
2. Rudder

Overview

The complete rudder will be made in this chapter. Two skins and a leading edge spar will be laid up, and three hinges attached. A rudder horn will be fitted to the bottom leading edge of the rudder.

Step 1

Preparation

Take the rudder core out of its foam jig blocks and set it aside for the moment. You can discard the loose end pieces but save the strip from along the leading edge for use later -see figure 1.

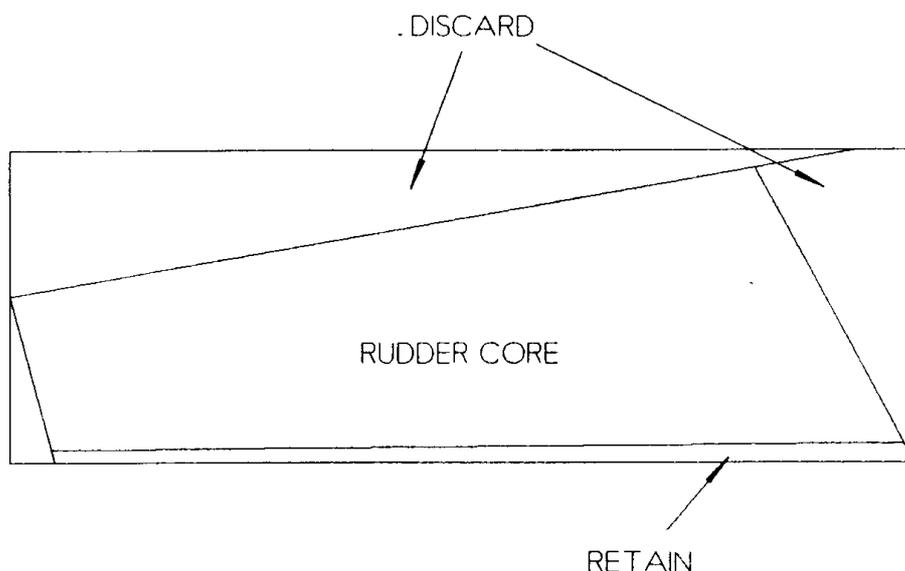


Fig 1. Sketch showing parts of rudder foam block.

With a hacksaw blade cut the edges off both foam jig blocks so they are about 6-7 cm (3") smaller than the rudder core all around *except* for the trailing edge.

Place the port side jig block, with the trailing edge support block cut-out in it, on your bench and, sighting along its leading and trailing edges to ensure that it's flat and not twisted, bond it to the bench with blobs of rapid epoxy, see figure 2.

Note: The joggle at the trailing edge, and the support block, are provided to ensure a strong glass-to-glass joint at the trailing edge - see figure 10 later in this chapter. The joggle will be filled later at the finishing stage.

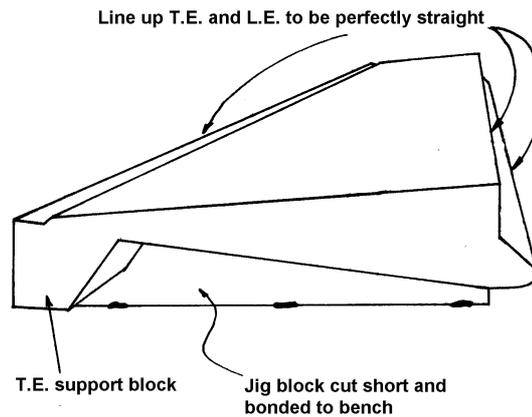


Fig 2. Rudder lying port side down in its jig block.

Next, remove all flashings of foam from the rudder core's leading edge to make a nicely rounded nose. Round off the tip of the rudder core, leaving the trailing edge support block intact. Use the supplied fin tip moulding as a pattern for the shape. The root should be formed with a complete radius (see figure 5) from the leading edge diminishing in size to the trailing edge. Also round off the leading edge to the tip and root.

Hint: If you temporarily attach the strip of foam from the leading edge back in place it can help you visually in forming the tip and root radii.

Now, with *small* dabs of rapid epoxy bond the rudder to the jig block and ensure that the leading edge and trailing edge are perfectly straight. See figure 2.

Lay a strip of peel ply in the trailing edge recess and on the edge of the leading edge corner, holding them in place with double sided tape. See figure 3. This recess is to enable the top and bottom skins to have an effective joint. It will be filled with micro at the finishing stage.

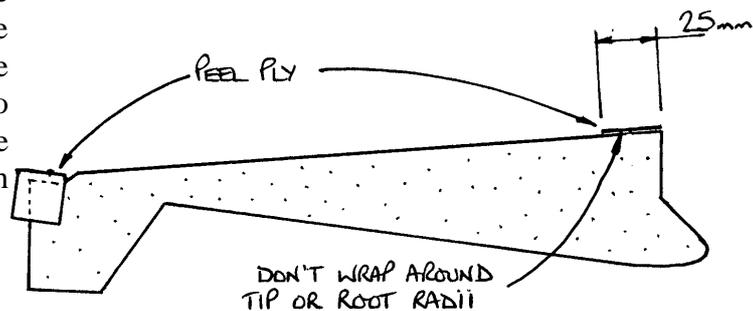


Fig 3. Positions for peel ply.

