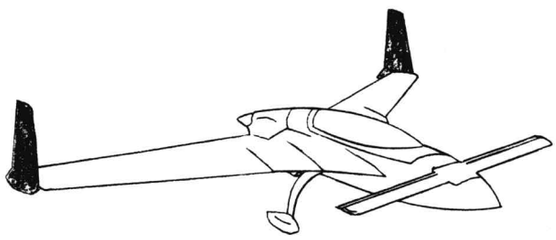
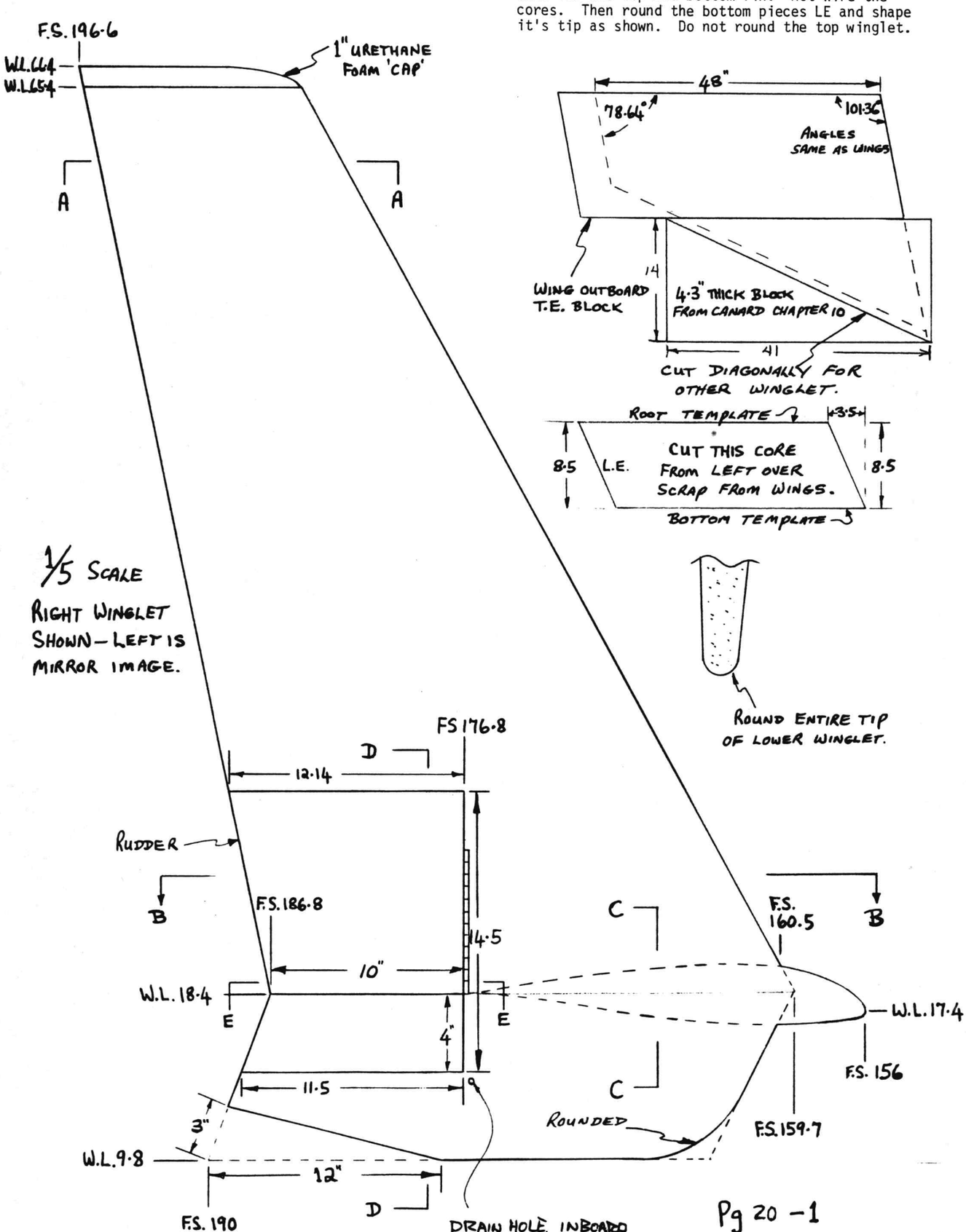
CHAPTER 20

WINGLET AND RUDDER

Overview: This chapter involves building the large vertical fins, mounting them to the wingtips, building and mounting the lower vertical fins, fabricating the rudders and hooking up rudder controls. The right wingtip is shown. Reverse to a mirror image for the left winglet. The upper fin has undercamber facing outboard. The lower fin is cambered inboard. In-flight, the upper fin lifts inward and the lower fin lifts outward. This lift distribution works against the normal vortex rotation at the wingtip, increasing the effective aspect ratio. The result is an increase in climb and range, as compared to a vertical fin not designed using the NASA Whitcomb-winglet technology.



