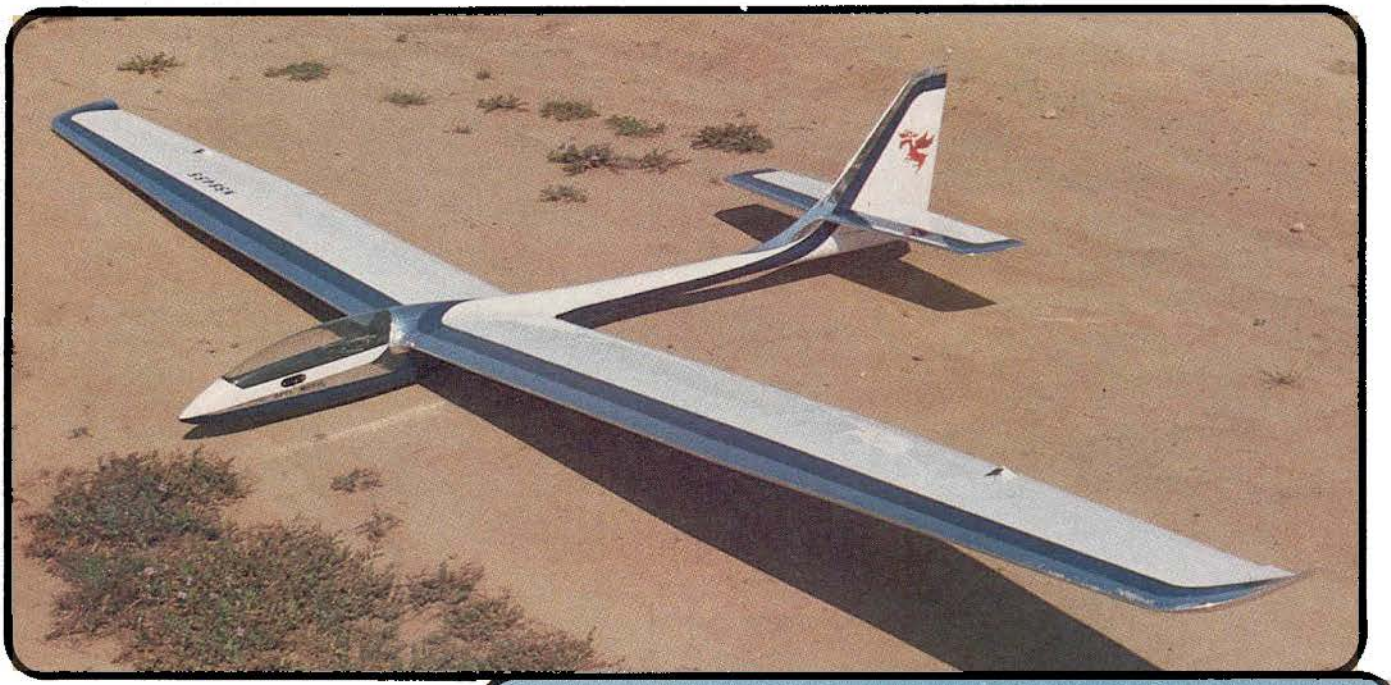
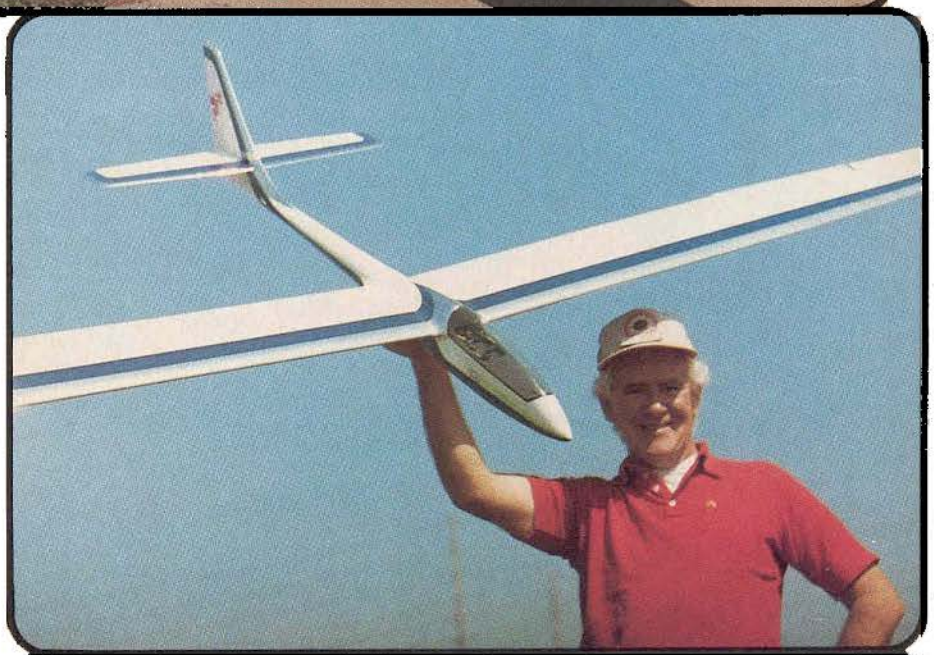
OPTI MOOSE





Introduction

First, a little background. Two main programs have been developed using an IBM PC to do model design and analysis work. I do a lot more analysis than the models really warrant, but that is part of the hobby for me. I find that designing, building, and flying radio controlled sailplane models is a lot more rewarding than my real job was for the last few years.

One of these programs uses a stability and control code with which I calculate the static stability and control derivatives. I am not very sure about the absolute level of these parameters but comparisons between configurations seem to be pretty good. The

ABOUT THE AUTHOR

Jim Stevens is 61 years old as of February 1987; is married, has three grown sons, a daughter-in-law and a grandaughter. He has built model airplanes of one form or another all of his life, including over 200 1/72nd scale fighter models which "get dusty on glass shelves in the family room." He says that while he has built and flown all types of models, sailplanes have always been his true love.

Jim received a B.S. in Aero Engineering from the University of Washington in 1949, and an M.S. in Aero Engineering from the University of Southern California in 1959. He worked at North American Aviation in Los Angeles from 1949 to 1954, and with an intervening period of about a year and a half in an Army TSU at Redstone Arsenal in Huntsville, Alabama. In 1955 he joined the Northrop Corporation, Aircraft Division, where he worked for 30 years in aerodynamic research and aircraft advanced design.

In March of 1985 Jim retired from Northrop and now spends most of his time designing, building, and flying radio controlled model sailplanes. Jim is a member of the Soaring Union of Los Angeles. He was vice president of S.U.L.A. and ran the novice instruction program for two years.

computer code has been "tuned" to model sailplane type configurations. The input for this code requires only the dimensions which may be measured from a reasonably accurate 3-view plus some airfoil data. The program is based on the Air Force DATCOM, the British ESDU Data Sheets, several text books, and a bunch of general aerodynamic junk collected over the years. This code was then applied to a number of models which were already flying, and a data base was developed for existing models. A rough layout for a proposed design is then analysed, and the areas and dimensions are adjusted by comparison with the data base. The handling qualities of the new model can then be predicted qualitatively by inference in comparison with the way existing models fly. The construction layout is then drawn using the final refined dimensions.

The second main program is a set of computer codes for airfoil design and analysis. These codes are based on a modification of the Weber Method for the potential flow velocities, and a combination of the Eppler, and the A.M.O. Smith methods (with a little judicious meddling here and there) for the boundary layer. Results from the analysis code compare very well with published results from the Eppler method for airfoils of interest for sailplane models. Comparisons with test data depend on the quality of the test data, and using the Schmitz and Althhaus data produces results which vary from excellent to terrible. These codes have been adapted to store and retrieve data in a format consistant with Chuck Anderson's airfoil plotting code.

The G9S-1 Opti Moose is the ninth model designed, built, and flown over the past five years, and has by far, better flying qualities than any of the previous eight. These nine models were a variety of configurations, and the only real ancestor of the G9 was the G7S Prim Moose which was the first aileron model. It flew well but was eventually destroyed on launch. Six others are still flyable.

The design goals for the Opti Moose are as follows:

1. Look like an airplane.
2. Sized for thermal conditions at S.U.L.A.'s field.
3. Clean lines for low drag (read penetration).
4. High max lift for thermalling and slow approach.
5. No tip stall in tight turns.
6. Minimum trim change due to changes in geometry.
7. Target wing loading equal/less than 10 oz./sq. ft.

Items 3, 4, and 5 indicate a low drag airfoil with moderate camber, flaps for high lift, and tailoring of the outboard panel. Experience indicated that Item 6 could be satisfied with a slotted flap and Schemp-Hirth spoilers on both upper and lower surfaces. The basic dimensional data for the Opti Moose airfoils are:

AIRFOIL	INBOARD PANEL	TIP
Max thickness	.12	.10
Chord location of max t	.35	.30
Lead. Edge, Radius	.0072	.01125
Max camber	.028	.027
Chord location of max cam	.50	.40
Design lift coeff.	.4	.4

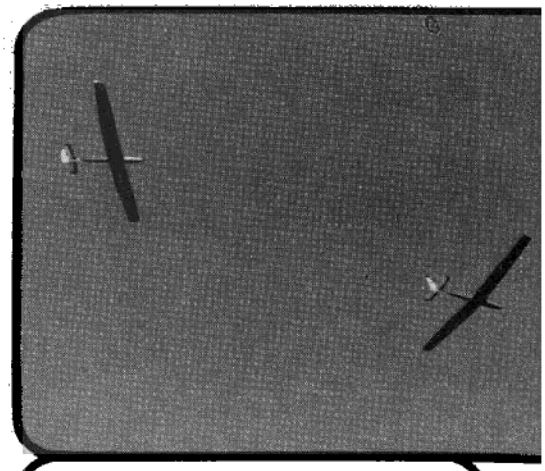
The larger normalized leading edge radius at the tip produces a constant physical l.e.r. over the entire span.

The model may look complicated at first glance, five channels and all, but any one of the design features, in itself, has been simplified as much as I could on previous models. For example, this is about the fifth version of the spoilers, and third set of slotted flaps that have been flown. I would not recommend the model as a first model, but with a little help from your friends, I think it would be a good first aileron model. I flew it in the coupled rudder/aileron mode at first, but more and more I have been flying it uncoupled. I am not a very good pilot (neither was Tony Fokker) and the best I have been able to do is Tenth at the Western States Meet in Sacramento last June. However, several of the really good pilots in S.U.L.A. have flown the model and they have all been very enthusiastic. The model is very easy to launch and fly and has not shown any bad habits at all. I have to build a second model to get the pictures for this article and offered to loan it to one of the best pilots in S.U.L.A., Randy Spencer, for competition, and he seems quite pleased and eager. Randy is quite outspoken and I don't think he was just being polite. If you build the model true it will have no unpleasant surprises for you at all, and I think you will find it to be a lot of fun.

The Opti Moose, designated G9S-1 by the designer, is the ninth model in the series. Jim feels he has arrived at what he set out to accomplish with this latest model. It has all the bells and whistles you can add and they all work well.

Building The Model

It may be tedious, but I find that cutting all the parts before starting the assembly saves time in the long run. So, **make a kit.** Major parts are shown on the pattern plan. Materials stock for the pattern parts as well as various sticks, sheets, and hardware are given in the parts list. There shouldn't be any difficulty, but here are a few comments about making parts. Photo 1 shows the use of a dressmaker's pattern wheel to transfer the outline of a part to a sheet of wood placed beneath the plan. Whenever mated parts are required, stack them and cut any common holes, slots, and openings in them all together. For example, the spoiler box sides and the spoiler blades should be drilled as a stack. Similarly, the holes in the four spoiler links should be drilled in a stack. I cut the wing ribs using the stack method. The ribs will



G9S-1 OPTI MOOSE

Designed By:
Jim Stevens
TYPE AIRCRAFT
Unlimited Class Sailplane
WINGSPAN
120 Inches
WING CHORD
10 Inches Inb'd
8.2 Inches Avg. Outb'd
TOTAL WING AREA
1092 Sq. In.
WING LOCATION
Shoulder Wing
AIRFOIL
1235 2850.12 Inb'd
1230 2740.15 Tip
WING PLANFORM
Constant Chord Center
Double Taper Tips
DIHEDRAL EACH TIP
3.75 Inches
O.A. FUSELAGE LENGTH
53 Inches
RADIO COMPARTMENT SIZE
(L) 10⅜" x (W) 2⅜" x (H) 1⅞"
STABILIZER SPAN
26 Inches
STABILIZER CHORD (incl. elev.)
5.5 Inches Avg.
STABILIZER AREA
143 Sq. In.
STAB AIRFOIL SECTION
8% Symmetrical
STABILIZER LOCATION
1/4 Up on Fin
VERTICAL FIN HEIGHT
10 Inches
VERTICAL FIN WIDTH (incl. rud.)
7 Inches (Avg.)
REC. ENGINE SIZE
NA
FUEL TANK SIZE
NA
LANDING GEAR
Skid
REC. NO. OF CHANNELS
5
CONTROL FUNCTIONS
Rud., Elev., Ail., Spoil., Flaps
BASIC MATERIALS USED IN CONSTRUCTION
Fuselage ..... Balsa, Ply & Basswood
Wing ..... Balsa, Ply & Spruce
Empennage ..... Balsa, Ply & Spruce
Wt. Ready To Fly ..... 74 Oz.
(4 Lbs. 10 Oz.)
Wing Loading ..... 9.76 Oz./Sq. Ft.