Step 2

First skin layup

Now's time to prepare for the first skin layup so cut pieces of 'uni' to the following dimensions:

- 1 full width x 160 cm (63")
- 1 full width x 140 cm (55")

HINT: To reduce waste on this layup you may like to place the cloth, correctly orientated, over the core in a dry run and cut the excess off first. To hold loose fibres at the cut lines together, stick masking tape on the cloth where cuts will be first and cut down the middle of the tape. Don't cut too close to the edges of the rudder core though, you don't want to find that you're short of cloth during the layup. Keep the triangular off-cuts in a clean box as you'll often find a piece will come in handy to cover a corner elsewhere. It's helpful also to mark the ply orientation angles onto the foam surface with a felt tipped pen.

Mix up some dry micro as required, to fill any dings and dents, then micro slurry the area to be glassed, without getting any on the peel ply of course.

Brush the whole surface with epoxy, then using the rudder's leading edge as your 0° reference, lay the first ply onto the core at 30° (it's not vital which goes on first but be careful, the lengths of cloth are such that the short one will only cover the rudder in one of the directions). See figure 4.

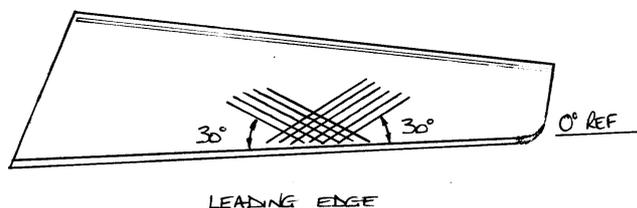


Fig 4. Side view of rudder core.

Wrap the cloth 3/4 of the way round the tip and root radii and scissor trim. See figure 5. Where the support block is, just run the cloth down it a little way.

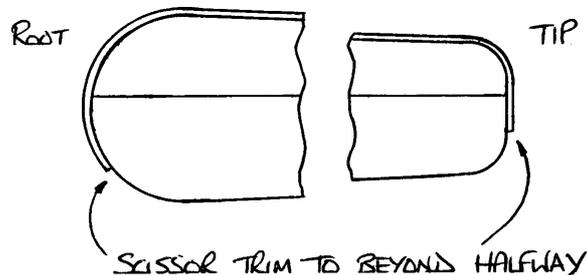


Fig 5. View looking at leading edge.

Trim the cloth at the leading and trailing edges to within about 1 cm (1/2") of the foam. See figure 6.

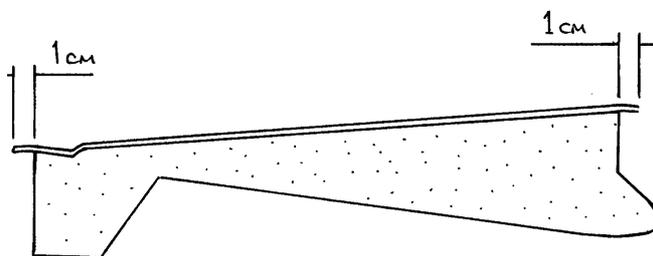


Fig 6. Section through rudder.

Note: The cloth does not go down the vertical face at the leading edge.



When the first ply has been properly wetted out, lay on the next ply at 30° the other way to the rudder's leading edge and repeat the wetting out and trimming process as before. Put peel ply on to cover the ends of the cloth on the tip and root and leave to cure, (remember to maintain workshop temperature during cure), knife trimming the overhanging ends back to the foam at the appropriate stage and sanding them after full hardness has been reached.

First skin layup summary

1 ply at 30° to the leading edge.

1 ply at 30° *the other way* to the leading edge.

Step 3

After cure remove the rudder from the jig block, flip it over and, using a hacksaw blade, remove most of the trailing edge block, then sand it down with a sanding block to be flush with the rudder profile.

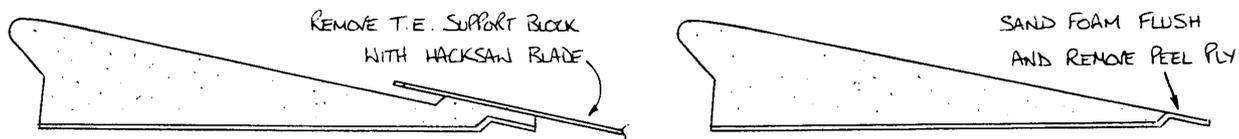
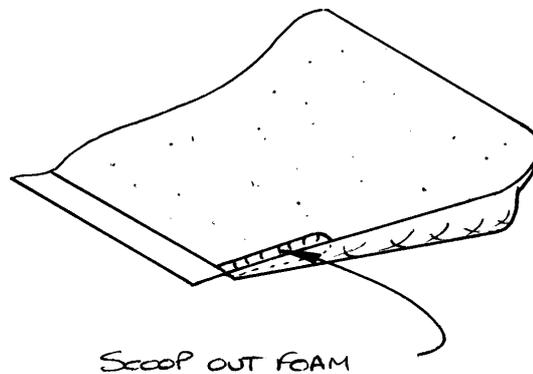


Fig 7. Removal of trailing edge support block.

