuel line installation. Turn needle valves to outboard side. Note the carpet thread kill system tied to fuel line. Use a short length of brass tubing inside fuel line to avoid collapsing it with the kill line.

MCDONNELL DOUGLAS DC-9
Designed By: John Valentine
TYPE AIRCRAFT Sport Scale
WINGSPAN 44½ Inches
WING CHORD 4¾" Avg.
TOTAL WING AREA 230 Sq. In.
WING LOCATION Low Wing
AIRFOIL Flat Bottom — Root; Semi-Symmetrical — Tip
WING PLANFORM Swept and Tapered
DIHEDRAL EACH TIP 1¾ Inches
O.A. FUSELAGE LENGTH 41¾ Inches
RADIO COMPARTMENT SIZE (L) 9" x (W) 2¾" x (H) 2¾"
STABILIZER SPAN 12½ Inches
STABILIZER CHORD (incl. elev.) 2¾" Avg.
STABILIZER AREA 17½ Sq. In.
STAB. AIRFOIL SECTION Flat
STABILIZER LOCATION T-Tail
VERTICAL FIN HEIGHT 4 Inches
VERTICAL FIN WIDTH (inc. rud.) 4⅞" Avg.
REC. ENGINE SIZE .049-.051 x 2
FUEL TANK SIZE 1.25 Oz. integral
LANDING GEAR Tricycle
REC. NO. OF CHANNELS 4
CONTROL FUNCTIONS Elev., Ail., Rud., Engine

BASIC MATERIALS USED IN CONSTRUCTION

Fuselage	Styrofoam, Fiberglass, Balsa, Ply
Wing	Styrofoam, Balsa
Empennage	Balsa, Ply
Wt. Ready To Fly	**32 Oz.**
Wing Loading	**20.12 Oz./Sq. Ft.**

what to reduce the possibility of over-melt towards the tip section.

After the cores are cut, sand out any cutting flaws and feather the trailing edge. Trace the entire wing drawing onto a piece of card stock and include all details. Place the wing cores in their respective top saddles and place this card stock wing template on the bottom of each core. Use a pin to puncture the template and core at the center of each lightening hole and at the center of the gear dowel hole. Now use your 1/2" foam bore, or a piece of sharpened brass tubing, to bore the lightening holes and the gear dowel hole. Set The Great American Foam Machine blade for a 6° miter and set the fence for a 1/8" thick cut. Place each core in both saddles and cut the dihedral angle at the root of each core. Be sure you have the wing top-side down when you cut the dihedral.

True-up the edges of the 1/32" x 3" x 36" sheet balsa and glue up two groups of three sheets each. Each 1/32" x 9" x 36" sheet will yield two top or two bottom skins each. Use Scotch 77 applied to the core and the wing skin to sheet the wing. Trim off the excess sheeting at the root, tip and leading edge and sand flush with the foam. Add the 1/4" sheet leading edge and sand to shape. Do not glue on the tip block **yet.** Place the cores in the top core saddles as you did to cut the lightening holes. Place the wing template over the sheeted cores again and with a pin locate the four corners of the aileron bay, the gear mounting plate and the exact location of the gear dowel hole. Make one puncture on the aileron cut line at the root as well. Then remove the template with the sheeted cores still bottom-side up and resting in the top saddles. Align a straightedge with the pin hole at the root and the two pin holes indicating the inner edge of the aileron bays; tape the straightedge securely in this position. Make several angular full length cuts to sever the trailing edge. Take care to keep the cut vertical.

Cut out the aileron bay section and

Photo #37: Background: The No. 2 ship being readied for a new paint scheme, while in the foreground is the No. 3 aircraft constructed for this article.

set aside the aileron. Cut the aileron torque tube and the torque tube bearings. Install the 1/2" torque tube bearing at the tip end of the aileron and then glue the tip section of the trailing edge back on.

Prepare the aileron horn and wrap the torque tube end with masking tape until it fits snugly in the aluminum torque tube. Then secure permanently with epoxy or CA. Install the 9" inboard torque tube bearing and then glue on the inboard trailing edge.

Line the aileron bay with 1/32" balsa facing on all three sides. Install the torque tube. Trim the ends of the aileron off to allow for the 1/32" balsa facing and clearance for finishing material. Cut a groove in the forward edge of the aileron for the torque tube. Miter the top and bottom of the forward edge of the aileron to allow for aileron movement. Glue the aileron to the torque tube. Be sure the aileron horn is in the correct position.