LIST OF PARTS AND MATERIALS — G9S-1

Balsa
6 — 1/16 x 3 x 36 — Ribs, other pattern parts
4 — 1/16 x 4 x 36 — Inb'd wing skins
4 — 1/16 x 4 x 28 — Outb'd wing skins
4 — 1/16 x 3 x 6 — Wing root skins
4 — 1/16 x 2 x 6 — Wing root skins
4 — 1/16 x 1/4 x 28 — Inb'd wing rear spar caps
4 — 1/16 x 1/4 x 30 — Outb'd wing rear spar caps
4 — 1/16 x 1½ x 28 — Flap skins
4 — 1/16 x 2 x 28½ — Aileron skins
44 — 1/16 x 1⅛ x 2 — Inb'd main shear webs
16 — 1/16 x 3/4 x 2 — Inb'd auxiliary shear webs
16 — 1/16 x 1⅛ x 2 — Outb'd main shear webs
16 — 1/16 x 1 x 2 — Outb'd main shear webs
12 — 1/16 x 3/4 x 2 — Outb'd main shear webs
2 — 1/16 x 1⅛ x 2½ — Drag spar shear webs
12 — 1/16 x 1/2 x 2 — H. tail shear webs
16 — 1/16 x 3/16 x 36 — Cap strips
1 — 1/16 x 3/8 x 12 — H. tail T.E. gussets
1 — 1/16 x 1/2 x 28 — V. tail diagonals
1 — 1/8 x 3 x 36 — Empennage ribs, other pattern parts
4 — 1/8 x 1/8 x 9 — Spoiler seat rails
4 — 1/8 x 3/8 x 28 — Outb'd wing main spar caps
2 — 1/8 x 1/2 x 28 — Inb'd wing sub leading edge
2 — 1/8 x 1/2 x 28 — Outb'd wing sub leading edge
2 — 1/8 x 1/4 x 28 — Inb'd wing rear spars
2 — 1/8 x 3/8 x 30 — Outb'd wing rear spars
2 — 1/8 x 1/2 x 13 — H. tail trailing edge
2 — 1/8 x 1/2 x 2 — H. tail rear rod box
1 — 1/8 x 3/8 x 10 — H. tail gussets
1 — 1/8 x 1/2 x 9 — Rib, V. Stn. 3.0
2 — 1/8 x 1/2 x 12 — Fin T.E. spar
1 — 1/8 x 3/8 x 12 — Rudder T.E.
2 — 3/16 x 1/2 x 28 — Flap spars
1 — 3/16 x 2 x 3 — V. tail tips
5 — 1/4 x 3 x 36 — Fuselage
2 — 1/4 x 1/4 x 28 — Flap slot fairings
2 — 1/4 x 1/2 x 28 — Inb'd wing leading edge
2 — 1/4 x 1/2 x 31 — Outb'd wing leading edge
2 — 1/4 x 3/8 x 28 — Aileron spars
2 — 1/4 x 1/4 x 13 — H. tail leading edge
1 — 1/4 x 3/8 x 15 — V. tail leading edge
1 — 1/4 x 1/2 x 12 — Rudder leading edge
6 — 3/8 x 3/8 x 3/4 — Aileron hinge blocks
1 — 3/8 x 3 x 36 — Filler blocks, dorsal fin, pattern parts
4 — 1/2 x 36 Triangle-cut — Fuselage, fairings
2 — 1/2 x 13 Triangle-cut — Lower wing fillets
1 — 3/4 x 2 x 28 — Wing tips, fuselage hatch, nose blocks

Basswood
1 — 3/8 x 3/8 x 18 — Servo & control mounts
1 — 3/8 x 1/2 x 4 — Tow hook mount
1 — 3/4 x 1 x 6 — Nose blocks

Spruce
4 — 1/8 x 3/8 x 36 — Wing main spar caps
4 — 1/8 x 1/4 x 15 — Wing auxiliary spar caps
4 — 1/16 x 1/4 x 13 — H. tail spars

Plywood
2 — 1/64 x 5/8 x 28 — Flap shrouds
4 — 1/64 x 3/8 x 28 — Aileron shrouds
2 — 1/64 x 1/4 x 12 — Rudder shrouds
4 — 1/16 x 1/2 x 2 — H. tail rear rod box
3 — 1/16 x 3/8 x 3⅞ — Fuselage rod box
3 — 1/16 x 1/4 x 3⅞ — Fuselage rod box
1 — 1/16 x 8 x 48 — Pattern parts
1 — 1/8 x 8 x 24 — Lite ply pattern parts

Hardware
1 — Airtronics adjustable tow hook & hardware
3 — 36" NyRods: Cut outer (1) 36 in. antenna tube; Cut inner (2) 36" rud., & horiz. control tubes; Cut inner (1) 16" + (2) 6" spoil. & flap
3 — 48" Nyrods: Cut inner (2) 44" aileron control tubes; Cut inner (3) 16" spoil. & flap cont. tubes
4 — Bicycle derailer cables: Cut (1) 38" + (1) 16" + (1) 10"; H. tail, flap & fuselage; Cut (1) 40" + (1) 16" + (1) 8" rudder, flap, & fuselage; Cut (1) 46" + (1) 18" aileron & spoiler; Cut (1) 46" + (1) 18" aileron & spoiler
1 — 4" rod, 2-56 threaded end, aileron
2 — 2-56 x 1½" threaded rods, flaps
1 — 1/4 o.d. x 12" Piano wire, wing rod
1 — 3/32 o.d. x 8" Piano wire, horiz. tail rod
1 — 1/8 o.d. x 8" Piano wire, wing rod
1 — 1/16 o.d. x 5" Piano wire: Cut (1) 4" + (1) 1" H. tail rod & V. tail hinge
1 — Approx. .05" x 10" Piano wire: Cut (9) 1" aileron, flap & rudder hinges
1 — 1/4 i.d. x 14" brass tube, wing tubes: Cut (1) 10" and (1) 4"
1 — 1/8 i.d. x 8+" and (1) 4" H. tail tubes
1 — 3/32 i.d. x 13" and (1) 4": Cut (1) 6" + (1) 4" + (4) 1/2" + (3) 1/4" wing, spoil. & H. tail
1 — 1/16 i.d. x 12" Brass tube: Cut (1) 4" + (9) 1" + (1) 1/2" H. tail, hinges & V. tail
8 — No. 2 x 1/4" wood screws — spoilers
2 — 2-56 x 3/4" bolts — rudder horn
7 — 2-56 x 1" bolts — spoilers & bell cranks
3 — 2-56 blind nuts — bell cranks
4 — 2-56 lock nuts — spoilers
10 — 2-56 washers
7 — control rod connectors
15 — 2-56 threaded couplers
16 — 2-56 tapped clevices

Nylon
7 — 4-prong Futaba servo horns
1 — 6-prong Futaba servo horns
1 — Small control horn
1 — Ball joint
6 — Hinge points
2 — 90 deg. bell cranks & hdwr.
2 — Wing tip skids
3 — Control cable exits (make or buy)

Misc.
1 — 11 or 12 inch sailplane canopy
1 — Pkg. carbon fiber tow
Micro-balloon filler
CA thin glue
CA slow glue
Aliphatic glue
30 min. epoxy
Solder

be trimmed to length during assembly. The shear webs for the wing and horizontal tail should be cut so that they are installed with vertical grains. Photo 2 shows the taper and notches required in the four triangle-cut stock for the aft fuselage. The lines of the 1/4" thick aft fuselage sides, top, and bottom are dead straight, so they can be cut using a long straight edge. Select your wood carefully. Use "C" cut for ribs and "A" cut for spars, etc. Use light wood for non-critical structure. Read through the building notes before cutting the parts. Some of the holes shown on the pattern plan are drilled during assembly.

In the construction notes I have indicated various types of glue as follows:

(AL) — Aliphatic glue such as Titebond, etc.

(CA) — Cyanoacrylate such as Hot Stuff, Zap, etc.

(SCA) — Slower kicking, gap filling CA.

(EP) — Epoxy glue.

I use CA as much as possible for lightness, however I use AL in places where shaping is going to be required. Sanding CA is like trying to sand glass.

I like to do the easy bits first, and also some components must be fitted to others, so I started with the horizontal tail.

Horizontal Tail

Place the building shims on the plan as indicated, and put a piece of wax paper over the plan and shims. Proceed as follows:

1. Pin lower main spar cap, leading edge spar and trailing edge in location.

2. Leave rod tubes in one piece. Drill holes for the rod tubes in rib stn. 25, the

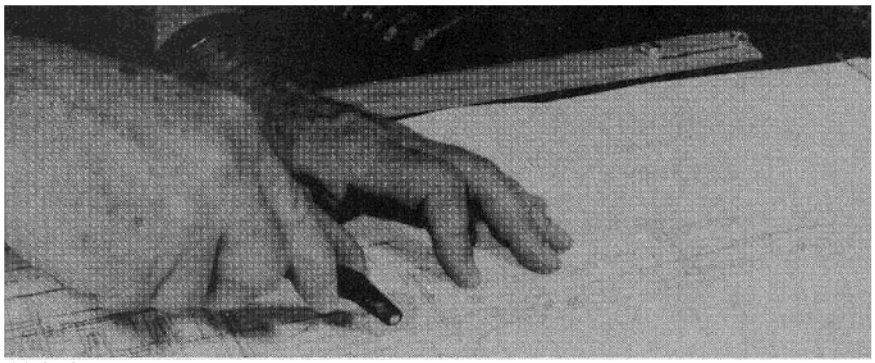


PHOTO 1

rear part of stn. 2, and stn. 4. Slide the ribs onto the tubes and set in place. Adjust the tubes so that they are horizontal and normal to the centerline. Glue the ribs to the spars.

3. Glue (CA) ribs 6, 8, and 10, and the tip blocks to the spars.

4. Glue (CA) 1/4" filler blocks to the main spar cap from stns. 25 to 4, and between the tip blocks, filling the space between the lower main spar and the level of the upper main spar cap.

5. Glue on upper main spar cap (CA).

6. Lay 1/16" ply tube box tops on tubes and glue to spars and ribs (CA).

7. Glue in 3/16" root trailing edge pieces, and 1/16" trailing edge gussets (CA).

8. Glue (CA) shear webs onto the rear of the main spar from stn. 4 to the tip, and onto front of the main spar in the two bays

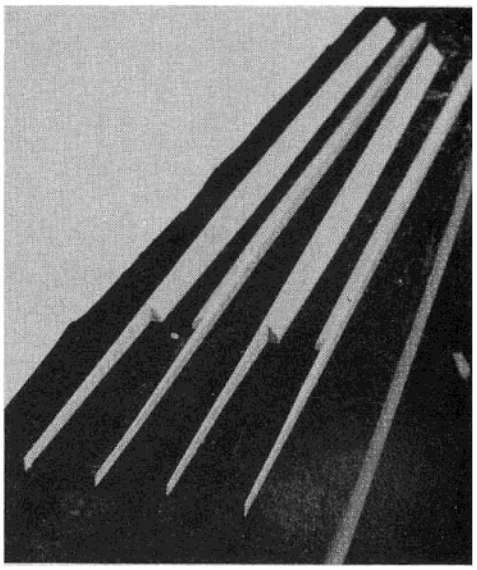
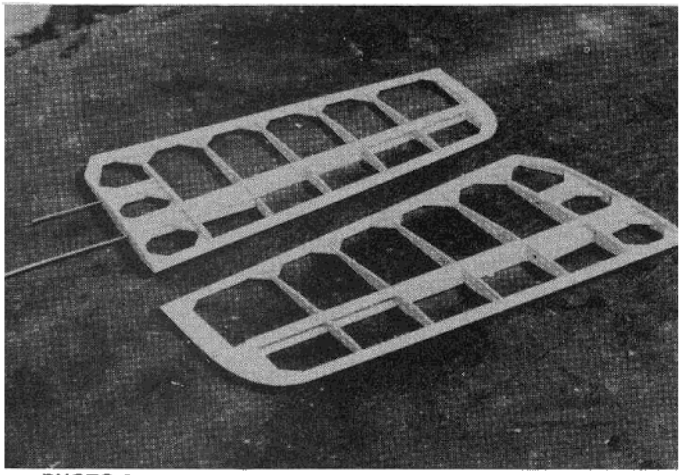


PHOTO 2



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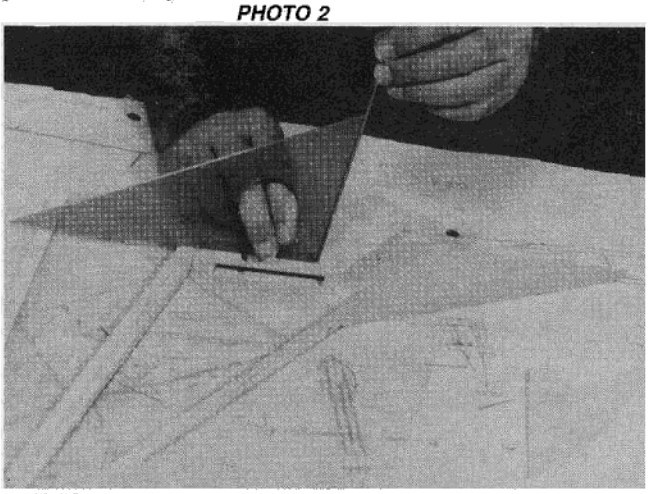

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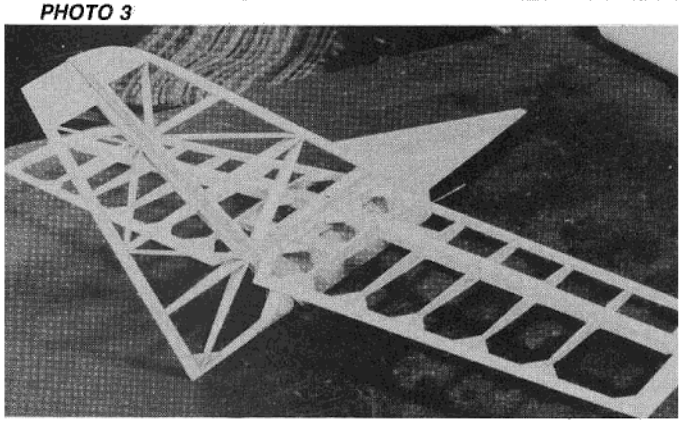

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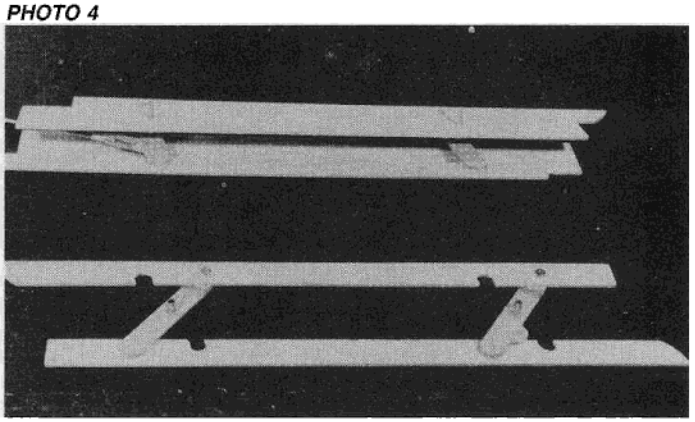


PHOTO 6

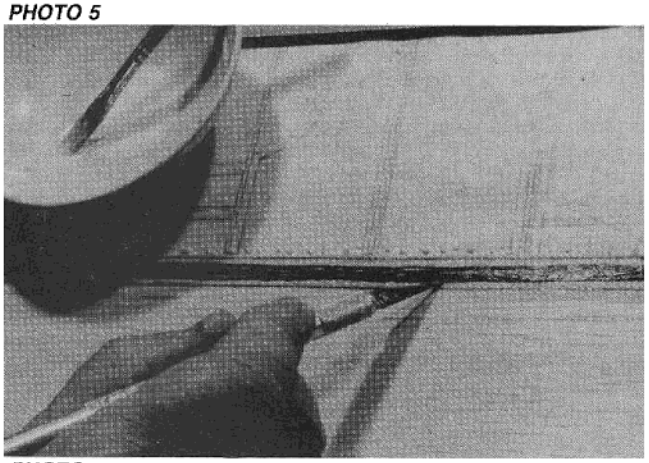


PHOTO 7

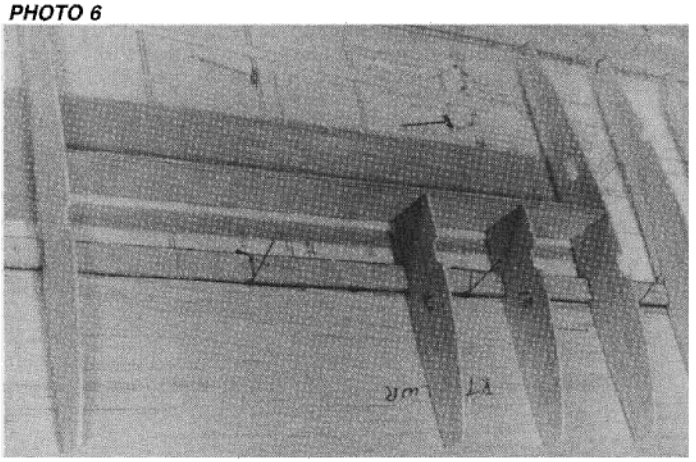


PHOTO 8

from stns. 4 to 8.