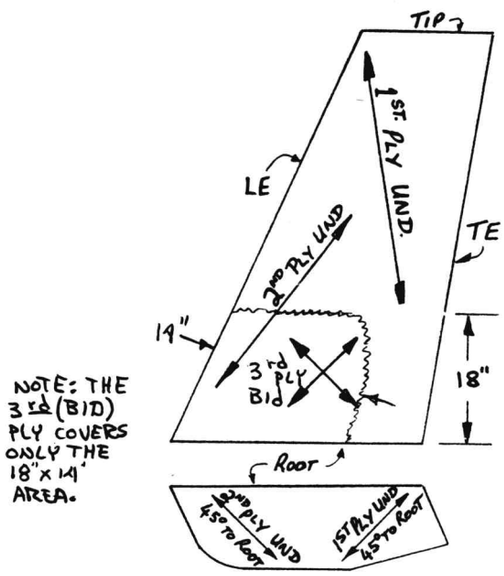
STEP 1. Cutting cores.
Refer to the planform view and hot-wire configuration drawing. The hot-wire templates are on page Refer to chapter 3 and 7 for details on hot-wiring cores. The root (WL 18.4) template is used for the top and bottom fin. Hot-wire the cores. Then round the bottom pieces LE and shape it's tip as shown. Do not round the top winglet.

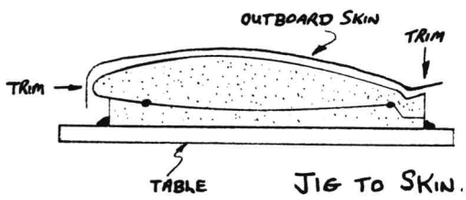


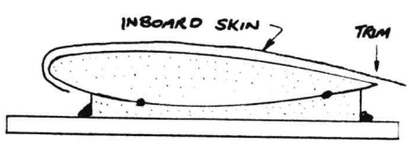
STEP 2. Glassing the skins.
Note the top fin is undercambered on the outboard side, full span. The bottom fin matches the top at WL 18.4 then transitions to a cambered-inward airfoil section at its bottom.
The left-over blocks the cores were cut from are used to jig the cores flat. Glue these to a flat table. The cores are easily warped until both skins are installed. Jig them for glassing by nailing at the root and tip and, if necessary, with small dabs of 5 minute. Recheck that rootand tip level lines are parallel (no twist).

Glass the outboard skin with the following schedule: 1st ply UND - orientation diagonally from the root TE to the LE. 2nd ply is also UND, and crosses, from root LE to tip TE. 3rd ply is on upper surface only - it is BID at 45° extending from root, up 18". Peel-ply the entire BID surface. Knife trim all around.

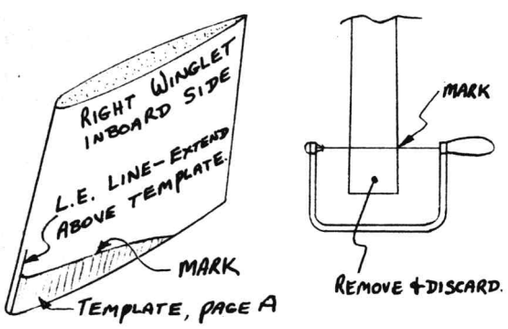
Refer to wing chapter for similar LE and TE details to obtain the correct skin overlaps, then jig and skin the inboard side using the same layup schedule, as outboard side. Be sure the root and tip level lines are parallel.
Refer to the plan view. Carve the 1" tall tip cap from urethane foam. Round to a pleasing shape and skin with 1 ply BID.