Don't forget to remove the strip of peel ply at the trailing edge and tips. See figure 7.



Scoop out a trough in the foam, 5-6 mm (1/4") wide and 5-6 mm deep, from the tip and root trailing edge forward about 6 or 7 cm (2 1/2 - 3"). See figure 8.

Fig 8. Trailing edge floc trough.

As unidirectional cloth doesn't like going around tight radii, such as at the tip and root trailing edge areas, these will effectively become floc corners.

Re-jig the rudder on the other jig block making sure that the trailing and leading edges are straight.

Step 4

Second skin layup

Cut two pieces of 'uni' to the following dimensions:

1 full width x 160 cm (63")

1 full width x 140 cm (55")

Prepare the foam with micro slurry as before, filling in any holes that were caused by the rapid epoxy with dry micro. Fill the trailing edge troughs with flox then brush a coat of epoxy on the surface and lay the first ply of cloth on at 30° to the leading edge, wrapping it around the leading edge as in figure 9 and overlapping the previous layup by about 2 cm (3/4") at the tip and root. Scissor trim this ply,

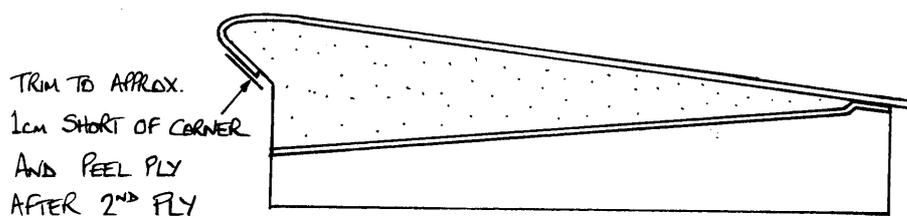


Fig 9. Extent of second skin layup.

wet it out then lay on the second ply.

Note: *Make sure you know for certain that the product you use is flox and not either of the of the two microfillers - only flox is structural.*

Once properly wetted out, squeegeed and trimmed, apply strips of peel ply over the tip and root fibre ends and all along the leading edge fibre ends then leave to cure. Knife trim the trailing edge at the appropriate stage, sanding it after full cure.

Second skin layup summary

1 ply 30° to the leading edge.

1 ply 30° *the other way* to the leading edge.

After cure the rudder can be removed from the jig block and prepared for the leading edge layup. It's a good idea to round off the trailing edge tip and root corners with a sanding block at this stage as they're quite vulnerable to damage if left sharp.

Step 5

Hinge flange

The foam at the leading edge must first be removed with a hacksaw blade and knife. Run the hacksaw

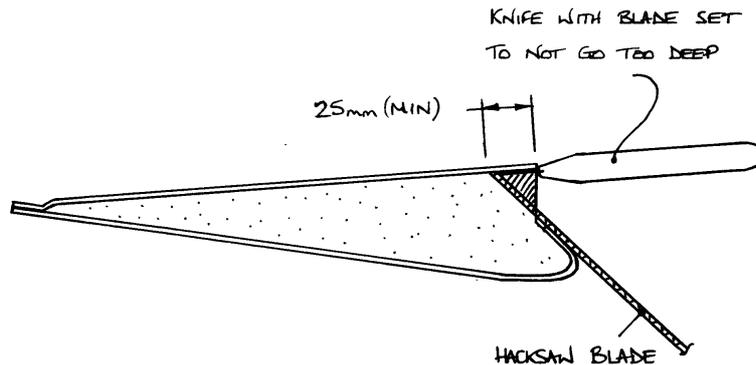


Fig 10. Preparing for hinge flange.

blade flat against the glassed leading edge and cut into the foam until you contact the inside surface of the skin, making sure that 25 mm (1") of skin is exposed. Do not cut into the skin though. See figure 10.

Cut into the foam just under the skin with a knife to meet the first cut line and remove the triangular sectioned strip of foam along the whole length of the rudder. Remove also the peel ply.

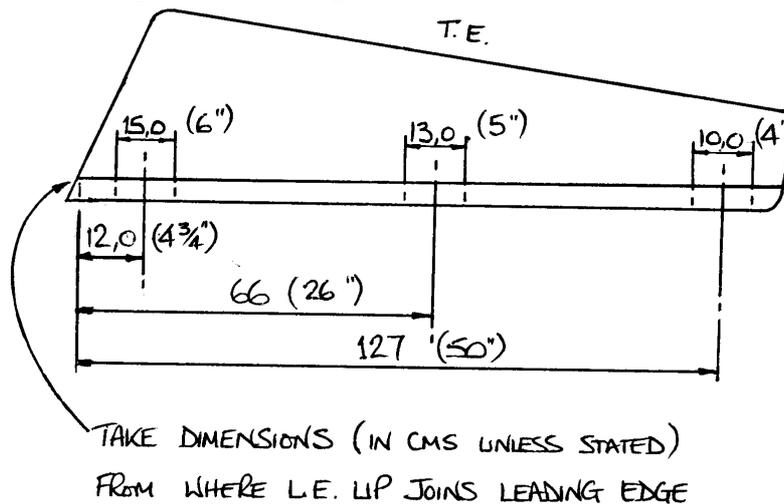


Fig 11. Hinge reinforcement positions.