9. Remove horizontal tail from plan.

10. Glue (CA) balsa packing blocks to each side of rod tubes.

11. Glue (SCA) 1/16" ply tube box tops to packing blocks, spars, and ribs.

12. Glue in (CA) front part of rib 2.

13. Cut and glue (CA) 1/8" gussets in the root region as shown.

14. Shape leading edges, tips, and trailing edges and sand everything.

15. Cut rod tubes to separate the two panels and file the tubes flush with the root ribs. The completed horizontal tail structures are shown in Photo 3. They weigh less than two ounces.

Vertical Tail

1. Put rods in horizontal tail rod tubes and mark hole locations on 1/16" ply horizontal tail bell crank.

2. Drill horizontal tail bell crank for 3/32" and 1/16" i.d. tubes.

3. Drill hole in bottom corner of bell crank for clevis. The clevis should move freely but with no slop.

4. Stack the two 1/16" ply vertical tail skins V1. Mark the locations of the front and rear horizontal tail rods. Drill front hole through both sides for 3/32" rod and saw out rear slots.

5. Place the building shims as shown on the plan. Put a piece of waxpaper over the shims and plan.

6. Pin down one 1/16" ply vertical tail skin, V1, flat on plan.

7. Pin down one 1/16" balsa vertical tail skin, V2, and glue edge to V1 (CA).

8. Taper the two 1/8" balsa fin main spars as shown on the plan. Sand the rear half of the spar 1/64" inside the front on both edges. Glue the two halves together (AL).

9. Pin main fin spar in position and glue (CA) to rear edge of V1.

10. Pin the fin leading edge in position and glue (CA) to V2.

11. Taper 1/4" balsa rudder leading edge and pin in position against fin main spar.

12. Glue (SCA) 3/8" balsa filler block V3 to V1, V2, and leading edge.

13. Glue (SCA) 3/8" balsa filler block V4 to V1 and main spar.

14. Glue (AL) 3/8" balsa dorsal fin V5 to V2 and the leading edge.

15. Place a piece of 3/8" scrap balsa on V1 in the region of the horizontal tail bell crank to support the top 1/16" ply skin. Use (AL) to provide time for adjustments. Smear glue on surface of V3 and V4. Slide the 3/32" horizontal tail rod through the hole in the top 1/16" ply skin V1. Set the rod in the hole in the bottom skin V1 and press the top V1 down onto V3 and V4. Use a right triangle from several directions to ensure that the rod is vertical, shifting the top V1 as necessary (Photo 4).

16. Glue (CA) the rear edge of the top V1 to the main spar.

17. Glue (AL) the top 1/16" balsa skin, V2, to the dorsal, leading edge spar, filler block V3, and top V1.

18. Glue in upper vertical tail rib blanks, diagonals, and tip blocks (CA).

19. Glue (CA) in 1/2" balsa gusset at rudder root leading edge.

20. When dry, remove vertical tail from plan and separate the fin and rudder.

21. Sand rudder ribs to contour.

22. Shape the rudder leading edge to a half-round section.

23. Glue the 1/64" by 1/4" ply shrouds to the rear half of the fin main spar. Terminate the shrouds about 1" above the fin root to clear the rudder control horn.

24. Taper the shrouds slightly towards the fin tip to allow the rudder leading edge to touch the fin main spar.

25. Flatten about 1/4" of the end of a 1/16" i.d. x 1" brass tube.

26. Drill a hole in the flat part of the tube a smidgen larger than the wire to be used for the hinge.

27. Mark the location of the hinge near the fin and rudder tips normal to the hinge line.

28. Drill a hole for the hinge tube from the hinge edge, through the fin main spar, and into the fin tip block.

29. Mill a slot about 1/8" deep by 1" long into the rudder leading edge for the hinge wire. Cut a gap in the rudder leading edge about 1/8" wide to clear the hinge tube.

30. Place the hinge wire through the hole in the end of the hinge tube and slide the wire into the slot in the rudder. Spot glue at the wire ends (CA). Fill the slot with scrap pieces of 1/16" balsa against the wire and glue (CA). Be sure the tube can rotate freely on the wire. Do not glue the tube into the fin at this time.

31. Drill a hole for the 1/16" i.d. hinge tube into the root end of the rudder leading edge spar and rudder control horn gusset at the rear face of the spar.

32. Push a 1/16" i.d. x 1/2" tube into the hole and glue (SCA).

33. Sand fin ribs to contour and smooth up the main spar and shrouds.

34. With a dowel sander, feather the inner rear edges of the shrouds.

35. Leave the fin leading edge and dorsal shaping until later. They would just get dinged up during further assembly.

36. Check the lengths of the 3/32" i.d. x 3/8" and 1/16" i.d. x 3/8" tubes for clearance within the fin root skins. Roughen the surface of the tubes near their mid-length with a rasp and glue the tubes, centered, into the horizontal tail bell crank (CA).

Photo 5 shows a trial assembly of the empennage. Set these parts aside until later.

Spoilers

The spoilers are Schemp-Hirth type, extending from both upper and lower wing surface. When fully extended, a gap exists between the inner edges of the spoiler blades and the wing. This type of spoiler should impose a minimum trim change when extended, but on this model a slight nose down change occurs. I don't usually even change the trim setting because I normally move the spoilers in and out to control the glide path and they are not open very long. This type of spoiler is available commercially, but only for one surface so far as I know. Build the spoilers as indicated below and they will be both lighter and cheaper.

1. Block two spoiler box sides (front and rear) apart with 1/2" scrap balsa blocks and check the lengths of the spoiler link tubes for slight end clearance.

2. File or rasp a short rough area near the mid-length of the link tubes.

3. Slide a link to the center of each tube and line up tube perpendicular to the link. Put a drop of glue (CA) on each side of the tube.

4. Glue (CA) a 1/16" balsa pad to opposite sides of opposite ends of each link. Be sure to make right and left hand lug links.

5. Fasten the blades onto pad sides of links and tighten the screws into the countersunk holes in the blades for free movement but no wobble. Put a drop of glue (CA) onto screw tip and link. Again, be sure to make left and right hand assemblies.

6. Check and cut as necessary the clearance slots for the link tubes in the inner edges of the spoiler blades.

7. Check that the hole in the lug for the clevis is free but not sloppy.

8. Double check the hole spacing in the spoiler box sides by assembling a box side to each side of the spoiler with bolts. The spoiler should move freely.

9. Remove the box sides and set the spoilers aside for now (Photo 6).

Wing

Reference will often be made to the wing (singular) in the following notes, but build both panels at the same time.

1. Make up the wing forward skins. Lay the spar edges of an inner and outer panel skin sheet against a long straight edge with the sheets overlapping in the region of the joint. Make the diagonal cut through both sheets at once using a straightedge. Put a piece of "magic tape" along the joint, turn the sheets over, and glue the seam (SCA).

2. Place the 1/4" thick building shims on the plan along the location of the wing trailing edge. The constant 1/4" thick shims under the wing trailing edge provide precisely the right amount of twist at the tip. Wedge up the shims along the aileron trailing edge as shown on the plan.

3. Cover the plan and shims with waxpaper.

4. Pin lower wing skin in place on the plan.

5. Pin wing lower trailing edge spar caps in place on the shims.

6. Chamfer the upper trailing edge of the lower flap skin and pin in place on the shims, up against the inboard lower spar cap.

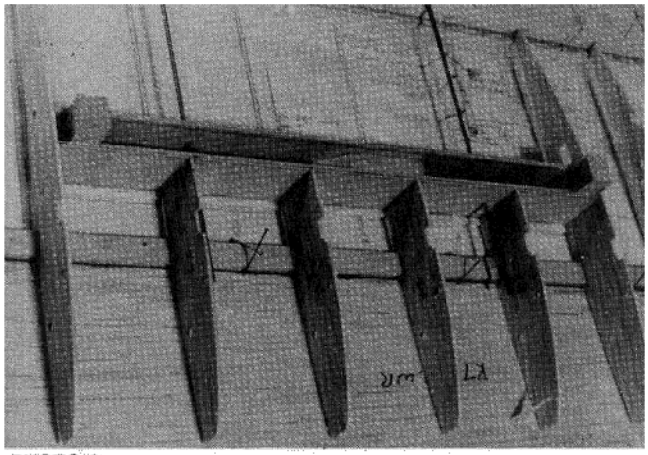
7. Chamfer the upper trailing edge of the lower aileron skin and pin in place on the shims, up against the outboard lower spar cap.

I have tried several times to make flaps and ailerons out of trailing edge stock, but when I shape the leading edges they always seem to warp in the plan view. This must have something to do with relieving the stresses in the wood. At any rate, I think the built-up controls are lighter.

8. Cut the bevel for the spar joints on the 1/8" x 3/8" spruce main spar caps. Lay the spruce spar cap on the 1/8" thick balsa outer panel spar cap and cut the bevel along the edge of the spruce spar.

9. Lay the lower main 1/8" x 3/8" spruce spar cap on the lower wing skin. The trailing edge of the spar cap should be 1/16" forward of the trailing edge of the skin so that the skin will cover the edges of the rear shear webs. Mark the skin along both sides of the spar cap, and take up the spar.

10. The carbon fiber tow I bought came in a ribbon about 1" wide and several yards long. Cut and separate off a piece about 36" long and 1/4" wide. It should be long enough to overlap the joint in the main spar caps. Pinch off a piece of this strip about 1/16" wide. Thin about a teaspoonful of



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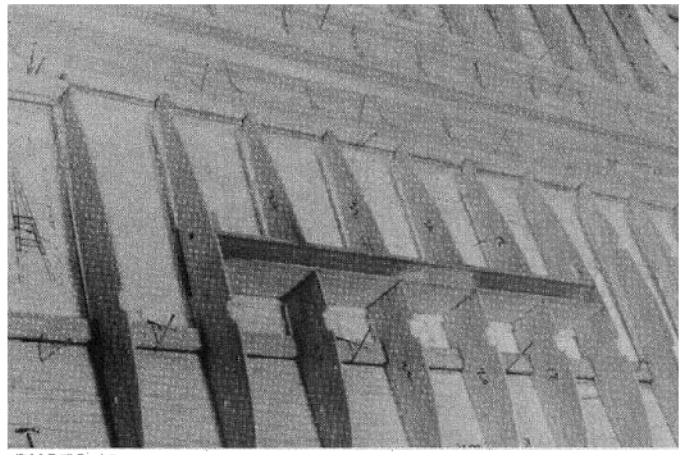

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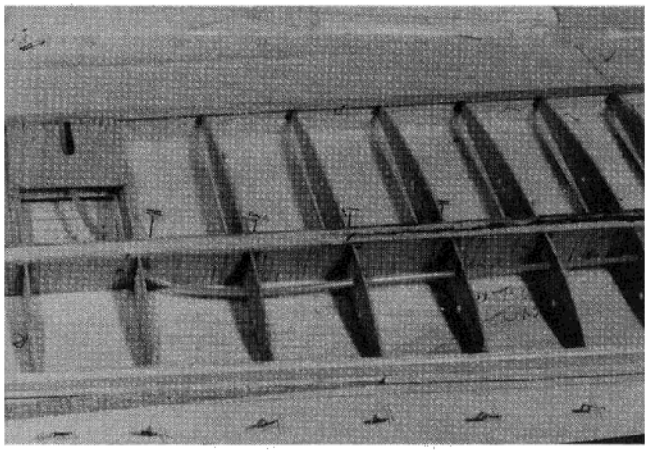

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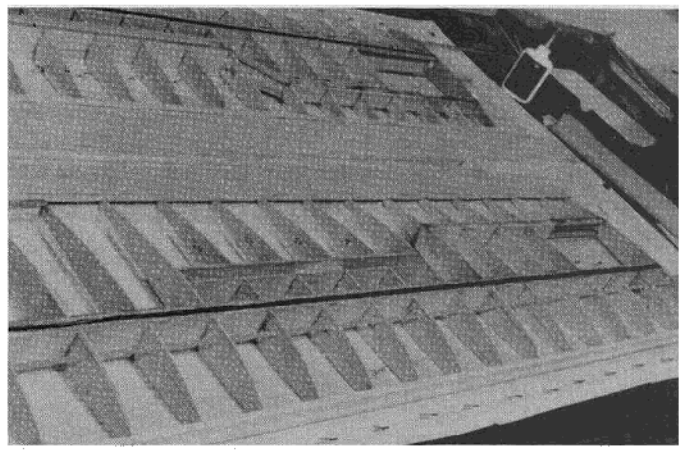

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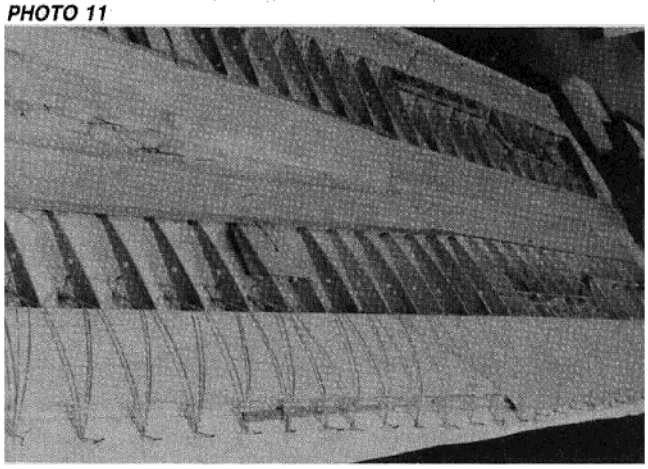

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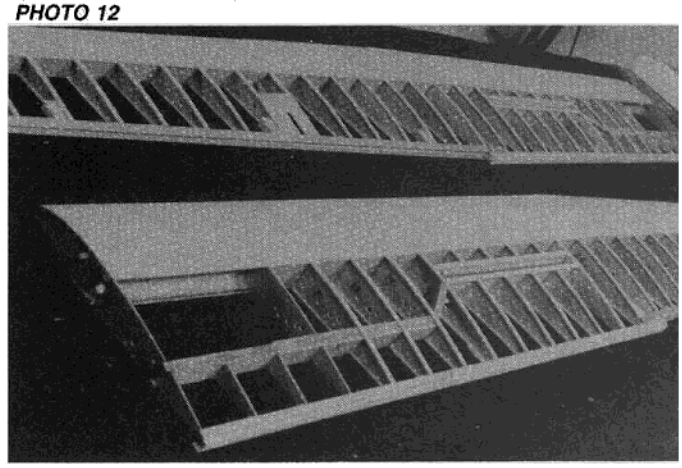


PHOTO 14

aliphatic glue to about half-and-half water, and paint the wing skin between the lines. Lay the carbon fiber on and squiggle down with the paint brush dipped frequently in the thinned glue. Spread the carbon fibers out with the tip of a modeler's knife so that the coverage is quite sparse (Photo 7). We want a wood-to-wood glue joint from the spar cap to the skin through the carbon fiber.