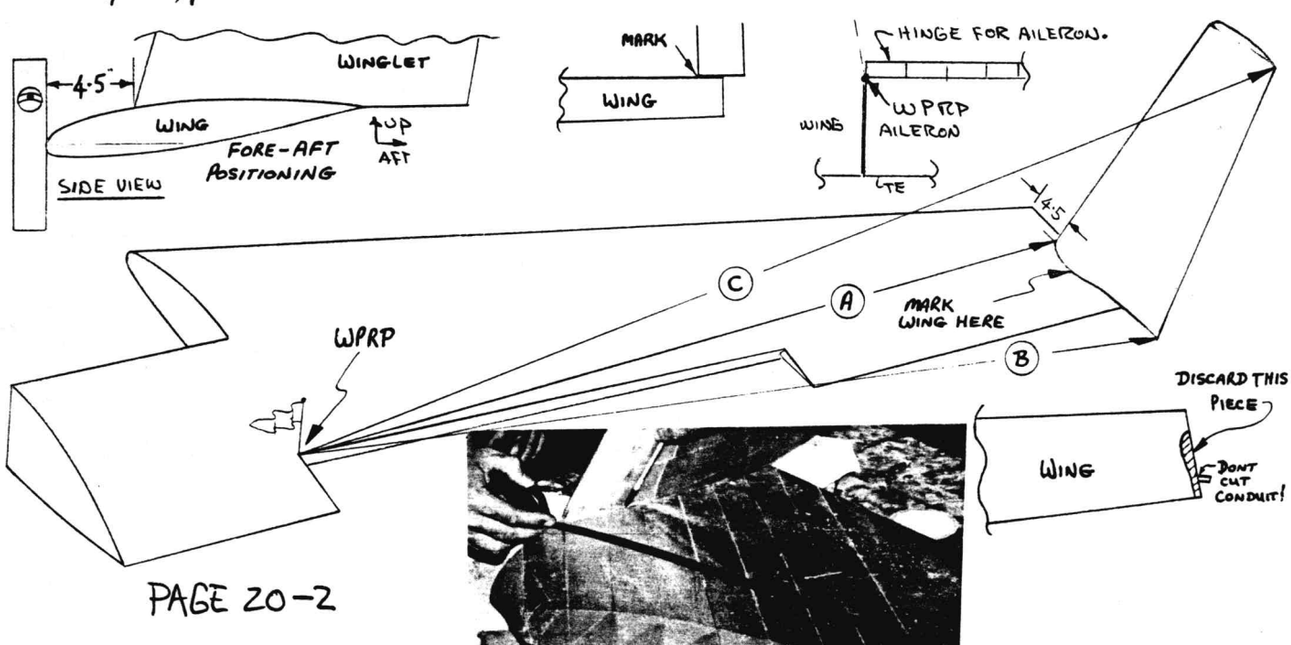


STEP 3. Jigging upper winglet to wing.
After cure, refer to page A 11 for the winglet trim template. Cut this piece of paper out and wrap it around the inboard side of the upper winglet, lining it up with the LE (extend the level-line up the LE), and lining it carefully along the root edge. Mark the trim line then saw the piece out (coping saw) sawing roughly perpendicular to the mark. Discard the piece.

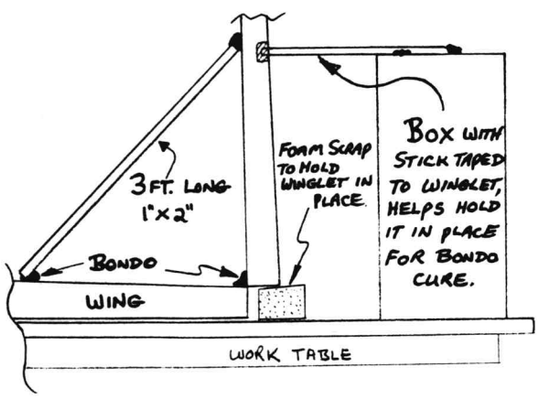


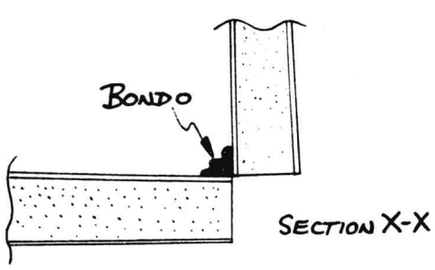
Now, layup your wing top-side up on the table, wedge it up so it doesn't rock around. Weight it down with about 50 lb of sand bags. Locate the winglet-positioning refer ce point (WPRP) and mark it clearly. This is the inboard front corner of the aileron cutout. BL 55.5 and FS 149.6 (see page 19-10). Now, set the winglet on top of the wing top surface. Have someone hold it and move it around until the A - B and C dimensions are achieved. It's best to set a box along-side and tape a stick to it to hold the winglet upright while jigging. The A dimension is from WPTP to the LE mark on the winglet at the top surface of the wing. The B dimension is from WPRP to the root TE of the winglet. The C dimension is to the tip TE of the winglet.

A and B are critical and should be within .05"
C is not critical and can be ± 1". Once positioned, mark the wing top skin at the inboard edge of the winglet. Remove winglet. Cut the wing all the way through, being careful to not knick the rudder conduit. Discard this piece.



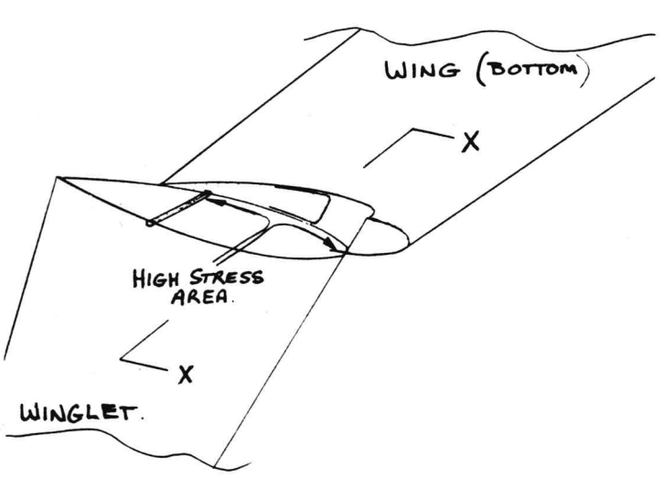
Now, lining up the edges as shown and rechecking the ABC dimensions, jig the winglet to the wing. This time hold it firmly in place with 2 or 3 3/4" diameter lumps of Bondo. Support it sideways with a 3 foot length of 1 x 2 lumber with lumps of Bondo on each end. Be sure this is not in the way of the A measurement.