Mark the hinge areas as in figure 11 so you will know where to place hinge reinforcement plies which will go between the two main plies of the leading edge layup.

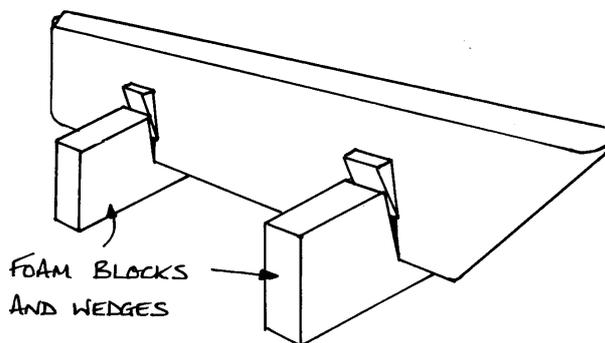


Fig 12. Rudder set in foam vee blocks.

Setting the rudder into a couple of foam blocks with vees cut into them will make life a little easier for the next stage - see figure 12.

Step 6

Cut pieces of 'bid' at +/- 45° to the following dimensions:

- 2 off Full length possible x 13 cm (5")
- 2 off 15 cm x 5 cm (6" x 2")
- 2 off 13 cm x 5 cm (5" x 2")
- 2 off 10 cm x 5 cm (4" x 2")
- and several strips of peel ply.

Stick a strip of masking tape onto the inside of the rudder's leading edge lip, as in fig. 13, to keep micro off it then, with dry micro, fill any dents in the foam and make a *small* radius at the bottom of the vee between the foam and skin just to give the fibreglass a chance to get around the corner without leaving an air bubble underneath. Remove the masking tape.

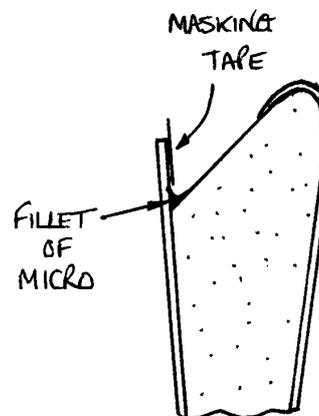


Fig 13. Section through rudder leading edge.

Micro slurry the foam, making sure to remove any that has strayed onto the glassfibre areas, then brush on a coat of epoxy resin and lay the first full length ply onto the layup area and adjust the cloth width to get the fibres orientated +/- 45°. This will adjust the length to fit also. Position the cloth to overlap the glass on the sloped face of the leading edge by about 2 cm then carefully push it down



with a brush *right into the bottom of the vee*, finally stippling it on to the other glassfibre skin and into the root and tip corners.

Wet out the cloth and scissor trim to about 1 cm (½") beyond the edge of the flange before laying in the hinge reinforcement pieces according to your reference marks. These pieces go down the glass flange and into the vee but don't overlap the leading edge skin as do the main plies.

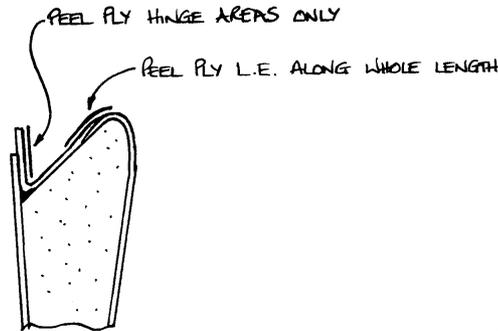


Fig 14. Peel ply on leading edge layup.

Lay in the second main ply, wet it out properly then peel ply the fibre's ends and also the hinge areas on the flange. See figure 14.

After cure trim off the excess and sand back to the previous skin line.

Step 7

Hinge attachment

The hinges will be bonded to the rudder and also held with rivets. Those used on the rudder are the wider 20001-5 hinges and are provided in the following lengths:

- 1 off x 127 mm (5")
- 1 off x 178 mm (7")

The 178 mm (7") piece is used to make one 102 mm (4") hinge and one 76 mm (3") hinge. When cutting hinge always remove the hinge wire first and cut the hinge half way through a lug so the ends are well supported.

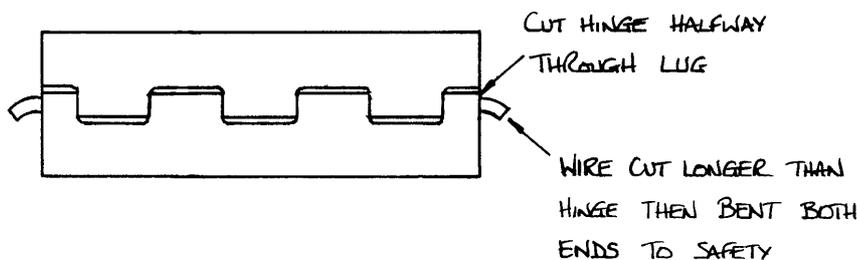


Fig 15. Hinge safety method.