11. Now run a bead of full strength glue (AL) along the skin and fibers and press and pin down the spar cap. Some glue and possibly some fiber may squish out. Not to worry. Take a piece of scrap wood and scrape the excess glue from the skin, pressing any fiber down into the corner where it will be trapped by the shear webs.

Hang the rest of the carbon fiber up somewhere out of the way. Handle this stuff as little as possible. Wash your hands thoroughly with cold water and foamy soap.

12. Glue the outboard balsa lower main spar cap to the inboard main spar cap and the lower wing skin and fiber ends. The rear edge should be parallel to, and 1/16" ahead of, the rear edge of the skin. Again clean off any excess glue where the shear webs will fit.

13. Chamfer the flap leading edge spar and glue it to the flap skin (AL).

14. Chamfer the aileron leading edge spar and glue it to the aileron skin (AL).

15. Glue the wing inboard and outboard rear spars to the rear spar caps. They should be pressed but not glued against the flap and aileron leading edge spars.

16. Cut a dihedral gauge from scrap 1/16" ply for canting the root rib. Three degrees is about equal to 5/8 inches in 12 inches. Glue (CA) the root rib to the spars canted with the dihedral gauge.

17. Glue (CA) ribs 8 through 16 to the spars. Omit ribs 4 and 6 for now. Trim the ribs to length and glue the trailing edge bits to the flap and aileron skins as you go.

18. Glue (CA) the front parts of ribs 18 and 20 to the main spar. Hold a front spoiler box side against these ribs to set the location of rib 26. Glue (CA) in rib 26, then the front parts of 22 and 24 (Photo 8).

19. Glue the front spoiler box side to the ribs with their upper edges even.

20. Place 1/2" scrap spacer blocks between the front and rear spoiler box sides. Hold or pin the rear spoiler box side against the spacer blocks. Place rods through the spoiler mounting holes to line up the rear box side. Glue the rear box side

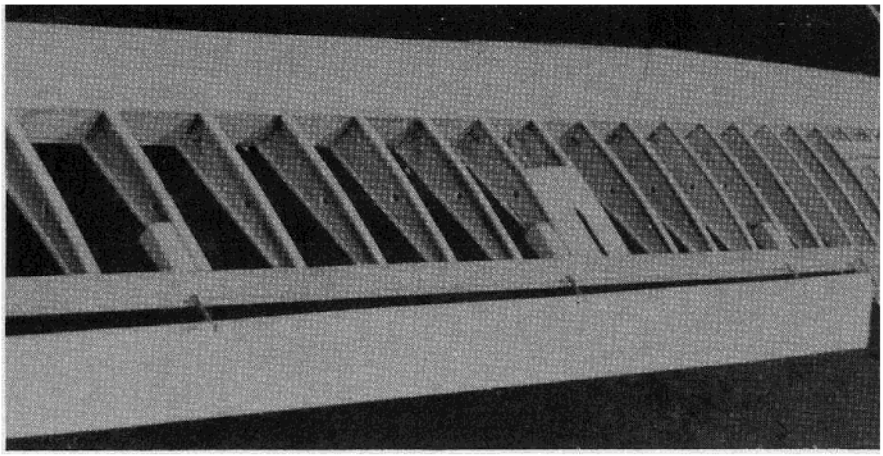


PHOTO 15

to ribs 16 and 26 with their upper edges even (Photo 9).

21. Glue (CA) in the rear parts of ribs 18 through 24.

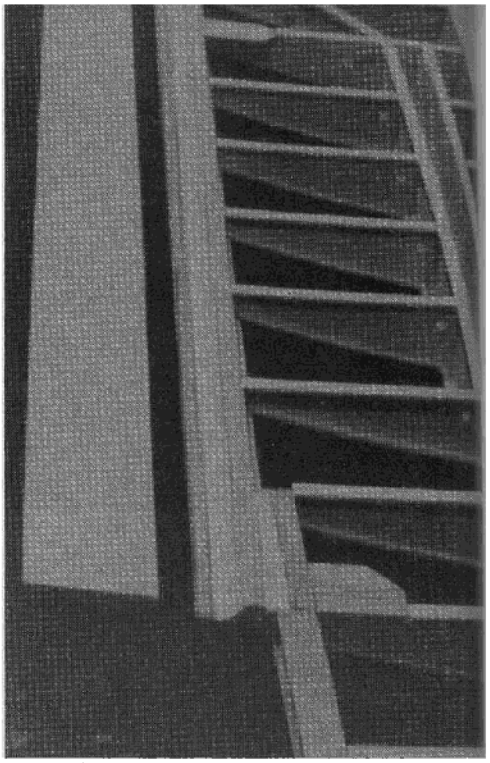
22. Glue (CA) in ribs 28, two 30s, and 32 through 56 (Photo 10).

23. Glue the spruce inboard and balsa outboard main upper spar caps into the notches in the ribs and to each other.

24. Pull the lower 1/8" x 1/4" spruce auxiliary spar cap up into the notches in ribs 2 through 14 and glue (CA).

25. Glue on the upper trailing edge spar caps, the upper auxiliary spar cap, and build the drag spar in rib bay 14-16.

26. True up the rib leading edges spanwise. Slide lengths of trailing edge stock under the lower forward wing skins to wedge the skins up against the ribs and glue the ribs to the skin (SCA).



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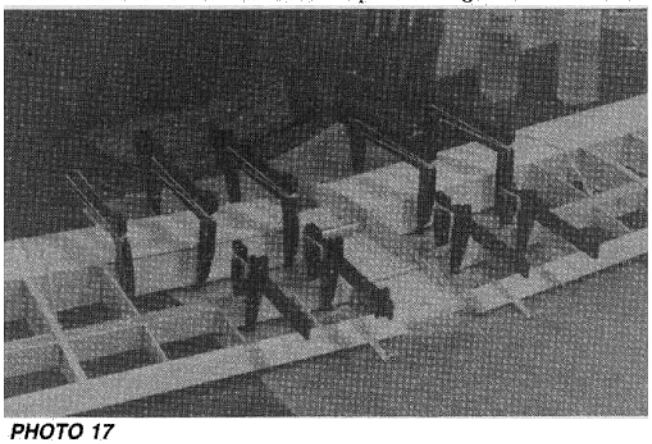

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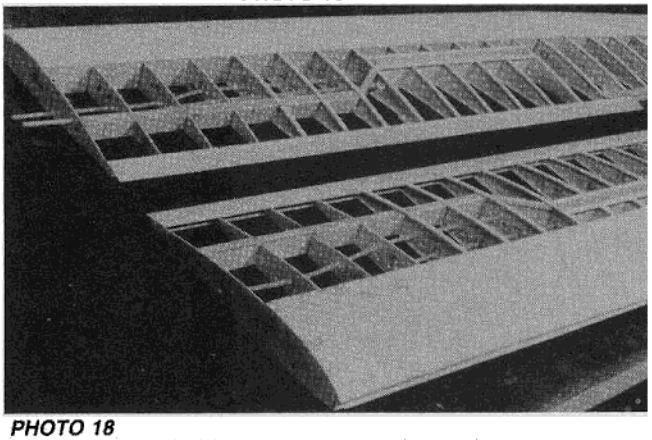

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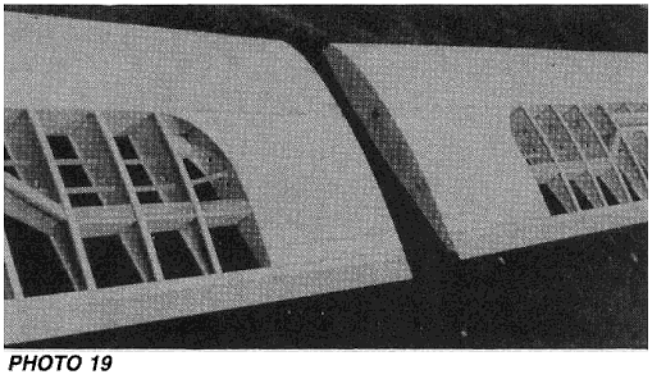

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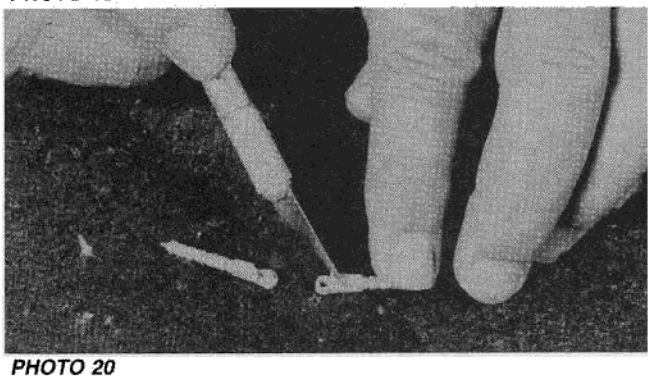

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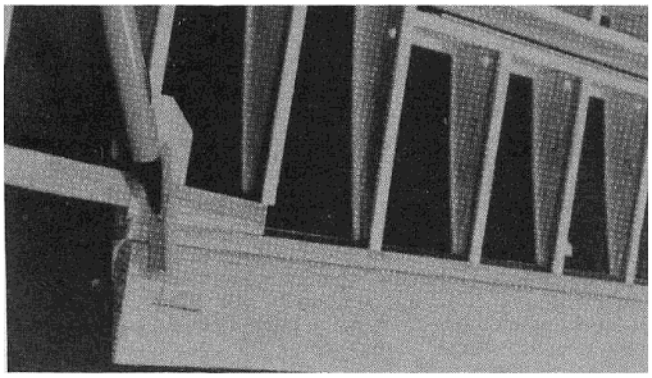

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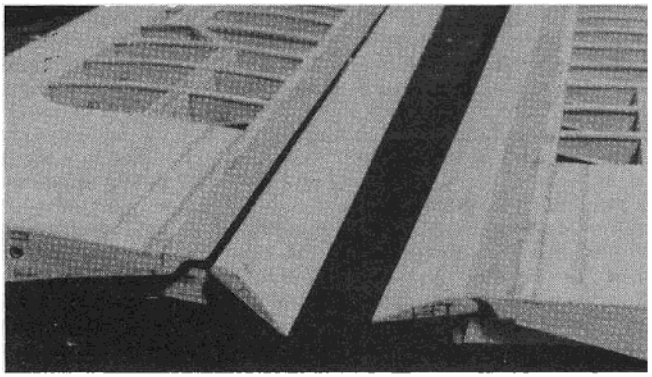

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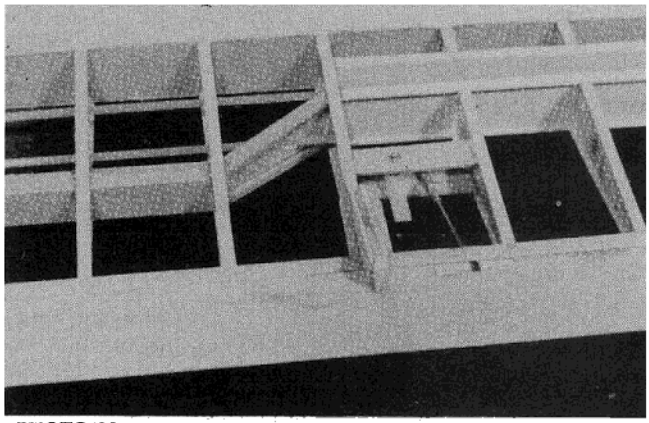

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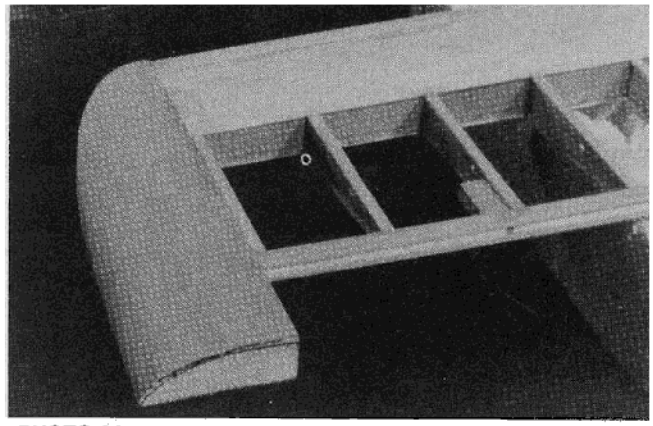

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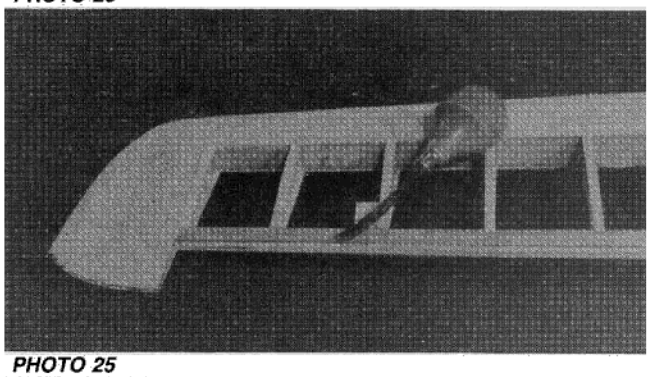

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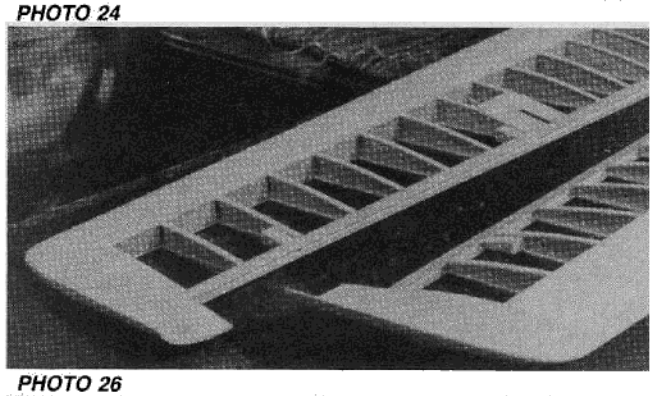

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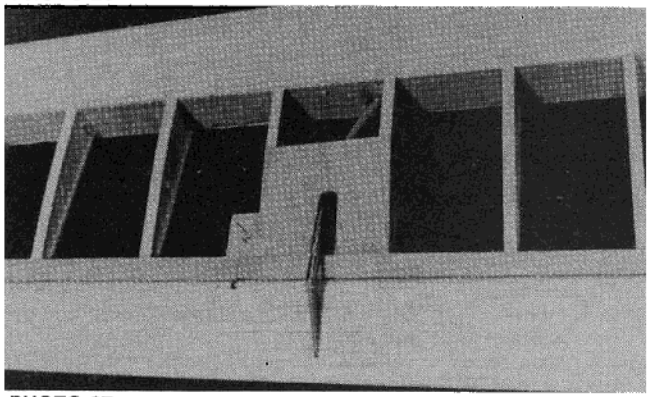

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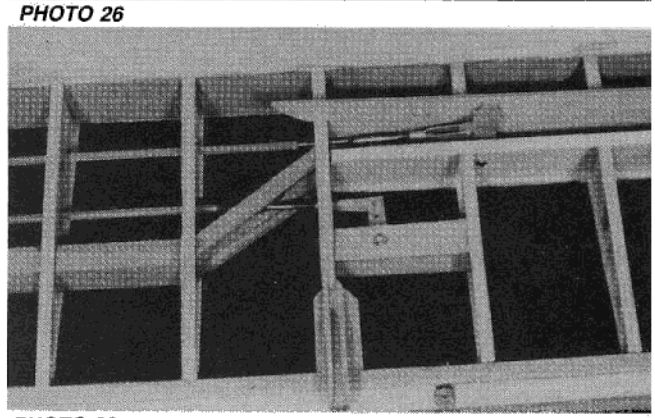


PHOTO 28

27. Chamfer the 1/8" thick sub leading edges slightly and glue to the ribs and skins.

28. Glue the trailing edge bits from ribs 4 and 6 to the lower flap skin.

29. Plane and sand the flap leading edge and the flap ribs to contour. Leave the inboard trailing edge spar 1/64" below outer contour.