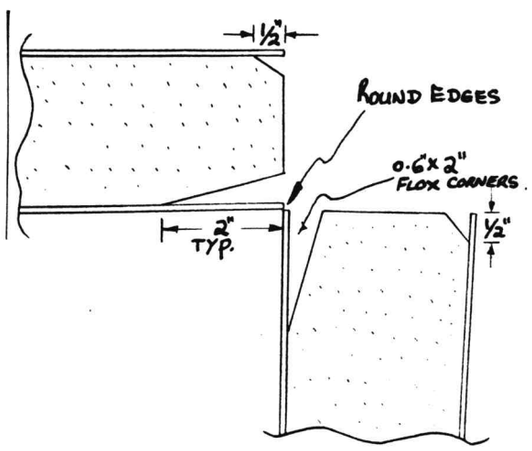




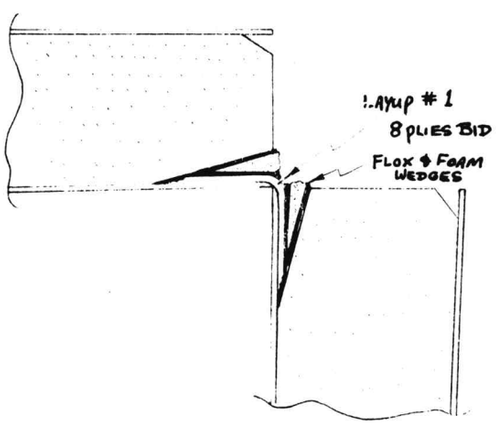
When the Bondo is hard, remove the box and recheck A - B and C.

STEP 4. Inside layups.
Study Section C-C to see the inside layups. Turn the wing over, extending the winglet off the side of the table, exposing the bare foam faces. Remove the foam locally, with a knife, as shown, by cutting out a triangular flox corner all around. This is 2" deep in the "high stress areas", and ½" deep around theother edges. The "high stress area" extends from the rudder conduit to the leading edge, along the winglet wing touching edges. Do not remove the wings' shear web. Sand the inside glass surfaces. Carve block A to fit nicely as shown. This extends from the wing TE to the winglet LE. It is carved from 2 lb (green-urethane foam. Laminate 2 pieces of 2" thick urethane. Do not glue in block A yet.

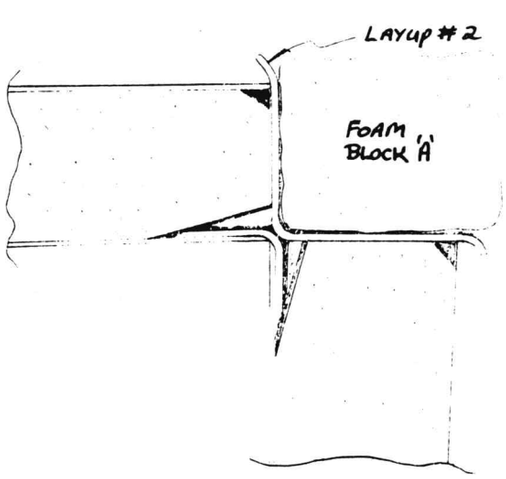




Cut 8 strips of 45° BID, 4" wide by 12" long. Now, layup the eight small inside tapes, (layup #1). Trowel in flox to fill the void. Where the void is excessive, fill portions of it with foam wedges (see sketch). The flox and foam wedges hold this layup firmly against the winglet skin and wing skin and spar cap. Knotch the 8 plies locally to fit around the shear web in the wing.

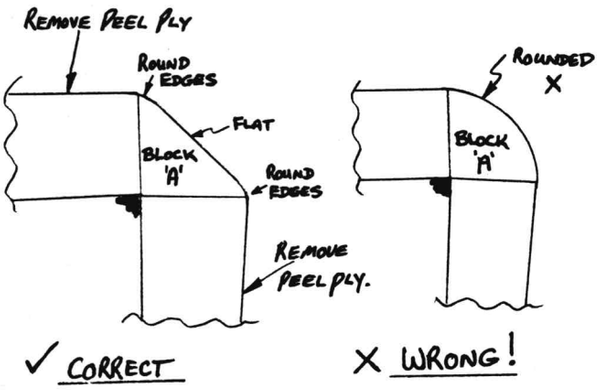


Allow this to partially cure to avoid an exotherm, then fill the flox corners and glass layup #2, the inside ribs. These are 8 plies BID forward of the rudder conduit. Extend two of the 8 plies aft to the winglet TE. Position the rudder conduit at 13.2" from the winglet TE along the outside edge of the winglet. Layup #2 joggles up over the conduit - trowell in dry micro to avoid air bubbles. After sufficient cure to avoid exotherm, trowell in some wet micro and install block A. Block A must fit well enough to avoid air voids. Weight or nail block A in place for cure.