Cut the opening for the gear mounting plate and relieve the foam for a flush fit. Open the gear dowel hole and install a piece of 1/2" hardwood dowel to butt the top sheeting and flush with the bottom sheeting. Drill a 3/32" hole in the center to accommodate the gear wire. Glue on the tip block and carve to shape. Glue the wing halves together, blocking each tip up 1¾".

Final Assembly:

Cut the wing opening in the fuselage & save the cut-out piece. You will need to remove a small portion of the wing leading edge at the root for a snug fit between formers at Station 16 and 22.75.

When you have the correct location and you have checked the incidence, tack-glue with 5-minute epoxy to the formers for and aft. Use a mixture of micro-balloons and epoxy applied with a 12" length of 3/32" piano wire to fill any gaps between the wing and the fuselage on the inside. Use the same mixture on the outside of the fuselage to produce the fillet.

Trim the cut-out portion of the fuselage to fit back in position under the wing & glue into place. Add the microballons and epoxy fillet here, too. Construct the elevator pushrod with the ball link socket on one end and position it inside the fuselage with the socket over the ball link. Secure the socket onto the ball by applying pressure with a piece of 1/4" square balsa through the access hole in the fuselage side. When the pushrod is secured, plug the access hole with a foam plug and sand smooth. Coat with a layer of epoxy.

Radio Gear:

Unlike most models we build, we don't have to worry about this model coming out tail-heavy. If anything, this one will come out nose-heavy; use your smallest servos and keep them as far back as possible. In the first two DC-9s I built, I use medium sized servos and had to locate the battery pack at Station 29.375 to achieve the correct C.G. range without adding unnecessary weight. The Mini Titen servos (by Royal) used in No. 3, allow positioning the pack just forward of the C.G.; however, this is only an arbitrary position and will be determined by your particular radio gear. If you are going to be using larger radio gear, you may want to make provisions for the battery pack in the rear portion of the fuselage when constructing it. Another good idea on this particular aircraft is to provide a means of internally guiding the antenna wire through the fuselage and out the rear-most portion of the tailcone. A piece of inner NyRod tubing will do this job nicely. In addition to improving the looks of your model, this will eliminate any chance of the antenna wire coming loose in flight and tangling in a prop.

Finishing:

The wing and elevator are covered with silver MonoKote and the fuselage and vertical fin are painted with Formula U. The entire aircraft could be painted with your favorite paint as there is no exposed foam when completed. Note that part of the windshield is also painted to appear as though it were part of the fuselage. The eyebrow windows and the windshield are trimmed in silver.

The Power Plant:

Five years of 1/2A pylon racing have proven to my satisfaction that all TDs are not created equal. Some just run better than others, so match your engines closely. My experience with twins shows that fuel consumption can vary widely between two identical motors running at the same rpm. After you have your engines mounted, top off both tanks, start the engines and let them run dry. Observe which one quits first and how long the other motor runs on. Keep this information in the back of your head. It may come in handy at the noisy flying field.

Flying:

If you've flown R/C twins before, most of this will seem old hat. However, I'll try to tell it as I would to a low-time or no-time twin pilot. Let's start with the take-off. Allow plenty of runway and let the aircraft reach flying speed before you rotate. More importantly, **do not rotate** abruptly — in other words, don't horse it off. An abrupt rotation or attempting to rotate before achieving flying speed could force one or both of the props to make contact with the ground. An engine cut on take-off could prove to be a real pickler, so ease in that elevator. As the nose comes up and the angle of attack becomes more positive, the wing will begin to create lift. As the lift increases, the aircraft will become lighter on its feet. This will allow the main gear to rotate down and slightly forward, increasing prop clearance even more. On the No. 1 prototype, I used a tail skid. I discarded it after ten flights because it never did touch the ground. Once you have a foot of altitude you can stand it on its tail.

This may look like a DC-9 but with twins TDs and only two pounds of airplane, it flies more like an F-16. Once you are airborne, put it through its paces. Inverted flight is alright, but don't keep it there too long or you'll dry out an engine.

Single engine operation is typical; you'll need lots of rudder into the live engine. Never execute a turn into the dead engine. Always turn in the direction of the live engine. When flying on a single engine, keep the airspeed up. Stay above the minimum controllable airspeed and don't confuse this with stall speed.

When both engines are out, keep the glide a little less shallow than you would for your Sunday sport jobs. That nose-high flare is a beauty to behold!

If you have questions pertaining to this style of construction or this design, I will answer them as time permits. Please phrase your questions as briefly and clearly as possible. Forward them to: John Valentine, 4116 E. Sacaton, Phoenix, Arizona 85044. Include a stamped, self-addressed envelope. Thank you. □

From RCModeler
Sep. 1984