30. Plane and sand the outboard trailing edge, aileron leading edge, and aileron ribs to contour.

31. Glue (SCA) the 1/16" ply rear side of the rear joiner tube box to the rear faces of the auxiliary spar caps and the root rib.

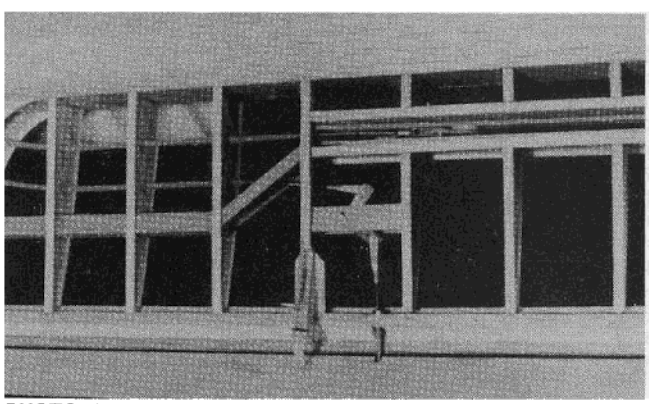
32. Glue (CA) in the parts of ribs 4 and 6 between the auxiliary spar and the trailing edge spar.

33. Glue (SCA) the inboard upper trailing edge spar cap to the wing ribs and the front face of the inboard trailing edge spar.

34. Glue (SCA) the outboard trailing edge spar cap onto the spar and the ribs.

35. Blue (SCA) the 1/16" ply front side of the forward joiner tube box to the front face of the main spar caps, the root rib, the forward lower skin, and rib 8.

36. Glue (CA) the front parts of ribs 4 and 6 to the front main tube box side, the lower



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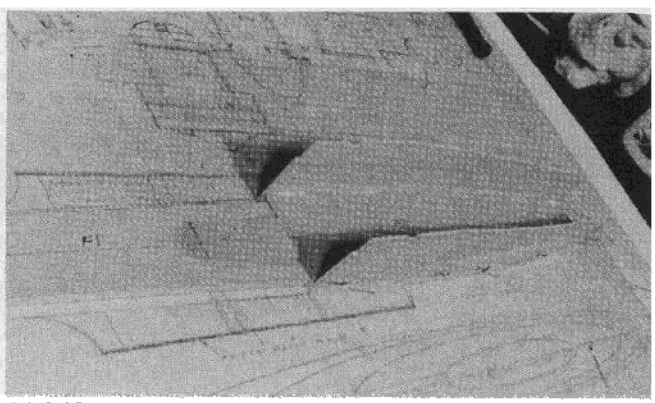


PHOTO 30

forward skin, and the sub leading edge.

37. Glue (AL) the upper flap skin to the flap leading edge, ribs, and lower skin.

38. Glue (AL) the upper aileron skin to the aileron leading edge, ribs, and lower skin.

39. Glue (SCA) shear webs to the front and rear of the auxiliary spar, the front and rear of the main spar out to wing stn. 46, and to the rear of the main spar from stn. 46 to the tip. Do not glue shear webs in the rib bays for the joiner tube boxes.

40. When dry, dress down the shear webs to the top of the spars.

41. Plane and sand the sub leading edge down to an extension of the rib upper contour.

42. Glue (CA) the control tube brace, and the aileron control exit plate between rib stns. 42 and 44.

43. Drill holes in rib 42 and the shear webs for a smooth curve for the aileron control tube.

44. Thread the inner NyRod aileron control tube through the ribs and out through the exit. Leave a little extra length for trim at the ends. Glue (SCA) the tube to each rib (Photo 11).

45. Lay carbon fiber on the upper main spar cap using the same method as for the lower side (Photo 12).

46. There are many ways of doing the next step, but I use "T" pins and rubber bands. At any rate, glue (AL) on the upper forward wing skins. The trailing edge of the skins should cover the edges of the shear webs (Photo 13).

47. When the skins are dry, carefully separate the ailerons from the wing.

48. Glue (CA) in the aileron hinge blocks.

49. Sand the outboard upper trailing edge spar cap down 1/64" and glue on the 1/64" thick ply upper aileron shroud (SCA).

50. Cut and glue (SCA) on the upper 1/16" x 3/16" rib cap strips and spoiler box frame.

51. Take the wings up from the plan (Photo 14).

52. Carefully separate the flaps from the wing.

53. Shape the aileron leading edges to a half-round section.

54. Plane and sand the flap leading edges to an airfoil shape as shown. Sand only a small radius on the lower leading edge.

55. Cut filler blocks to shape and glue between the trailing edge spars in bay 28-30.

56. Dress down the lower edges of the shear webs and sand the lower rib edges.

57. Sand the outboard lower trailing edge spar cap down 1/64" and glue on the 1/64" ply lower aileron shroud.

58. Glue 1/16" balsa flap hinge bases to the lower sides of ribs 16 and 30.

59. Cut and glue on the lower spoiler box frame and the lower cap strips from rib 10 to the tip.

60. Taper the aileron shrouds slightly outboard so that the aileron leading edge touches the wing trailing edge.

61. Feather the inner rear edges of the aileron shrouds.

62. Using 1" tubes and wires, make six aileron hinges in the same manner as for the upper rudder hinge (Photo 15).

63. Glue (CA) the 1/4" x 1/4" slot fairing strips to the inboard trailing edge spar flush with the top of the spar. Sand to a slight angle to match the rib contour.

64. Glue the 1/64" ply flap shroud to the inner trailing edge spar and the slot fairing strips, edge to edge with the upper trailing edge spar cap.

65. Carve and sand the flap shroud fairing strips to a quarter-round molding in the corner, feathering out against the shroud and rear spar. Sand a small radius on the lower rear edge of the lower rear spar cap. Feather the lower rear edge of the shroud. An "S" shaped path should be formed so that with the flap deflected, the air flows smoothly from the wing lower surface, through the slot, and over the upper surface of the flap (Photo 16).

66. **Look out,** here comes a tricky bit. Install the wing joiner tubes. The 1/4" i.d. tubes go in the main spar, and the 1/8" i.d. tubes go in the auxiliary spar. There are probably as many ways of doing this as there are scratch builders. Here is one way. We want three degrees of wing dihedral on each side with straight joiner rods. Also the wings are rigged on the fuselage with the lower surface tangent to the horizontal reference plane, so the tubes are set in the wings at some combination angle. To start, glue a piece of scrap 1/4" x 1/2" balsa to each wing main spar, sticking straight down from the wing, at wing station 26, and cut them off 1¼" from the wing lower surface.

67. Leave the joiner rod tubes in one piece. They should be 2" too long. Cut a piece of 1/4" sheet about 8" long and 2" wide with parallel edges. Place this sheet on the building board. Slide the tubes into the wings and set the wing root ribs against the sheet. The pegs at stn. 26 should also be resting on the building board, holding the wings up at the proper angle. Hold the wings down with pins and rubber bands.

68. Cut and trim joiner tube filler blocks to size and check fit to make sure the tubes are level and normal to centerline.

69. Epoxy the filler blocks on top, bottom, and ends of the tubes.

70. Epoxy the 1/16" ply tube box sides to the tubes, the filler blocks, and the ribs on the front of the auxiliary spar and the rear of the main spar. Smear any leftover epoxy onto the joints between the box sides and the root ribs. Clamp everything together and let dry overnight (Photo 17).

Good morning. Had your coffee?

71. Cut the tubes to separate the panels and take the wings up from the board. Cut and file the tubes flush with the root ribs. Remove the dihedral pegs.

72. Glue (CA) the middle parts of ribs 4 and 6 between the main and auxiliary spars.

73. Thread the spoiler and flap control cable tubes into the appropriate holes in the ribs of the right and left wing panels. End the flap tube about 1/4" outboard of wing sta. 14, and the spoiler tube about 1/4" inboard of wing sta. 16. Glue (SCA) the tubes to each rib (Photo 18).

74. Dress the ribs and auxiliary spar down to contour in the root region.

75. Glue (SCA) on upper and lower 1/16" sheet skins in the region from the main spar to the trailing edge, and from the root to wing sta. 8. Glue (CA) in the triangular gusset pieces at wing sta. 8, and sand or cut a radius in the gussets (Photo 19).

Now get into a flap.

76. On six hinge points, cut back the shoulder on each leg so that they can be deflected to an acute angle (Photo 20).

77. Mark the hinge locations on the flaps about 3/8" out from the root and at the centerlines of the hinge bases.

78. Mark the location of the flap actuator about 1/2" inboard of wing sta. 18.

79. Flatten the ends of two 1/16" i.d. x 1" tubes and drill as for the aileron hinges.

80. Ream out the other end of the tubes with a .072" drill.

81. The 2-56 x 1½" threaded rods should have about 1" of threads. Cut the rod about 1/4" in from the threads. Stick this smooth part of the rod into the tube and solder or glue with CA.

82. Drill three 3/32" holes in the flaps at the hinge location marks, centered 3/8" back of the flap leading edge and perpendicular to the flap lower surface.

83. Mill a slot about 1" long and 3/16" deep and cut a gap about 1/8" wide in the flap leading edge at the actuator location. The slot should be about 1/8" above the flap lower surface.

84. Put a wire through the hole in the actuator tube and position the wire in the slot in the flap leading edge. Fill the slot with scrap balsa, up against the wire and glue (CA).

85. Trim and sand the filler strips flush with flap leading edge.

86. Glue the hinge points into the holes in the flaps. The hinge must be located with the free end straight forward in the plan view, and the center of rotation 1/2" below the flap lower surface.

87. Cut off the protrusion of the hinge point, through the flap, flush with the flap upper surface.

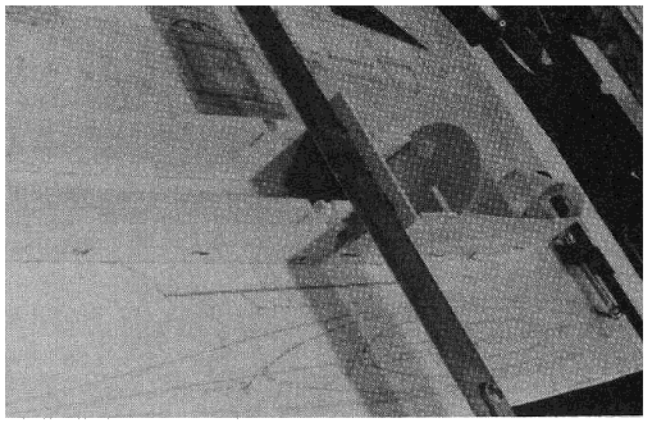
88. At the location of the actuator, cut away a gap in the flap slot fairing about 1/4" wide. Drill a 1/4" hole in the wing trailing edge spar. Reinforce the hole with a piece of 1/4" i.d. brass tubing about 1/4" long (CA).

89. Place the wing upside down on the board. Block up the leading edge and pin down the trailing edge so that the upper aft part of the wing and the flap shroud are flat on the board. Place the flap flat on the board and up against the wing trailing edge as for zero flap deflection.

90. Place a 1/8" hard balsa center lamination of each flap hinge support in line with, and directly under, the free end of each hinge point and glue the support to the wing. Do not glue the hinge point to support at this time (Photo 21).

91. Take the wing and flap up from the board and remove the flap. Glue (CA) a 1/16" outer lamination of the hinge support to each side of each center piece, forming a trough in which the wing end of the hinge point will lie.

92. Pin, do not glue, the hinge points into the supports and check the flap clearance. The upper surface of the flap should just touch the trailing edge of the shroud for most of the flap deflection. It thus acts as a variable camber plain flap. As the flap reaches full deflection, with the flap leading edge below the shroud trailing edge, the slot unports, and the flap becomes a slotted flap (Photo 22). (Flap chord ratio 15% c., shroud lip 90% c., flap deflection 45 deg., gap 1% c., overhang zero.) Sand the flap upper surface if necessary to just touch but not bind against the shroud at intermediate deflections.