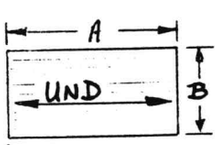


STEP 5 - outside layups.

After cure, carve block A to a flat diagonal, not round, as shown. Remove peel ply. Round

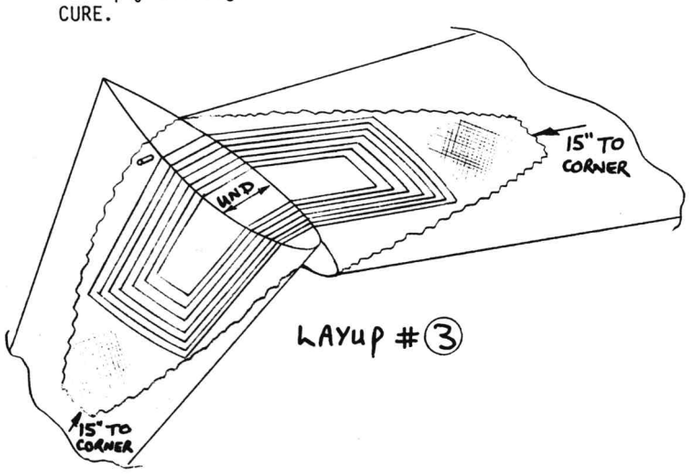


the edges for layup and glass layup #3, the structural bottom - outboard layup. This layup consists of 2 plies BID, extending 15" up the wing and 12" up the winglet in a tapering fashion as shown plus 7 plies UND. Make the 2nd BID ply about 2" shorter to taper its edges. Thread The BID around the rudder conduit. Now, cut the follwing 7 UND plies, using care to orient fibers along the A dimension.

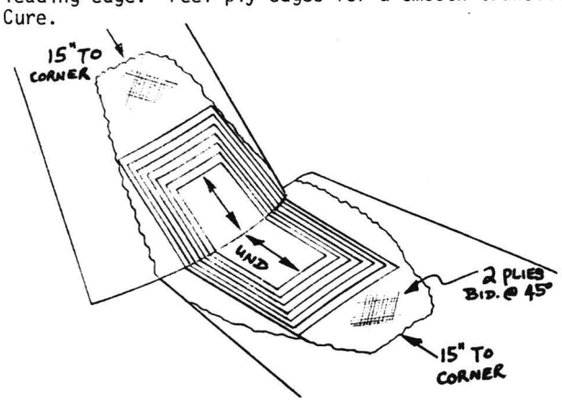


Ply #	A-in.	B-in.
1	24	12
2	22	11
3	20	10
4	18	9
5	16	8
6	14	7
7	12	6

Refer again to the sketch, layup the 7 plies of UND with fibers running around the corner as shown, centered on the corner. Keep fibers straight. Peel-ply all edges to make a smooth transition. CURE.



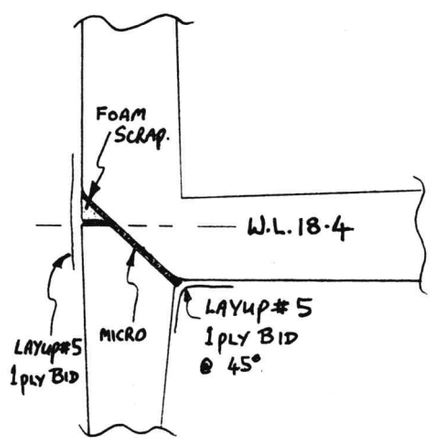
After cure, turn wing over, knock out the Bondo lumps in the corner, remove peel ply and glass layup #4, the structural top - inboard layups. This layup is identical in size, number of plies, and orientation as layup #3. Lap the 2 BID plies 1" onto the outside of the winglet at the lower leading edge. Peel-ply edges for a smooth transition. Cure.



The top winglet is now structurally attached to the wing. Remove the 3 foot 1 x 2 board.

Do not increase the number of plies - your winglet joint can withstand 90-degrees sideslip flight at 170 mph - considerably over normal requirements.

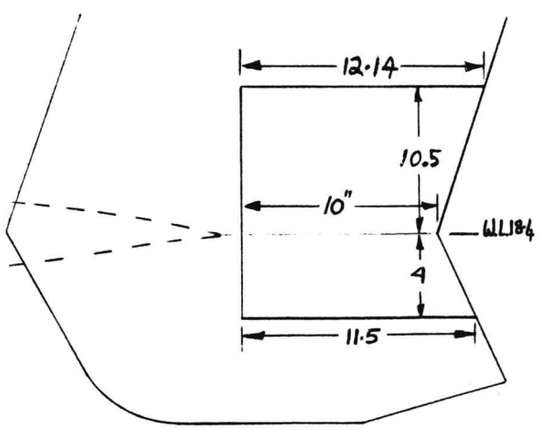
STEP 6 - Lower winglet attach.
Trim the lower winglet as shown so its root - WL 18.4 fits up to match the upper winglet. Fill the small voids shown with urethane foam and micro it in place. Glass a 2" wide tape of BID at 45° to structurally attach the lower winglet at the outside and inside as shown (layup #5).