Cut the hinge wire separately to be about 13 mm (½") longer than the hinge itself to allow for a bend at each end to enable safetying. See figure 15.

To end up with the appropriate lengths of hinge wire use the 127 mm (5") length taken from the hinge and the extra 228 mm (9") length provided and cut them as follows:-

Cut the 228 mm (9") length to make 1 x 140 mm (5 ½") length for the 127 mm (5") hinge and 1 x 88 mm (3 ½") length for the 76 mm (3") hinge. Cut the 127 mm (5") length of wire to make 1 x 115 mm (4 ½") length for the 102 mm (4") hinge.

A similar exercise will need to be carried out for the hinges used to attach the anti-servo tab to the

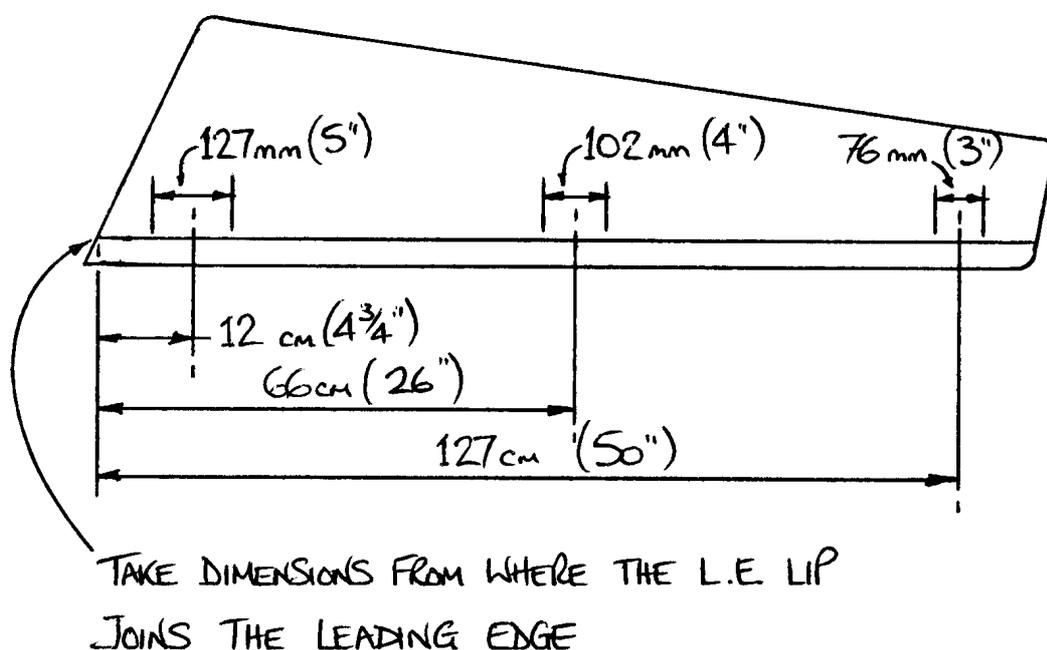


Fig 16. Hinge locations.

tailplane. The wire you removed from the 178 mm hinge will be required so don't throw it away. If you wish to make the tailplane's hinges now, refer to the instructions in chapter 4.

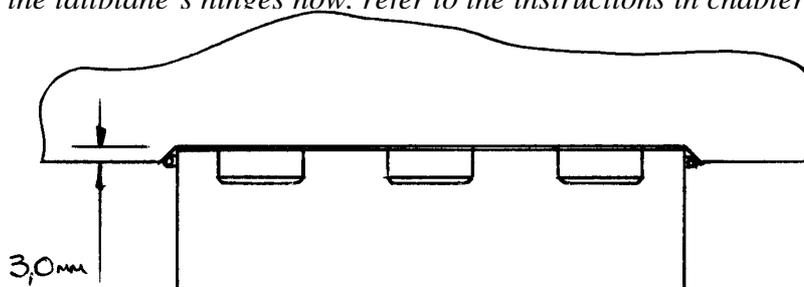


Fig 17. Typical hinge clearance cut-out



Mark the positions of each hinge on the leading edge lip to the dimensions in figure 16.

At each marked area cut the lip back 3mm, to allow for the hinge pivot to locate, then sand the corners back at about 45° to allow room for the hinge pin. See figure 17.