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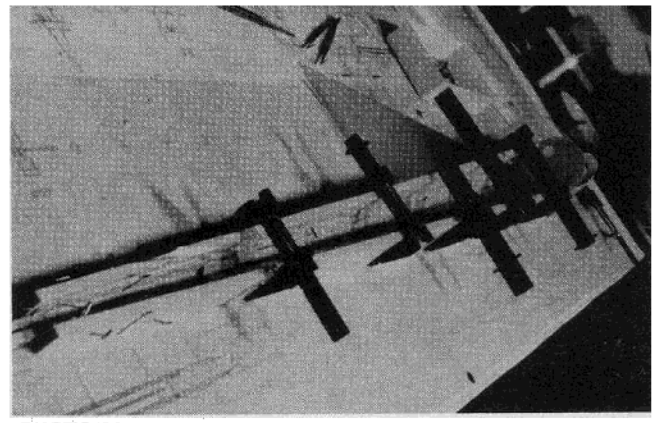

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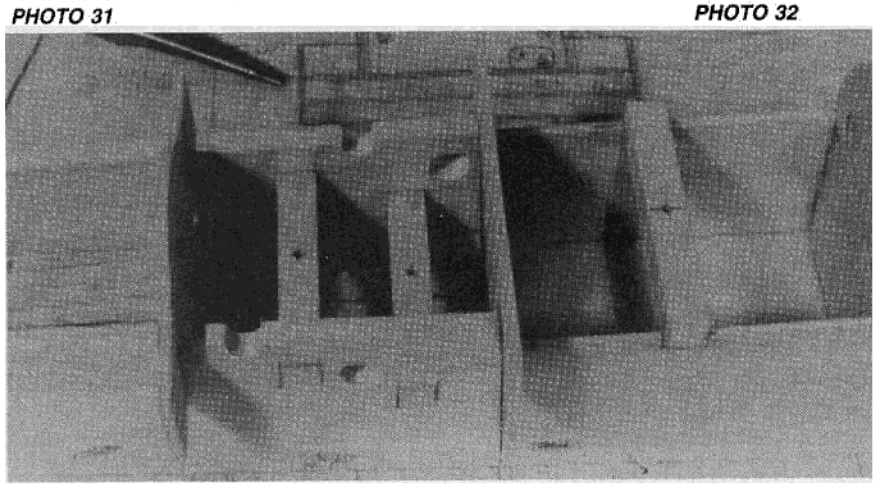

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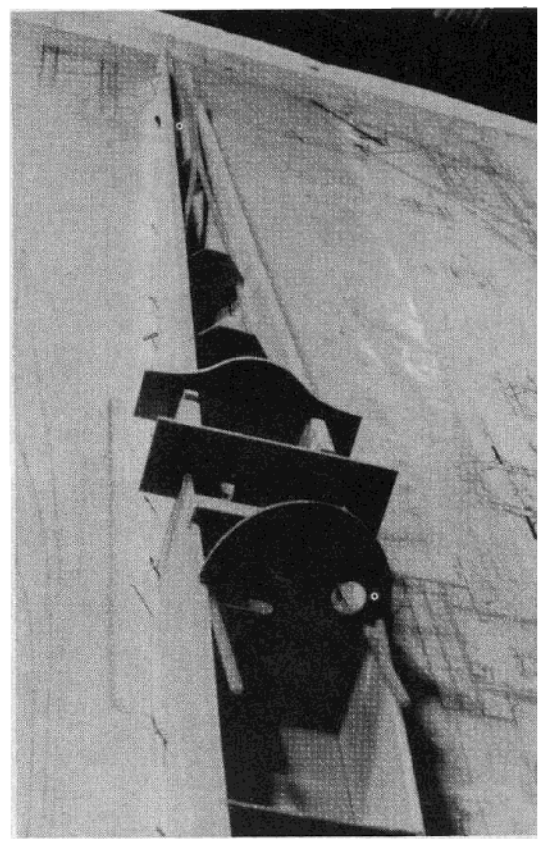


PHOTO 34

93. Leave the flaps pinned on. Crop the ends off two bell cranks as shown. Check the clevis fit; free but not sloppy. Check and mark the fore and aft locations of the bell crank axis on the ribs. Glue (SCA) the 1/16" ply bell crank supports inside the cap strips. Check and mark the spanwise location of the bell crank axis. Drill holes in the mounting plates for the bell crank bolts and install the bell cranks.

94. Adjust the clevis on the threaded actuator rod so that the bell crank is 10 or 15 degrees forward of neutral with the flap closed (Photo 23).

95. Remove the flaps.

96. Dress down the sub leading edge and the tip rib. Taper the inner and outer panel leading edges for their joint as shown.

97. Glue (AL) the leading edges to the wing.

98. Dress down the leading edges at the wing tip. Cut the wing tip blocks to rough planform and glue onto the tip ribs.

99. Draw a quarter-ellipse on the trailing edge of the tip block from the lower inboard corner, up and out, to the upper tip corner. Draw another quarter-ellipse about 1/16" above the lower one.

100. Shape the block lower surface in a straight curve spanwise to the lower line on the trailing edge (Photo 24).

101. Plane and sand the wing leading edge on an extension of the forward upper skin slope. Shape the upper forward portion of the tip block to match the tip rib. Do the same for the lower surface of the leading edge and lower forward surface of the tip block.

102. Mark a line on the inboard side of the tip block from the upper edge of the wing trailing edge to the upper line on the tip block trailing edge.

103. Plane and gouge out the tip block rear upper surface to match the tip rib at the block root, the upper ellipse line at the block trailing edge, and to remain straight along the block upper tip edge (Photo 25).

104. Make a leading edge shape template from 1/16" ply or plastic using the root profile shown on the plan. Shape the wing leading edge, checking often along the span with the gauge. Mark the edge of the gauge with a crayon. Rub the gauge along the wing, and sand off the mark. The wing leading edge gets thinner on the outboard panel towards the tip, but the extreme leading edge radius should be constant.

105. Carry the shaping out and around the tip block to about the maximum wing thickness. The tip shape should be faired out to a sharp edge from about the mid-chord to the trailing edge. The lower forward surface of the block should be shaped up smoothly to the leading edge contour (Photo 26).

Wing Controls

1. Tin about 2" of one end, and about 3" of

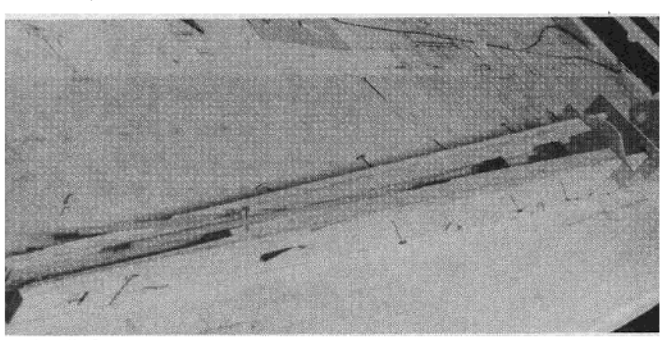
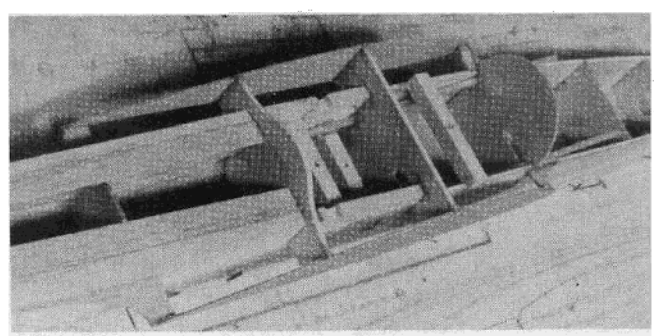


PHOTO 35



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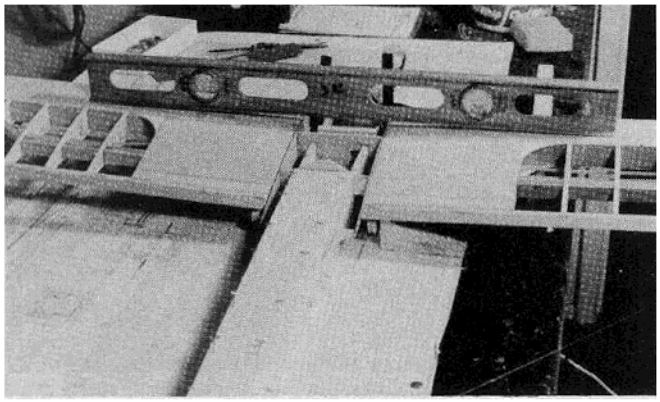

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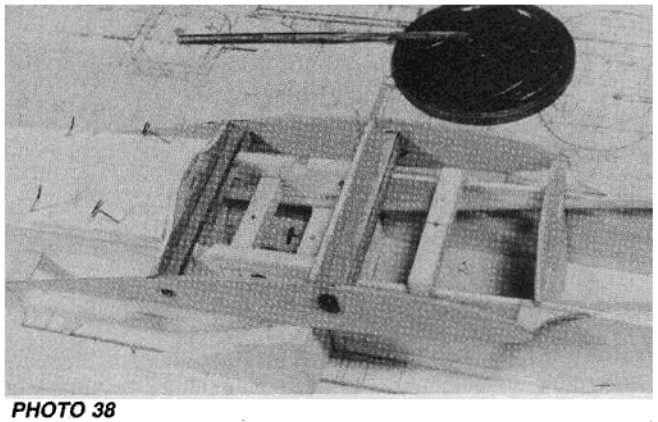

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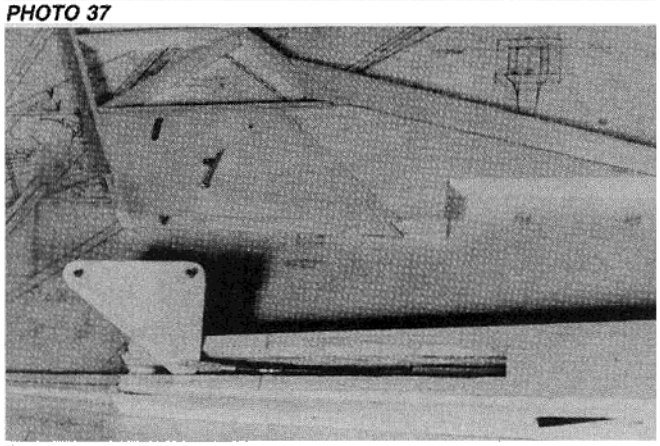

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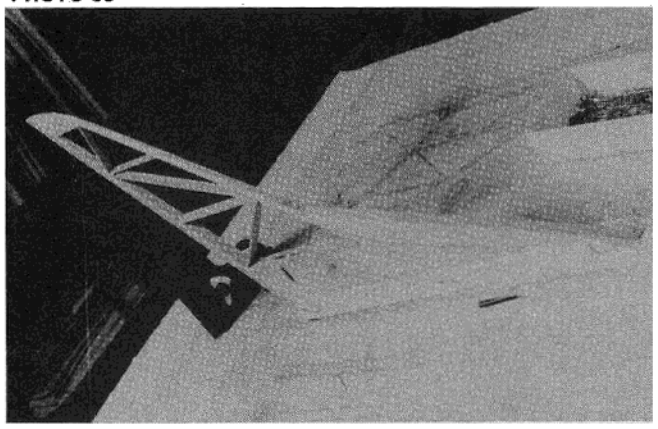

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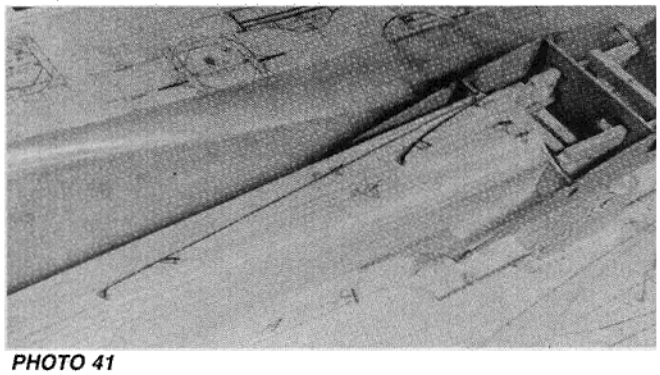

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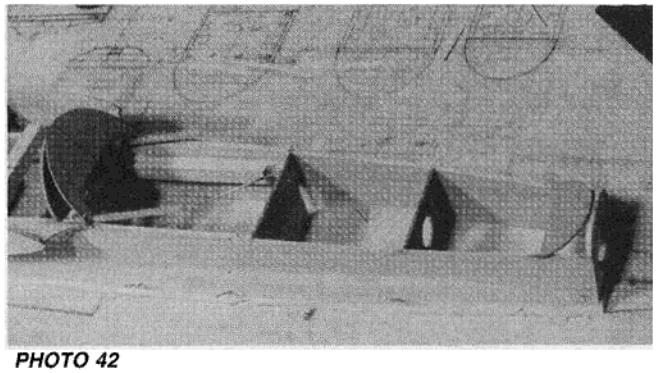

PHOTO 42

the other end of each 46" control cable. Solder a threaded coupler to the 2" tinned end.

2. Tin about 2" of one end, and about 3" of the other end of each 18" control cable. Solder a threaded coupler to the 2" tinned end.

3. Solder a threaded coupler to one end of each 16" control cable and tin about 3" of the other end.

4. Screw a clevis on to each threaded coupler.

5. Check a clevis on the 1/16" ply aileron control horn for free but not sloppy fit.

6. Slide the aileron hinge tubes into the hinge support blocks and mark the location of the horn on the aileron upper skin. Cut a 1/16" slot in the aileron upper skin, normal to the hinge line, and glue in the aileron horn (CA).

7. Thread the aileron control cable (46") on to the aileron control tube. Connect the clevis to the aileron control horn and check for free movement (Photo 27).

8. Temporarily install the spoilers with 2-56 x 1" bolts. Thread the spoiler control cable (18") into the control tube from the spoiler end. Connect the clevis to the spoiler lug link and check for free movement (Photo 28).

The photographs show the spoiler control lug and control cable on the lower surface of the wing. This arrangement caused a

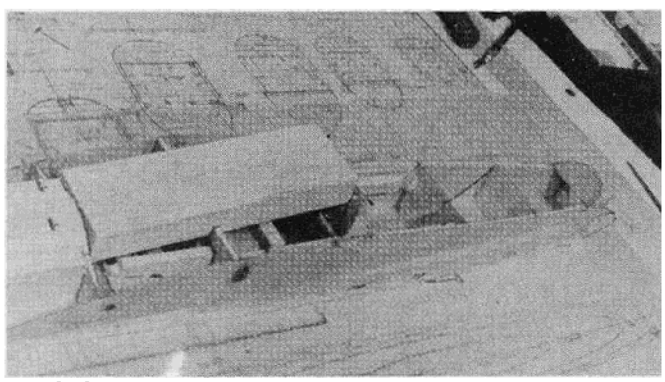

PHOTO 43

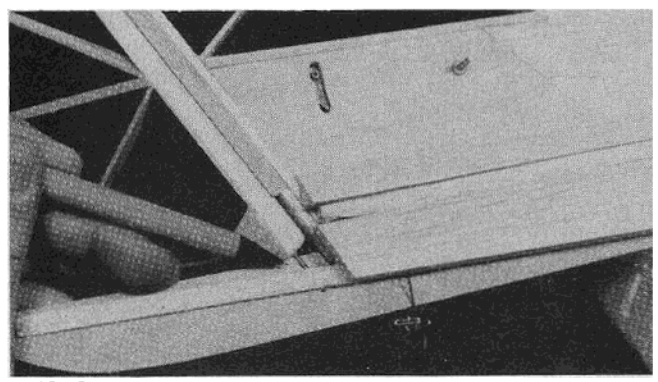

PHOTO 44

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problem in that the wing flexing during launch tended to pull the spoilers open slightly. I have since learned that with the spoilers connected on the upper side, the wing flexing keeps the spoilers closed, so install the spoilers with the lug on the inboard link toward the upper surface of the wing.

9. Thread the flap control cable (16") into the control tube from the bell crank end and connect the clevis to the bell crank. Enlarge the holes in the drag spar shear web and rib 16 as necessary for free clearance.