Now you can install your desired wingtip light (see Section III). The light must be installed at the position shown. Do not add weight aft of that location. Also do not cut into the structural area.

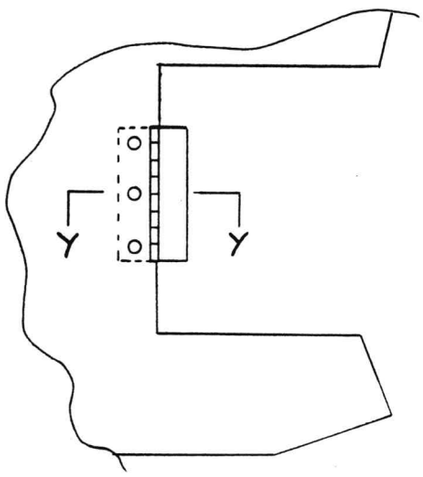
An optional fairing block can be installed as shown in view B-B to fair the wing tip into the the winglet surface. Use any type foam covered with 2 plies BID

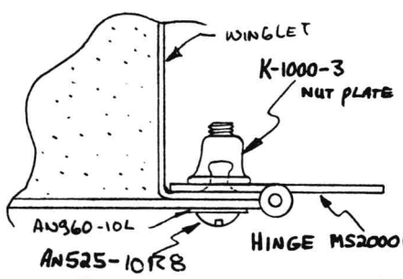
STEP 7 - Rudder
Carefully layout the rudder dimensions shown, on the outside and inside of the winglet. Saw through the skin on both sides with a razorsaw, then cut through the foam, to remove the rudder. The rudder is hinged on its outboard edge with a piano hinge. The piano hinge is 7.5" long, extending from WL 18.4 up. Study section D-D, view B-B and Section E-E.



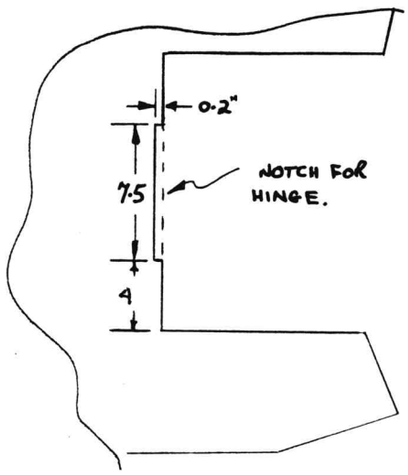
Set the wing leading-edge-down. Remove foam as shown, .6" deep at the top and bottom and 1" deep at the front. Glass 3 plies BID in this entire area plus an extra ply on the edge where the hinge will go (layup #6). Knife trim. After cure, trim the hinge area forward 0.2" x 7½" to recess the hinge. Drill and fasten the hinge to the wing with three AN525 -10R8 screws, with K-1000-3 nutplates on the hinge. Trim the hinge width as required to fit.

Grab the rudder and , in a similar fashion, remove foam all around the edges. Remove 0.6" top and bottom and 0.8" on the forward face. In addition, remove a tapered depression to reinforce the belcrank as shown. The depression extends 2.4" deep from the hinge line, on the outboard side. It is conical in shape and centerd at WL 18.7. Glass this area (layup #7) with 3 plies BID plus an extra ply at the hing and belcrank depression.





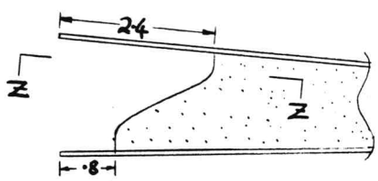
SECTION Y-Y. HINGE INSTALLATION.



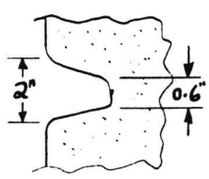
When cured, install the hinge and belhorn using the 7 pop rivets and 2 each AN 525-10R8 screws, AN 906-10L washers and MS 21042-3 nuts. Install cable and swage fitting. Max rudder travel is 30° however the swage must <u>still</u> have at least 0.7" travel until it bottoms on the conduit - brake master cylinder <u>is</u> the rudder stop - any other stop will leave you without brakes!

Return spring - this returns the rudder to neutral on the ground. In-flight, the airloads force the rudder to neutral unless the pilots steps on the rudder pedal. In stall the tube and hook shown, near the top of the rudder along the inboard skin. The 1" hole in the foam can be cut easily if you file some notches in the end of a tube and rotate it to saw the hole like a long "holesaw".

The edge, marked "A" is the rudder stop. Long-EZs do not have, nor need inflight rudder trim the edge at A can be trimmed to allow the rudder to move more inward or shimmed to move the stop outward, to provide ground - adjustable rudder trim. Once trimmed for ball-centered flight, further adjustment should not be needed.