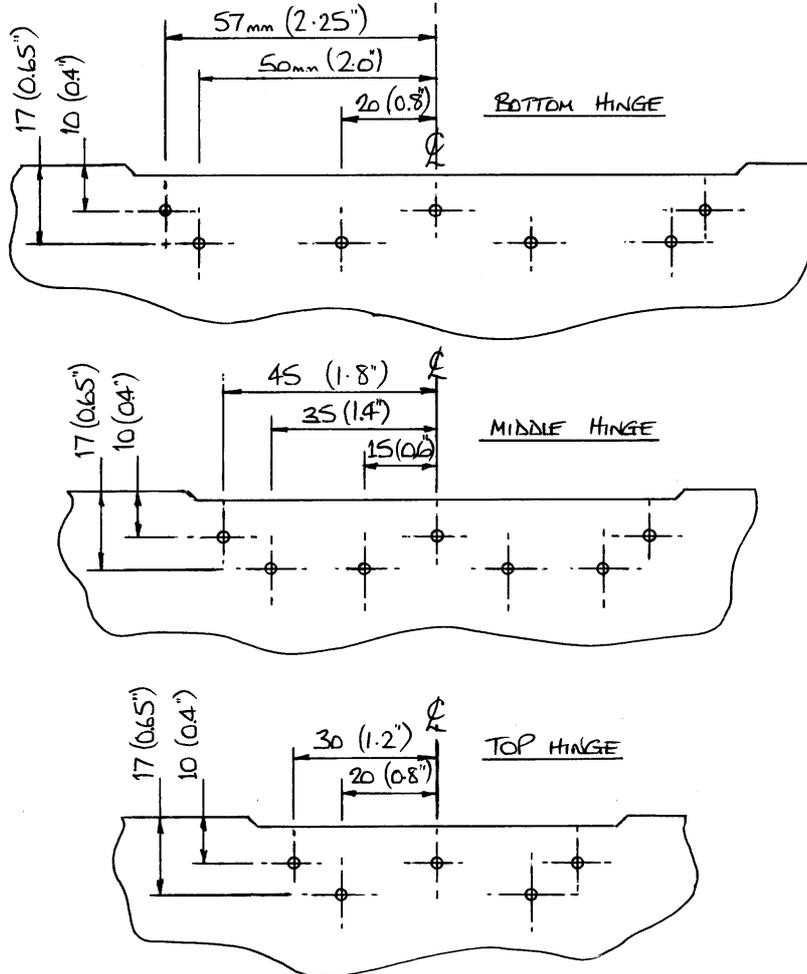


Fig 18. Hinge rivet hole positions.

Hint: To ensure that the hinge cut-outs are all in line mark the tip and root ones first then, with a straight edge lined up with these, mark the middle one.

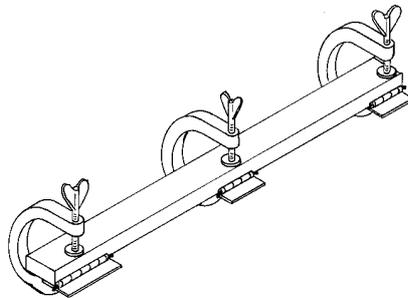


Fig 19. Hinges clamped to straight edge.

Next mark the centres for the rivets referring to figure 18 for their positions.

You will now need to find a straight edge that is at least 1270 cm (50") long. Clamp the hinges, in their relevant positions, to the straight edge making sure they are exactly in line with each other. See figure 19.

Offer the hinges up to the cut-outs in the rudder lip to ensure that they all fit correctly. Make any adjustments to the cut-outs with a sanding block.

(You may need an extra pair of hands for this bit.) Hold the hinges in position, with their free flaps against the inside of the rudder lip and drill through both the flange and hinge at one of the rivet positions of each hinge with a 3.3 mm drill. Use a cleco to hold each hinge flap in place then drill the remaining holes.

When all the holes have been drilled remove the cleco fasteners and roughen the hinge flaps ready for

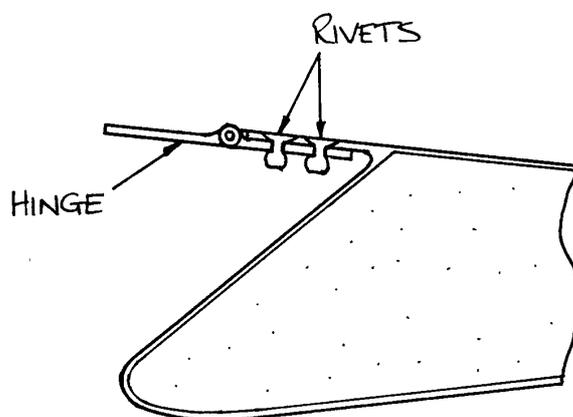


Fig 20. Section through hinge area.

bonding. Clean any swarf away from the hinge and rudder lip.

To countersink the holes in the glassfibre flange to accept the flush pop rivets TLPK424BS, lightly spin a drill bit of at least 1/4" diameter, (or, if you have one, a 120° countersink bit) between your fingers (not in a drill), in the hole trying a rivet in it to ensure that the correct depth is not exceeded. See figure 20.



Be **very careful** not to countersink too deep into the flange.

With everything to hand, mix some epoxy and add floc to make a paste then coat the jointing areas. Ensure no epoxy gets on the hinge joint. Before the epoxy has gone off attach the hinges, first with cleco fasteners to locate them, then rivet them up. Remove any excess epoxy and allow to cure before unclamping the straight edge.