10. Put the flap actuator rod through the hole in the wing trailing edge and pin the flap hinge point arms into the hinge supports. Connect the flap actuator rod to the bell crank and check for free movement (Photo 29).

11. Remove the flaps and glue the flap hinge fairings to the flap skin.

Fuselage

1. The fuselage is built with the floor, F1, flat on the plan. Make a bulkhead tilt gauge to match the angle of the bulkheads in the side view from stn. 13 aft. Cover the top view of the plan with waxpaper and pin the floor, F1, in place.

2. Glue (AL) the 1/16" ply cockpit floor doubler, F2, to the forward fuselage floor.

3. Pin and glue (AL) the 1/8" lite ply sides, F3, to F1 and to the outside edges of F2 (Photo 30).

4. Pin and glue (AL) the aft fuselage sides, F4, to the outside edges of F1. Scrape excess glue from the interior corners.

5. Glue (CA) fuselage bulkheads 2.5, 5.75, and 8.75 to the sides and floor. Use a right triangle to set these three bulkheads vertical to the floor.

6. Glue (CA) fuselage bulkheads 13 and 16.5 to the sides and bottom. Use the bulkhead gauge to set these bulkheads vertical to the upper edges of the sides. Use a long straightedge to align bulkhead 16.5 perpendicular to the fuselage centerline (Photo 31).

7. The aft fuselage is also reinforced with carbon tow. Press the two triangle-cut pieces (the longer ones) down into the corners of the aft fuselage. Mark the inside edges on the fuselage floor and the upper edges on the sides. Remove the triangle-cuts.

8. Pinch off four sparse pieces of carbon fiber tow about 30" long. Glue these with 50-50 thinned AL about 1/8" outboard of the lines on the fuselage floor and about 1/8" below the lines on the sides. The carbon fiber should be placed so as to be trapped by the triangle-cut strips, but not out into the part of the fuselage cross section which will be carved away.

9. Run a bead of full strength AL along two sides of the lower triangle-cuts and press firmly down into the fuselage corners. Pin and use clamps, and check that the fuselage sides are vertical (Photo 32).

10. Line up bulkhead 19.5 with the bulkhead gauge and a long straightedge, and glue (CA) to the fuselage sides and floor.

11. Glue (CA) the three remaining bulkheads into the aft fuselage.

12. Drill a hole for the 2-56 bell crank bolts at the midpoint of each of the three 3/8" x 3/8" basswood bell crank supports.

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shaping the dorsal and fin leading edge.

67. Start smoothing down. I use something around 200 grit; one piece on a "T" bar, and another piece wrapped around a foam rubber block for the curvy places. Place a fairly strong light, low, near the work board. Shining across the fuselage it will show up high spots. Also, from now on, rest the model on stryofoam blocks to keep it from getting dinged up.

68. Glue (SCA) the rudder lower hinge pin in place.

At this stage the body and fin weigh about 16 ounces.

69. Carefully run a thin knife around the hatch block and remove the hatch.

Fuselage Controls

1. Place five servos in the servo bay. Mark and drill pilot holes in the mounting rails for mounting screws. Fasten the servos down temporarily.

2. Clip the arms from one 6-arm, and two 4-arm Futaba servo horns for the bell cranks in the wing root area as shown. Enlarge the holes in the centers of the bell cranks for the 3/32" x 1/4" tubes, and press the tubes into place. Pack the space around the tubes, on the underside, with micro-balloons and fill with CA. Bolt the bell cranks to the supports with 2-56 x 1" bolts and washers (Photo 49).

3. Measure the locations of the control cables on the left and right wing roots and mark the fuselage butt ribs.

4. Bore out the filler blocks through the butt ribs and into the servo bay. These holes should allow passage and free movement of clevises; about 1/4" in diameter, flared on the inboard side.

5. Now, depending on the type of radio gear, you may have to do some layout work to route the control rods and/or cables for the flaps, spoilers, and ailerons. With Futaba gear, the arrangement on the prototypes is pretty much as shown on the plans. I did enlarge the hole in bulkhead 13 to get some needed clearance, and used a rod instead of a tube and cable for the spoilers on the 2nd prototype. Check the system for clearance and free movement.

6. Provide a mounting for the switch. On the prototypes, the switch is mounted on the left side of the fuselage above the receiver.

7. Clip the horizontal tail and rudder control tubes to clear the servo horns. (Don't cut the horizontal tail control cable.)

8. Temporarily install the flaps, spoilers, and ailerons on the wings. Hook up a receiver and battery. Put the wings on by sliding the wing control cables through the holes into the fuselage. Measure the length of a threaded coupler with a clevis screwed on fully.

9. The next step depends on how you want to set up your controls. The objective is to cut the wing control cables to the proper length. With a Futaba 7-channel G-series, I use the transmitter throttle control for the spoilers, and the lower left slide control for the flaps. Cycle each of the wing controls and mark the wing control cables for the minimum distance from the hole in the bell crank to the wing root with the appropriate control surface at its corresponding deflection. The aileron trailing edge deflection should be about 3/4" up, and 1/2" down in full rate. At full deflection, the flap trailing edge will be about 3/4" down. Set the spoiler links a little beyond vertical, fully open.

10. Remove the wings from the fuselage. Clip the wing control cables according to the marks, allowing for the length of the coupler and clevis, the depth of the hole in the threaded coupler, and about 1/8" long for adjustment of the fuselage bell crank.

11. Solder a threaded coupler to each cable and screw on a clevise.

12. Put the wings back on the fuselage and connect the clevises to the bell cranks. Cycle the controls and check the cables and clevises for clearance and free movement (Photo 50).

13. Check the hatch block for clearance above the bell cranks and control rods. On the prototypes I framed the sides of the hatch block opening in the fuselage with 1/64" ply sheet to keep the edges from getting dinged up.

14. Remove the wings from the fuselage, and remove the flaps and ailerons from the wings.

15. Temporarily install the rudder. Mark and drill the mounting block for the control horn bolts, and install the rudder control horn.

16. Tin 3" or 4" of each end of the 40" control cable. Solder a threaded coupler to one end of the cable. Screw a nylon ball joint cup onto the coupler, and install a ball joint ball in the control horn. Thread the control cable into the control tube and connect the ball joint. Check for clearance and free movement. On the prototypes, the rudder root trailing edge travel is ± 1.5" in full rate.

17. As a finishing touch, and to cut down drag a little, build an exit fairing around the tube with scrap balsa and filler.

Canopy

1. Remove the servos and radio gear from the fuselage. Place pieces of waxpaper on the fuselage in the canopy region.

2. Assemble the canopy frame in place on the fuselage (CA).

3. Remove the canopy frame and sand and bevel the edges undersized by the thickness of the canopy (Photo 51).

4. Check again for fit on the fuselage.

5. Paint the canopy frame and the upper inner walls of the fuselage servo bay flat black.

6. When dry, glue (SCA) the canopy to the frame. Finish with trim tape around the edges.

Spoiler Caps

1. Install the spoilers in the wing (if they are not still there) with 2-56 x 1" bolts and lock nuts. Do not tighten the nuts so much as to deform the spoiler box sides.

2. Connect the control cable clevises to the lug links.

3. Glue (CA) the 1/8" sq. seating rails to the inside walls of the box sides, lower rear and upper front, about 3/32" inside the wing external surface. Notch the seating rails to clear the clevises if necessary.

4. Carefully trim the 1/8" thick spoiler caps to fit into place. Chamfer the spoiler caps on the underside at the end corresponding to the angled end of the blade.

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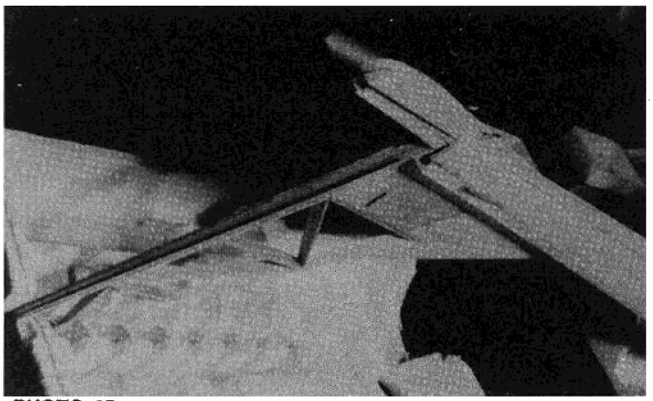

PHOTO 45

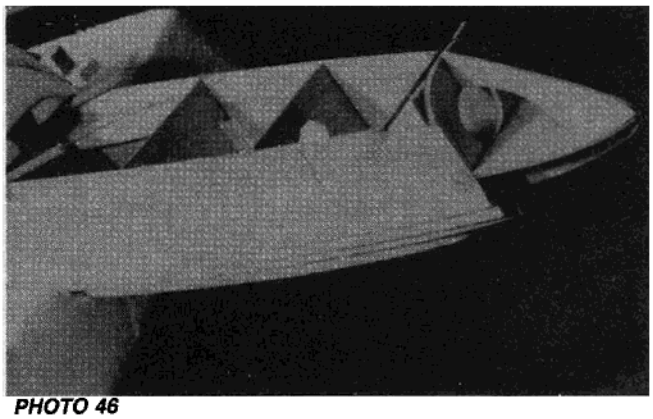

PHOTO 46

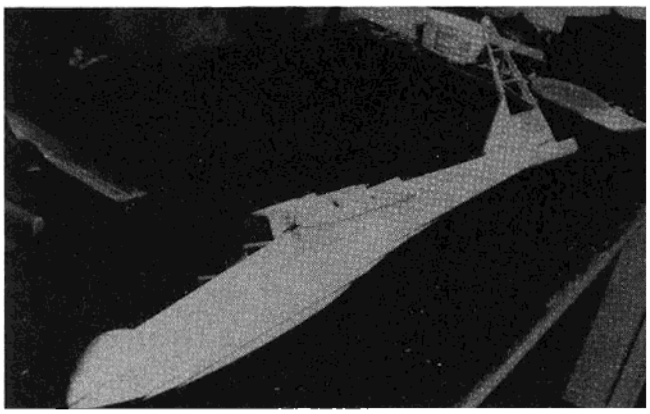

PHOTO 47

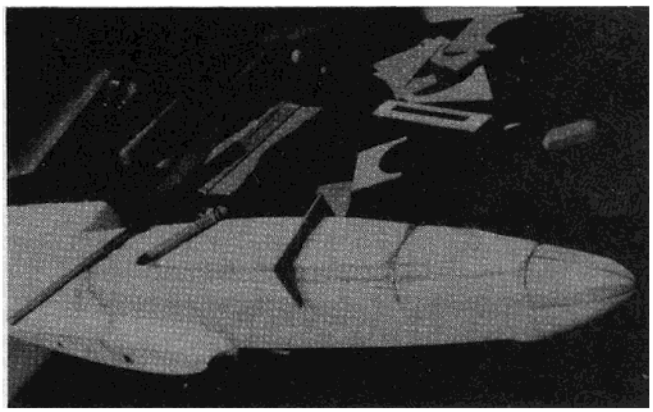

PHOTO 48

The bolt should be a tight fit in the support so it won't wobble. You may need to enlarge the hole in the bottom of the support for the shank of the blind nut.

13. Pull a blind nut into each support block and put a drop of glue (CA) under the flanges.

14. Cut grooves for the control tubes in the support blocks as shown on the parts plan.

15. Glue (CA) the support blocks into the fuselage at stn. 15 and between stns. 16.5 and 19.5 as shown (Photo 33).

16. Trim away the lower right triangle-cut at the antenna tube outlet in the right side of the aft fuselage.

17. Thread an outer NyRod tube through the exit and forward through the holes in the lower right side of the fuselage bulkheads, and into the receiver (middle) bay in the forward fuselage.

18. Thread an inner NyRod horizontal tail control tube through the holes in the right side of the fuselage bulkheads. Thread an inner NyRod rudder control tube through the holes in the left side of the bulkheads and lay it into the diagonal slot in the top of the left side in the region of fuselage station 42. These tubes should extend about 2½" or 3" into the servo (rear) bay. Glue (SCA) the tubes to the fuselage sides and bulkheads (Photo 34). I have used inner NyRods for control runs on all of my models, and I have enough outer NyRod left over to plumb a good sized doll's condo.

19. Trim the upper triangle-cut strips to fit around the control and antenna tubes.

20. Glue sparse strands of carbon fiber tow to the fuselage sides about 1/8" above the level of the lower edges of the upper triangle-cuts using the method previously described.

21. Glue (AL) in the upper triangle-cut strips (Photo 35).

22. While these are drying, work on the wing root area.

23. Place the two fuselage butt ribs, lower edge to lower edge, on the plan side view and mark the locations of the two 1/8" ply bulkheads.

24. Mark a line on the outside of the aft fuselage sides, 3/4" down from the upper edges of the sides. This is the horizontal reference line. The bottom edges of the wing stubs on the two 1/8" ply bulkheads (stns. 16.5 and 19.5) should lie along this line.

25. Check that the upper edge of bulkhead 16.5 is exactly level. True up the ends of the wing stubs on bulkheads 16.5 and 19.5 to be exactly vertical and lined up fore and aft.

26. Glue (CA) the butt ribs to the bulkheads with the upper edge of the rib even with the top edge of bulkhead 16.5. The lower edge of the butt rib should be even with the lower edge of the bulkheads and the lower edge of the rib trailing edge should be opposite the horizontal reference line.

27. Check the width of the leading and trailing edge fillet plates to be sure that the butt ribs are straight.

28. Glue (CA) in the leading edge fillet plates. Angle these down slightly from the butt rib leading edge to the top of the fusleage side. Glue (CA) in the trailing edge fillet plates from the butt rib trailing edge to the fuselage along the horizontal reference line (Photo 36).

29. Dress down the upper edges of the aft fuselage sides and upper triangle-cuts.

30. Apply sparse strands of carbon fiber to the top of the upper triangle-cuts about 1/8" outboard of the inner edges.

31. Clean house in the aft fuselage. Check for leftover pins, balsa chips, etc.

32. Glue (AL) aft fuselage top to the sides and triangle-cuts. Hold the top down with pins or pins and rubber bands.

33. Mark a centerline on the aft fuselage top if it is not already there.

34. The next step will require enough room space for the wingspan. Slide the forward wing rod tube (1/4 i.d.) and aft wing rod tube (1/8 i.d.) onto the wing joiner rods. Place the 1/16" ply tube box bottoms across the fuselage. Slide the joiner rods and tubes through the butt ribs and across the fuselage. Slide the wings onto the wing rods. Align the wing root ribs with the butt ribs and check the wings for level with an incidence meter or carpenter's level. Check the lateral alignment by measuring from like points on each wing panel to the fuselage centerline near the tail. Rout out the holes in the butt ribs to obtain alignment and match, and pack up the wings with scrap balsa blocks if necessary (Photo 37).

35. Tack glue (CA) the tube box bottoms and the tubes to the bulkheads. Glue (EP) the tube box sides to the box bottoms and tubes. Fill the boxes with epoxy around the tubes. Glue (EP) the box tops to the boxes. Smear any excess epoxy around the joints between the boxes and the bulkheads and the butt ribs.