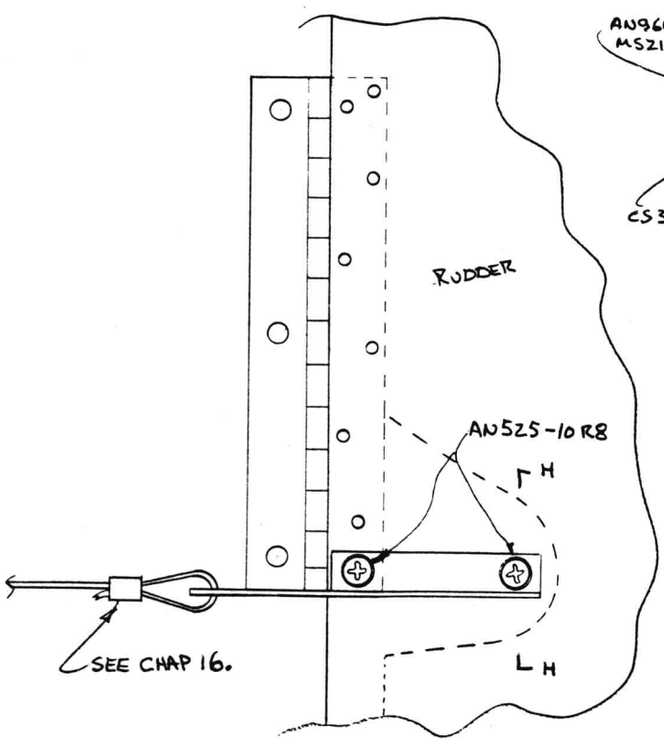


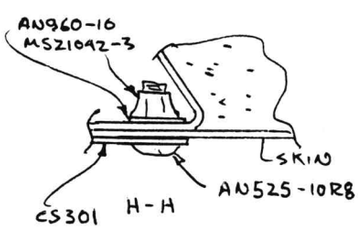
SECTION E-E - RUDDER AT WL.18.4.

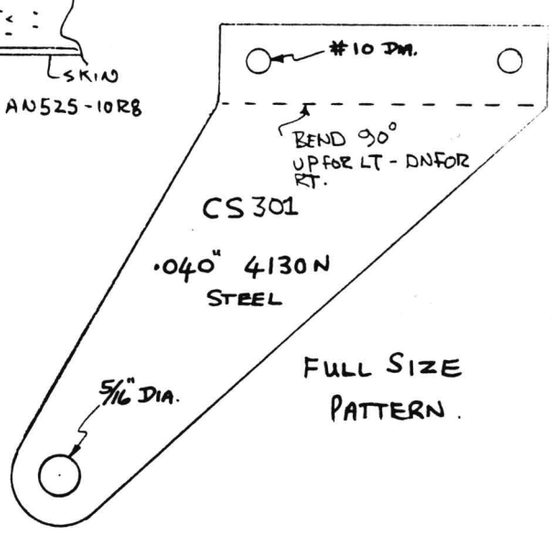


SECTION Z-Z

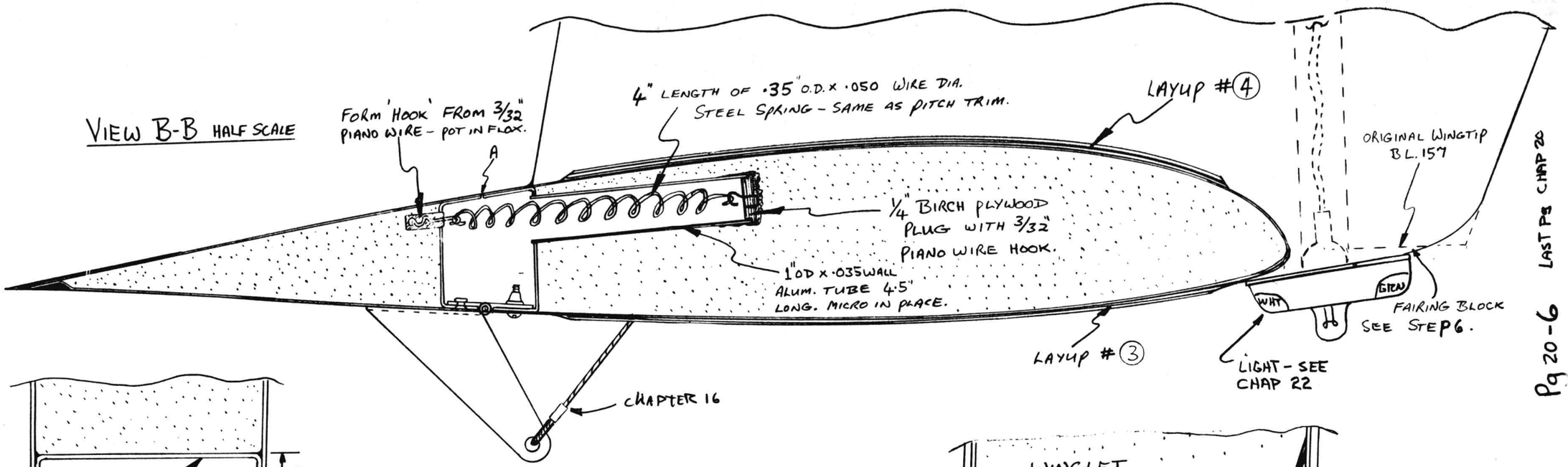
Now, go back to Chapter 16 and finish the rudder control system.