Step 8

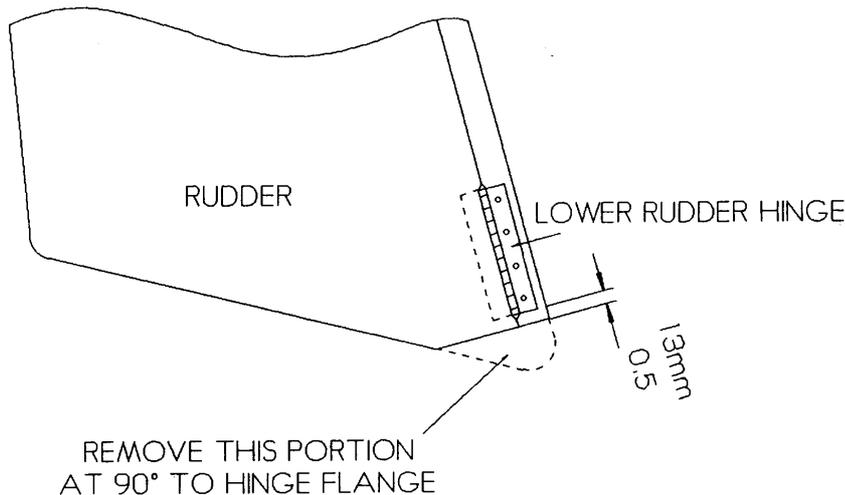


Fig 21. Cutting dimension for rudder horn.

Rudder horn

Using the bottom of the lower hinge as a reference, mark a line on the rudder 13 mm (1/2") down from it and at 90° to the hinge flange. Cut this part of the rudder off, then scoop out the foam to a depth of 15mm (5/8"), leaving the foam as flat as possible. One way of doing this is to drill several small holes to a depth of 15mm (5/8") and then clear out the remaining foam.

Remove the portion of flange at the leading edge of the rudder (not the side skin flanges) until it is flush with the foam and radius the corner in preparation for a layup.

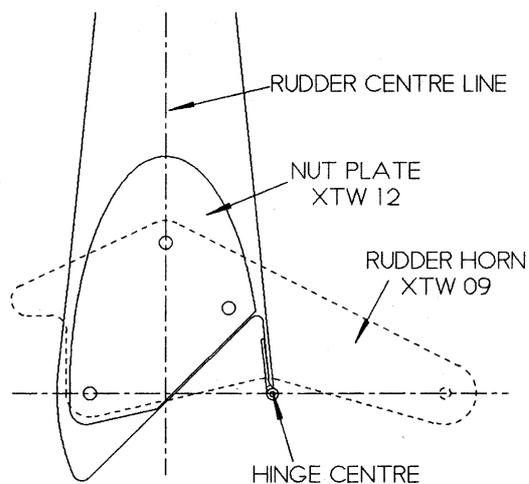


Fig 22. View of rudder, nutplate and horn from below.

Layup 4 plies of 'bid' onto the foam in the rudder base and lap up onto the flanges all around and up the leading edge; cover with peel ply and allow to cure.

After cure, remove the peel ply and trial fit the nutplate XTW12 into the base of the rudder. Trim its edges if required until it is able to fit properly onto the glassfibre rib. Figure 22 shows the position of the nutplate (and the rudder horn which will be fitted later) in relation to the hinge centre - a line between the forward hole and the hinge centre must be at right angles to the rudder centreline.

Drill through the holes of the nutplate into the glassfibre with a 4.8 mm drill then, removing the plate, enlarge the holes in the glassfibre to allow the nut part of anchor nuts, which will be riveted to it, to enter. Other smaller holes will be necessary to allow clearance for the rivet tails. The flanges of the anchor nuts will cause there to be a gap between the glassfibre and the nut plate; this will be taken up by floc.

Attach three MS21047-3 anchor nuts to the upper side of the nut plate using TLPK429BS rivets. The holes in the anchor nut flanges will need to be drilled out to 3.3 mm to accept the rivets. Carefully mask or block the holes for the bolts with masking tape, plasticine or modelling clay to prevent epoxy from entering. This will be cleared away later when inserting the attachment bolts.

Scuff sand both sides of the nut plate for bonding, then floc the plate in place to the base of the rudder, ensuring that floc does not squeeze into the anchor nuts.

Next, having made a floc fillet all around, layup 4 plies of 'bid' over the plate and up onto the flanges. At the leading edge of the rudder, wrap the cloth onto the rudder close-out. Peel ply the layup and allow to cure. See figure 23.

After cure, remove the peel ply and drill open the bolt holes. Be careful not to drill right through into the thread of the anchor nuts of course. Using AN970-3 washers as spacers/shims between the rudder base and XTW09 rudder horn on the hole nearest the