36. Carefully remove the wings and rods from the tubes before the epoxy sets up. Some epoxy might seep around and glue the whole thing together (Photo 38). You may want to double glue the plywood joints with epoxy in the forward fuselage at this time.

Incidentally, a dentist's spatula is great for mixing and applying epoxy, and dry epoxy will scrape right off of it.

37. Tin about 2" of one end of the 38" control cable and solder on a threaded coupler. Tin about 4" of the other end.

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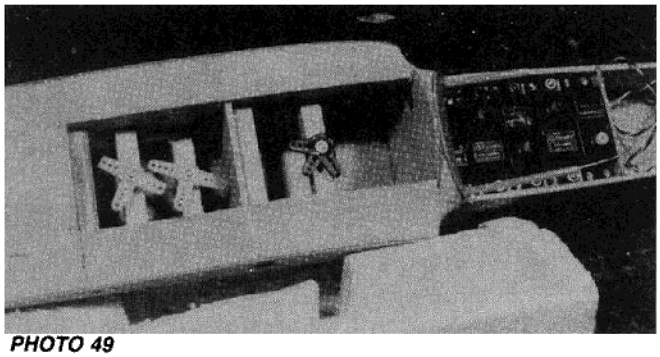

PHOTO 49

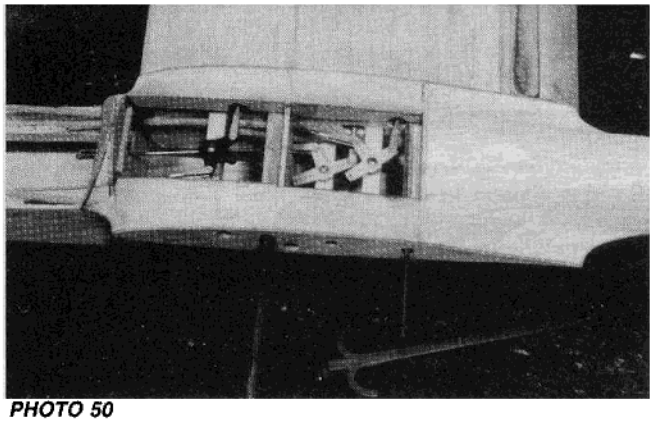

PHOTO 50

38. Screw a clevis onto the coupler and attach the clevis to the 1/16" ply horizontal tail bell crank (Photo 39).

39. Trim the tail end of the horizontal tail control tube so as not to restrict the control cable.

40. Fiddle the bell crank around inside the vertical tail until the tube and front holes line up, and retain with a 2-56 bolt and nut.

41. Thread the horizontal tail control cable into the control tube, and set the vertical tail in the aft fuselage, through the slot in the top and resting on the fuselage floor. Line up the dorsal fin centerline with the aft fuselage centerline. Check vertical alignment with a square and retain with a bracing thread to the building board. Glue (CA) the fin to the aft fuselage.

42. Glue (AL) soft balsa triangle-cut fillet blanks to the vertical tail root and aft fuselage (Photo 40).

43. Glue (AL) the upper mid fairing blocks to the fuselage and bulkhead 19.5 (Photo 41).

44. Trim the 3/8" square basswood servo rails to fit the fuselage side and to provide the proper width for the servos. Glue (SCA) them in. Cut grooves to clear the servo leads.

45. Fit and glue (CA) front and rear 1/16" ply canopy bulkheads in place (Photo 42). Glue scrap balsa filler blocks into the triangular gaps at the canopy bulkheads.

46. Fit and bevel the ends of the 3/4" x 2" hatch block and cut a slot to fit over bulkhead 16.5. Pin the block in place (Photo 43).

47. Build up the center section area over the top of the fuselage between the butt ribs with scrap balsa blocks.

48. Take the fuselage up from the plan. Mark a centerline on the bottom of the fuselage with a long straightedge.

49. Pin the 1/16" ply ventral fin and tailskid core to the bottom of the fuselage.

50. Put the lower hinge pin in the tube in the bottom of the rudder. Slide the rudder into place and check the pin slot location in the ventral core (Photo 44).

51. Remove the rudder and glue (CA) the ventral core to the fuselage.

52. Glue (SCA) ventral fairing blanks to the ventral core and fuselage (Photo 45).

53. The bottom of the fuselage should be fairly flat, but give it a little sanding anyway to get rid of any glue bumps, etc.

54. Glue (AL) the lower fuselage block F8, in place.

55. Glue (AL) the basswood towhook block into the slot in F8.

56. Glue (AL) the lower fuselage blocks F9 and F10 in place.

57. Put a whole bunch of rubber bands and clamps around the fuselage and let the glue dry.

58. When the glue is dry, remove the clamps and rubber bands. Dress down bulkhead 2.5 and the front edges of the blocks, and glue (CA) on the 1/16" ply nose cores (Photo 46).

59. Cut the balsa and basswood nose blocks to rough outline. Hollow out the upper nose blocks, corresponding to the upper core, for nose weight. It won't hold enough but it will get some of the weight as far forward as possible. Glue (SCA) the nose blocks to the nose cores and the front bulkhead.

60. Fill the gap on the underside of the wing root with pieces of scrap balsa. Glue triangle-cut fillet blanks in the lower wing root corners, full chord.

61. Now, all the wood is glued on and we have this big funny shaped block of wood. To paraphrase the famous sculptor, we'll now cut away everything that doesn't look like an airplane. So sharpen the plane and chisels, brush out the perma-grit sticks, and change the paper on the sanding blocks. I usually square everything off along the profile and plan view, cut down to any plywood cores with straight cuts, and shape the fuselage boat-tail in the plan view, before I do any shaping in cross-section (Photo 47).

62. The fuselage boat-tail (see plan view) should be a smooth curve, in to the width of the fin main spar, and to a thin edge at the tail of the dorsal.

63. I use a variety of sanding block shapes with 150 grit and perma-grit sticks to do the initial shaping. Sand the upper fuselage hatch block and the wing fillets to rough shape.

64. Use templates to shape the lower fuselage. I learned how to use templates to carve a fuselage by watching professional model builders many years ago. If you ever get a chance to visit an airplane factory be sure to ask to see the wind tunnel model shop if you can. In my opinion, wind tunnel model builders are some of the finest craftsmen anywhere. Most of you probably know this trick, but some may not. Cut the templates from 1/16" ply or plastic from the cross sections shown on the plan. Mark lines on the fuselage side near the maximum width at each template section, and put a mark on the template corresponding to these lines. Use a rat-tail rasp or 1/4" dia. perma-grit stick to cut each cross section as a groove around the fuselage. Mark the shape edge of the template with a crayon. Press the template down into the groove, remove, and sand away the crayon mark. Keep doing this until you get a crayon mark all the way around the cross section and the marks and lines match up (Photo 48). Then plane and sand a smooth contour along the fuselage between the cross sections. A wire comb template gauge is also very handy for checking the symmetry of cross sections.

65. Cut the dorsal fin to rough profile.

66. Install the horizontal tail, temporarily. Mark the limits of the area swept by the horizontal root on the side of the vertical tail. Remove the horizontal tail. Do not cut into the marked area when

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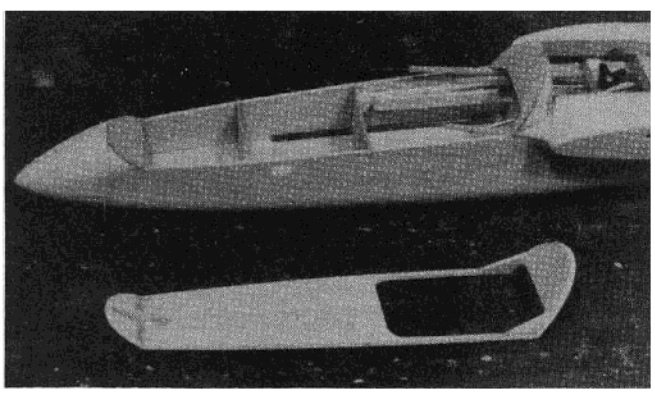

PHOTO 51

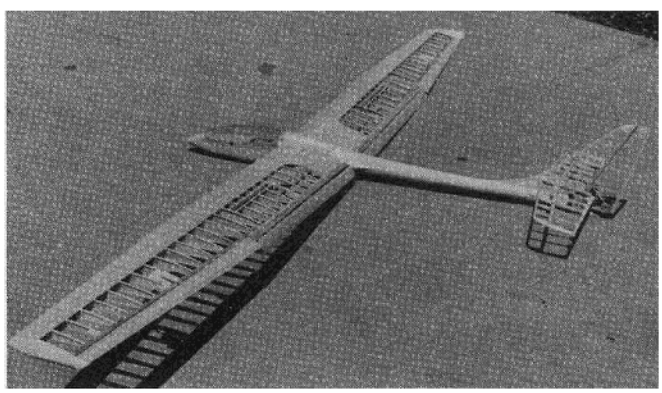

PHOTO 52

5. Open the spoiler. Put a couple of drops of SCA along the outer edge of the blade. Close the spoiler. Hold the cap in position and pull the blade up against the cap with the spoiler control cable. Cycle the spoiler with the control cable to be sure the cap seats properly. Adjust if necessary, and finish gluing (CA) the cap to the blade. Repeat for the other three caps.

6. Plane and sand the caps down to wing contour.

Covering and Assembly

1. Fill all the gaps and dings. I use "Model Magic."

2. Sand everything with finer and finer sandpaper. A trial assembly of the completed structure is shown in Photo 52.

3. I covered the entire model with "Super MonoKote." You could fiberglass and paint the fuselage. The glassed fuselage would probably be heavier, and I think you have sufficient strength with the carbon fiber. If you use the white, blue, and chrome color scheme of the prototypes, the chrome covers the white, and the blue covers both the white and the chrome. I like the chrome trim. I have flown the model at extreme altitudes and ranges and the sun will flash across the chrome trim like a neon light.

4. The flaps, ailerons, and rudder are covered before assembly. Wrap the covering around the leading edges of the surfaces. This will reduce any friction of the surface against the shrouds.

5. Install the rudder, pushing the top hinge tube into the tip block. The rudder should be a close fit, but free to move. Glue (CA) the top hinge tube into the tip block.

6. Install the flaps. Adjust and pin the hinge point arms in the hinge supports so that the shroud touches the flap, but does not restrict its movement until near full deflection, as described earlier. Glue (SCA) the hinge point arms into the hinge supports.

7. Fill and fair the slots in the hinge supports around and in front of the hinge point arms with balsa scraps and filler.

8. Install the ailerons, keeping a close fit but free to move. Glue (CA) the hinge tubes into the hinge blocks.

9. Finish covering the model.

10. Make or buy fairings for the aileron control cable exits. The fairings on the first prototype were store bought, but vacuformed for No. 2.

11. Install the rudder control horn, thread the control cable, and hook up the ball joint.

12. Line the receiver and battery bays with foam rubber tape.

13. Install the servos. Set the servo horns and connectors in place but don't tighten yet.

14. Connect the servo leads to the receiver and check for proper function with the transmitter.

15. Thread the antenna into its tube, tuck the extra servo lead length under the receiver, and put the receiver to bed in the foam rubber.

16. Install the switch, and connect the switch lead to the receiver. The battery lead from the switch goes through the hole in bulkhead 5.75 into the battery bay.

17. Install the tow hook.

18. Install the landing skid. On the No. 1 prototype, the skid is a commercial rubber type, but on No. 2 it is laminated basswood.

19. Assemble the model and double check the controls for function and freedom of movement.

20. Balance the model at the Center of Gravity shown, or a little forward to start, if you prefer. The prototypes required 6 and 5 ounces of nose weight to balance. (Sorry about that.) The total weight of the prototypes are 76½ ounces and 75 ounces, which meets the target wing loading.

Flying Red Moose shown on the rudder, was cut from MonoKote, ironed onto the model, and the black details hand painted with enamel.

Trimming, Rigging and Flying

The model is being flown with the C.G. and tow hook locations shown on the plans. If you are nervous about first flights (as I am) you might want to start with the tow hook maybe a quarter inch or so ahead of the location shown. Before a first flight of a new model, I like to have someone give me a couple of hand launches just to get the neutral trims set somewhere near right.

I fly the model using a 7-channel Futaba G-Series transmitter. The horizontal tail and ailerons are on the right stick, the rudder and spoilers are on the left stick, and the flaps are on the lower left trim type control. If you are using different radio gear or find another set-up more convenient that's okay, but the control deflections given below are for the set-up I use. The horizontal tail deflections are set at plus or minus 3/4" at the trailing edge root in full rate, and a little more than half that in low rate. The model is quite responsive and you might want to make the first few flights in low rate on the horizontal tail. The rudder is set at ± 1.5" in full rate. With the control link up shown on the plans, the aileron trailing edge throws should come out at about 3/4" up and 1/2" down in full rate. I never use low rate on the rudder, however, I initially flew in the rudder-aileron coupled mode. In the coupled mode, the rudder deflections are about ± 1", which provides a pretty well coordinated turn when thermalling. I normally add a little rudder override when rolling into a turn from straight flight.

To launch the model, I set about 1/4 flap and neutral trim. I hold the transmitter with my thumb on the rudder control, and take up the slack plus a fair amount of tension — not too much, this is not an F3B model. I throw the model firmly at a low upward angle and let the winch establish the climb. Use the rudder for directional control. Stay off the ailerons for at least the first half to three-quarters of the launch. (I once had an instructor in a full scale glider beat hell out of the inside of my thighs with the stick for putting in aileron on a car-tow.) As you go over the top of the tow, select flaps up. You can do a mild zoomy off the top with the carbon reinforced wings. Do your thermal search with zero flaps. When you find lift, roll into the turn and select about 1/4 flap. If you circle rather tightly, you will probably want to touch top aileron once in a while just to level the wings up a bit. I am not an aerobatic pilot, and while the structure will withstand quite violent maneuvers, others tell me that the ailerons are not powerful enough for a truly aerobatic ship. Landings are a delight for my aging reflexes. Full flap requires about 2 or 3 clicks of nose down trim, so be ready for that. With full flap and spoilers (the spoilers will compensate a little of the trim) a very steep descent can be made. You should not touch down with the spoilers open. They are very effective and you will hit pretty hard, and also the lower spoiler caps can tag grass tufts, etc. With full flap you can really float up to the landing spot. The model has never surprised me with a sharp desire to quit flying.

During some early flights you might want to check the C.G. location. To do this, get some altitude and trim for straight and level flight, clean (flaps up, spoilers in). Put the model in a dive (not straight down), and let the speed build up. Release the stick. I like the model to pull up smoothly through level flight. If the model pulls up abruptly, it is needing too much nose up trim, and a little weight should be removed from the nose. If the model continues or steepens in the dive, it has too much nose down trim, and some weight should be added to the nose. Use small amounts of weight such as small fish sinkers.

Well, that's about it. Good luck, and I hope you find a new interest with a multi-control model and I am sure your contest scores, if you compete, will start coming in after a relatively few practice flights. □

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