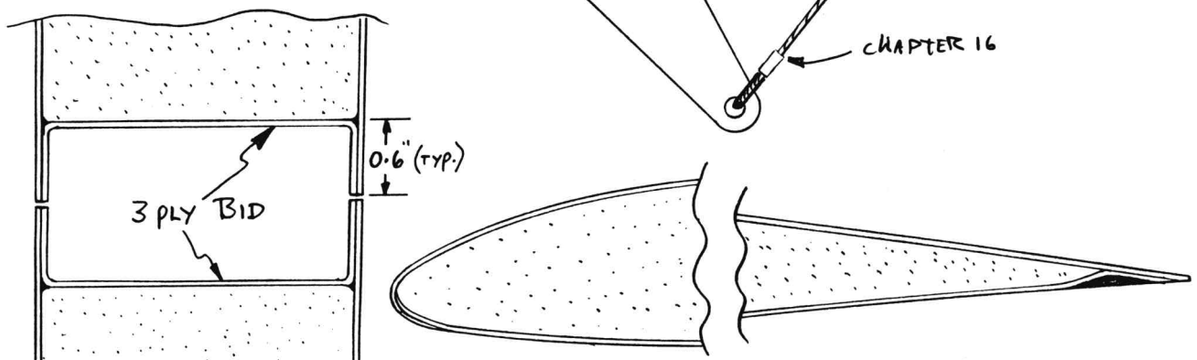






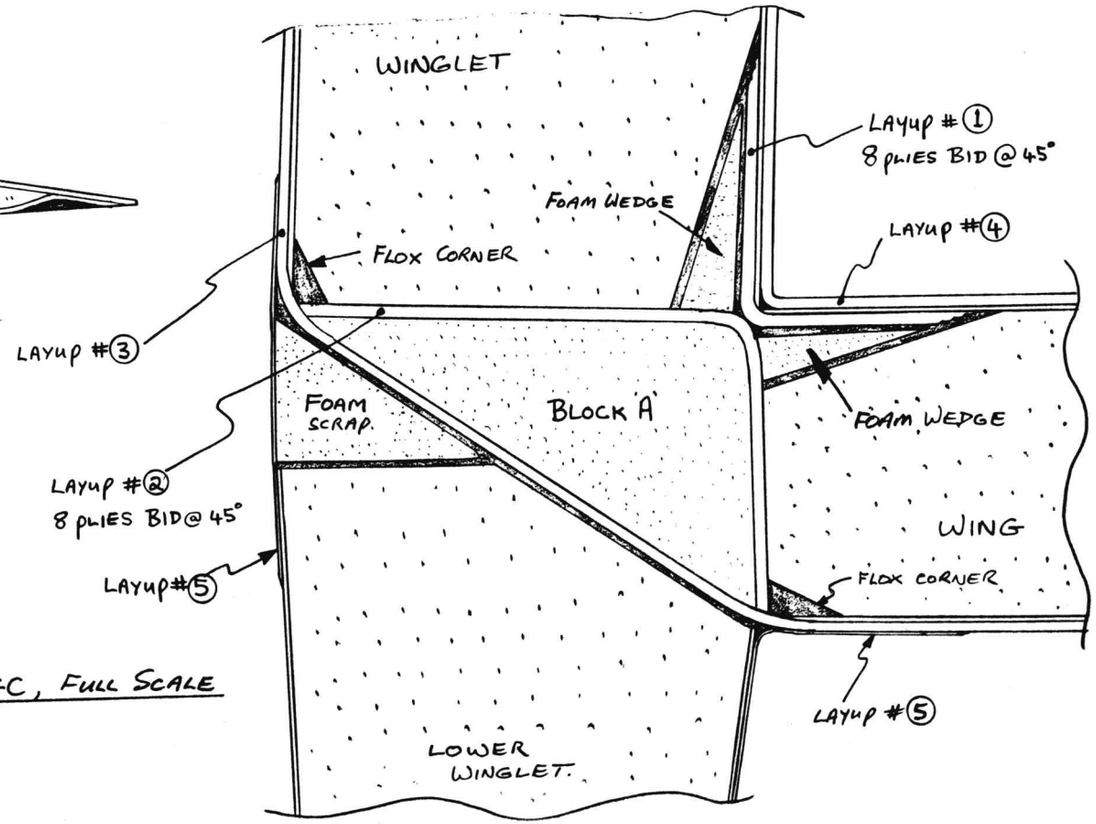
VIEW B-B HALF SCALE





SECTION D-D FULL SCALE

SECTION A-A, FULL SCALE



SECTION C-C, FULL SCALE