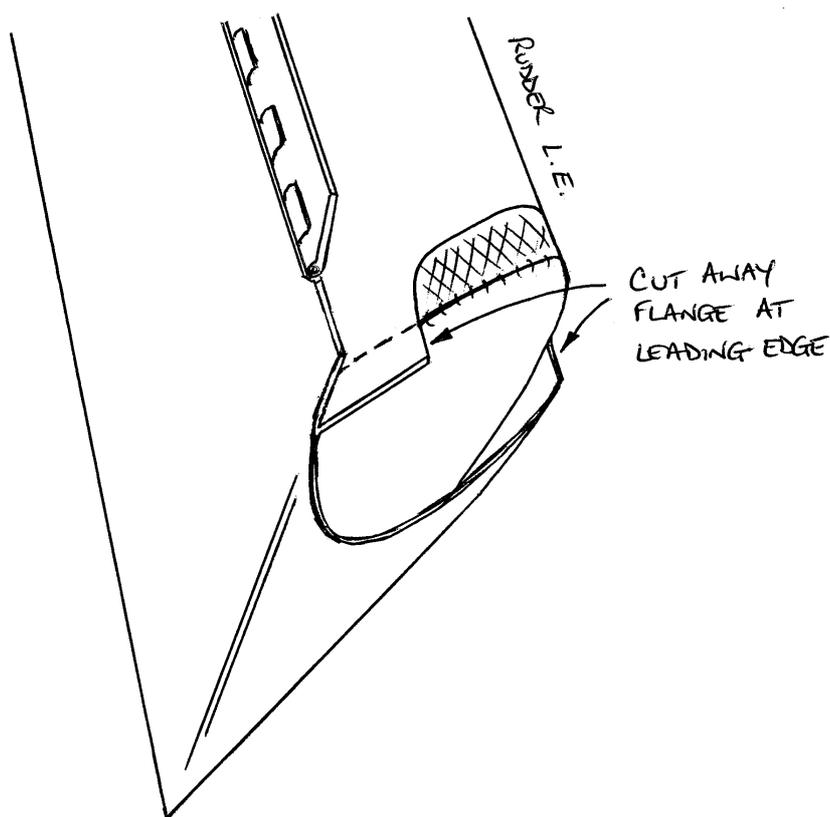
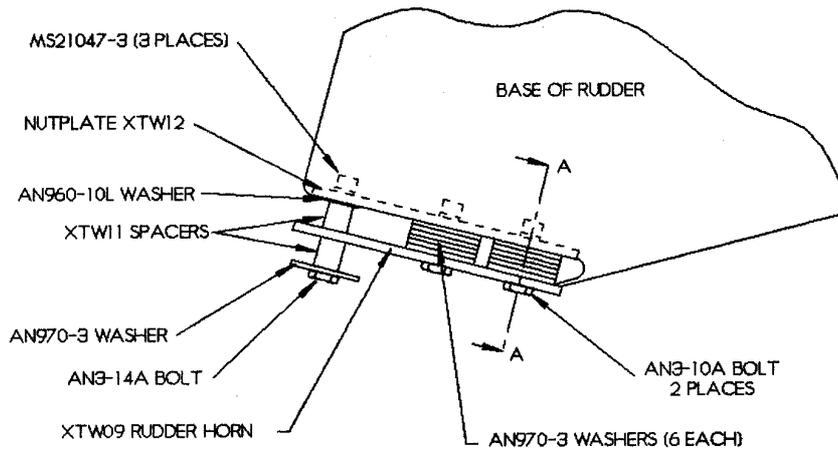
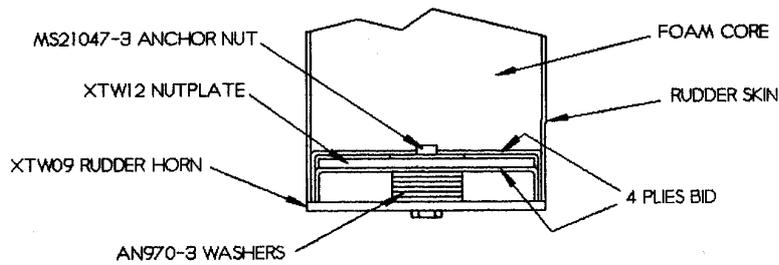


Fig 23. Wrapping cloth at lower leading edge.

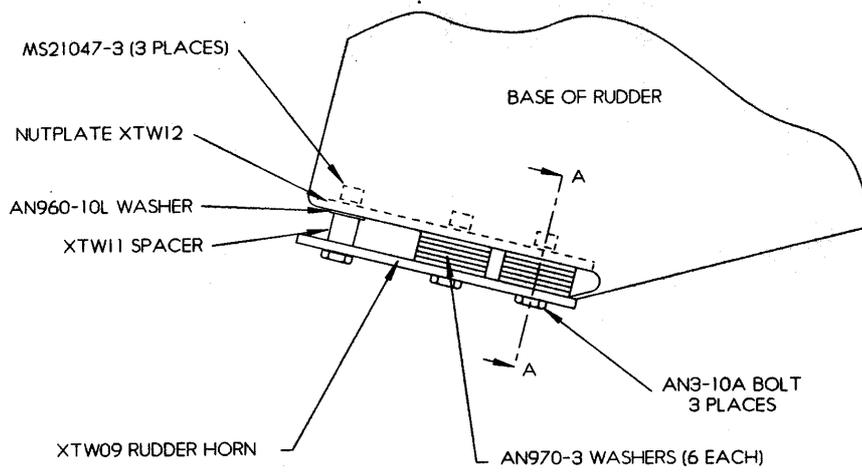


SIDE VIEW OF RUDDER BASE



SECTION A - A

Fig 24. Attachment of rudder horn - monowheel.



SIDE VIEW OF RUDDER BASE

Fig 25. Trigear rudder base fittings.



hinge and the rearmost hole attach the horn to the rudder. The long horn should be orientated to starboard. The vacant hole will be used later for cable attachment. Figure 24 overleaf shows the attachment for the monowheel, and figure 25 for the trigear.